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Protective clothing for firefighter's who are engaged in support activities associated with structural fire fighting — Laboratory test methods and performance

Vêtements de protection pour sapeurs-pompiers engagés dans des activités de support associées à la lutte structurelle contre les incendies — Méthodes d'essai et exigences de performance

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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. www.iso.org/directives

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For an explanation on 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 the following URL: http://www.iso.org/iso/foreword.html

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment, Subcommittee SC 14, Fire-fighters personal equipment.*

This second edition cancels and replaces the first edition (ISO 11613:1999), which has been technically revised.

This edition has been completely rewritten as the Scope and tittle of this document have changed.

Introduction

The purpose of this document is to provide minimum performance requirements for protective clothing designed to protect firefighters who are engaged in support activities associated with interior attack firefighting.

This document is intended for firefighters who are engaged in support activities associated with interior attack firefighting. It is not intended for firefighters who are engaged in interior attack firefighting. Interior attack firefighting and support activities of firefighting are defined in 3.8.1 and 3.8.2.

It provides guidance on the considerations for conducting a risk assessment of firefighting risks (see Annex A).

Protective clothing for firefighter's who are engaged in support activities associated with structural fire fighting — Laboratory test methods and performance

1 Scope

This document specifies test methods and minimum performance requirements for protective clothing used by firefighters who are engaged in support activities of firefighting. This clothing is not intended for interior attack firefighting. These support activities of firefighting are defined (see 3.8.2) as activities such as:

— water and material supply;

— extinguishing fires from the outside of the structure;

— prevention of exterior spreading to adjacencies, preventing enviromental damage and limiting effect of smoke;

— securing traffic and environment;

— first aid base activities;

— preparing the fire ground for subsequent activities;

— RPD replenishment tasks;

— assessment zone;

— BA communication;

— forward command post;

— evacuation;

— assist planning;

— assist logistics;

— assist communication;

— transportation.

This document covers the general clothing design, the minimum performance levels of the materials used, and the methods of test for determining these performance levels.

This document is not equivalent to ISO 11999-3, clothing worn by firefighters who are at risk of exposure to high levels of heat and/or flame while fighting fires occurring in structures. This document provides lower minimum level of protection.

Selection of the appropriate system of clothing is dependent on carrying out an effective risk assessment which identifies the hazards to be faced, evaluates the likelihood of those hazards, and provides the means to reduce or eliminate these hazards. Details of one example of a recommended risk assessment approach and some factors for consideration are included in Annex A

This document does not cover special clothing for use in other high risk situations such as specialized firefighting, or clothing for use in long term firefighting operations in high ambient temperature, for example bush, wildland, or forest firefighting where clothing according to ISO 15384 could be more

appropriate. It does not cover clothing for use in high-risk fire exposures, for example reflective protective clothing according to ISO 15538 could be more appropriate.

It does not cover protection for the head, hands and feet or protection against other hazards, for example chemical, biological, radiation and electrical hazards. These aspects can be dealt with in other standards.

NOTE Additional "fit for purpose" personal protective equipment to protect the head, hands, respiratory system and feet should be worn with clothing specified in this document and in majority of situations appropriate protection is also required to be worn. Firefighters need to be trained in the use and care of protective clothing covered by this document including an understanding of its limitations and of the other items of personal protective equipment that can be required depending on the risks encountered

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 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 — Professional care, drycleaning and wetcleaning of fabrics and garments — Part 2: Procedure for testing performance when cleaning and finishing using tetrachloroethene*

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

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

ISO 6530, *Protective clothing — Protection against liquid chemicals — Test method for resistance of materials to penetration by liquids*

ISO 6942, *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 9151, *Protective clothing against heat and flame — Determination of heat transmission on exposure to flame*

ISO 13688:2013, *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 13937-2, *Textiles — Tear properties of fabrics — Part 2: Determination of tear force of trouser-shaped test specimens (Single tear method)*

ISO 14116:2015, *Protective clothing — Protection against flame — Limited flame spread materials, material assemblies and clothing*

ISO 15025:2016, *Protective clothing — Protection against flame — Method of test for limited flame spread*

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

ISO/TR 19591, *Personal protective equipment for firefighters — Standard terms and definitions*

ISO 20471:2013, *High visibility clothing — Test methods and requirements*

CIE 054.2, *Retroreflection — Definition and measurement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 19591 and the following 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 http://www.electropedia.org/

3.1
char
formation of a brittle residue when material is exposed to thermal energy

3.2
collar lining
that part of the collar fabric component assembly that is next to the skin when the collar is closed in the raised position

3.3
closure system
method of fastening openings in the garment including combinations of more than one method of achieving a secure closure, for example a slide fastener covered by an overlap fastened down with a touch and close fasteners

Note 1 to entry: This term does not cover seams.

3.4
component assembly
combination of all materials and hardware of a multilayer garments presented exactly as in the finished garment construction

Note 1 to entry: This term does not cover reinforced materials.

3.5
coverall
one-piece garment that is designed and configured to provide protection to the torso, neck, arms, and legs, excluding head, hands, and feet

3.6
drip
to run or fall in drops or blobs

3.7
firefighters' protective clothing
garments configured as a *jacket* (3.17), trousers or *coverall* (3.5) for the protection for the firefighters upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet

3.8
firefighting activities

3.8.1
interior attack firefighting
activities of rescue, fire suppression and property conservation generally performed in the interior or in the immediate vicinity of the fire of the involved structure

3.8.2
support activities of firefighting
activities executed by firefighters, who are not involved in interior attack but support through activities such as

— water and material supply

— extinguishing fires from the outside of the structure

— prevention of exterior spreading to adjacencies, preventing enviromental damage and limiting effect of smoke

— securing traffic and environment

— first aid base activities

— preparing the fire ground for subsequent activities

— RPD replenmishiment tasks

— assessment zone

— BA communication

— forward command post

— evacuation

— assist planning

— assist logistics

— assist communication

— transportation

3.9
garment
single item of clothing which may consist of single or multiple layers

3.10
hardware
non-fabric components of protective clothing including those made of metal or plastic

Note 1 to entry: Examples include fasteners, *closure systems* (3.3), rank markings, buttons, zippers, embroideries, braces, etc.

3.11
HTI_{12}
heat transfer index to one decimal place calculated from the mean time (measured in seconds, to one decimal place) to achieve a temperature rise of (12 ± 0,1) °C in the calorimeter

Note 1 to entry: When tested according to ISO 9151 with an incident heat flux of (80 ± 2) kW/m^2.

3.12
HTI_{24}
heat transfer index to one decimal place calculated from the mean time (measured in seconds, to one decimal place) to achieve a temperature rise of (24 ± 0,2) °C in the calorimeter

Note 1 to entry: When tested according to ISO 9151 with an incident heat flux of (80 ± 2) kW/m^2.

3.13
impregnation
procedure to maintain or regain the repellent properties of the outer fabric and/or chemical penetration resistance of the clothing

3.14
innermost lining
lining on the innermost face of a *component assembly* (3.4) which is intended to be nearest to the wearers skin

Note 1 to entry: Where the *innermost lining* (3.14) forms part of a material combination, the material combination is regarded as the innermost lining.

3.15
interface area
area where openings interrupt the continuity of material(s) or *garments* (3.9)

3.16
interlining
layer between the outermost layer and the *innermost lining* (3.14) in a multilayer *garment* (3.9)

3.17
jacket
long sleeved *garment* (3.9) incorporating materials meeting the requirements covering the areas of the neck, shoulders, and torso, upper and lower back extending to the waist or the hips

3.18
main seam
outer-shell seam assemblies where rupture could reduce the protection of the *garment* (3.9) by exposing the moisture management component, *thermal barrier* (3.32), the wearer's station/work uniform, other clothing, or skin

3.19
manufacturer
entity that assumes the liability and provides the warranty for the compliant product

3.20
materials
substances, excluding *hardware* (3.10) and labels, of which an item of clothing is made

3.21
material combination
material produced from a series of separate layers, intimately combined prior to the item's manufacturing stage

3.22
melt
to liquefy a material, usually by heat resulting in an non-reversible change

Note 1 to entry: For the purpose of this document, melting is observed as the response to heat as evidenced by flowing or dripping.

3.23
moisture management component
fabric or membrane used in a *component assembly* (3.4) to achieve the properties of hydrostatic pressure and water vapour permeability

Note 1 to entry: Moisture management component may not prevent the passage of some chemical (except incidentally), biological or radiological agents. Appropriate PPE should be provided to protect the wearer in such incidents.

3.24
multilayer clothing assembly
series of layers of protective clothing arranged in the order as worn

Note 1 to entry: It may contain multilayer materials, material combinations or separate layers of clothing material in single layers.

3.25
non-woven
sheet of fibres, continuous filaments, or chopped yarns of any nature or origin, that have been formed into a web by any means, and bonded together by any means, with the exception of weaving or knitting.

Note 1 to entry: Felts obtained by wet milling are not non-wovens.

3.26
outer material
outermost material of which the protective clothing is made

3.27
outer shell
outside facing portion of the *component assembly* (3.4) with the exception of *trim* (3.33), *hardware* (3.10), reinforcing material, and *wristlet* (3.35) material

3.28
protective garment
single item of clothing which can consist of single or multiple layers of material

EXAMPLE Protective *jacket* (3.17), protective trouser, or protective *coverall* (3.5).

3.29
pre-treatment
standard way of preparing the samples before testing

Note 1 to entry: This might include e.g. a number of cleaning cycles, submitting the sample to heat, mechanical action or any other relevant exposure and is finished by conditioning.

3.30
$RHTI_{12}$
radiant heat transfer index to one decimal place calculated from the mean time (measured in seconds, to one decimal place) to achieve a temperature rise of (12 ± 0,1) °C in the calorimeter

Note 1 to entry: When tested according to ISO 6942 with an incident heat flux of 40 kW/m^2.

3.31
$RHTI_{24}$
radiant heat transfer index to one decimal place calculated from the mean time (measured in seconds, to one decimal place) to achieve a temperature rise of (24 ± 0,2) °C in the calorimeter

Note 1 to entry: When tested according to ISO 6942 with an incident heat flux of 40 kW/m^2.

3.32
thermal barrier
that portion of the *component assembly* (3.4) designed to provide thermal protection

3.33
trim
retroreflective and fluorescent material attached to the *outer shell* (3.27) for visibility enhancement

Note 1 to entry: retroreflective materials enhance night-time visibility, and fluorescent materials enhance daytime visibility.

3.34
undergarment
garment (3.9) designed to be worn separately under an outer garment in order to provide thermal insulation

3.35
wristlet
circular, close-fitting part of a garment that encircles the wrist or ankles tightly

4 Symbols and subscripts

4.1 Symbols

Ar	total retroreflective trim surface area
A_p	total surface area of the plate
C_l	coefficient of luminous intensity
C_r	coefficient of reflectivity
H	heat power input
I_m	permeability index
I_Q	heat transmission index
I_T	thermal protection index
m	mass
p	water pressure
p_a	water pressure of the ambient environment
p_p	water pressure at the plate surface
R_e	evaporative resistance
$R_{e,in}$	intrinsic evaporative resistance of the test specimen
$R_{e,p}$	evaporative resistance of the bare plate
$R_{e,tot}$	total evaporative resistance
R_T	thermal resistance
$R_{T,in}$	intrinsic thermal resistance of the test specimen
$R_{T,p}$	thermal resistance of the bare plate
$R_{T,tot}$	total thermal resistance
T	temperature
T_a	temperature of the ambient environment
T_p	temperature of the bare plate
t_1, t_2	time necessary to reach the levels 1 and 2
w	mass fraction expressed as a percentage
w_w	mass fraction of water absorbed

4.2 Subscripts

a	ambient environment
f	final
i	initial
in	intrinsic
p	plate or bare plate
tot	total
w	water

5 Design and performance requirements

5.1 General

General requirements which are not specifically covered in this document shall be in accordance with ISO 13688.

Subsequent clauses specify test methods and minimum requirements for protective clothing to be worn by firefighters who are engaged in support activities associated with interior attack firefighting.

5.2 Design requirements

5.2.1 Configuration

The firefighters' protective clothing shall provide protection for the firefighters upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet. It shall consist of:

a) a one-piece protective *coverall* (3.5) designed to cover the upper and lower torso including the neck, arms, and legs, or

b) an outer two piece suit consisting of a jacket and a pair of trousers with sufficient overlap as described in 5.2.9, or

c) a series of outer and undergarments designed to be worn together to achieve the required performance (see 5.2.3).

NOTE For compatibility, see relevant clauses in ISO/TS 11999-2.

5.2.2 Restriction of movement

The personal protective clothing shall not restrict the wearer in any of the movements expected to be made during firefighting support activities. Conformity shall be assessed by visual inspection.

NOTE For compatibility, see relevant clauses in ISO/TS 11999-2.

5.2.3 Multilayer clothing assemblies

Where multilayer clothing assemblies are constructed as a single garment to be worn together or by detachable linings to achieve the specified performance levels (see also 5.2.9 and 7.4), each layer shall be clearly labelled that they shall always be used in combination, using the following statement or equivalent:

5.2.4 Component assembly

Where a component assembly is used, it shall consist of a component assembly that provides the necessary number and type of layers for achieving the performance specified in this standard.

Any component assembly reinforcement or padding used in high-wear or load-bearing areas, such as pockets, cuffs, knees, elbows, and shoulders shall meet the requirements of at least flame resistance and heat resistance contained in 7.1.1, 7.1.2 and 7.1.6 equivalent to the level achieved by the garment.

Padding can include additional thermal barrier material, meeting the requirements as specified herein.

5.2.5 Extension of interlining and innermost layers

In protective jackets and single outer garments, the interlining and innermost layers shall extend, at a minimum, to the top edge of the collar, to within 75 mm of the bottom outer material hem, and to within 25 mm of the sleeve end of the outer material. The interlining and innermost layers shall be configured to overlap at all closures.

In all protective trousers and single outer garments cover all the interlining and innermost layers shall extend, at a minimum, to the waistline seam, and to within 75 mm of the bottom outer material hems of the legs.

The ends of the interlining and innermost layers shall be attached at or adjacent to the jacket sleeves or the trouser legs. The distance between the attachment points of any mechanism used to attach the liner shall not be greater than 25 mm, and the mechanism shall not be expandable.

5.2.6 Size designation

Size designation shall be in accordance with the requirements of ISO 13688:2013, Clause 6.

5.2.7 Hardware

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

Protective clothing shall be designed to ensure that the hardware shall not have sharp edges, roughness or projections which are likely to cause injury to the wearer. Verification of the fulfilment of this requirement shall be made by manual and visual inspection.

5.2.8 Closure systems

Closures shall not interrupt the protective integrity of the garment. This means closures of the garment shall be constructed in a manner that provides secure and complete moisture and thermal protection to the requirements of this standard. If non-positive fasteners, such as snaps or hook and pile tape, are utilized in these closures, except where used in the collar and pocket closure system (see 5.2.10 and 5.2.12.2), a positive locking fastener, such as hooks and eyes or zippers, shall also be utilized.

A positive locking fastener shall not be opened by inadvertently pulling on it.

5.2.9 Interface areas

While raising both hands fully above the head and bending over from an upright position until fingertips reach the ground without bending the knees, wrists and ankles shall remain covered, when wearing appropriate sized clothing. Where protection is provided by an outer two piece suit, that an overlap between the jacket and trousers shall always be retained. Conformity shall be assessed by visual inspection.

NOTE For compatibility, see relevant clauses in ISO/TS 11999-2.

5.2.10 External pocket requirements

All pockets with external openings shall be constructed entirely from the outer material and the external opening shall be provided with a cover or closure system. Pocket flaps shall overlap the pocket opening by no less than 10 mm on either side. All pockets with external openings shall be constructed entirely of materials that have performance levels that are equal to or greater than the outer shell. Pockets may be fitted with a means of draining water. Conformity shall be assessed by visual inspection and physical measurement.

5.2.11 High-visibility materials

5.2.11.1 General

Firefighter's clothing shall have high-visibility materials fitted which shall meet the requirements in either 5.2.11.2 or 5.2.11.3.

5.2.11.2 Option 1 — Placement based on minimum area of coverage

The minimum area requirements for high-visibility materials shall be as specified in 5.2.11.2.1 for retroreflective materials and as specified in 5.2.11.2.2 for fluorescent or combined retroreflective/fluorescent materials.

5.2.11.2.1 Retroreflective material

Retroreflective material shall be attached to the outermost surface of the protective clothing with a minimum area of not less than 0,13 m^2. All-around visibility shall be ensured by having at least one band encircling each of the arms, legs, and torso regions of the garments.

5.2.11.2.2 Fluorescent material or combined retroreflective/fluorescent material

When fluorescent or combined retroreflective and fluorescent material is applied, the minimum area of fluorescent material shall not be less than 0,2 m^2. All-around visibility shall be ensured by having at least one band encircling each of the arms, legs, and torso regions of the garments.

5.2.11.3 Option 2 — band encircling each of the arms, legs and torso

5.2.11.3.1 General

The minimum pattern requirements for high-visibility materials shall be as specified in 5.2.11.3.2 to 5.2.11.3.5.

5.2.11.3.2 Type of high-visibility materials

High-visibility trim utilized to meet retroreflectivity and fluorescence requirements shall be permanently attached to the outermost surface of protective garments and shall have both retroreflective and fluorescent surfaces. The width of the retroreflective surface of trim shall not be less than 16 mm. Fluorescent and retroreflective areas of trim shall appear to be continuous for the length of the trim with gaps between areas of retroreflectivity of no more than 3 mm.

5.2.11.3.3 High-visibility materials exceeding standard pattern

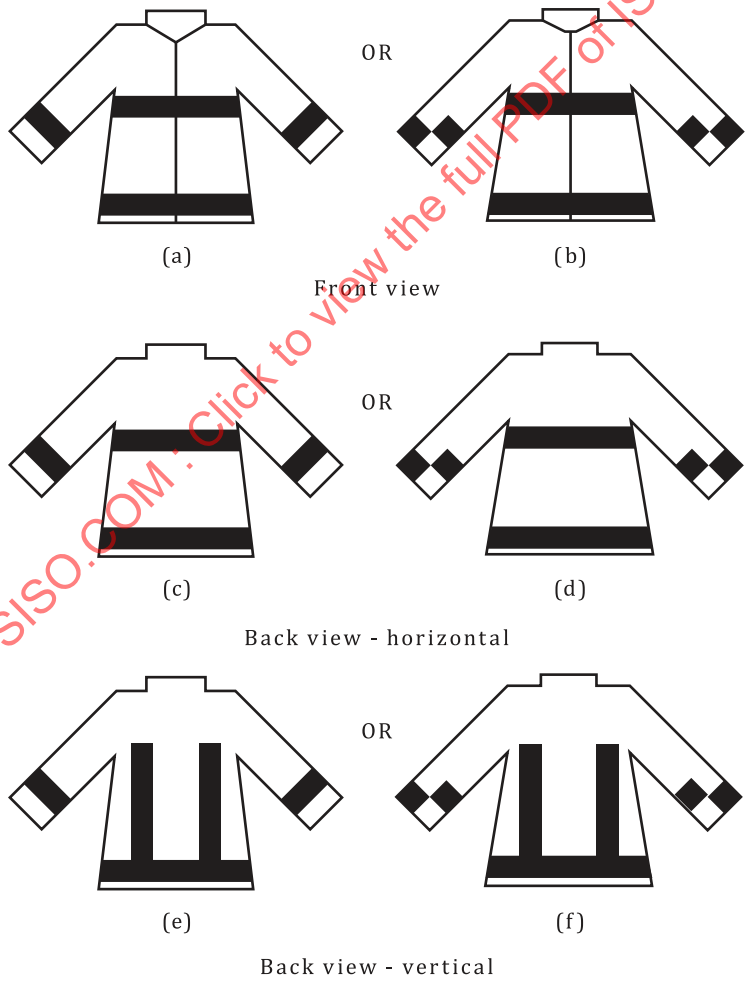
High-visibility material affixed to protective garments exceeding the standard pattern requirements illustrated in Figures 1 and 2 shall be permitted to be obscured by components such as, but not limited to, pockets, storm flaps, and reinforcing patches as long as the minimum high-visibility material required in 5.2.11.3.5 and 5.2.11.3.6 is not obscured.

5.2.11.3.4 Standard pattern for garments covering the upper torso including arms

The configuration for high-visibility materials on garments covering the upper torso including the arms shall be as illustrated in Figure 1. The standard pattern of high-visibility material for the garments covering the upper torso including the arms shall have one circumferential band of high-visibility material or a staggered 360-degree visibility pattern meeting or exceeding the surface areas of a continuous circumferential band around the bottom of the jacket. The lower edge of the circumferential band on the lower part of the jacket shall be within 25 mm of the jacket hem's highest point. The front of the jacket shall also have at least one horizontal band of high-visibility material at the chest level. No vertical strips of high-visibility material shall be permitted on the front of the jacket.

The back of the jacket shall also have a minimum of either two vertical strips of high-visibility material perpendicular to the bottom band with one strip located on both the left and right sides of the back of the jacket or a minimum of one horizontal band of high-visibility material at the chest/shoulder blade level.

The minimum high-visibility material configuration for each sleeve, between the wrist and elbow area, shall be one circumferential band or a staggered 360-degree visibility pattern meeting or exceeding the surface area of a continuous circumferential band. Where trim on the garment covering the upper torso including the arms intersects a zipper, a maximum gap in the trim of 25 mm shall be permitted.



NOTE Diagrams (a) and (b) represent alternative placement for the front of the jacket; Diagrams (c), (d), (e), and (f) represent alternative placement for the back of the jacket.

Figure 1 — Minimum pattern for placement of high-visibility materials on garments covering the upper torso including the arms

5.2.11.3.5 Standard pattern for garments covering the lower torso including the legs

The minimum high-visibility material pattern for garments covering the lower torso including the legs shall consist of one circumferential strip of high-visibility material around each leg at least 50 mm from the bottom hem in accordance with Figure 2.

Figure 2 — Minimum pattern for placement of high-visibility materials on garments covering the lower torso including the legs (front and back)

5.2.12 Additional requirements

5.2.12.1 Sleeve ends and wrist protection

The ends of the sleeves shall be designed to protect the wrist and to prevent the entry of water and burning debris. They shall not hinder the donning of the garment and shall be compatible with the wearing of protective gloves. Conformity shall be assessed by visual inspection.

NOTE 1 Purchasers need to consider specifying wristlets with a thumb hole or loop for wearer's thumb in order to assure protection when arms are in raised position.

NOTE 2 For compatibility, see relevant clauses in ISO/TS 11999-2.

5.2.12.2 Neck protection

Protective jackets or single outer garments shall have a component assembly collar no less than 75 mm in height at any point, with a closure system. Collar and closure system shall meet at least the flame and thermal requirements specified in 7.1, equivalent to the level achieved by the garment. Conformity shall be assessed by visual inspection.

NOTE For compatibility, see relevant clauses in ISO/TS 11999-2.

6 Sampling, pre-treatment and conditioning

6.1 Sampling

6.1.1 Samples

The number of samples and the size of the specimens of garment materials or garments subjected to the different test methods shall be in accordance with the respective test standards specified in the requirements.

Samples for testing shall be taken from the original garment or shall be representative of the component assembly, exactly as used in the finished garment. Materials not having sufficient surface area shall be taken in combination with the outer layer to make it possible to take samples with the dimensions as needed.

6.1.2 Exposure surface

In all surface tests, the outermost surface of the component assembly shall be exposed, except for flame spread testing of the innermost lining (see 7.1.1), testing of water vapour resistance (see 7.1.13) when the innermost surface is exposed.

6.2 Pre-treatment and conditioning

6.2.1 Pre-treatment by laundering or dry cleaning

In order to ensure consistency of testing, pre-treatment by laundering or dry cleaning is done to remove contaminants, finishes, or dressings from the manufacturing process.

NOTE Ageing and life expectancy is not to be confused with these pre-treatments.

Unless otherwise speicified (see 7.1.1, 7.1.2, 7.1.4 and 7.1.9), material test samples that are labelled as washable, shall be laundered in line with the manufacturer's instructions on the basis of standardised processes for five cleaning cycles. If the cleaning method is not specified the samples shall be subjected to five cleaning cycles in accordance with the procedure defined in Table 1.

Table 1 — Laundering procedure

Wash Procedure	Dry procedure
ISO 6330 6N (front load, normal, 60 °C, 1 g/l ECE detergent in soft water)	F (tumble dry)

Unless otherwise indicated (see 7.1.1, 7.1.2, 7.1.4 and 7.1.9), materials that are labelled as dry cleanable only shall be dry cleaned five times in accordance with ISO 3175-1.

A laundry bag shall not be used.

6.2.2 Conditioning

Conditioning is done to provide uniformly treated materials for test.

Unless otherwise specified in the specific test methods, all specimens shall be conditioned for a minimum of 24 h by exposure to a temperature of 20 °C ± 2 °C and a relative humidity of 65 % ± 5 % prior to testing.

Unless otherwise specified in the specific methods, all specimens shall be tested within 5 min after removal from the pre-treatment from the conditioning.

7 Requirements

7.1 General

The following Table 2 provides a summary of requirements for fabric and component assembly tested under Clause 7 of this document.

Table 2 — Summary of requirements for fabric and component assembly

Performance category	Applicable subclause
Flame resistance(7.1.1, 7.1.2)	7.1.1 Procedure A Index 3 Intermediate layer not intended for thermal protection (Index 1) 7.1.2 Procedure B
Heat transfer (flame exposure 7.1.3)	$HTI_{24} \geq 9$ s $HTI_{24} - HTI_{12} \geq 3$ s
Heat transfer (radiant exposure 7.1.4)	$RHTI_{24} \geq 10$ s $RHTI_{24} - RHTI_{12} \geq 3$ s
Residual tensile strength (7.1.5)	Woven ≥ 450 N Knitted: No requirement
Heat resistance (7.1.6)	Temp: 180 °C $^{+5}_{0}$ °C Shall not melt, drip, separate, or ignite Shrinkage ≤5 %
Tensile strength (7.1.7)	≥450 N (woven fabric) ≥100 kPa (50 cm^2 test area) (knitted fabric) ≥200 kPa (7,3 cm^2 test area) (knitted fabric)
Tear strength (7.1.8)	≥25 N
Water absorption resistance(7.1.9)	≤15 %
Dimension stability(7.1.10)	≤5 %(woven fabric) ≤5 %(non-woven fabric or knitted)
liquid chemical penetration resistance (7.1.11)	4 chemicals shall achieve >80 % run-off and no penetration to the innermost surface
Water penetration resistance (7.1.12)	≥20 kPa
Thermal comfort (7.1.13) Water vapour resistance	≤20 m^2 Pa/W
Seam strength(7.1.14)	≥225 N (woven fabric) ≥100 kPa (50 cm^2 test area) (knitted fabric) ≥200 kPa (7,3 cm^2 test area) (knitted fabric)
Additional garment testing (7.3) (optional)	Report results

7.1.1 Flame resistance (surface exposure)

All materials and main seams shall be tested before and after the pre-treatment specified in 6.2.1 according to ISO 15025, procedure A and they shall achieve flame spread index 3 of ISO 14116:2015, Table 3. Results shall be evaluated when the specimens are on the test frame.

Table 3 — Requirements for limited flame spread index 3

Properties	Requirement
Flame spread	No specimen shall permit any part of the lowest boundary of any flame to reach the upper or either vertical edge.
Flaming debris	No specimen shall give flaming or molten debris.
Hole formation	No specimen shall give hole formation of 5 mm or greater in any direction, except for an interlining that is used for specific protection other than flame protection. e.g. moisture management component.
Afterglow	Afterglow time shall be ≤2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of this clause, shall not be regarded as afterglow
Afterflame	Afterflame time shall be ≤2 s.

For each component assembly, 3 specimens in machine direction and 3 specimens in cross direction shall be tested. The component assembly of the outer garment shall be tested by applying the test flame to the surface of the outer material. In this case the number of test specimens have to be duplicated. If the levels of protection are achieved by clothing assemblies which are separate garments, the outer surface. For main seams, 3 specimens seam shall be tested and they shall not open. Specimens shall be oriented with the seam running up the centre line of the test specimen so that the burner flame impinges directly upon the seam.

If the clothing assembly incorporates wristlet materials (as parts of the sleeves or legs of the garment) these shall be tested separately applying the flame to the outer surface of the wristlet material and they shall achieve flame spread index 3 of ISO 14116:2015, Table 3.

Interlining layers, not intended to provide thermal protection and situated between two thermal protective layers meeting Index 3 (Table 3), shall at least meet the requirements of Index 1 (Table 4).

Table 4 — Intermediate layer not intended for thermal protection (Index 1)

Properties	Requirements
Flame spread	No specimen shall permit any part of the lowest boundary of any flame or hole to reach the upper or either vertical edge.
Flaming debris	No specimen shall give flaming or molten debris.
Afterglow	Afterglow time shall be ≤2 s. A glowing inside the charred area is defined in ISO 15025 as afterglow without combustion and, for the purpose of this clause, shall not be regarded as afterglow

NOTE Such intermediate layers are only used for specific protection other than thermal protection, for example protection against liquid penetration and/or wind.

Hardware that is directly exposed or that is covered, e.g. by a flap, when all closure systems in the firefighters protective clothing are in the closed position, shall be tested. Three specimens containing the hardware shall be used. Each one shall have the vertical dimension specified in ISO 15025 and be oriented so that the burner flame impinges directly upon the hardware if exposed or upon its storm flap if covered. If zippers are directly exposed the flame shall impinge on the slider and any plastic teeth. Specimens containing closure systems shall be oriented so the closure system runs vertically. Specimens containing hardware shall meet the requirements of Index 3. At least 5 min after the test closure systems shall be capable of being opened once.

Labels, badges, retro-reflective materials, etc., which are applied to the outermost surface of the garment, shall be tested only after pre-treatment according to 6.2.1 in combination with the outer layer to make it possible to take samples with the dimensions as indicated in ISO 15025, procedure A. Three specimens containing the item shall be tested. The items shall be oriented with the longer dimensions running up the centreline of the test specimen so that the burner flame impinges directly upon the centre of the item. The combination consisting of the item and the outermost layer of the garment shall

meet the requirements of Index 3 (Table 3). This requirement is not applicable for sewn in labels with a surface area of less than 10 cm^2.

7.1.2 Flame resistance (Edge ignition)

The flame spread test shall also be carried out in accordance with procedure B of ISO 15025, edge ignition on a hemmed fabric specimen before and after the pre-treatment specified in 6.2.1 using the edge application procedure and a flame application time of 10 s. The following requirements shall be satisfied:

a) no specimen shall produce molten or flaming debris;

b) the mean value of the afterflame time shall be less than 2 s;

c) any afterglow shall not spread from the carbonized area to the undamaged area after the cessation of flaming;

d) the mean char length shall be less than 100 mm, if measured as specified in ISO 15025:2016, Annex C. The hemmed fabric specimen shall be prepared in the same manner as used in the construction of the clothing.

Retroreflective and fluorescent materials shall be fixed with the bottom edge unstitched to the fabric specimen.

Interlining layers or membrane not intended to provide thermal protection and situated between two thermal protective layers do not need to conform to the performance requirements given in 7.1.2 d).

NOTE Such intermediate layers are only used for specific protection other than thermal protection, for example protection against liquid penetration and/or wind.

7.1.3 Heat transfer (flame exposure)

The component assembly or multilayer clothing assembly when tested in accordance with ISO 9151 after the pre-treatment specified in 6.2.1 shall give the following:

— a mean heat transmission index (HTI) of $HTI_{24} \geq 9$;

— a mean $(HTI_{24} - HTI_{12}) \geq 3$.

7.1.4 Heat transfer (radiant exposure)

The component assembly or multilayer clothing assembly when tested in accordance with method B of ISO 6942 at a heat flux density of 40 kW/m^2, before and after the pre-treatment specified in 6.2.1 shall give the following:

— a mean $RHTI_{24} \geq 10$ s;

— a mean $(RHTI_{24} - RHTI_{12}) \geq 3$ s.

7.1.5 Residual strength of material when exposed to radiant heat

Three specimens in the machine direction and three in the cross direction of the outer material shall be tested in accordance with ISO 13934-1 for woven texiles, or ISO 1421, Method 1 for coated textiles, after pre-treatment of the complete assembly or multi-layer clothing assembly by ISO 6942, Method A, at a heat flux density of 10 kW/m^2. Each specimen shall have a tensile strength ≥450 N. The testing does not apply to knitted fabrics.

The sample used after exposure at 10 kW/m^2 according to ISO 6942 shall be stripped in order to obtain a 50 mm width. This width shall contain the exposed surface.

7.1.6 Heat resistance

Each layer of the component assembly including closure systems and other materials which are intended to be worn next to the skin when tested in accordance with ISO 17493 at 180 °C +5/-0 °C, pre-treated as specified in 6.2.1, shall not melt, drip, separate, ignite, or shrink more than 5 %.

Shrinkage shall not be measured for materials or components that are smaller than the required specimen dimensions specified in ISO 17493.

The following requirements shall also apply.

a) The outer shell and collar lining shall not char.

b) Moisture management component seams shall also be tested and shall not drip or ignite.

c) Clothing hardware and closure systems shall be tested and shall not ignite and shall remain functional.

NOTE 1 Hardware penetrating the outer material shall not be exposed on the innermost surface of the component assembly (see 5.2.7).

NOTE 2 Other materials may include labels, badges, etc.

7.1.7 Tensile strength

The outer material when tested in accordance with ISO 13934-1 (woven fabric) shall give a breaking load in both machine and cross direction ≥450 N.

When tested in accordance with ISO 13938-1 or ISO 13938-2, knitted outer materials shall have a minimum burst strength of 100 kPa, when using 50 cm^2 test area, or of 200 kPa, when using 7,3 cm^2 test area.

7.1.8 Tear strength

The outer material when tested in accordance with ISO 13937-2 shall give a tear strength in both machine and cross direction ≥25 N.

7.1.9 Water absorption resistance

The outer material and collar lining fabrics when tested in accordance with Annex B, both before and after pre-treatment by laundering or dry cleaning as specified in 6.2.1 shall have a percent water absorption (PWA) of ≤ 15 %.

7.1.10 Dimensional Stability

The materials of the outer garment assembly when tested in accordance with ISO 5077 using the cleaning pre-treatment specified in 6.2.1 shall give a dimensional change in both the machine and cross machine directions ≤5% for woven materials, and ≤5% for knitted or non-woven materials.

The combination of materials in a component assembly shall be prepared so that the layers of material are sewn together around all four sides of the test specimen.

If the result is more than the allowed dimensional change value, two further specimens shall be tested and the evaluation shall be based on the average of the three results.

Dimensional change shall be measured after the specimen has been placed on a plane surface and has been uncreased and flattened by hand as far as possible without any stretching of the test specimen. In case that the test specimen consists of several layers sewn together and that differential shrinkage between the layers is observed, such sewing shall not be removed in order to achieve eventual further flattening of the test specimen. The lateral distance between opposite marks of the test specimen shall be measured and compared to the original lateral distance between opposite edges, and the

percentage versus the original lateral distance shall be calculated. This percentage shall be reported as dimensional change.

The test on performance of the component assembly shall not be performed if each single layer of the assembly meets individually the dimensional change requirements.

7.1.11 Liquid-chemical penetration resistance

The component assembly or multilayer clothing assembly when tested in accordance with ISO 6530 using:

a) 40 % sodium hydroxide (NaOH) at 20 °C ± 2 °C;

b) 36 % hydrochloric acid (HCl) at 20 °C ± 2 °C;

c) 37 % sulfuric acid (H_2SO_4) at 20 °C ± 2 °C;

d) o-xylene 100 % at 20 °C ± 2 °C;

and shall achieve > 80 % run-off and no penetration to the innermost surface.

All tests shall be carried out with a pouring time of 10 s ± 1 s and at a temperature of 20 °C ± 2 °C.

7.1.12 Water penetration resistance

The layer not including seams providing the resistance of water entry, when tested in accordance with ISO 811 using a rate of increase in pressure of (0,98 ± 0,05) kPa/min shall achieve a pressure of ≥20 kPa.

7.1.13 Thermal comfort: Water vapour resistance

The thermal comfort performance of the component assemblies used in firefighter protective clothing shall conform to the requirements for the performance levels specified in Table 5.

Materials for special purpose such as reinforcement materials for shoulder pads, knee pads, or materials with heat reflective surface or reflective tapes for visibility do not need to conform to the performance requirement given in Table 5.

Table 5 — Thermal comfort performance

Observation	Performance Level
Water vapour resistance	≤20 m^2 Pa/W

NOTE Material for special purpose, such as reinforcement materials for shoulder pads, knee pads, or materials with heat-reflective surface or liquid-repellent surface or reflective tapes for visibility and/or pockets may adversely impact on actual physiological performance.

Water vapour resistance shall be tested on the component assembly or multilayer assemblies in accordance with the modified form of ISO 11092 under non-isothermal conditions and achieve the performance level as specified in the above table.

7.1.14 Seam strength

The main seams of the outer material when tested in accordance with ISO 13935-2 shall give a breaking load ≥225 N.

When tested in accordance with ISO 13938-1 or ISO 13938-2, knitted outer materials shall have a minimum burst strength of 100 kPa, when using 50 cm^2 test area, or of 200 kPa, when using a 7,3 cm^2 test area.

7.2 Photometric requirements of high-visibility retroreflective/combined performance materials used on garments

Photometric requirements of retroreflective/combined performance materials shall be determined in accordance with CIE 054.2 following the procedures described in ISO 20471:2013, 7.3. The coefficient of retroreflection shall be calculated taking into account the width of the retroreflective material.

7.2.1 New materials

The minimum coefficient for new retroreflective/combined performance material shall be in accordance with Table 6 or 7, as appropriate.

Table 6 — Minimum coefficient of retroreflection in cd/(lx·m²) for separate performance material

Observation angle	Entrance angle β_1 (β_2 = 0)			
	5 °	20 °	30 °	40 °
12 '	330	290	180	65
20 '	250	200	170	60
1 °	25	15	12	10
1 °30 ′	10	7	5	4

Table 7 — Minimum coefficient of retroreflection in cd/(lx·m²) for combined performance material

Observation angle	Entrance angle β_1 (β_2 = 0)			
	5 °	20 °	30 °	40 °
12 '	65	50	20	5
20 '	25	20	5	1,75
1 °	5	4	3	1
1 °30 ′	1,5	1	1	0,5

NOTE The values for combined performance materials are for any colour.

7.2.2 Performance after exposure

After exposure to abrasion, flexing, folding at cold temperature, temperature variation, washing, dry cleaning, and rainfall, according to 7.4 and 7.5 of ISO 20471:2013, the coefficient of retroreflection R' for separate performance retroreflective materials shall exceed 100 cd/(lx·m²) measured at observation angle 12 ' and entrance angle 5 °; the coefficient of retroreflection R' for combined performance material shall exceed 30 cd/(lx·m²) measured at observation angle 12 ' and entrance angle 5 °.

When determining the influence of rainfall in accordance with 7.4.5 of ISO 20471:2013, the coefficient of retroreflection R’ for combined performance material shall exceed 15 cd/(lx·m²).

The coefficient of retroreflection R' for orientation of sensitive material after exposure shall comply with the same (above) requirements, as appropriate, at one of the two orientations described in ISO 20471:2013, 7.3 and shall be not less than 75 % of those required values at the other orientation.

NOTE ISO 20471:2013-Rainfall is clause 7.4.5 in the document and calls up Annex C – 7.4.5 Rainfall

Samples shall be tested in accordance with Annex C. If the material is orientation sensitive when dry, measurements shall be made at the rotation angle which gave the lowest measured performance when dry.

7.2.3 Colour requirements of high-visibility fluorescent/combined performance materials used on garments

When determined following the procedures described in ISO 20471:2013, 7.2, the chromaticity of fluorescent materials shall lie within one of the areas defined in Table 8 and the luminance factor shall exceed the corresponding minimum in Table 14. The mean luminance factor and chromaticity of orientation sensitive retroreflective material shall comply with the requirements of Table 8 when measured at the two rotation angles defined in ISO 20471:2013, 7.3.

Table 8 — Colour requirements for background and combined performance material

— Colour	— Chromaticity coordinates — x	— y	— Minimum luminance factor — ßmin
Fluorescent yellow	0,387 0,356 0,398 0,460	0,610 0,494 0,452 0,540	0,70
Fluorescent orange-red	0,610 0,535 0,570 0,655	0,390 0,375 0,340 0,345	0,40
Fluorescent red	0,655 0,570 0,595 0,690	0,345 0,340 0,315 0,310	0,25

The colour of the fluorescent and combined performance material shall also be measured after exposure to xenon light, in accordance with ISO 20471:2013, 5.2 and shall lie within one of the areas defined in Table 8, and the luminance factor shall exceed the corresponding minimum in Table 8. If the colour changes from one colour box to another (Table 8), this shall be mentioned in the instructions for use.

7.2.4 Heat resistance of high-visibility materials used on garments

Retroreflective, fluorescent, or combined performance materials shall meet heat resistance requirements according to 7.1.6.

7.2.5 Flame spread of high-visibility materials used on garments

The retroreflective, fluorescent, and combined performance materials used on garments shall be tested as specified in 7.1.1. Materials shall meet all performance requirements of the corresponding flame test method, including no hole formation for 7.1.1.

7.3 Additional garment testing (Optional)

If required by user, the complete component assembly or multi-layered clothing assembly may be optionally tested using an instrumental manikin according to ISO 13506-1 and ISO 13506-2.

This optional test shall use the following exposure duration and conditions: 4 s at heat flux of 84 kW/m^2.

The duration of exposure can be increased based on the risk assessment of the user.

Also additional integrated devices to be used with the protective clothing should be included in this testing.

7.4 Marking

General marking requirements shall meet the requirements of ISO 13688 in addition to the ones below.

On the label the following information shall be printed

a) The name, trademark, or other means of identifying the manufacturer.

b) The manufacturer's model number.

c) The size.

Where multilayer clothing assemblies are used to achieve the specified performance levels of this standard (see 5.2.3), the following shall be declared on the labels of all the garments involved using wording with the equivalent meaning:

"IN ORDER TO ACHIEVE THE CLAIMED LEVEL OF PERFORMANCE FOR THE CLOTHING ASSEMBLY, ALL LAYERS BEARING THIS LABEL SHALL ALWAYS BE WORN TOGETHER."

7.5 Manufacturers' information

The manufacturer's information shall be given as specified in ISO 13688.

The manufacturer shall provide, as a minimum, the results of the thermal performance (7.1.3, 7.1.4) levels, Thermal comfort (7.1.13) performance levels and an explanation of the meaning of these performance level.

The manufacturer's instructions shall be supplied to the customer with information written at least in the official language(s) of the state/country of destination.

In addition, the following warning notices shall be provided:

For materials which need to be re-impregnated after cleaning for the purpose of maintaining and or restoring water repellency and chemical penetration resistance performance, the manufacturer shall give the following additional instruction:

— the impregnation agents to be used and instructions on how to carry out the impregnation procedure;

— the number of cleaning cycles during which the water repellency and chemical penetration resistance impregnation remains effective.

— a statement regarding the innocuousness of the re-impregnation of fire-fighters' clothing

The manufacturer shall include a note in the information to the effect that in the event of an accidental splash of chemical or flammable liquids on clothing covered by this document, the wearer should immediately withdraw and remove the garments, which shall then be cleaned or removed from service.

The manufacturer shall include a note in the information to the effect that dampness, moisture or wetting inside or outside of the clothing will have an effect on the performance of the clothing covered by the International standard in comparison to the performance of the same clothing when in a dry condition.

Annex A
(informative)

A recommended approach and considerations for performing a risk assessment

A.1 General

Personal protective equipment is only one part of an effective system of firefighter safety. Well trained, closely supervised and properly staffed fire departments are equally essential elements of minimizing the operational risk.

Regardless of location, the primary goals of firefighting and rescue work are to control an emergency as quickly as possible and at the same time take steps to minimize eventual damage to and loss of materials and persons.

In order of priority, the objectives of a firefighter at an incident are to:

a) save lives and to prevent or minimize injury;

b) prevent or minimize damage to property;

c) prevent or minimize damage to the environment.

The role of firefighters' personal protective equipment (PPE) is not only to protect the firefighter but also to enable the firefighter to achieve these objectives while engaged in support activities associated with structural firefighting.

However, in emergency situations where the firefighter is unable to achieve these objectives, the PPE shall also provide sufficient protection to enable the firefighter to escape without receiving unacceptable injury. The type of PPE and the protection it offers shall be selected on the basis of a risk assessment specific to PPE use for identifying hazards, evaluating those hazards, and selecting specific performance requirements which eliminate or reduce these hazards.

A.2 General approach for conducting a risk assessment

The three major steps of the risk assessment process are as follows.

a) **Risk identification:** for every aspect of the operation of the fire department or brigade, list potential problems and hazards. The following are examples of sources of information that may be useful in this process:

   1) a list of the risks to which members are or may be exposed;

   2) records of previous accidents, illnesses, and injuries, both locally and nationally;

   3) facility and apparatus surveys, inspections, etc.

b) **Risk evaluation:** evaluate each item listed in the risk identification process using the following questions.

   1) What is the level or potential severity of the occurrence?

   2) What is the potential frequency or likelihood of the occurrence?

   3) What are the potential consequences of the occurrence?