TECHNICAL REPORT

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Second edition
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Guidance on the selection, use, care and maintenance of personal protective equipment (PPE) designed to provide protection for firefighters

Lignes directrices sur la sélection, l'utilisation, le soin et l'entretien des équipements de protection individuelle (PPE) conçus pour pourvoir à la protection des pompiers

Reference number
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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.

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 are noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective equipment*, Subcommittee SC 14, *Firefighters personal equipment*.

This second edition cancels and replaces the first edition (ISO/TR 21808:2009), which has been technically revised and completely rewritten.

Introduction

The information in this document has been produced to assist firefighters, fire services and purchasers (or the person who advises the employer) in making the necessary decisions regarding the selection, use, care and maintenance of PPE for firefighters.

The purpose of this document is to establish a guidance document for PPE with the goal to evaluate and reduce the hazards and potential health risks associated with firefighting. This selection use, care and maintenance guideline provides basic answers, criteria, and options for the fire service personnel that are selecting or using PPE through its life cycle with respect to protection it provides related to heat and flame or damaged PPE.

The main topics that the fire service needs to consider are highlighted in this document. This guidance document goes through the various steps and considerations such as risk assessment, compatibility, testing, cleaning, information to be provided with the PPE so that the right management choices can be made for each fire service. Many paragraphs of the document contain bullet-lists as thought provokers or options that may need to be considered. The annexes provide additional information that if included, would make the main body of this document too complicated to read, but are necessary to describe hazards and risks, the value of the test methods for the end user, for example Annex E "Description of burn injury risks" and Annex F "Guidance on some of the items that may be addressed in labelling, subject to the required use of the PPE" provide importance guidance information.

The selection of appropriate PPE for heat and flame are based on your own risk assessment and not be copied from other procurement documents.

The compatibility in this document focused mainly on the physical compatibility between each element of PPE and the documentation.

This document is not intended for cleaning, inspection or repair of firefighter PPE. Use ISO 23616[1)] for cleaning, inspection and repair of firefighters personal protective equipment (PPE).

Currently, TC 94/WG1 works to establish a parent standard for the development of this document. In case of the parent standard publication, the consistency of this document is to be considered.

1) Under preparation. Stage at the time of publication ISO/DIS 23616:2021.

Guidance on the selection, use, care and maintenance of personal protective equipment (PPE) designed to provide protection for firefighters

1 Scope

This document sets out guidance for the selection, use, care and maintenance of PPE designed to provide protection for firefighters while carrying out their duties.

The PPE covered in this document is intended for firefighting personnel exposed to risks associated with but not necessarily limited to the following activities:

— structural firefighting;

— wildland firefighting;

— incidents involving hazardous materials;

— incidents involving motor vehicle;

— urban search and rescue.

The purpose of this document is to highlight the main areas that a Fire service needs to consider when providing PPE to its members. This document is a supplement to the information provided in the PPE standards or used in conjunction with them. Most paragraphs of the document contain bulletlists, these lists are provided for guidance only and they are not exhaustive.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 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
base-layer garment
the first layer of a textile structure that is in direct contact with the skin (i.e. briefs, t-shirts, bras, socks)

3.2
care
processes and procedures for cleaning, decontamination, and storage of protective clothing and equipment

[SOURCE: ISO/TR 19591:2018, 3.30]

3.3
cleaning
act of removing soils and contaminants from protective clothing and equipment by a mechanical, chemical, thermal, or combined processes

[SOURCE: ISO/TR 19591:2018, 3.45]

3.4
compatibility
capability of two or more items or components of personal protective equipment to exist or function in the same system without modification, adaption or mutual interference with respect to interfaces and performance

3.5
contamination
contaminate
process by which elements of PPE are exposed to hazardous materials, body fluids, CBRN agent, the products of combustion, soils and general dirt

3.6
coverall
one-piece garment that completely covers the wearer's torso, together with arms, and legs, excluding the head, hands, and feet

3.7
deterioration
downgrading of the effectiveness or physical characteristics of PPE component due to use, *care* (3.2), maintenance or storage conditions

3.8
ensemble
combination or assembly of multiple items that are individually compliant with a standard that provide protection to the head, upper torso including arms and hands and the lower torso including feet

[SOURCE: ISO 11999-1:2015, 3.24]

3.9
flame resistance
property of a material whereby combustion is prevented, terminated, or inhibited following the application of a source of ignition, with or without subsequent removal of the ignition source

[SOURCE: ISO/TR 19591:2018, 3.114]

Note 1 to entry: Usually flame resistance materials for fire fighter are Index III of ISO 14116, but flame resistance is denoted by meeting one of the Index of ISO 14416 using the flame spread test method ISO 15025.

3.10
maintenance
the act of preserving PPE from loss or *deterioration* (3.8) and includes procedures for inspection, repair and ultimate removal from service

3.11
risk
probability of a specific undesired event (e.g. injury) occurring so that a hazard is realized

[SOURCE: ISO/TR 11610:2004, 3.205]

3.12
risk assessment
overall process that identifies hazards, estimates the potential severity of injury or damage to health, estimates the likelihood of occurrence of injury or danger to health

3.13
selection
process determining/assessing what PPE is necessary for protection of fire and emergency services response personnel from an anticipated specific hazard or other activity, the procurement of the appropriate PPE, and the choice of the proper PPE for a specific hazard or activity at an emergency incident

3.14
use
application of PPE including its limitations

4 General

Fire services develop procedures for selection, use, care, and maintenance (SUCAM) of PPE for firefighters.

NOTE 1 ISO 23616[2)] is a companion to this document.

NOTE 2 ISO/TS 16975-1 is also a companion to this document.

NOTE 3 ISO/TR 18690 is an additional companion to this document.

5 Selection

5.1 General

The process for selecting appropriate PPE is predicated by the use of a risk assessment process that includes the identification of the tasks to be undertaken and the hazards associated with those tasks. The aim of this process is to ensure that firefighters are provided with PPE that is suitable for the task being undertaken and provides protection against heat and flame and other related hazards.

The process of selecting PPE is divided into several stages:

5.2 Identify and assess risk

The process of carrying out a risk assessment include the following items as a minimum but not be limited to:

— identification of the activities and work environment to be undertaken by person(s) wearing the PPE;

— type of incident (understand mitigation measures in place, organisation's knowledge, training and other control measures before the application of PPE);

— geographical location and climate (environmental temperature and conditions);

— frequency and term of use of the PPE;

— a list of the hazards present;

— thermal hazards: heat flux, (e.g. convective, radiant, mixture of heat types), and contact heat etc.;

— chemical: phase of chemical (e.g. gas, liquid, particulate or solids), and which chemical or mixtures (e.g. acids/basis, organic solvents, petrol, chlorine, etc.), combustion residue (e.g. smoke, particulates, etc);

— biological: viruses, bacteria and other biological risks;

— contaminants: smoke, particulates, asbestos;

2) Under preparation. Stage at the time of publication ISO/DIS 23616:2021.

— hot or cold: environmental temperature or cryogenics, etc.;

— mechanical: abrasion, cut, vibration, flying object, etc.;

— other hazards (e.g. noise, electrical hazards, fall, lighting, etc.);

— other aspects;

— a quantification of the risks that would result from exposure to the hazards;

— what other factors are there to mitigate the risks/hazards;

— determination of the level and extent of protection required from the PPE (in absolute or relative terms);

— evaluation of risks resulting from the use of the PPE (frequency and term of use of the PPE);

— organisation's knowledge;

— evaluation of risks resulting from the use of the PPE;

— learning from incidents and reviews injuries and causes.

A number of risk assessment models may be used to determine the level of risk associated with the activities.

For further guidance see Annex A.

5.3 Defining the level of protection required from the PPE for each activity

When defining the level of protection required, consideration is given to the following as a minimum, but not be limited to:

— determine which parts of the body require protection;

— identify what kind of protection is required;

— identify the appropriate Standards or methods that provide the required protection;

— determine the level(s) of protection required (for the relevant parts of the body) in relative or absolute terms for each item of PPE;

— assessment of previously used PPE for meeting standards (any issues and concerns these may have caused such as comfort, incidents, improper use);

— identify compatibility issues and requirements of PPE items.

5.4 Optimal performance of personal protective equipment (PPE)

Select PPE that provides the optimal level of protection as under-protection can lead to the risk of injury through burns, or other hazards while over-protection may lead to a lack of comfort or heat stress.

Heat stress occurs when the body is no longer able to control its internal temperature. In addition to ambient air temperature, factors such as work intensity, humidity and clothing worn while working may lead to heat stress.

Although when looking at heat stress one focuses on the clothing; boots, gloves, fire hood, helmet, RPD, weight of combined PPE are all factors that lead to overexertion and to heat stress. Fire services are required to be sensitive to these factors as firefighters working in hazardous environments are more likely to behave in an unsafe manner due to their loss of ability to make sound decisions. For example

— firefighters might not wear PPE properly in hot environments increasing the risks for burn injury, and

— firefighter's ability to concentrate on a given task may start to drop off, which increases the risk of errors occurring.

Firefighters are required to be protected from the hazards associated with the tasks they are undertaking; therefore, the fire services has to balance the health and comfort, and the long-term and short-term risks. Therefore items of PPE are to be worn as late as possible, and for as shortest period possible without exposing firefighters to potential hazards.

By identifying the hazards that firefighters might face and then engineering out or reducing the hazard level where possible, may reduce the risk. In some cases, and only after being based on a risk assessment process, the fire service can often reduce the required flame-resistant protection level needed for protective garments and therefore increase the comfort and breathability. PPE is the last line of defence for the firefighter.

Provision of optimal performance PPE depends on several factors. The following provides some examples of what can be adopted:

— The ability to layering concept especially used in garment technology to achieve a balance between comfort and level of protection needed for different tasks e.g. station wear/work wear providing limited heat and flame protection could be used for some tasks and for those tasks requiring additional protection a second heat and flame-resistant garment layer added.

— When a layered approach is used, clearly identify so it is understood that if such layered protective clothing is capable of being compliant with the required Standard.

— PPE construction can increase or decrease the perception of comfort.

NOTE 1 The more pockets, pads, etc. that are added the heavier the garment becomes, and the PPE's breathability is reduced.

— Use of liners may have a positive effect by increasing protection against hot steam, chemical, moisture, etc. but they may also decrease the breathability.

— PPE materials can be a critical factor in determining comfort.

— RPD construction can protect scratches or dents on metal surface or deterioration of rubber materials by adding protective pads or increasing thickness of materials but it may affect the ease of movement due to bulkiness and may lead to fatigue accumulation of firefighters due to added weight. Familiarize with the construction of RPD to determine correct action.

— High breathability (air permeability and/or water vapour permeability) of PPE influences strongly wearing comfort.

NOTE 2 The body produces sweat when regulating the body's core temperature back to normal temperatures. The evaporation of the sweat and breathability of the PPE allows moisture displacement from the skin. Comfort of fabric is frequently measured by its vapour resistance (Ret). Different fabric weaves will provide a difference level of air permeability. Knitted fabrics will generally be more air permeable than woven fabrics.

— When considering comfort, one needs to consider not only the PPE but the whole clothing system including underwear and base layers influence on the moisture management.

Supporting equipment which provides information such as environmental temperature, remaining air pressure of cylinders, communication, etc. are capable of increasing safety and accuracy of activities of firefighters. Adding such equipment is one of the most important factors and needs to be considered.

5.5 Collecting information on available PPE

When purchasing PPE, the fire service carry out market research to determine products that are available.

Consider that systems and innovations of protection have consequences (advantages and disadvantages) and are taken into account and that this can also cause a paradox.

Take into account:

— sensibility;

— comfort; e.g. heavy weight;

— ergonomics;

— compatibility of all items of PPE;

— suitable for purpose;

— correct fitting;

— durability;

— guidance given regarding wash and care (including and coating re-impregnation/refurbishment);

— information obtained from the potential suppliers on performance levels and manufacturer's information including the compliance to relevant standards and certification by a recognised independent certification body.

— Information gathered from comparable organisations using similar items of PPE for similar tasks.

NOTE If after collating all available information, it is established that suitable PPE is not available, then it can be necessary for a fire service to carry out research and development work.

5.6 Considerations for practical evaluation of selection and performance parameters

When procuring PPE, practical evaluation are conducted to assess the compatibility and the ergonomics of the PPE. See also Annex B.

Structured trials with participants undertaking standardised, representative tasks are recommended. The number of participants, the diversity as well as the repeatability using the same population need to be considered.

When conducting practical evaluation, a systematic approach is adopted with the following issues considered:

— ability to protect based on expectation and the outcomes of the risk assessment;

— ease and speed of putting on and taking off;

— ease of activity;

— hindrance of use of PPE;

— durability;

— ease and extent of adjustability;

— acceptance in terms of comfort, mobility, weight and metabolic heat release;

— compatibility with all other items of PPE;

— ability to undertake all tasks expected without hindrance or difficulty;

— preservation of the protection in all working positions.

Practical evaluations are carried out under the following conditions:

— participants are selected based on a cross section of the firefighters (height, weight, age, gender, etc.);

— participants evaluate each item of the PPE on trial individually;

— performance of the garments including fire hoods after a number of cleaning cycles according to the manufacturer's instructions;

— objective physiological measurements are used to determine thermal impact (metabolic heat release/retention);

— the number of firefighters are sufficient to ensure that the results obtained are statistically significant and representatives of the total workforce.

Evaluation feedback is obtained in a structured manner allowing for both qualitative and quantitative data collection and analysis. Using a structured questionnaire, structured or semi-structured interviews and/or group discussions may achieve this.

NOTE 1 For consistency of data the same firefighters are used to conduct the practical evaluation. Obtaining feedback from the intended firefighters is imperative at this stage, as such information will provide valuable data relating to the practical performance of the PPE and give confidence to the firefighters, thus ensuring that the selected items are suitable for use.

NOTE 2 Further guidance on the ergonomics of PPE in general can be found in EN 13921. A detailed test protocol, specifically for firefighters PPE, can be found in BS 8469. Also, selection protocol can be found in the German Fire Protection Association (vfdb) guideline 0810 (*Guideline for the selection of personal protective equipment (PPE) based on a risk assessment for operations of German fire services*).

Table 1 — Summary on properties and wearability of Head protection. (Helmet)

Property	Consideration	Parameters (as examples)
Physiological	— Sound attenuation	— Jet style all surround shell design
	— Loss of spatial awareness	— Decrease in visual and audio sensitivity
	— Increased brain temperature (hyperthermia)	— Heat dissipation rate, good air ventilation
Ergonomics	— Weight	— Pressure points; neck muscles fatigue
	— Weight distribution (helmet design, add-on accessories)	— Fit when running
	— Wearing height	— Area of coverage; wobbliness
	— Wearing comfort	— Heat dissipation; air circulation; sweat wicking material on headband
	— Interface with other components	— Between neck protector and jacket collar; between face shield and BA mask; between headband and BA mask; between helmet and comms system
	— Head size	— Gender specific helmets
	— Head shape	— Non-ethnocentric liner design that fits user of all ethnic groups
	— Wearing size	— Fits a wider range of head sizes; secure down-sizing kit for smaller head sizes
	— Interface with BA mask that uses mounting adaptor	— Face seal security
Durability	— Resistance to chemical	— Cleaning agents; adhesive from decals and retro-reflective trims

Table 1 *(continued)*

Property	Consideration	Parameters (as examples)
	— Resistance to UV degradation	— Solar radiation
Wash and care	— Decontamination of internal components	— Ease of component removal and re-assembly
Protection: Thermal (convective, radiant and contact heat)	— Flame resistance — Heat resistance — Heat insulation	— Inherently FR shell; FR componentry — Level of dropping ad sagging — Increase in internal temperature
Protection mechanical & other	— Resistance to impacts — Resistance to crushing — Electrical insulation	— Shock impacts (force, acceleration) — Penetration by blunt and sharp objects — High speed particle shock impacts — Shell design — Non-conductive shell or paint

Table 2 — Summary on properties and wearability of Respiratory protection (RPD)

Property	Consideration	Parameters (as examples)
Physiological	— Comfort — Activity — Fitness	— Weight — Field test — Fatigue resistant — Movement of limbs and body — Transport — Training — Airtightness
Ergonomics	— Comfort — Environmental performance	— Size — Visibility — Conversation — Breathing — Activities — Interference with other PPE — Abrasion with other PPE
Durability	— Comfort — Environmental — Performance	— Comfort — Flame resistance — Abrasion resistance — Weatherability — Aging of materials
Wash and care	— Cleaning — Decomposition and Manual	— Materials not affected by detergent — Not to affect breathability performance — Visibility
Thermal (convective, radiant and contact heat)	— Environmental performance	— Flame resistance

Table 2 *(continued)*

Property	Consideration	Parameters (as examples)
		— Heat resistance

Table 3 — Summary on properties and wearability of protective clothing, protective gloves, and firehoods

Property	Consideration	Parameters (as examples)
Physiological	— Breathability — Flexibility — Elasticity — Skin effects	— Air permeability — Water vapour permeability — Thermal heat loss by sweating torso or manikin test — Weight — Thickness — Surface roughness — allergy — pH value and chromium (VI) content in a case of leather PPE
Ergonomics	— While carrying out work	— Size — Fit — Weight — Freedom of movement and work — Friction against undergarments in walking — Dressing — Compatibility with another PPE — Heat stress — Discomfort
Durability	— While being worn — In storage	— Tensile strength — Tear strength — Burst strength — Abrasion resistance — Flex cracking — Seam resistance — Aging
Wash and care	— Single use — (Water) washing — Laundry — Workplace — Home — Dry cleaning	— Easy to clean — Dimensional stability — Pilling — Visual appearance — Absence of physical damages after cleaning — Performance preservation
Thermal (convective, radiant and contact heat)	— Insulation for heat — Feeling heat	— Compare exposed body parts — Protection from burns

Table 3 *(continued)*

Property	Consideration	Parameters (as examples)
		— Skin burn risk prediction by thermal human simulator measurement

Table 4 — Summary on properties and wearability of Foot protection (Fire Boots)

Property	Consideration	Parameters (as examples)
Physiological	— Cold — Environment — Cold surface — Moist or wet conditions — Drops — splashes	— Cold insulation — Water penetration and water — Absorption of upper — Water resistance
Ergonomics	— Wearing comfort — Walking and standing — Orthopedic footwear — Stepping down from height (e.g. cab of truck)	— Energy absorption of seat — Region
Durability	— Wear and tear	— Strength (tensile, burst, etc) — Abrasion
Wash and care	— Ensure protective function — Wear and tear of garments	— Maintaining repellency (to water and chemical) washing away treatment and need for re-treatment — Potentiation re-activation of repellency — Chemicals used in cleaning (bleach and peroxide, starch) as they all have an effect on the heat and flame requirements
Thermal (convective, radiant and contact heat)	— Environment — Hot surfaces	— Heat insulation — Heat resistance of outsole — Flame resistance — Insulation against heat — Resistance to hot contact — Resistance to radiant heat
Mechanical hazards	— Falling objects — Compression — Sharp objects — Cut (by sharp objects or chain saw) — Slip potential	— Toecap — Metatarsal protection — Ankle protection — Penetration resistance — Cut resistance — Resistance to chain saw cutting — Cleated outsole slip resistance (coefficient of friction)

Table 4 *(continued)*

Property	Consideration	Parameters (as examples)

See also ISO/TR 18690 SUCAM Footwear and other PPE offering foot and leg protection.

5.7 Additional evaluations for fire services

5.7.1 General

To assist any decision making process, additional evaluations, tests or assessments can be required to determine the strength or weakness of various items of PPE. For example, bench scale testing for clothing, firehoods and gloves.

Laboratory bench scale transferred energy tests are used to select suitable materials for a protective clothing ensemble. While these tests can allow ranking of garment or ensemble materials and components, the tests do not allow a complete assessment of a garment or ensemble made of the materials. Bench scale transferred energy test methods use small amounts of material, up to 150 mm × 150 mm in area, and hold the material initially flat, either in a vertical or horizontal plane. Multiple layers are used where appropriate (e.g. fire-fighting ensembles). In this case, the layer normally worn on the exterior is exposed directly to the energy source, while the layer normally worn on the inside is away from the energy source.

With the planar orientation and alignment of materials, shrinkage has little effect on the outcome of the test, unless the shrinkage is so severe as to cause holes to form in the material during the exposure to the energy source. Sagging, however, does directly affect the results, as an air gap can form or grow in size, adding an insulating effect. With the aforementioned test methods, it is possible to test seams, zippers, pockets, buttons or other closures, metal and plastic clips or other features that can be included in a complete garment such as heraldry, company logos, etc. However, it is often considered easier to evaluate these aspects together with the overall design features of a garment or ensemble that can affect the performance by testing complete garments or ensembles on a manikin. It is for this purpose the thermal manikin standard series was created (ISO 13506-1 and ISO 13506-2).

NOTE 1 Bench scale is not appropriate for RPD selection.

NOTE 2 For guidance of thermal manikin test, refer to ISO 13506-1.

NOTE 3 For guidance relating to the physiological performance of the garment refer to ISO 13506-2.

NOTE 4 For guidance relating to RPD refer to ISO 17420-5[3].

5.7.2 Clothing

5.7.2.1 General

There are a number of garment standards for firefighter such as

— ISO 21942 station wear,

— ISO 11613 clothing for support activities associated with structural fire fighting, and

— ISO 17723-1 clothing for hazardous material incidents and CBRN.

For structural firefighting and wildland more detail is provided in the subclauses below.

3) Under preparation. Stage at the time of publication ISO/FDIS 17420-5:2021.

5.7.2.2 Structural firefighting clothing

Additional requirements and information for structural firefighting clothing may be found in ISO 11999-3.

This protective clothing is designed to provide protection for the firefighter's upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet. It usually consists of an outer garment which can be, for example

— a one-piece protective cover all designed to cover the upper and lower torso including the neck, arms, and legs,

— a protective coat and a pair of protective trousers with an overlap of sufficient length to provide protection to the wearer, or

— a series of outer and undergarments designed to be worn together.

Where multi-layer clothing assemblies are used to achieve the specified performance levels, the layers are to be either permanently attached or the various layers are clearly labelled as follows:

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

To assist with the choice based on a user risk assessment, a number of levels of protection are included in ISO 11999-3:2015, Table 1.

The scope of ISO 11999-3 does not include clothing for use in high-risk fire exposures where for example, reflective protective clothing according to ISO 15538 could be more appropriate, or for use in long-term firefighting operations in high ambient temperature, for example bush, wildland.

Flame and thermal resistance performance of ISO 11999-3 conforms to all requirements for the respective performance level specified in ISO 11999-3:2015, Table 2. The firefighter protective clothing is classified for flame and thermal resistance performance to the lowest performance achieved for any performance property.

For the purpose of marking, each item of PPE, for which compliance with ISO 11999-3 is claimed, are labled permanently and conspicuously attached, upon which the following information is printed in letters at least 1,5 mm high:

— where practical, the pictogram given in ISO 11999-3:2015, Figure 1;

— the name, trademark, or other means of identifying or tracing back the manufacturer;

— the manufacturer's model number and/or user's specified number;

— the size.

For detailed requirements for marking, refer to ISO 11999-1.

5.7.2.3 Wildland firefighting clothing

Additional requirements and information for wildland firefighting clothing may be found in ISO 15384, *Protective clothing for firefighters — Laboratory test methods and performance requirements for wildland firefighting clothing*.

The purpose of ISO 15384 is to provide minimum performance requirements for protective clothing designed for use for extended periods during wildland firefighting activities. The minimum performance requirements and methods of test for personal protective equipment (PPE) covering the head, hands, feet, eyes and ears for wildland firefighting are covered in ISO 16073 (all parts).

NOTE ISO 16073 (all parts) is a placeholder and simply indicates the content is covered by existing standard, ISO 15384.

Wildland firefighting involves work primarily in summer temperatures, for many hours in which the firefighter can develop high levels of metabolic heat. Loose-fitting clothing is as important as the fire resistance of materials in preventing serious burn injury. Clothing that is tight-fitting poses a danger to the wildland firefighter from radiant heat and heat stress, while, at the same time, diminishing the firefighter's ability to perform. Consequently, the protective clothing needs to be light, flexible and commensurate with the risks to which the firefighter can be exposed in order to be effective without introducing heat stress to the wearer.

The general clothing designs of wildland clothing are capable of satisfying the levels of performance specified in ISO 15384 and protect the wearer's body, except the head, hands, and feet. It may be comprised of

— a coverall,

— a protective suit provided with an interface overlap area, or

— a number of inner and/or outer garments designed to be worn together.

Ensure the clothing does not restrict the wearer in any of the movements expected to be made during wildland firefighting, for example bending, reaching, twisting, and crouching.

Closure systems, label accessories, touch and close fasteners, retro-reflective and/or fluorescent materials etc. attached to the personal protective clothing is designed to not adversely affect the clothing's performance.

All closure systems are designed to prevent the entry of burning debris.

Conformity to these requirements include an assessment by visual inspection and practical testing, such as to check sizing and correct fit by donning and doffing of the garment.

Compliance marking for each item of PPE for which compliance with ISO 15384 is claimed, the label is permanently and conspicuously attached, upon which the following information is printed in letters at least 2,0 mm high:

— designation of the type as appropriate;

— name, trademark or other means of identifying the manufacturer;

— style/model designation;

— size;

— a reference to this document, i.e. ISO 15384:2018;

— material composition.

In addition to the marking, the following information is provided to the firefighter, it is appropriate that the manufacturer gives as much information as possible on known factors of durability, especially on durability to cleaning:

— the name and address of the manufacturer or its authorized representative;

— the intended use of the product;

— a reference to this document, i.e. ISO 15384:2018;

— test to be carried out by the user before use, if necessary;

— the instructions explaining how to put on and take off the garment, if necessary;

— the limits of use (e.g. scale of temperatures);

— the storage and maintenance instructions;

— the instructions for cleaning and/or decontamination;

— the method of drying;

— a warning against problems which might arise, if necessary;

— any illustrations, if these might be useful;

— the type of packaging suitable for transport.

5.7.3 Gloves

5.7.3.1 General

Additional requirements and information for structural firefighting gloves may be found in ISO 11999-4.

These gloves consist of a component assembly meeting the design and performance requirements of ISO 11999-4. The component assembly is permitted to be configured as a continuous or joined single layer or as continuous or joined multiple layers. The component assembly may be different for the palm, back and fingers.

5.7.3.2 Additional marking for gloves

The gloves are marked with the number of the relevant part of this International Standard, i.e. ISO 11999-4.

Where practical, the pictogram given in ISO 11999-4:2015, Figure 1 and requirements within ISO 11999-4:2015, Table 1 can be used.

In the case that the gloves have flame and thermal category rating A1, then “ISO 11999-4 Type 1” is written underneath the pictogram given in ISO 11999-1:2015, Figure 1

In the case that the gloves have flame and thermal category rating A2, then “ISO 11999-4 Type 2” is written underneath the pictogram given in ISO 11999-1:2015, Figure 1

At the bottom right of the pictogram given in ISO 11999-1, the following letter designation is used to represent the different performance category levels for gloves:

— heat and flame performance category;

— mechanical performance category;

— barrier performance category;

— ergonomic performance category.

The performance level achieved by the gloves can be found next to the letter for each performance category, for example, a_2,b_3,c_2,d_2.

Other requirements are set in various firefighter standards such as:

— ISO 16073-4 for wildland;

— ISO 18639-4 for rescue operation (both USAR and RTC).

NOTE USAR stands for Urban Search and Rescue, RTC for Road Traffic Crash incidents.

5.7.4 Helmets

Additional requirements and information for structural firefighting helmets may be found in ISO 11999-5.

They may consist of at least the following assembled components as detailed in ISO 11999-5:

— shell;

— energy absorbing system;

— retention system.

The retention system includes a chinstrap having a minimum width of 19 mm. (Optional for Type 1 helmets, area 3a according to EN 443:2008).

— Neck protector

— Ear covers (Optional for Type 1 helmets, area 1b according to EN 443:2008).

— Face shield or goggles or both (Optional for Type 1 helmets, area 3b or area 2 according to EN 443:2008).

Where a faceshield is selected, the faceshield is attached to and tested with the helmet.

Where goggles are selected, the goggles are permitted to be unattached.

The following is an example of the marking that can be found on Type 1 ISO 11999-5 certified helmets:

Every helmet carries visible, legible and unambiguous, permanent and durable marking giving the following information:

— a reference and year of this part of ISO 11999, i.e. ISO 11999-5:2015;

— name or identification mark of the manufacturer;

— year of manufacture;

— type of helmet, e.g. Type 1;

— model of helmet (manufacturer's designation);

— size or size range (in cm).

Every helmet claimed to conform to the optional requirements of ISO 11999-5 carries visible, legible and unambiguous, permanent and durable marking on the shell or carry durable self-adhesive label, stating that the optional requirements have been complied with.

The following is an example of the marking that can be found on Type 2 Helmets certified to NFPA 1971:

The following information is printed legibly on each product label with all letters at least 1,5 mm (1/16 in.) in height:

a) manufacturer's name, identification, or designation;

b) manufacturer's address;

c) country of manufacture;

d) manufacturer's element identification number, lot number, or serial number;

e) month and year of manufacture, not coded;

f) model name, number, or design;

g) size or size range;

h) principal material(s) of construction — For principal materials of construction of helmets, generic terminology for the shell material be provided;

i) cleaning precautions.

Compliance statements are printed legibly on the product label, example as follows for Type 2 helmets:

“THIS STRUCTURAL FIRE FIGHTING PROTECTIVE HELMET MEETS THE HELMET REQUIREMENTS OF NFPA 1971:2013 EDITION. . DO NOT REMOVE THIS LABEL.”

All product label letters and figures be at least 2,5 mm (3/32 in.) in height.

For helmets only, the helmet manufacturer places a unique manufacturer’s part number, the symbol of the certification organization, and the words “NFPA 1971:2013 ED.” permanently on each replaceable performance critical part of the goggle lens or face shield.

5.7.5 Footwear

Additional requirements and information for footwear may be found in ISO 11999-6.

Examples of types of footwear for firefighters are:

— Type 1: Outdoor interventions, fire and wildland firefighting; no protection against penetration, no toe protection, no protection against chemical hazards.

— Type 2: All fire suppression and rescue interventions where protection against penetration and toe protection are needed, no protection against chemical hazards.

— Type 3: All fire suppression and rescue interventions where protection against penetration and toe protection are needed, including protection against chemical hazards.

For Type 1 firefighters’ footwear only, the presence of a safety toe cap is denoted by the marking T. The marking code R indicates the presence of a rigid toe puff offering protection against compression forces not exceeding 500 N for protection against minor mechanical risks.

Type 3 firefighters’ footwear may offer resistance to chemicals and this protection is indicated by the marking code CH

Type 3 firefighters’ footwear be constructed from all-rubber (i.e. entirely vulcanized) or all polymeric (i.e. entirely moulded) footwear

The level of heat insulation properties of the product is given by the marking codes HI1, HI2 and HI3. The performance of these products will be as described in Table 5.

Table 5 — Insulation against heat: requirements for footwear degradation and thermal insulation

Performance level	Test temperature Thp (°C)	Temperature rise (°C) inside the footwear	Degradation not occur
HI1	150	<42 after 10 min	20 min exposure
HI2	250	<42 after 10 min	30 min exposure
HI3	250	<42 after 10 min	40 min exposure

Other additional protection categories are denoted by the appropriate marking codes as given in EN 15090.

Footwear be marked with the marking codes for the main protective categories as given in Table 6.

Table 6 — Marking symbols

Footwear type	Symbol	Additional categories of protection
For Type 1:	F1A	Antistatic properties
	F1PA	Penetration resistance and antistatic properties

Table 6 *(continued)*

Footwear type	Symbol	Additional categories of protection
	F1I	Electrical insulating properties
	F1PI	Penetration resistance and electrical insulating properties
For Type 2:	F2A	Antistatic properties
	F2I	Electrical insulating properties
For Type 3:	F3A	Antistatic properties
	F3I	Electrical insulating properties

5.7.6 Respiratory Protective Devices (RPD)

When Fire service procures RPD and deploys it to firefighters, fire service will confirm whether the construction and performance of the RPD are appropriate for the firefighting activities tactics and activities by having firefighters use the RPD during firefighting training. Confirmation that the RPD does not become a hindering factor to firefighting activities will ensure risk elimination and safety. If there is mismatch between the tactic and RPD, it is necessary to secure time to implement tactic change and equipment modification.

5.7.7 Other considerations

To establish the overall performance and total cost of ownership of the PPE, consideration is given to the following:

— the training offered as part of the procurement package (including training provided by third parties);

— the quality control measures that are in place prior to the delivery;

— the quality control procedures used by subcontractors e.g. care and maintenance of the PPE;

— the requirements for cleaning and decontamination;

— the specific inspection and maintenance requirements;

— the replacement requirements relating to the life cycle of the PPE;

— the delivery lead time for standard and special sizes;

— the range of sizes available;

— the level of stock held by the supplier;

— the collection and delivery arrangements;

— the level of stock to be held within the organisation;

— how the internal distribution to the firefighters will be managed;

— how the corporate/role identity (e.g. badges on garments) can be incorporated without adversely affecting performance;

— compliance and certification;

— how the end of life and contaminated PPE will be disposed of.

5.8 Thermal manikin testing

5.8.1 General

The thermal manikin test method (ISO 13506-1) uses a stationary, upright adult-sized manikin which is dressed in a complete garment and exposed to a laboratory simulation of a fire with controlled heat flux, duration and flame distribution. The average heat flux to the exterior of the garment is 84 kW/m2, a value similar to those used in ISO 9151, ISO 6942 (maximum level) and ISO 17492. Heat flux sensors fitted to the surface of the manikin are used to measure the heat flux variation with time and location on the manikin and to determine the total energy absorbed over the data-gathering period.

The data gathering period is selected to ensure that the total energy transferred has been completed. The information obtained can be used to assist in evaluating the performance of the garment or protective clothing ensembles under the test conditions. It can also be used to estimate the extent and nature of skin damage that a person would suffer if wearing the test garment under similar exposure conditions (ISO 13506-2).

The manikin is used in a standing position in initially quiescent air. Controlled air motion for simulating wind effects or body movement is not presently possible. It is possible to move the manikin through a stationary flame, but motion of this nature is not within the scope of this document. Variations in the fit of the test garment that can occur when sitting or bending are not evaluated.

5.8.2 Benefits of thermal manikin testing

The thermal manikin test is not designed to measure material properties directly, but to evaluate the interaction of material behaviour and garment design. One can compare relative material behaviour by making a series of test garments out of different materials using a common pattern.

Most manikins do not have sensors on the hands and feet, but it is possible to assess some aspects of hand protection depending upon the specific design of the hands. The head, however, does contain heat flux sensors. The reason for this is that many outer garments include an integral hood, but not gloves or footwear. Tests for gloves and footwear are covered by other ISO documents for specific end uses.

The protection offered by the test specimens is evaluated through quantitative measurements and observations such as:

— enables the materials used to construct the PPE ensemble to be compared;

— enables PPE ensemble designs to be compared;

— enables PPE ensemble prototypes produced for a particular application to be evaluated;

— takes into consideration air gaps where small scale bench top heat transfer testing is limited;

— may provide more realistic results when compared to bench top heat transfer testing;

— provides the opportunity for male or female specific garments to be tested on gender specific manikins (ISO 13506 series only covers a male manikin; a number of labs have female manikins, but the shape and size has not yet been standardised).

NOTE In the revision of ISO 13506-1 it is intended to have a female form manikin and respective measurements.

5.8.3 Repeatability and variation of thermal manikin testing (and with bench scale tests)

The fire simulations are dynamic. As such, the exposure is more representative of an actual industrial accident fire than the exposures used in bench scale tests. The heat flux resulting from the exposure is neither constant nor uniform over the surface of the manikin/garment. Under these conditions, the results are expected to have more variability than carefully controlled bench scale tests. In addition, the garment is not constrained to be a flat surface but is allowed to have a natural drape on the manikin.

The effect these variables have on a garment can be seen in several ways: ignition and burning of the garment and heraldry, sagging or shrinkage in all directions after flaming, hole generation, smoke generation and structural failure of seams. Many of these failures rarely appear in the bench scale testing of the materials because they are a result of garment design variables, interaction between material properties and design variables, construction techniques and localized exposure conditions that are more severe.

Fit of the garment on the manikin is important, thus variations in garment design and how the manikin is dressed by the operator can influence the test results. A test garment or specimen size is selected by the laboratory from the size range provided by the manufacturer to fit the laboratory's manikin.

Experience suggests that testing a garment one size larger than the standard will reduce the total energy transferred and percentage body burn by about 5 %. A number of control measures can be taken to reduce the uncertainty of measurement or improve the reproducibility of the results:

— One test laboratory is used for all testing associated with the garment procurement process. This applies to all PPE, including both male and female garments, and also same design of comparing the composition of the ensemble (determine use of under garments and if the garments are washed or not).

— The same technician will be used for the manikin dressing and testing processes for all garments being tested for comparison purposes, clear specification are given regarding the closure, how the PPE provides an overlap.

— Testing is carried out on the same day under the same conditions where practical (take pictures of PPE before and after on the manikin, take video as well of the test).

— A maximum acceptable burn prediction is determined for use as a pass or fail criteria. Determine the exposure time and the measurement time:

— for industrial/single layer garments 4 s and a 120 s measurement time is usually used under ISO, see ISO 11612 note (NFPA uses 3 s),

— for turn out gear usually 8 s and a 240 s measurement time is used.

— Testing is overseen by fire service PPE specialist where possible

— Information and how it is to be reported will utilise a common template

In the last round robin on ISO 13506-1 and ISO 13506-2, the following results of reproducibility was achieved. Further work is on-going including a revision of the standards, to further improve the reproducibility of the test method. Different garments were tested by the twelve labs that included 3 coveralls (A, B, and C) and a firefighter ensemble (D). The coveralls and firefighter ensemble were exposed for 4 s or 8 s respectively at a heat flux of 84 kW/m^2. The overall inter-laboratory test results for transferred energy and burn risk predictions (2nd and 3rd) are listed in the Table 7 below.

Table 7 — Summary of results from the Interlaboratory study on ISO 13506-1 and ISO 13506-2 in 2016

Garment	Transferred energy in kJ (according to ISO 13506-1)				Burn risk prediction in % of covered area (according to ISO 13506-2)			
	avg.	S_r	S_R	No of labs	avg.	S_r	S_R	No of labs
A	271,2	11,0	69,3	12	50,3	4,3	21,7	12
Statistical analysis according ISO 5725 was applied: avg. is the mean of the mean total transferred energy reported by each laboratory based on the area covered by sensors. S_r is the repeatability standard deviation (for intra-laboratory precision). S_R is the reproducibility standard deviation (for inter-laboratory precision). For garment D for the burn prediction one lab is excluded from the statistical assessment as an outlier.								

Table 7 *(continued)*

Garment	Transferred energy in kJ (according to ISO 13506-1)				Burn risk prediction in % of covered area (according to ISO 13506-2)			
	avg.	S_r	S_R	No of labs	avg.	S_r	S_R	No of labs
B	279,2	29,7	98,9	12	53,4	8,75	33,90	12
C	291,5	8,4	70,6	12	65,0	3,00	22,57	12
D	236,4	7,8	50,1	12	14,4	2,69	11,56	11

Statistical analysis according ISO 5725 was applied:

avg. is the mean of the mean total transferred energy reported by each laboratory based on the area covered by sensors.

S_r is the repeatability standard deviation (for intra-laboratory precision).

S_R is the reproducibility standard deviation (for inter-laboratory precision).

For garment D for the burn prediction one lab is excluded from the statistical assessment as an outlier.

The standard deviations are exacerbated due to off-set errors in some of the data and some labs having had exposures slightly beyond the defined exposure time. For garment D for the burn prediction one lab is excluded from the statistical assessment as an outlier.

The performance of the complete garments will not necessarily be ranked in the same order as might be obtained when the materials are tested using ISO 9151. Correlations between small scale tests and results from single-layer garments have been examined.

5.8.4 Thermal manikin testing using RPD

The RPD uses products that have passed the flame test described in ISO 17420-5. Performing a thermal manikin test may also be possible when looking at compatibility between other items of PPE.

6 Batch testing

6.1 General

In some regions or countries, batch testing is conducted at predetermined times to confirm that the PPE being supplied and the materials they are made of continue to meet the performance requirements specified in the original contract.

Batch testing is conducted using a set of predetermined requirements that an item of PPE can be tested against. These are the same as the performance requirements contained in the relevant Standard, thus ensuring continual compliance with the specifications.

These tests are conducted according to regional requirement, regulations and specifications.

It is recommendable to make available and submit material certificates and testing results which satisfy the fire service. Batch testing is a decision for the fire service to make and is not a mandatory requirement.

6.2 Product certification

In some region or countries, as part of the procurement process fire services specify and require that the selected PPE is independently certified to the relevant Standard (International, Regional or National). The product certification body is accredited to a national or internationally recognised accreditation system (e.g. ISO/IEC 17065). At least all testing is carried-out by labs accredited to ISO/IEC 17025 for that test and to guarantee correct testing and reproducibility.

Product certification is conducted according to regional requirements, regulations and specifications (for example, NFPA 1971, EU PPE Regulation 2016/425, Brazil CA certification scheme).

6.3 Laboratory material testing

The following are examples of tests that may be carried out to determine durability of the PPE:

— resistance to/behaviour after laundry/cleaning;

— resistance to/behaviour after decontamination;

— resistance to/behaviour after UV exposure;

— explosive risk and anti-static properties (see also IEC/TR 16832:2015 SUCAM Selection, use, care and maintenance of personal protective equipment for preventing electrostatic risks in hazardous areas (explosion risks)) and see also Footwear SUCAM;

— abrasion resistance;

— flex fatigue;

— durability of the properties (protective or other) of the PPE after extended period of use;

— resistance of assembling systems (i.e. seams, sealings, weldings);

— liquid barrier properties: water, chemical repellence (e.g. oil, solvents, acids and bases).

6.4 Application of batch testing arrangements

Any batch testing arrangements are developed between the fire service, Manufacturer, Testing Authority and potentially Certification Body. They include specified intervals for required batch testing.

NOTE 1 For example, protective clothing — Batch tests are carried out at 1/400 garments for the first 5 batches of a new model. The 1/400 garment tested is garment number 400. Following successful 1/400 testing, testing is carried out at the rate of 1/1 000 with the 1/1 000 garment tested being garment number 1 000. If a failure occurs during the 1/1 000 test, batch testing will revert to the original new model requirements of 1/400 for the subsequent 5 batches.

The following tests are an example of what could be carried out for protective clothing in accordance with the specified standard:

Table 8 — Batch testing requirements

Clothing (on total assembly)	Helmet	Boots/footwear	Gloves
Flame Spread	Flame Resistance	Flame Spread	Flame Spread
Heat Transfer	Force impact resistance	Heat Transfer	Heat Transfer
Heat Transfer Radiation	Penetration resistance	Heat Transfer Radiation	Heat Transfer Radiation
Heat Resistance	Retention system strength	Tensile Strength	Heat Resistance
Tensile Strength		Impact Resistance	Tensile Strength
Main Seams		Penetration Resistance	Main Seams

NOTE 2 Performance requirements for RPD is specified in ISO 17420-5 hence not included in this table.

Copies of test reports of the required batch testing are made available to the fire service.

6.5 Accredited laboratories

Batch Test reports are only accepted from laboratory's accredited against ISO/IEC 17025, for the specific test, to guarantee correct testing and reproducibility. The report refers to the laboratory's accreditation to ISO/IEC 17025 or equivalent.

Test reports from manufacturers must not be accepted. Only in the case that the manufacturer has its own laboratory that is accredited against ISO/IEC 17025, the test report can be accepted.

6.6 Test report life for type testing

Test reports have a limited validity in time. Test validity, for each item of PPE, is specified based on regional requirement, regulations and specifications. Tests older than 3 years to 5 years are not considered for both product specifications and batch verification. Test are carried out in accordance with the test method (including date of issue) determined in the product specification and/or tender.

6.7 Changes to certified product

Suppliers are not be permitted to implement changes or modifications to the design and/or construction of a certified product that impacts on the product's current certification with the specified Standard unless both

— written notification of any proposed changes that may affect certification is provided to the product certification body, prior to implementation, for the purpose of review and re-certification, and

— written approval for the changes to occur has been provided, prior to implementation, and by the fire service procuring the item of PPE.

6.8 Auditing

To ensure product certification validity, audit by certification authority of new PPE, is carried out at least once in every twelve-month period to verify the manufacturer's processes, quality control procedures, test results and associated records.

7 Compatibility

7.1 General

Compatibility is the capability of two or more items or components of personal protective equipment to exist or function in the same system without modification, adaption or mutual interference with respect to interfaces and performance. ISO/TS 20141 provides general information of Compatibility. This document refers to ISO/TS 20141 for basic references and understandings of compatibility. In some specific cases specified for ER purpose, following information is provided.

This table shows necessity of consideration about compatibility between PPE combinations. For new equipment, there are cases where it does not apply to the classification of this table, so careful attention is paid to the compatibility with related equipment.

Table 9 below shows the interactivity with the various parts of PPE, with in addition underwear.

Table 9 — Compatibility of PPE

Compatibility with	Helmet	Fire hood	Eye protection	Hearing protection	RPD	Neck protection	Clothing	Base layer garment	Over garment	Gloves	Foot protection	Fall protection	Others
Helmet		X	X	X	X	X	X	X	X			X	X
Fire hood	X		X	X	X	X	X	X	X				X
Eye Protection	X	X		X		X	X		X				X
Hearing protection	X	X	X		X	X	X		X				X
RPD	X	X		X		X	X	X	X	X		X	X
Neck protection	X	X	X	X	X		X	X	X			X	X
Clothing	X	X	X	X	X	X		X	X	X	X	X	X
Base layer garment	X	X			X	X	X		X	X	X	X	X
Over garment	X	X	X	X	X	X	X	X		X	X	X	X
Gloves	X				X		X	X	X				X
Foot protection							X	X	X				X
Fall Protection	X				X	X	X	X	X				X
Others	X	X	X	X	X	X	X	X	X	X	X	X	

NOTE PPE samples which are widely used in the current work field include, but are not limited to the following:

— helmet: fire helmet, Safety (mechanical protective and electric shock) helmet;

— fire hood: fire hood for firefighting;

— eye protection: safety glasses, goggle, face shield, RPD type;

— hearing protection: earmuff, ear plug;

— RPD: breathing apparatus, non-powered respirator;

— neck protection: SHIKORO, fire hood, stand collar type apart of clothing;

— clothing: firefighting clothing (structural, wildland), rescue activity clothing (RTC, USER);

— base layer garment: briefs, t-shirts, bras, socks, station uniform, radiation protection (head protector), FR underwear, protective undergarment for cold atmosphere (including foot protection), body cooling device for heat stroke prevention;

— over garment: chemical (biological) protection, radioactive particle protection, mechanical risk protection (elbow guard, knee guard, chaps), including partial protective devices for each hazard;

— gloves: firefighting glove, mechanical risk protection (cut resistance), thermal risk protection (low temperature resistance), chemical (biological) protective glove, including over glove style;

— footwear: chemical (biological) protection, radioactive particle protection, mechanical risk protection, including partial protective devices for each hazard;

— others: protective equipment excluding above group, multi-functional protective equipment.

7.2 Physical compatibility

Physical interactions between the various PPE such that the various pieces of PPE don't hinder each others protection properties and reduce/jeopardise the level of protection: In addition, ensuring the overlaps between the various pieces of PPE are sufficient. Ensure the overlaps, freedom of movement and potential hindrance are evaluated using practical performance test movements (see Annex B) in addition to specific ones such as firehoods and gloves that may have specific movements between respectively with respiratory protective device (RPD) or glove dexterity for handling various tools and PPE. For optimum protection garments are selected for having a level of ease, or not too tight fitting (air provides additional layer of protection).

NOTE Guidance for structural firefighters gear can be found in ISO/TS 11999-2.

7.3 Thermal protection compatibility

The thermal protective properties of different layers will not have a negative impact on each other, e.g. by reduction of air layers between different items of PPE. Different items of PPE will not increase the thermal physiological impact of the PPE on the wearer. Wearers are aware of the materials of the underclothing when using protective clothing against heat and flame to consider the melting possibility of underwear.

7.4 Chemical protection compatibility

The chemical thermal protective properties of the outer layer of is critical to providing chemical protection of the fire fighter whether this is for structural clothing or hazardous materials incidents.

Repellency, in garment such as for structural fire fighting, station wear, rescue clothing, needs to be ensured after washing through re-impregnation. If not the garment could absorb or let through chemicals during an incident or cleaning operations. These chemicals (e.g. solvent, oil) may have a negative impact the heat and flame protection of the garment, glove, boot, etc.

Wear and tear, and specifically abrasion, can negatively impact the chemical protection of boots, gloves and garments. Helmets may lose their robustness if exposed to chemicals (e.g. solvents, acids).

Chemical protection of the ensemble need to ensure, if one part e.g. gloves protect against a specific chemical, set of chemicals or mixtures, that the other parts (e.g. boots, garments, RPD, visor) provide similar protection.

8 Use

8.1 General

Fire services define the conditions in which the PPE may be used, including the duration of time it can be worn. This is determined by using a risk assessment process that takes into consideration frequency of exposure identified risks, the characteristics of the workplace and the performance of the PPE.

If during use, the PPE is damaged or compromised, the firefighter will exit the danger zone and the PPE is removed.

NOTE ISO/TS 16975-1 is considered as a reference for use of RPD for firefighters.

After the selection of the PPE, several stages are followed to ensure its correct use:

8.2 Training

All personnel are trained on how to use their PPE correctly prior to the PPE being introduced into service. The basis for this training is the instructions for use provided by the manufacturer/supplier.

The training includes but not be limited to

— information concerning limitations and capabilities of the PPE,

— what the PPE will protect from,

- what the PPE will not protect from,
- what the effects are (if any) of long term use,
- how to care for and maintain the PPE in accordance with the manufacturer's requirements,
- how to undertake routine inspections of PPE before and after use,
- how to don and doff, and if appropriate, how to make adjustments correctly for the correct use and wear of the PPE,
- the compliance with the manufacturers/supplier's instructions,
- how to store the PPE when not in use,
- how to ensure appropriate cleaning and decontamination (including avoidance of cross contamination to maintenance operator and environment),
- how to determine when the PPE is no longer fit for purpose,
- how to obtain replacements, and
- the importance of using PPE that is fit for purpose and has been cleaned and maintained in accordance with the manufacturer's instructions.

The instructions and training provided to the firefighter will depend on the level of risk and complexity of the PPE provided. The provision of written instructions or information may not be sufficient, and the firefighters may need to be involved in practical demonstrations, training and exercise.

8.3 Introducing PPE into service

Before individual items of PPE are introduced or replaced, care is taken to ensure that the compatibility and interfacing of the PPE is maintained and satisfactory training has been provided. For further information see 7.2.

8.4 Record keeping

In the overall management of PPE, consideration is given to build a full life history for each item, from manufacture to disposal. Detailed controls are identified in product specifications.

Record keeping incorporates the following, but not limited to

- the specification of the PPE (manufacturer, delivery date, batch number,
- to whom the PPE was issued, including date,
- the service history of the PPE (date of issue, name of wearer),
- training records of operatives using the PPE, including the duration of exposure to risks and the identity of the risks,
- details of hazards to which the PPE has been exposed, record keeping,
- information relating to care,
- cleaning,
- decontamination,
- storage,
- records of maintenance,

— inspection,

— damage and repair,

— disposal, and

— problems arising from the use of the PPE.

These records are made readily available to the current user.

8.5 Routine examination

ISO 23616 is considered as a reference for cleaning, inspection and repair of PPE for firefighters.

Each individual item of PPE is examined before and after use by the user. Routine examinations include checks for

— soiling,

— physical damage to clothing including fire hoods and gloves (rips, tears, cuts, damage to seams and/or other connections non-functional or missing hardware and other components e.g. reflective/fluorescent applications etc.) physical damage to other PPE items (helmet, footwear and RPD), and

— contamination from hazardous materials (including from oil products of combustion or biological agents (including from body fluids), thermal damage (charring, burn holes, melting, change in colour).

Routine examinations for RPD are conducted in accordance with the instruction manual supplied by manufacturer. If there are rejected items, quick repair is done if it is practical.

Ongoing evaluation of system fit and interfaces/overlaps and closure systems are undertaken by a competent person.

8.6 In service evaluation and monitoring

A system is in place to ensure that the performance of all PPE is constantly evaluated and monitored.

The items to be monitored may include:

— accident/injury statistics;

— failure rates of PPE including trends for similar repairs;

— feedback from firefighters;

— feedback from service company;

— changes in working conditions and available PPE on the market;

— additional testing, including destructive manikin testing on a selected number of garments.

9 Care

9.1 General

The method of care of PPE is conducted according to the laws and regulations of each country and follows the manufacturer's instructions. Not following the manufacturer's instructions could jeopardize the protective properties of the PPE and could void the guarantees that go with the PPE. Care includes both hygienic cleaning and decontamination. These will vary with each item of PPE and with the type of contamination hazard. After cleaning or decontamination, the PPE is inspected for fit for purpose.

NOTE 1 ISO/TS 16975-1 is considered as a reference for care of RPD for firefighters.

NOTE 2 Detailed guidance of routine and advanced cleaning of PPE refer to ISO 23616.

9.2 Cleaning

9.2.1 General

To ensure PPE performs in accordance with the standard it is certified to, the PPE equipment is cleaned (i.e. washing, drying and decontamination) in accordance with the care instructions provided by the manufacturer, especially when it becomes dirty or contaminated.

When determining the arrangements for cleaning the PPE, fire services consider:

— manufacturer's Instructions;

— when and how often the PPE is cleaned? What is considered clean? No unpleasant odours, visibly clean?

— who will carry out the cleaning (e.g. professional, industrial laundry)? What arrangements are in place for the collection and delivery? For clothing, the load (quantity of clothing) in the machine versus liquid (water) and cleaning agents can have a significant effect on the cleaning process.

NOTE Home cleaning is not considered for a number of reasons: a) cross contamination b) cleaning and drying instructions of manufacturer (e.g. with respect use of bleaches, peroxides (frequently included in home detergents that can damage some PPE) c) re-application of finishes.

— Where the cleaning will be carried out?

— The type of cleaning methods to be used;

— Any risks that may be associated with the cleaning process e.g. cross contamination, etc.

During incidents, PPE may become contaminated with hazardous materials, e.g. asbestos; body fluids; chemicals, etc. When this occurs additional processes and procedures will be required to manage the contaminated PPE. When determining the arrangements for management, decontamination and cleaning of this PPE fire services consider:

— How the contaminated PPE is to be handled at the incident scene?

— How it can be segregated from other items that could become contaminated, i.e. prevention of cross contamination?

— How it is to be managed prior to transportation, e.g. bagged?

— How it is to be transported?

— How it is to be cleaned and treated and where that will occur, e.g. a specialist facility?

— How it is to be disposed if decontamination is not viable or cost effective?

After cleaning, the PPE is inspected for deterioration. The fit for purpose of PPE may change depending on age, usage and other factors. When determining when PPE is replaced, fire services consider appropriately specified cleaning and maintenance practices that will ensure that the clothing will provide optimal protection for its operational life and the wearer or persons handling it will not be subject to any foreseeable risks or exposures.

9.2.2 Clothing

For clothing, Cleaning can be divided into three different levels, namely:

— routine cleaning.

The light cleaning of ensembles or ensemble elements performed by the end user without taking the elements out of service:

— advanced cleaning.

The thorough cleaning of ensembles or elements by washing with cleaning agents (excluding bleach and peroxides as they can affect heat and flame characteristics of the clothing):

— specialized cleaning.

NOTE ISO 23616 is currently under development. Once this standard is published, this section will be reviewed to ensure consistency between both documents.

Remove hazardous materials (decontamination) or body fluids (disinfection). The cleaning can be divided in different methods, namely:

— dry cleaning (may require re-impregnation);

— wet (washing);

— chemical (may require re-impregnation);

— steam;

— other.

The amount of washing cycles as mentioned in the relevant standards does not say anything about cleaning of the items. It does not say anything about the realistic amount of cleaning cycles that can be reached.

WARNING — Flammable residues in garments after cleaning can ignite in proximity to an ignition source. Reprocessing of protective clothing against heat and flame at home is not recommended. Reprocessing with suitable cleaning agents and procedures carried out by external service providers is advisable.

Drying process is of influence on:

— durability of clothing (pilling, colour (retro) reflection, etc.);

— mechanical wear and tear of the clothing will differ with different drying processes (tumble, tunnel, etc.);

— temperature of drying may have an influence on repellency and shrinkage.

NOTE The drying process is necessary for re-impregnation.

Fire services are responsible for determining the arrangements used for cleaning and maintaining the clothing and inform all parties who may become involved in the cleaning process, including the end user, of any risks associated with it.

9.2.3 Other PPE

For detailed guidance on the cleaning of other items of PPE refer to ISO 23616, except RPD.

ISO/TS 16975-1 is considered as a reference for cleaning of RPD for firefighters.

9.3 Storage

Manufacturers indicate any specific storage requirements of the PPE and the firefighter follow these instructions. Manufacturer provide appropriate storage condition in Clause 9.

If the life cycle of the protective PPE is influenced by the storage condition, this is indicated by the manufacturer.

The following is an example of the storage condition for PPE:

— Not be stored in direct sunlight or exposed to direct sunlight while not being worn (e.g. UV degrades polymers, fabrics and plastics).

— Not be stored in airtight containers unless they are new and unissued or unless on manufacturers guidelines.

— Be stored in a clean, dry, well-ventilated area at a temperature that will not adversely affect the items of the protective clothing.

— Not be stored at temperatures below −32 °C (−25°F) or above 82 °C (180°F).

NOTE These are extreme temperatures for storage, not necessarily for use.

— Not be stored or transported in compartments or trunks with sharp objects, tools, or other equipment that could damage the PPE. Where PPE is required to be transported or stored in such environments, PPE is not placed in a protective case or bag to prevent damage.

— Not be stored in living quarters or with personal belongings or taken or transported in the passenger compartment of personal vehicles.

— Not be stored in contact with contaminants such as, but not limited to, oils, solvents, acids, or alkalis. The PPE is not adversely affected by the method of storage.

— Is cleaned and dried before storage when soiled.

10 Maintenance

10.1 General

The method of care of PPE is conducted according to the laws and regulations of each country and follows the manufacturer's instructions. Not following the manufacturer's instructions could jeopardize the protective properties of the PPE and could void the guarantees that go with the PPE. Based on these instructions, the fire service determine the arrangements for maintaining PPE, and they inform all parties involved (including the user).

NOTE 1 ISO/TS 16975-1 is considered reference for maintenance of RPD for firefighters.

NOTE 2 ISO 23616 is considered reference for maintenance of PPE for firefighters.

Maintenance arrangements include:

— inspection;

— What inspection criteria is applied? who carries out the inspections?

— When the inspection is done?

— General file with history of PPE;

— repair:

— What kind of repairs are acceptable?

— Who will be responsible for the repairs?

— General file with history of PPE;

— removal from service and ultimate disposal:

— When the PPE is required for disposal?

— How the PPE is disposed of ensuring no damage to the environment?

NOTE It is advised to let maintenance only be performed by trained and competent personnel.

10.2 Inspection

10.2.1 General

Regular inspection of the PPE is essential to ensure that it will continue to provide the protection intended.

Any elements suspected of being contaminated with hazardous materials or biological agents are decontaminated in accordance with manufacturer's procedures as soon as possible after contamination and before reaching the regular inspection process.

A person with appropriate skills that is appointed to this task additionally inspect the PPE. This person needs to be familiar with the PPE and the types of wear and tear that could influence its performance. Ongoing inspections are necessary to ensure that the PPE is fit for purpose and that it still meets the minimum performance requirements, if not the initial requirements.

An inspection programme is drawn up for each type of PPE and include:

— an inspection schedules;

— elements to be inspected;

— effectiveness of any closure systems;

— the decisions and actions based on the inspection results;

10.2.2 Inspection schedule

The inspection schedule includes:

— regular inspections, considering any manufacturer requirements;

— frequency of inspection considers;

— How often the PPE is used;

— How often the PPE has or is required to be cleaned or decontaminated;

— The wear and tear the PPE has or is likely to have been subjected to;

— How the PPE is stored and its impact on performance, e.g. UV degradation?

— additional inspections;

— after every deployment to an incident;

— whenever the user suspects that the PPE is no longer fit for purpose;

— after any repair;

— prior to re-issue after re-calling a batch or type of PPE;

— if damage to the PPE, or injury to firefighters, is a frequent occurrence;

— inspections after recalling a whole batch or type of PPE, if damage to the PPE, or injury to the user, is frequent.

10.2.3 Elements to be inspected

The inspection process takes into consideration the integrity of PPE, with special attention being paid to the closure systems, seams and fabrics, integrity of the systems that comprise the whole of the PPE including the extremities. Wear and tear and laundering/cleaning will have a diminishing effect on performance over time and a physical inspection is crucial. This is done initially by visual appraisal against the manufacturer's specification. The PPE is inspected for:

— soiling;

— material integrity (including all accessories); effects of chemical or UV-degradation (e.g. discoloration, flaking);

— damaged/non-functional or missing hardware, (all components);

— integrity/legibility of the label;

— contamination of the PPE from hazardous materials or biological agents;

— physical damage to all layers of the PPE including inner liners (this is not always possible without destruction);

— thermal damage to all layers of the PPE including liners;

— loss or shifting of liner material;

— loss of joint/seam integrity; broken or missing;

— effectiveness of closure systems.

Ageing is gradual and expected and affects product performance. Manufacturers forecast effective lifespan by indicating the maximum number of cleaning cycles the protective clothing can safely be exposed to. Deterioration due to ageing has an effect on the performance of the protective clothing, however, the loss of performance never falls below what is the minimum performance specified in the relevant product standard.

Ageing is caused by a combination of several factors, such as: exposure to chemicals, biological agents such as bacteria, fungi, insects or other pests and physical exposure such as radiation, wear and tear.

The performance aspects of the PPE can be preserved if the correct care and maintenance requirements are followed.

NOTE Technical documentation is made available on the pass/fail criteria in the relevant product standard for all the above elements. In addition to the inspections, it is important to carry out testing (in some cases destructive) to validate the inspection criteria.

10.2.4 Decisions

The decisions based on the inspection results include:

— fit for purpose;

— fit for limited use only (in this case the label must be adapted to show this lower level of protection for example "Non-Fire Training Only";

— requires repair/alteration;

— requires cleaning/decontamination;

— should be removed from service and destroyed.

10.3 Repairs and alterations

Repairs and/or alterations to PPE are carried out, following the manufacturer instructions, by individuals or organisations trained to do so. No repair will adversely affect the performance of the PPE. The materials used are of comparable or higher performance to the original. After repair/alteration, the PPE is inspected by a suitably qualified person.

10.4 Disposal

The fire service develops specific criteria for removal of PPE from service, which includes, but is not limited to, issues that are specific to the PPE, the manufacturer's instructions, and the experience of the fire service. PPE that is no longer fit for purpose is not to re-enter service, even by another fire service (even in another country). In addition, disposal of PPE is carried out in accordance with each country regulations and guidance.

Several factors are considered when disposing of PPE:

— the environment;

— the health and safety of anyone coming into contact with the PPE;

— the manner in which the PPE is to be disposed of so as to ensure that it will not be used in any firefighting or emergency activities, including live fire training.

When an item of PPE has been identified as no longer fit for purpose, it is marked accordingly or kept in a container that clearly identifies the items are not to be used and are awaiting disposal.

11 Manufacturer information

11.1 General

The manufacturer's information can be split into four types of information:

— required by laws and regulations of each country/region (may be required in paper version with each PPE in the local language);

— required by PPE performance standard (may be required in paper version with each PPE in the local language);

— information on the labels and marking (may be required in paper version with each PPE in the local language);

— additional information that the manufacturer may share about the PPE.

All items of PPE are provided with manufacturer information, including use instructions accordance with each PPE regulation, guidance and requirement depends on the country. Each type of PPE has designated appropriate information style to clarify manufacturing information (i.e. both of label and documents are preferred for clothing).

11.2 Manufacturer information for selection and use

Use instruction include but are not limited to:

— designation of product type, commercial name or code;

— significance of any marking or labelling;

— pictograms;

— specify what is safety critical, risk against which the PPE is designed to protect (product specification the PPE has been certified to);

— what the PPE will protect from;

— information on levels of protection (including test results);

— information concerning limitations and capabilities of the PPE;

— what the PPE will not protect from;

— size designation;

— information on accessories, if any;

— what the effects are (if any) of long term use;

— how to don and doff, if appropriate adjust correctly;

— the importance of complying with the manufacturers/supplier's instructions;

— the importance of using PPE that is fit for purpose and has been cleaned and maintained in accordance with the manufacturer's instructions.

11.3 Manufacturer information for care

All items of PPE are provided with manufacturer information, including care instructions accordance with each PPE regulation, guidance and requirement depends on the country. Each type of PPE has designated appropriate information style to clarify manufacturing information (i.e. both on label and in printed documents).

Care considerations include but are not limited to:

— cleaning;

— what cleaning methods are used?

— what temperature?

— what are the capabilities of the institution cleaning the PPE?

— when and how often the items are cleaned?

— third party collection and deliveries, if available?

— what drying method? And at what temperature?

— Is re-application of finishes/treatments necessary?

— frequency;

— impregnation agents and concentration;

— procedure of application;

— what practices or cleaning agents are to be avoided (e.g. bleach, peroxides on some flame resistant fibres)?

— what are the effects of cleaning on the performance properties of PPE, if it has a significant impact?

— decontamination;

— what are the established decontamination procedures?

— storage;

— has the manufacturer indicated any specific requirements;

— is the life cycle of the PPE influenced by the storage? This is indicated by the manufacturer, if it has a significant impact.

11.4 Manufacturer information for maintenance

All items of PPE are provided with manufacturer information, including maintenance instructions.

The fire service make arrangements for maintaining the PPE in accordance with the manufacturer's recommendations and they inform all parties involved.

If the fire service contracts a manufacturer or professional cleaning (laundry) to conduct cleaning (laundering) and repair services, they determine and enforce when such cleaning (laundering) and/or repairs are required. Where such arrangements are in place, the fire service have systems in place that enable additional checks to be conducted between annual checks, to ensure that the PPE remains fit for purpose at all times, is free of contaminants and does not pose a health hazard to the wearer.

Maintenance considerations include:

— Inspection:

  — what inspection criteria is applied?

  — who carries out the inspections?

  — when inspection is to be done?

— Repair:

  — what kind of repairs are acceptable? How they are to be carried out?

  — who will be responsible for the repairs?

— Removal from service and ultimate disposal:

  — when should the PPE be disposed of?

  — how the PPE is disposed of ensuring no damage to the environment or inadvertent reuse?

NOTE Only trained and competent personnel perform maintenance.

Annex A
(informative)

Risk assessment

A.1 Introduction

Organisations are responsible for carrying out a risk assessment in determining the level of and the type of PPE that is required for their firefighters. National risk assessment models and standards are used as guidance on this subject.

Examples of risk assessments for PPE can be found in EN 469, NFPA 1851, and for guidance purposes the following Risk Assessment Template may be of assistance:

Emergency response organizations are cautioned that base-layer garments could degrade the protection or performance of the certified clothing or equipment; interfere with form, fit, or function of the certified clothing or equipment; or become a hazard to the wearer.

Base-layer garments are not part of the certified clothing but could be worn under certified clothing by means not engineered, manufactured, or authorized by the clothing manufacturer.

Additionally, if the base-layer garments are not designed and manufactured from suitable materials for the hazardous environments of emergency incidents, the failure of the base-layer garments could cause injury to the emergency responder.

If a base-layer garment causes the structural integrity of the certified clothing to be compromised, the certified clothing might not be compliant with the standard with which it was originally certified.

A.2 Risk assessment guideline for selecting PPE for emergency service personnel

This risk assessment guideline was developed previously based on the work of CEN Technical Committee TC 162, Joint Working Group for firefighters Personal Protective Equipment and has been modified to encompass PPE worn by all emergency service personnel. (CEN/TC 162/JWG FFPPE N 52 “Risk assessment guidelines for choosing the PPE for firefighters”)”.

During incidents being undertaken by emergency service personnel, many different hazards may be encountered. Where possible, the level of risk that each hazard presents to the emergency service personnel is to be eliminated or reduced to an acceptable level. The guidance given in this document indicates how to carry out a Risk Assessment by acknowledging the hazards that may be present, the likelihood of the emergency service personnel becoming exposed to them and possible consequence of such exposure.

This guideline has been produced to assist fire service in making the decision on choosing the most appropriate type of PPE for emergency service personnel for whom they are responsible:

— structural firefighting;

— wildland firefighting;

— incidents involving hazardous materials;

— incidents involving mobile property e.g. motor vehicle, train, boat;

— specialist rescue e.g. USAR, swift water, vertical;

— emergency medical response;

— storm and tempest, and flood recovery.

A.3 Basis of this guideline

A definition of risk is the probability that the harm or damage from a particular hazard is realised. Risk reflects both the probability and the consequences of the harm.

In the hazard table in part E below, categories of many of the hazards likely to be encountered by emergency service personnel in the execution of their duties are listed. It is very unlikely that all the hazards listed will be encountered during one incident, nor is the list of hazards definitive. Hazards may be deleted or added to by any fire service carrying out a particular Risk assessment, subject to local conditions and requirements.

By considering all the various hazards to which emergency service personnel may be exposed to and by applying the Risk Assessment formula in this model, line by line, the more serious risks are identified by their higher score. This highlights where decisions are taken to ensure adequate and correct levels of protection for emergency service personnel.

Risk assessment formula

where:

L = Likelihood of the emergency service personnel being exposed to the hazard, and

S = Severity / Consequences to the emergency service personnel if exposed to the hazard.

R = Risk

$R = L \times S$

PPE chosen is based on protecting the emergency service personnel against the identified risks. Values of "*L*" and "*S*"

Likelihood		Severity/Consequence	
1	Never	1	NIL: e.g. No Injury
2	Exceptional	2	LOW: e.g. Minor Injury: Small Cuts; Burns etc. etc.
3	Occasional	3	MODERATE: e.g. Major Injury; Broken bones; Serious Burns
4	Very likely	4	HIGH: e.g. Life threatening
5	Always	5	EXTREME: e.g. Death

"1 Never" is only allowed where there is absolutely NO chance of the hazard being encountered.

The following table is provided for guidance only and is not intended to provide an exhaustive list of possible hazards.

Table A.1 — Risk assessment guidelines hazard table $L \times S = R$

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control Measures**	**L**	**S**	**R**	**Outcome from Action**	**Responsi-ble Officer**	**Timeline**	**Priority**
1 Thermal Hazards											
a. Convective Heat											
b Radiant Heat											
c Conductive Heat											
d Flame											
e Contact Heat											
f Molten Metal/Plastic Drops											
g Burning Embers											
h Flashover											
2 Radiation											
a Non-ionizing radiation											
— UV, visible, laser, IR, microwave and radio frequency											
b Ionizing radiation											
— radioactive contamination, alfa											
— beta, gamma, X- radiation											
3 Electrical Hazards											
a Electric Arc											
b Static Electricity											
c Electrical Current, High Voltage >1 000											
overhead wires etc. 3 phase industrial											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control Measures**	**L**	**S**	**R**	**Outcome from Action**	**Responsi-ble Officer**	**Timeline**	**Priority**
d Low Voltage < 1 000 — domestic power, house etc											
4 Environmental Hazards											
a Ambient Hot											
e.g. heat exhaustion											
b Ambient Cold											
e.g. Hyperthermia											
c Cold Surfaces											
d Air Velocity/High Winds											
e Rain and hail											
f Discharge											
e.g. Steam, Splashes											
g Falling in water											
h Loss of buoyancy control											
5 Mechanical Hazards											
a Penetration											
e.g. sharp objects etc.											
b Cut											
c Abrasion											
d Falling objects											
e Flying particles											
f Impact mechanical force											
g Caught up											
e.g. Entrapment											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control Measures**	**L**	**S**	**R**	**Outcome from Action**	**Responsi-ble Officer**	**Timeline**	**Priority**
h Pressure											
e.g. compressed air rescue equipment etc.											
i Falling down											
j Slipping											
k Vibration											
l Bites											
m Gunshot											
6 Noise											
a Deafness											
7 Non-Visibility Hazard											
a Not being seen											
8 Biological/Chemical Hazards											
If full protection is required, EN 136, EN 137, AS 1716 EN 943-1 (gas), AS 3765.2 If protection against splashes EN 469, and AS/NZS 4967 with moisture barrier included.											
a Explosive substances and articles											
b Flammable solids and liquids											
c Oxidizing substances											
d Toxic substances											
e Infectious substances											
f Corrosive substances											
g Asphyxiant gases											
h Compressed gases											
i Other liquids and substances not listed above											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control Measures**	**L**	**S**	**R**	**Outcome from Action**	**Responsi-ble Officer**	**Timeline**	**Priority**
j Contamination by body fluids											
k Smoke											
l Airborne particles											
9 Other Hazards											
a Getting lost											

A.4 Risk Assessment reference Standards

For a list of Standards for firefighter's personal protective equipment (PPE) in which requirements and levels of protection against particular hazards are outlined, refer to Annex C, *Examples of relationship between type of activity, the heat/flame hazard linked to the activity and clothing to be chosen for protection based on the existing product standards.*

As for risk assessment for RPD, ISO 17420-5 is a good reference.

Different PPE types are tested differently against particular hazards and the protection level they give is not always equal. See also Annex D for further information on standards.

A.5 Other Factors to be considered

The training, tactics and operational procedures of each fire service will have an impact on any Risk Assessment and will probably dictate how each hazard is regarded and indicate the figures to be applied to —L and —S.

Even if not identified as a potential serious risk under par. 7a of the Hazard Table, the physiological aspects of wearing PPE is also considered when carrying out the Risk Assessment as these can have a serious impact on the health and safety of the firefighter.

It may be decided by some that even with different risks being identified by the Risk Assessment, the decision taken will be to provide protection against the risk of the highest severity.

Emergency response organizations are cautioned that base-layer garments could degrade the protection or performance of the certified clothing or equipment; interfere with form, fit, or function of the certified clothing or equipment; or become a hazard to the wearer.

A number of documents on risk assessment and risk assessment models are available. The following examples offer guidance on this subject:

— EN 469, ISO 11999-1:2015, Annex A

— CEN/TC 162/JWG FFPPE N 52 —Risk assessment guidelines for choosing the PPE for firefighters

— Helena Mäkinen, Finnish Institute of Occupational Health, 3rd Seminar on PPE in Europe, 1996, — Risk assessment for the selection and use of protective clothing – a practical example, page 57 – 62

— Helena Mäkinen, Finnish Institute of Occupational Health, 4th Seminar on PPE in Europe, 1997, —A systematic risk assessment and PPE programme‖ page 113 – 117

— NFPA 2113 Selection, care, use and maintenance of flame resistant garments for protection of industrial personnel against short-duration thermal exposure.

— ISO/TS 16975-1, Respiratory protective devices – Selection, use and maintenance – Part 1: Establishing and implementing a respiratory protective device programme.

For further reference, readers can contact their national standards bodies and refer to Table A.1.

Table A.2 below give qualitative information on the different heat and flame risks (convective -flame, radiant and contact heat) in different activities.

Table A.2 — Thermal hazards present in the work place

Industry	Convective Heat – Flame	Radiant Heat	Contact heat
Fire fighting — Brush fire — Oil well fire — Solvent flash over — Apartment fire — Auto gas tank explosion	++	++	+
Oil and Gas/chemicals	+	+/−	+/−
Welding/Cutting (sparks of molten metal)	+	+	++
Glass factory	+	++	++
Electric Arc	+	++	+/−
Foundry (drops of molten metal)	+	++	++
Military	++	++	+
Munition, flares and pyrotechnics	+/−	+/−	+/−

Annex B
(informative)

Practical performance tests

B.1 Ergonomics

The ergonomics test attempts to replicate thermal environment and workload conditions where the wearer is able to thermoregulate whilst wearing reference clothing. To achieve this, the environmental conditions need to allow heat loss. The first test is a performance assessment, which measures the hindrance of the clothing in a work simulating test drill in a thermally neutral climate (20 °C ± 2 °C, RH 55 % ± 5 % or equal conditions). This test allows then dry and evaporative heat loss through the clothing. The following elements are part of this test and measure time or distance (Table B.1). All test items are carried out in the same sequence for reliable comparisons.

Table B.1 — Work simulating test drill on physiological impact of protective clothing

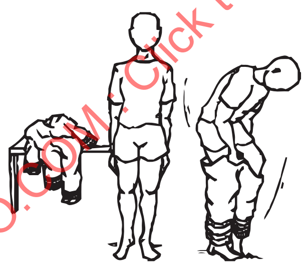
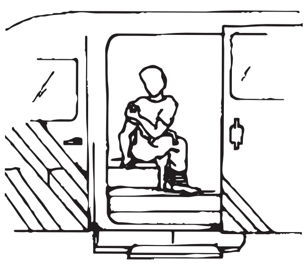
Number Test Item	Test item activity	Goal of test item	Performance in
1	**a. Donning in a workplace environment:** On a signal don the garments, in front of the test wearer on a table, as fast as possible, so that a good fit is achieved with all closures closed. 	The goal of this test item is to measure the ergonomics of the closure systems and the flexibility of the clothing	s
	b. Donning in a truck: On a signal don the jacket of the garments on a chair in the fire truck, as fast as possible, so that a good fit is achieved with all closures closed. This is done in a stationary and driving situation 	The goal of this test item is to measure the ergonomics of the closure systems and the flexibility of the clothing in a small room	s
2	**Running:**		

Table B.1 *(continued)*

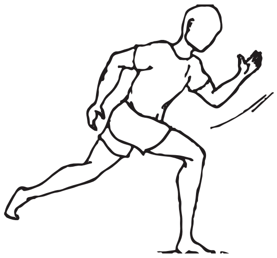
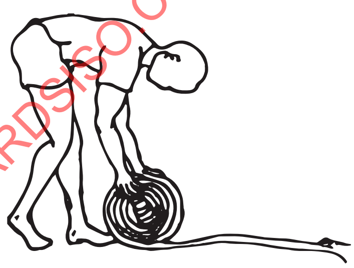
Number Test Item	Test item activity	Goal of test item	Performance in
	On a signal sprinting over 50m as fast as possible. Time in seconds will be registered. 	The goal of this test item is to measure the load of the clothing on running	s
3	**Hose unrolling:** Test wearers walk and roll the hose in his hands. While rolling, the other end of the extended hose is stationary on the floor. A standard hose is used for the test (e.g. weight, length and diameter of the standard hose are 6 kg, 25 m and 39 mm, respectively.) 	The goal of this test item is to measure the hindrance of the clothing while performing a task specific activity	s
4	**Hose rolling up:** Test wearers roll up the unrolled hoses. A standard hose is used for the test (e.g. weight, length and diameter of the standard hose are 6 kg, 25 m and 39 mm, respectively.) 	The goal of this test item is to measure the hindrance of the clothing while performing a task specific activity	s
5	**Stand-and-reach:**		
	Bending the torso as far as possible forward with the right leg on a table with a height of 80 cm and left leg on the floor. Both feet are completely horizontal. After practicing several times the wearer reaches out and holds that position for at 1 s to 2 s while the distance is recorded.	The goal of this test item is to measure the available space in the pants' crotch	cm

Table B.1 *(continued)*

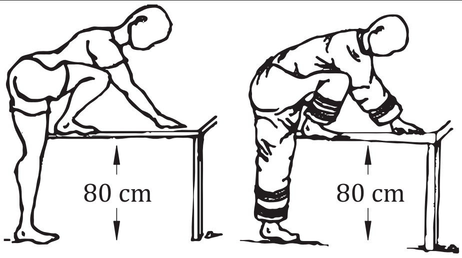
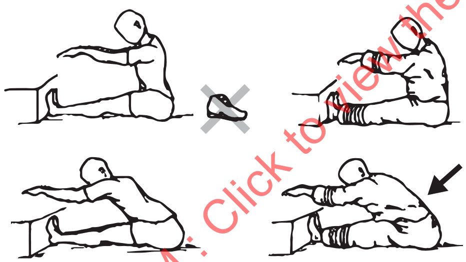
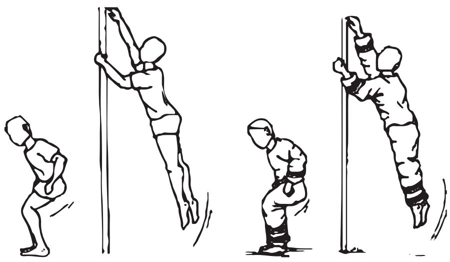
Number Test Item	Test item activity	Goal of test item	Performance in
			
6	**Sit-and-reach:** This test involves sitting on the floor with legs stretched out straight ahead. Shoes are removed. The soles of the feet are placed flat against the box. Both knees are locked and pressed flat to the floor. With the palms facing downwards, and the hands on top of each other or side by side, the test wearer reaches forward along the measuring line as far as possible. Ensure that the hands remain at the same level, not one reaching further forward than the other. After some practice reaches, the test wearer reaches out and holds that position for 1 s to 2 s while the distance is recorded. 	The goal of this test item is to measure the space in the jacket and pants	cm
7	**Sargent jump:** The Sargent or vertical jump test consists of measuring the difference between a person's maximum vertical reach before jumping and at the highest point during a jump. The person swings his or her arms downwards and backwards, assumes a crouching position, pauses momentarily to get balance, and then leaps as high as possible, swinging the arms forcefully forwards and upwards. Usually, the fingers are covered in chalk so that a mark can be made on a board to record the heights reached before and after jumping.	The goal of this test item is measure the sleeve feed	cm
	This test is meant to measure the freedom and/or hindrance of the sleeve and sleeve-insert. 		
8	**Stretch arms/back:**		

Table B.1 *(continued)*

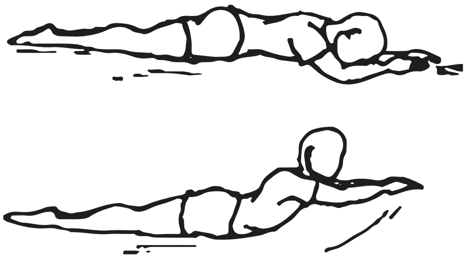
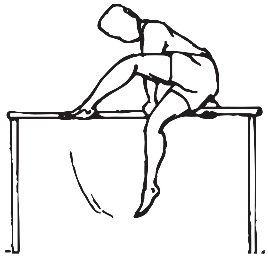
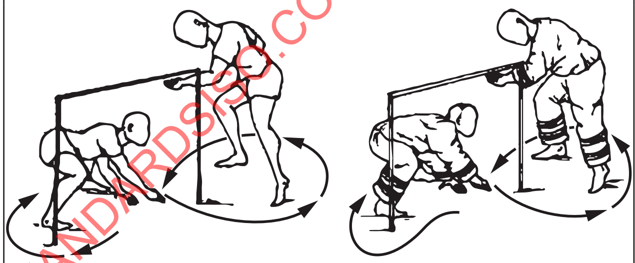
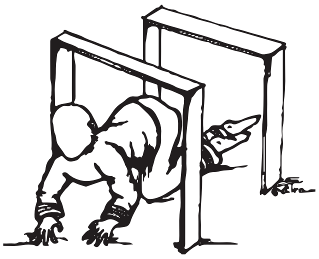
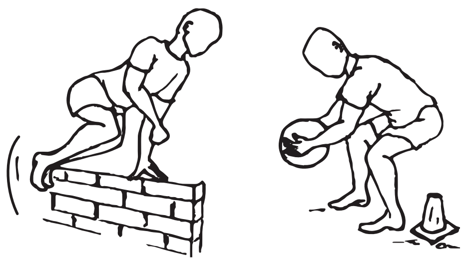
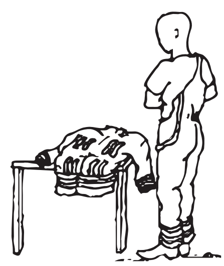
Number Test Item	Test item activity	Goal of test item	Performance in
	Lifting up the torso, lying on the belly with both legs and feet on the ground. The arms are stretched besides the body. Distance between ground and chin will be measured in cm. After practicing several times this test clement will be carried out once. 	The goal of this test item is to measure the available space on the back of the clothing.	cm
9	**Fence climbing:** Climb over a fence of 1,30 m when standing before the obstacle. Test is completed when standing straight behind the fence. Judges the freedom of movement of legs and crotch 	The goal of this test item is to measure the overall flexibility of the clothing	cm
10	**Running 8-shaped curves with bending:** Running as much 'eights' as possible during 30 s around 2 connected poles at a distance of 130 cm and a height of 130 cm. To determine the freedom of buck, knees bending, coordination and balance. 	The goal of this test item is to measure the overall flexibility of the clothing	amount of complete ran eights in s
11	**Crawling:** Crawling through a 'tunnel' of 15 m with a height and a width of 70 cm. 	The goal of this test is to measure the flexibility of the protective clothing	s

Table B.1 *(continued)*

Number Test Item	Test item activity	Goal of test item	Performance in
12	**Obstacle course:** A short course with all kinds of obstacles where test wearers have to climb, crawl, bend and stretch. 	The goal of this test item is to measure the overall flexibility of the clothing	s
13	**Donning and doffing a SCBA set with the garments:** On a signal put on as fast as possible the SCBA set, which is lying in front on a table. Time is stopped when the wearer is breathing adequately through the SCBA-set. Then the SCBA set is taken off and time is stopped when the SCBA set is in front of the table. 	The goal of this test item is to measure the compatibility of the clothing with the SCBA.	s
14	**Release (Doffing):** At the end of the test releasing the garments as fast as possible. 	The goal of this test item is to measure how fast you can release the clothing in case of emergency	s

Parts of the above test battery is repeated while wearing additional protective equipment (e.g. a SCBA set). In case the test drill starts with test element 2 (donning the SCBA set) and continues until test element 12. After that the SCBA set is doffed and put on a table (time is measured). The test can also be carried out with helmet, boots etc. to determine the compatibility with other protective equipment.

The goal of the practical performance test is to look at the ergonomics hindrance (thermal load or restriction of movement) linked to the PPE being worn (clothing but also other PPE such as boots, gloves, RPD, firehood, helmet, radio, etc.) for certain defined tasks.

B.2 Cold protection

Cold protection properties of the protective clothing are also measured. Test wearers were asked to complete a test circuit of one hour in a deep freeze warehouse at a temperature of -10 °C (e.g. test elements from the test battery except test element 1 and test element 13 for a period of one hour). After fulfilling the test circuit, they were asked to fill in the relevant questions of the questionnaire and give their ratings of perceived exertion, thermal comfort and humidity sensation.

B.3 Rain protection

Rain protection is tested in a relevant scenario. The protective clothing is worn by the test wearers in an artificial rain environment (e.g. constant rainfall at a rate of 20 mm h^{-1}). Test wearers need to walk through the rain performing a small obstacle course at a low speed during 20 min. The obstacle course consists of climbing over objects, as well as crawling under objects and e.g. moving bricks from low to high positions and vice versa (see Figure). These movements test the design of the clothing (gaps when bending over), the waterproofness of materials, seems and closure systems in normal conditions and under pressure and stress (knees, elbows). The clothing performance is measured in terms of water absorption, water penetration to the underclothing (both by weighing the respective garments and underwear), the leakage locations and the test wearers subjective judgements.

Figure B.1 — Rain protection

B.4 Parameters to be measured

Loss of performance as a measure of hindrance is measured in time or distance compared to the same test in reference clothing (station wear or previous protective clothing in use). The following formulae are used to calculate the loss of performance:

— for increasing test results (time elements of the test):

$$\text{LoP} = \frac{\text{test result - reference value}}{\text{test result}} \times 100\%$$

— for decreasing test results (**distance or amount** elements of the test):

$$\text{LoP} = \frac{\text{reference value - test result}}{\text{reference value}} \times 100\%$$

The loss of performance is given in percentages with respect to the reference value (this is a test with a beforehand defined standard, either basic station gear or previous protective clothing in use). Test result is the result with the (new) protective clothing.

After all test elements subjective sensations are measured following the international accepted and validated scales as described in Heus and Havenith (1996)[82], for temperature, sweat and comfort and for perceived exertion. All test wearers are requested to fill in a questionnaire about their experiences with the functionality of the (new) protective clothing ensemble.

B.5 Additional testing

The tests described below require medical supervision because of the risk of skin burns or heat stress. It is also recommended to measure skin temperatures and core temperatures of the test wearers to monitor the safety limits[4].

B.6 Heat protection

The heat protection against skin-burns test is carried out in a small room of 4 m × 4 m with a standardized and constant heat-flux load of about 7 kW m^{-2} in the middle of the room. All test wearers were exposed with the protective clothing with their front and back to the heat load with a maximum duration of 2 min making stepping movements on the place.

Test wearers are asked to withdraw from the heat source when they feel too hot[5]. Time until withdrawal is measured. Time until recovery is also measured (test wearer indicates that (s)he is back to normal temperatures).

The complete test is repeated with standardized wet underwear (100 g water per set of underwear).

B.7 Physiological heat load

Exposures where time is limited by Self Contained Breathing Apparatus (SCBA) or by heat strain (indoor fire attack): high air temperature (equal to or above skin temperature) with medium radiation and medium work load allows for working times up to 30 min (new types of 300 bar SCBA may allow longer working times and test limit times may be adjusted for this). The heat strain will be mainly determined by the ability of the wearer to lose his/her body heat through the clothing to the environment. Considering the high air temperatures, dry heat transfer will be negligible or towards the body, and body heat loss will have to be through evaporation. However, this test measuring the physiological impact of the protective clothing will be performed without using SCBA to measure only the impact of the protective clothing. The test conditions have to be around 40 °C to create an environment that only allows heat transfer from the body to the environment by sweat evaporation. In this environment subjects are requested to walk with a speed of 5 km h-1 for a period of 20 min[6] (see specific parameters in Table B2).

4) Skin temperatures not higher than 42 °C and core temperatures not higher than 38,5 °C.

5) Generally test wearers withdraw just before burning of the skin at a skin temperature of 42 °C.

6) An alternative test in this environment is a test with test elements of the before described PPT. These test elements can be performed for a maximum period of 30 min, but skipping test element 1 and 14.

Table B.2 — Physiological impact of walking

Number	Activity	Environment	Criterion
15	Physiological heat stress test: subjects walk with 5,0 km·h^{-1} in a heated room with fire fighters' protective clothing during 20 min.	40 °C ± 1 °C, RH 30 % ± 5 % (abs. vapour pressure 2,2 kPa ± 10 Pa)	Heat storage <8 J g^{-1} body weight T_{core} <38,5 °C T_{skin} <37 °C
	Heat storage is derived from the heat balance. Heat storage = (0,8 dT_{core} + 0,2 dT_{skin}) × 3,48 dT_{core} = difference in core temperature form begin till end of the test dT_{skin} = difference in mean skin temperature form begin till end of the test 3,48 = specific heat of human tissue in J g^{-1} °C^{-1}		

Borg Ratings of Perceived Exertion (RPE) (Borg,1998)[83], thermal comfort, and humidity sensation will be measured. Besides that test wearers were requested to fill in the relevant questions of the questionnaire.

Annex C
(informative)

Examples of relationship between type of activity, the heat/flame hazard linked to the activity and clothing to be chosen for protection based on the existing product standards

Table C.1 below is presented as a guide, to be used when selecting clothing to protect against heat and flame. The following control measures/Standards are provided as guidance only and are not an exhaustive list of references. Each fire service considers the impacts identified in relevant Standards that may exist within their country.

As it is ultimately the responsibility of the employer to select the most appropriate items of protective clothing, after carrying out a risk assessment, the table is used strictly as an explanatory guide.

WARNING — In selecting the appropriate protective clothing, care is made not to over protect the wearer, as this can lead to discomfort and / or excessive stress that may prove hazardous.

This table is based on the existing standards at publication.

Table C.1 — Link between activity hazard and protective clothing

Type of activity	Main hazard (test method)	Suggested protective clothing (product standard)
Work in laboratory or firm with risk of brief contact with small igniting flames without significant heat hazard (including students in labs)	Small flames – accidental contact with flame (ISO 15025 Limited Flame spread test)	Lab coat (Clothing to ISO 14116 Index 1 or 2)
Clothing to protect main heat and flame protective clothing for oil, dirt and grime, not intended to provide additional protection	This clothing is only there to protect the main heat and flame protective clothing Small flames – accidental contact with flame (ISO 15025 Limited Flame spread test)	Clothing worn over protective clothing against heat and flames offering other types of protection such as against foul weather or low visibility (Clothing to ISO 14116 Index 1 or 2)
Construction plant/pipeline	Very small flame (roofing tar), indirect sparks) (ISO 15025 Limited Flame spread test)	Non-meltable clothing (ISO 14116 Index 2)
Plant modification, expansions, turnarounds	Small flame (roofing tar, welding), indirect sparks) (ISO 15025 Limited Flame spread test, ISO 9151 csonvective heat test)	Single layer coverall or pants and coat (ISO 11612 A Index 3 levels B1)
Welding and cutting	Sparks and small molten metal drops (ISO 15025 Limited Flame spread test and ISO 9150 small molten metal splash)	Flame resistance coverall (Clothing to ISO 11611 Class 1 or higher)
Working beside hot stuff (e.g. in a production process)	Contact heat (ISO 15025 Limited Flame spread test and ISO 12127-1 contact heat tester)	Coverall or pants and coat (ISO 11612 levels F1 or F2 or higher)

Table C.1 *(continued)*

Type of activity	Main hazard (test method)	Suggested protective clothing (product standard)
Aluminium, Iron and steel works a. Welding and cutting -small activities but potential for small metal drops b. aluminium and iron foundry — medium activities but potential for medium metal drops c. metal drops but potential for large quantities of metal drops	Molten metal splash and contact heat (ISO 15025 Limited Flame spread test, ISO 9150 small molten metal splash, ISO 9185 molten metal splash and ISO 12127-1 contact heat tester) For other metals, understanding of their melting temperature and behaviour are to be analysed	Coverall or pants and coat; potentially multi-layer clothing or even aluminised clothing — low to high risk – to -layer clothing or even aluminised clothing) fl, non meltable underwear a. ISO 11611 Class 1-2 or ISO 11612 levels D1, E1 and F1 b. ISO 11611 Class 2 or ISO 11612 levels D2, E2 or F2 c. Clothing to ISO 11612 levels A Index 3, B2 and C3 or C4, D1 to D3 or E1 to E3.
Industrial work e.g. glass working, or other exposure to small controlled flames and fires) a. Working beside small fires (e.g. in a production process) b. Fire extinguisher training c. Presence of flame/convective heat	Larger flames and convective heat (ISO 15025 Limited Flame spread test, ISO 9151 convective heat test)	Single layer coverall or pants and coat — non meltable underwear (ISO 11612 A Index 3 and B1- B2).
Industrial work a. Working close to furnaces	Radiant heat and occasional flames (ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test)	Single layer coverall or pants and coat, non meltable underwear
b. Working near a furnace in a production process c. Inside kilns		(ISO 11612 A Index 3 levels B2 and C2)
Live electrical working – risk of short circuit electric arc	Convective heat, radiant heat and small molten metal drops, arc flash resistance (ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test, 9 150 small molten metal splash IEC 61482-1-1 open arc test, IEC 61482-1-2 box test	Single or multi-layer layer coverall or pants and coat, non meltable underwear (ISO 11612 levels A Index 3, B1, C1 and E2-E3 or IEC 61482-2 ATPV 8 or higher Class 1-2)
Industrial work with potential of gas/solvents being available in for example explosive zone a. Racing driver crash b. Oil gas worker	Convective heat, radiant heat and flame engulfment (ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test, ISO 13506 thermal manikin)	Single or multi-layer layer coverall or pants and coat, non meltable underwear a. ISO 14460 b. /c./d: minimum ISO 11612 A Index 3, B1 C1, ISO 13506 less than 30 %-50 % body burn

Table C.1 *(continued)*

Type of activity	Main hazard (test method)	Suggested protective clothing (product standard)
c. Petro-chemical worker d. Pharmaceutical raw material production		
Firefighting	Intense heat and flame Flashover in fire-fighting	
a. Entering a burning building	(ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test, EN ISO 12127-1 contact heat tester, ISO 17493 hoven test, ISO 13506 thermal manikin)	Multi-layer layer pants and coat, non meltable underwear
b. Surrounded by/in proximity to a large fire		EN 469 level 2 or EN 1486 Type 2-3
c. Aircraft crash		ISO 13506 less than 10 % body burn
d. Fire in petrochemical storage tanks		
e. Wildland fire-fighting in open countryside		
Firefighting	Less intense heat and flame	
a. Wildland fire-fighting in open countryside	(ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test, ISO 12127-1 contact heat tester, ISO 17493 hoven test, ISO 13506 thermal manikin)	Multi-layer layer pants and coat, non meltable underwear a. Clothing to ISO 15384
b. Volunteer fire fighting (no entry into flaming buildings)		b. EN 469 level 2
c. Flames and burning debris		c. ISO 11612 levels B2 and C2.

Annex D
(informative)

Performance levels relating to clothing designed to provide protection from heat and flame

D.1 General

This list is based on existing standards at the time of publishing this document. Note that several of the Standards mentioned are currently under revision and that others undergo cyclic reviews. Therefore, the publication year is not mentioned.

There are standards describing test methods (these are only mentioned with their title and what method is tested but there are no pass/fail criteria or levels) and standards specifying performance requirements for garments (product standards have pass/fail criteria and levels). The standards from this last type are mentioned with title, scope and, where applicable, with the performance levels as described in the standard.

WARNING — Performance levels mentioned in Standards may vary in successive editions of a standard. Please check with your Standardization Body what the most recent available edition of the standard is before making any decisions.

At the moment there is no clear distinction between the terms ‘resistant' and ‘retardant’, often leaving some buyers and end-users puzzled. Currently the CIRFS (European Man-Man Fibres Association), the representative body for the European man-made fibre industry, is attempting to create an official definition for the various combinations of terminology using resistant, retardant, inherent or treated in the name to clear up confusion. As a rule of thumb, the following definitions are widely accepted:

Flame resistant fabric (FR) and Flame retardant (FR) are two terms that are used to describe a material that is self- extinguishing after removal of an external ignition source.

The distinction of inherent versus non-inherent fibres of fabrics, is whether the flame resistant or retardant properties are intrinsic to the polymer or fibre properties or whether a flame retardant or resistant chemical treatment applied somewhere after the fibre production. The flame resistance of a fabric is primarily a consequence of the properties of the fibre. Different yarn properties and fabric construction can contribute to increased flame resistance.

— Flame resistance treated/coated materials

Non-inherent fabrics, sometimes known as coated FR or coated flame retardant fabrics, use a chemical treatment to achieve protection. The treatment chemicals are frequently ‘activated’ by intense heat, producing char and gases that inhibit combustion for a certain time. The limitations of flame retardant treated fabrics are that the added chemicals can be affected or removed by external factors such as washing, exposure to heat or exposure to other chemicals. The non-inherent fabrics are limited in that the heat and flame protective properties are maintained for the indicated wear life, i.e. for up to an indicated maximum number of cleaning cycles. However, this will only stay true as long as the user adheres strictly to the manufacturers cleaning instructions, otherwise there is risk of damage to the flame protective properties, potentially putting the wearer at risk.

— Inherent materials

When a fabric offers inherent protection, this is because it is manufactured with fibres, whose intrinsic structural properties make them naturally flame resistant. Because the properties are part of the structure, they cannot be washed out or removed by cleaning processes, wear and tear, and will continue to offer the same level of protection throughout the garment’s lifetime. The advantage of these types of protective fabrics is that the performance is robust despite the probable non-observance of the manufacturers cleaning instruction.

— Mixed materials

These mixtures of fibres may include FR and non-FR fibres, all inherently flame resistant fibres, FR treated or a combination. These mixtures are made for various reasons:

— reduce cost;

— increase comfort;

— better balance of properties;

— better type of heat and flame protection.

— Whatever the material used the garment meets a number of key requirements:

— flame resistance;

— integrity of the garment when exposed to heat and flame (e.g. remain intact during the exposure, no excessive shrinkage, seams need to last after the exposure, not deposit tar or other conductive liquids);

— insulation (the function of the garment is to slow down the heat transfer from the source through the garment to the skin, in order to allow sufficient escape time).

— Other aspects that can impact the choice and life of the garment to consider are:

— tear and abrasion resistance;

— seam strength;

— resistance to UV degradation (strength and appearance);

— resistance to ozone (welding creates ozone that can degrade certain materials from a strengths perspective);

— low heat flux thermal damage (low heat radiation e.g. 5, 10 kW and influence the strength of the garment and protection at high heat fluxes);

— cleanability (ease and completeness of cleaning) conditions or risk of washing at different condition temperature, bleach, peroxides, softener to heat and flame resistance;

— liquid repellency (e.g. avoid penetration of water, oils, solvents and other liquids), life span of repellency, what needs to be done in cleaning cycle to maintain it (e.g. drying).

For any treatment, one needs to understand the life span and the conditions at which the garment needs to be washed (e.g. temperature, use of bleach or peroxides, effect of starching for ironing, as these will potentially have effects on the heat and flame protection) or dried.

Different fibres have different heat and flame properties due to their thickness, and strength. In addition to the number of washing, the wear and treat of a garment will have a negative effect on its heat and flame properties as well. All materials will become thinner due to washing, due to wear and tear, rubbing against other surface (abrasion).

The required level of performance is chosen following a risk assessment (see also Annex C for examples).

D.2 Standards describing performance requirements for protective clothing or materials

This sub-clause will start with the product standards followed by the test methods (see Tables D1 to D4)

Table D.1 — Firefighter product specification

<table>
<tr><th>Standard</th><th>Standard title (summarised)</th><th>Required tests</th><th colspan="2">Highlights of description of limits or pass/fail criteria</th></tr>
<tr><td rowspan="14">EN 469:2020</td><td rowspan="14">Protective clothing for firefighters- Performance requirements for protective clothing for firefighting</td><td rowspan="14">This document specifies minimum performance requirements for protective clothing designed to be worn during firefighting activities.

This document makes distinction between firefighting activities dividing them into two performance levels based on a risk assessment:

— Level 1: specifies the minimum requirements for firefighting clothing involving work associated with outdoor firefighting and their support activities, taking into account the environments and conditions of the expected operational scenarios of such firefighting activities.

The level 1 is not applicable for protection against risks encountered in fighting fires or rescue from fire activities in structures, unless combined to a level 2 or other specialized PPE.

— Level 2: specifies the minimum requirements for firefighting clothing for risks encountered in fighting fires and rescue from fire in structures.

The distinction between Level 1 and Level 2 clothing is restricted to the requirements for heat and flame (X1 or X2 - Heat and Flame). These levels of protection can be reached by a single garment or a combination of separate garments.

Additional marking provides two grades of protection for Y (protection against water penetration) and Z (water vapour resistance). It is essential that these performance grades are indicated on the marking of the clothing and explained in the instructions for use.</td><td colspan="2">Thermal (Determining Level 1 and Level 2)

— Limited Flame test — Procedure A index 3
— Thermal resistance — 180 °C, 5 min, >5 % shrinkage and no ignition or melting
— Residual tensile strength-ISO 6942 10 kW/m2, 3 min ≥ 450 N
— Thread no melting at 260 °C</td></tr>
<tr><td>Level 1</td><td>Level 2</td></tr>
<tr><td colspan="2">Contact heat</td></tr>
<tr><td>not required</td><td>250 °C for 10 sec
ISO 12127-1</td></tr>
<tr><td colspan="2">Radiant heat
ISO 6942 Method B (20 kW/m^2)</td></tr>
<tr><td>$RHTI_{24}$≥10, $RHTI_{24-12}$≥3;</td><td>$RHTI_{24}$≥18, $RHTI_{24-12}$≥4</td></tr>
<tr><td colspan="2">Convective heat
ISO 9151 (80kW/m^2)</td></tr>
<tr><td>HTI_{24}≥9,
HTI_{24-12}≥3;</td><td>HTI_{24}≥13,
HTI_{24-12}≥4;</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Water/vapour
— Water penetration- Y1 < 20 kPa or Y2 ≥ 20 kPa with moisture barrier</td></tr>
<tr><td colspan="2">— Water Vapour Resistance (RET) — Z1 < 30 m^2 Pa/W to ≤ 45 m^2 Pa/W or Z2 ≤ 30 m^2 Pa/W</td></tr>
<tr><td colspan="2">Chemical (ISO 6530) 80 % repellency
— Sulfuric Acid , 30 %, Xylene</td></tr>
<tr><td colspan="2">Mechanical
— Tensile ≥ 450 N fabric, ≥ 225 N structural seams
— Tear strength ≥ 30 N.</td></tr>
<tr><td colspan="2">Others
— Dimensional change :
Woven ≤ +/- 3 % ,
Non-woven ≤ +/- 5 %
— Visibility
— Thermal manikin (optional) ISO 13506-1:2017
— Comfort/physiology (optional)</td></tr>
</table>

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
EN 1486	*Test methods and requirements for reflective clothing for specialised fire fighting*	This standard specifies test methods and minimum performance requirements for reflective protective clothing used in specialised firefighting. This clothing provides protection against flame lick and intense radiant heat and is worn for short periods only, to enable the fire fighter to enter specific high-risk firefighting and fire rescue situations which also require the use of breathing apparatus and head, hand and foot protection. This standard only covers protective clothing that relies upon the ability of the outer material to reflect intense radiant heat. This type of reflective clothing may also be used for industrial applications involving high levels of radiant heat.	Heat transfer (radiant heat):
			when the component assembly is tested according to ISO 6942 a heat flux density of 40 kW/m2
			RHTI 24 > 120
			Heat transfer (convective heat): ISO 9151 80 kW/m^2; HTI 24 > 21 Contact heat: when the component assembly is tested according to EN 702 (all parts) at a contact temperature of 300 °C. Threshold time be 15 s.
		The reflective clothing specified in this standard for specialised use is not covered in EN 469. Non- reflective protective clothing as specified in EN 469 may also be used for specialised firefighting applications in conjunction with appropriate head, hand, foot and respiratory protection.	
EN 13911:2017 (Under revision)	*Requirements and test methods for fire hoods for firefighters*	This standard specifies minimum safety requirements and test methods for a fire hood worn by a firefighter whilst wearing protective clothing (EN 469), breathing apparatus (EN 136 and EN 137) and helmet (EN 443)	Heat transfer (flame) ISO 9151, 80 kW/m2 HTI $_{24}$ ≥ 8 s HTI $_{24-12}$ ≥3 s, Heat transfer (radiation) ISO 6942 method B, 20 kW/m^2 RHTI $_{24}$ ≥11 s, RHTI $_{24-t12}$ ≥3 s, Thermal resistance- 180 °C, 5 min, >5 % shrinkage and no ignition, nor melting, nor breaking in addition to mechanical requirements
ISO 15384:2018	*Protective clothing for firefighters – Laboratory test methods and performance requirements for wildland firefighting clothing*	This standard is similar, but not identical to, EN 15614 or ISO 16073 ISO 15384 will replace EN 15614 and will also be replace to in the clothing part of the ISO 17063 ensemble standard.	Garments are required to pass certain design and physical requirements Garments/materials/seams will be certified to the limited flame test Index 3 of ISO 14116

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
		It specifies methods of test and minimum performance requirements for protective clothing to be worn in wildland firefighting and associated activities. This clothing is not intended to provide protection during fire entrapment.	Radiant heat ISO 6942, 40 kW/m^2
			RHTI $_{24}$ ≥ 11 s RHTI $_{24\text{-}12}$ ≥ 4 s Heat and Thermal Shrinkage ISO 17493 at 260 °C, no melt, drip, ignite or shrink >10 % (hardware tested at 180 °C)
		It covers the general design of the garment, the minimum level of performance for the materials employed and the methods of test to determine these levels.	Water Vapour Resistance ISO 11092< 10 m2Pa/W Thermal Resistance ISO 11092 < 0,055 m^{2}K/W
			Tear Strength ISO 13937-1: ≥ 25 N Seam strength ISO 13535-2 ≥ 300 N Tensile Strength ISO 13934-1: ≥ 600 N Thermal stability of hardware and visibility ISO 17493: 180 °C, and not melt, drip, ignite, Cleaning Shrinkage EN 25077: Dimensional change woven <3 % for knitted <5 %

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
EN 16689:2017	*Fire fighting for technical rescue operation*	This European standard specifies the minimum requirements for technical rescue clothing. Technical rescues involves work associated with the environments and conditions associated with operational scenarios such as but not limited to those found during road traffic collisions and when working in and around collapsed structures often for extended periods of time after natural disasters (earthquake, landslides, etc.) This European Standard covers the general clothing design, the minimum performance levels of the material used, the methods of test to be used to determine these performance levels and marking and information supplied by the manufacturer. Unless combined with other specialised PPE, this standard is not applicable to clothing used to protect against risks encountered in fighting fires or rescue from fire, dealing with hazardous chemicals, working with chainsaws and water and rope rescue and Wildland. This European Standard does not cover protection for the head, hands and feet or protection against other hazards e.g. chemical, biological, radiological and electrical hazards. These aspects are covered in other European Standards.	Garments are required to pass certain design and physical requirements Limited flame test (ISO 15025) method A Index 3 of ISO 14116), Radiant heat ISO 6942, 20 kW RHTI $_{24} \geq 7$ s Contact Heat ISO 12127-1 Simulates accidental contact with hot surfaces. When tested at 100 °C, the performance levels are: ≥ 5 s Thermal resistance- 180 °C, 5 min, with respectively for woven and non-woven: ≤3 % and ≤5 % shrinkage and no ignition or melting Residual tensile strength-ISO 6942: 10 kW/m^2, 3 min ≥ 450 N Abrasion >20 000 cycles using ISO 12947-2 (Martindale) Visibility meeting requirement ISO 20471. In addition to other requirements
ISO 11613:2017	*Protective clothing for firefighter's who are engaged in support activities associated with structural fire fighting*	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.	Garments are required to pass certain design and physical requirements
		Interior attack firefighting and support activities of firefighting are defined as: 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	Limited flame test (ISO 15025) method A Index 3 of SO 14116), Convective Heat HTI$_{24}$ ≥ 9,0
		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	HTI$_{24\text{-}12}$ ≥ 3,0 Radiant heat ISO 6942, 20 kW/m^2 RHTI $_{24} \geq 10$ s

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria		
		— extinguishing fires from the outside of the structure	RHTI $_{24-12}$ ≥ 3 s		
		— prevention of exterior spreading to adjacencies, preventing environmental damage and limiting effect of smoke — securing traffic and environment — first aid base activities	Residual tensile strength-ISO 6942 10 kW/m^2, ≥450 N (woven only) Thermal resistance- 180 °C, 5 min, >5 % shrinkage and no ignition or melting		
		— preparing the fire ground for subsequent activities — RPD replenishment tasks — assessment zone — BA communication — forward command post	Tensile strength — ≥450 N fabric woven, — ≥100 kPa (50 cm2 test area) (knitted fabric) — ≥200 kPa (7,3 cm2 test area) (knitted fabric) Tear strength ≥ 25 N.		
		— evacuation — assist planning — assist logistics — assist communication — transportation	Water absorption resistance ≤15 % Dimensional change — ≤5 % (woven fabric) — ≤5 % (non-woven fabric or knitted) Water penetration- ≥20 kPa Water Vapour Resistance (RET) — ≤ 20 m2 Pa/W Seam Strength — ≥225 N (woven fabric) — ≥100 kPa (50 cm^2 test area) (knitted fabric) — ≥200 kPa (7,3 cm^2 test area) (knitted fabric) Garment test: thermal manikin 4 sec optional Cleaning Shrinkage EN 25077: Dimensional change < 3 %		
ISO 11999-3:2015 (Under revision)	*Protective clothing for firefighters- Performance requirements for protective clothing for firefighting*	The purpose of this standard is to provide essential performance requirements for protective clothing for firefighters whilst firefighting. The clothing in this standard can be used by firefighters in other activities subject to a risk assessment.	Heat resistance (No ignition/ melting on all materials ≤ 5 % shrinkage)	Level A1 ISO 17493 180 °C, 5 min	Level A2 ISO 17493 260 °C, 5 min
		Level A1 is close to identical to EN 469 Level A2 is close to equivalent to NFPA 1971	Flame Spread	ISO 15025 Proc A & B Index 3 and max Char 100mm	
			Heat Transfer –Flame (80 kW/m^2)	ISO 9151 HTI24≥13 HTI24-12≥4	HTI24≥17, HTI24-12≥6
			Heat Transfer-Radiant (40 kW/m^2)	ISO 6942 Method B RHTI$_{24}$≥18, RHTI$_{24-12}$≥4;	ISO 6942 Method B RHTI$_{24}$≥26, RHTI$_{24-12}$≥8

Table D.1 *(continued)*

<table>
<tr><th>Standard</th><th>Standard title (summarised)</th><th>Required tests</th><th colspan="3">Highlights of description of limits or pass/fail criteria</th></tr>
<tr><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6"></td><td>Contact heat (Tested dry and wet)</td><td>ISO 12127-1 55 kPa on knee 14 kPa on shoulder 180 °C for both</td><td>ISO 12127-155 kPa on knee 14 kPa on shoulder 260 °C for both</td></tr>
<tr><td>Dimensional Change (Shrinkage after 5 cleaning cycles)</td><td colspan="2">ISO 5077 ≤ +/- 3 % in both directions</td></tr>
<tr><td>Resistance to penetration by liquid chemicals (NaOH, HCI, H2SO4, O-xylene)</td><td>ISO 6530 Level C1 No penetration Repellency >80 %,</td><td>Level C2 ISO 13944 Proc. C no penetration 1 hr</td></tr>
<tr><td>Resistance to water penetration</td><td>EN 20811 hydro pressure at 0.98 kPa/min < 20 kPa</td><td>EN 20811 hydro pressure at 5,9 kPa/min ≥175 kPa</td></tr>
<tr><td>Water vapour Resistance</td><td>ISO 11092 ≤40m^2 Pa/W ASTM F168, Part C THL ≥200 W/m^2</td><td>ISO 11092 ≤30m^2 Pa/W ASTM F168, Part C THL ≥300 W/m^2</td></tr>
<tr><td>Surface Wetting (water absorption)</td><td colspan="2">EN 24920 Spray Rating ≥4</td></tr>
<tr><td>ISO 16073-3</td><td>Ensemble for wildland see for clothing ISO 15384</td><td></td><td colspan="3"></td></tr>
<tr><td rowspan="4">ISO 18639-3:2017</td><td rowspan="4">Fire fighting for technical rescue operation</td><td>Similar to the European but split in to two different activities:</td><td colspan="3">Requirements common to both RTC and USAR</td></tr>
<tr><td rowspan="3">RTC – Road Traffic Crash

USAR — Urban Search and Rescue</td><td colspan="3">Limited flame test (ISO 15025) method A Index 3 of ISO 14116),
Tensile strength for fabric and seam ≥450 N, non-woven ≥360N
Tear ≥ 25N
Dimensional change: respectively for woven and non-woven: ≤3 % and ≤5 % shrinkage</td></tr>
<tr><td colspan="3">Abrasion >20 000 cycles using ISO 12947-2 (Martindale)
Water Vapour Resistance (RET) ISO 11092
≤20 m2Pa/W
Visibility meeting requirement ISO 20471
Viral or biological requirement ISO 16604
Additional requirements for RTC
RHTI 24 ≥ 7 s</td></tr>
<tr><td colspan="3">Contact Heat ISO 12127-1 at 100 °C, performance levels are: ≥ 15 s</td></tr>
</table>

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria		
ISO 21492:2019	*Station uniform for firefighters*	This standard sets out minimum performance requirements for station uniforms for firefighters that are provided by agencies to be worn under primary protective garments compliant with the relevant standards. This document specifies two levels of requirements for station uniforms: — Level 1 specifies minimum no melting nor dripping requirements that provide no additional protection but ensure the firefighter is not harmed by the melting of station uniform materials in cases where heat or flames impinge the station uniform. — Level 2 specifies heat and flame requirements to provide minimum protection. It can be combined with additional layers or garments to meet the requirements of a standard for a specific primary protection garment, this combination should provide improved protection and comfort.		**Level 1**	**Level 1**
			Thermal requirements		
			Limited flame spread	Index 2	Index 3
			Heat resistance ISO 17493 for 5 min, no material shall melt, drip, ignite	180 °C shrink >5 %	180 °C shrink >5 % 260 °C shrink >10 %
			Heat transfer (convective) ISO 9151, shall meet at least value of HTI24 ≥ 4 s		required
			Heat transfer (radiant) ISO 6942 Method B, 20 kW/m2,RHTI24 ≥ 7 s		required
			Dimensional change	woven material (length or width direction) ≤5 % and for knitted materials ≤8 %	
			Mechanical requirements		
			Tensile strength (woven materials)	ISO 13934-1 ≥ 300 N	
			Tear strength (woven materials)	ISO 13937-2 ≥ 10 N	
			Burst strength (knitted materials)	ISO 13938-1 or ISO 13938-2, when using a 50 cm^2 test area, mean >100 kPa or, using a 7,3 cm^2 test area >200 kPa	
			Structural seam strength	ISO 13935-2 ≥ 225 N for coveralls and trouser, and ≥150 N for shirts	
			Abrasion resistance (optional)	ISO 12947-2, 12kPa, ≥15 000 rubs for woven materials	
			Ergonomic and Comfort Requirements		
			Thermal resistance	ISO 11092, < 0.010 m2 K/W	
			Water vapour resistance or	ISO 11092, < 5 m2 Pa/W	
			Color fastness (optional)	ISO 105-B02:2014, ISO 105-X12:2016, ISO 105-E04:2013 ISO 105-C06:2010 or ISO 105-D01:2010, Grade 4	
			Electrostatic resistance (optional)	EN 1149-5 or equivalent	

Table D.2 — Gloves Product Specifications

<table>
<tr>
<td>EN 388:2016+A1:2018 (identical to ISO 23388:2018)</td>
<td>Protective gloves against mechanical risks</td>
<td>All specimens shall be taken from the palm of different gloves for classification purposes. For arm protectors, specimens shall be taken from the area for which protection is claimed.

A protective glove against mechanical risks shall have performance level of 1 or above for at least one of the properties (abrasion, blade cut, tear and puncture) or at least level A of the cut test of ISO 13997:1999 (e.g. TDM).

An addition optional impact protection was included in the revision as a pass/faill criteria.</td>
<td>
<table>
<tr><td>Test</td><td colspan="6">Level</td></tr>
<tr><td>Resistance</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td></td></tr>
<tr><td>Abrasion (rubs)</td><td>100</td><td>500</td><td>2000</td><td>8 000</td><td>—</td><td></td></tr>
<tr><td>Coupe cut test : (index)</td><td>1,2</td><td>2,5</td><td>5,0</td><td>10,0</td><td>20,0</td><td></td></tr>
<tr><td>Tear (N)</td><td>10</td><td>25</td><td>50</td><td>75</td><td>—</td><td></td></tr>
<tr><td>Puncture (N)</td><td>20</td><td>60</td><td>100</td><td>150</td><td>—</td><td></td></tr>
<tr><td>Resistance</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Cut TDM (ISO 13997)</td><td>2</td><td>5</td><td>10</td><td>15</td><td>22</td><td>30</td></tr>
</table>
</td>
</tr>
<tr>
<td>EN 407:2020 (ISO 23407 final ballot for identical requirements)</td>
<td>Protective gloves against thermal risks — heat and/or fire</td>
<td>This document specifies requirements, test methods, information to be supplied and marking for protective gloves against heat and/or fire. It should be used for all gloves which protect the hands against heat and/or flames in one or more of the following forms: fire, contact heat, convective heat, radiant heat, small splashes or large quantities of molten metal. This standard is only applicable in conjunction with EN 420.</td>
<td>
Limited flame spread (ISO 15025)
<table>
<tr><td>Performance level</td><td>After flame time
s</td><td>After glow time
s</td></tr>
<tr><td>1</td><td>≤ 15</td><td>no requirement</td></tr>
<tr><td>2</td><td>≤ 10</td><td>≤ 120</td></tr>
<tr><td>3</td><td>≤ 3</td><td>≤ 25</td></tr>
<tr><td>4</td><td>≤ 2</td><td>≤ 5</td></tr>
</table>
Contact heat (ISO 12127-1):
<table>
<tr><td>Performance level</td><td>Contact Temperature T_c
°C</td><td>Threshold time t_t
s</td></tr>
<tr><td>1</td><td>100</td><td>≥ 15</td></tr>
<tr><td>2</td><td>250</td><td>≥ 15</td></tr>
<tr><td>3</td><td>350</td><td>≥ 15</td></tr>
<tr><td>4</td><td>500</td><td>≥ 15</td></tr>
</table>
For contact heat performance levels of 3 or 4, the limited flame spread shall reach at least level 3, otherwise the maximum contact heat performance that shall be reported is level 2 (all the tables below shold have a similar statement)

Heat transfer (convective heat): ISO 9151 (80 kW/m^2)
<table>
<tr><td>Performance level</td><td>Heat transfer index HTI
s</td></tr>
<tr><td>1</td><td>≥ 4</td></tr>
<tr><td>2</td><td>≥ 7</td></tr>
<tr><td>3</td><td>≥ 10</td></tr>
<tr><td>4</td><td>≥ 18</td></tr>
</table>
</td>
</tr>
<tr>
<td></td><td></td><td></td>
<td>
Heat transfer (radiant heat)
ISO 6942 with a heat flux density of 20 kW/m^2
<table>
<tr><td>Performance level</td><td>Heat transfer t_{24}
s</td></tr>
<tr><td>1</td><td>≥ 7</td></tr>
<tr><td>2</td><td>≥ 20</td></tr>
<tr><td>3</td><td>≥ 50</td></tr>
<tr><td>4</td><td>≥ 95</td></tr>
</table>
</td>
</tr>
</table>

Table D.2 *(continued)*

<table>
<tr><td></td><td></td><td></td><td>Small molten metal splash
EN 348 (similar to ISO 9050)
<table><tr><th>Performance level</th><th>Number of droplets</th></tr><tr><td>1</td><td>≥ 10</td></tr><tr><td>2</td><td>≥ 15</td></tr><tr><td>3</td><td>≥ 25</td></tr><tr><td>4</td><td>≥ 35</td></tr></table></td></tr>
<tr><td></td><td></td><td></td><td>Large molten metal splash
ISO 9051
<table><tr><th>Performance Level</th><th>Molten iron
g</th></tr><tr><td>1</td><td>30</td></tr><tr><td>2</td><td>60</td></tr><tr><td>3</td><td>120</td></tr><tr><td>4</td><td>200</td></tr></table></td></tr>
<tr><td>EN 659:2003+A1:
2008
in revision</td><td>Structural Fire fighting glove</td><td></td><td>Limited Flamespread — No after flame
≤ 2 s, No afterglow ≤ 5 s, (EN 407 Level 4)
Convective ISO 9151 (40 kW) HTI24
≥13
(EN 407 Level 3)
Radiant ISO 6942, Met. B RHTI24 ≥22
Contact ISO 12127-1 at 250 °C tt ≥10 s
Abrasion (EN 388) Level 3
Cut (EN 388) Level 2
Tear (EN 388) Level 3
Puncture (EN 388) Level 3</td></tr>
<tr><td>ISO 11999-4:2015/
(ISO 15383:2001)</td><td>Structural Fire fighting glove</td><td></td><td>Limited Flamespread Index 3 Convective ISO 9151 (40 kW)
— HTI >13 HTI24-12 ≥ 4, HTI >17 HTI24-12 ≥6)
— (HTI > 9 HTI24-12 ≥ 3, HTI >13 HTI24-12 ≥ 4, HTI >17 HTI24-12 ≥6)
Radiant ISO 6942, Met. B
— RHTI >20 RHTI24-12 ≥ 4,
RHTI >26 RHTI24-12 ≥ 8
— (RHTI >11 RHTI24-12 ≥ 4,
RHTI >22 RHTI24-12 ≥ 6,
RHTI >33 RHTI24-12 ≥ 10)
Contact ISO 12127-1 at 250 °C
— tt ≥ 10 s, tt ≥ 14s, tt ≥ 14s
— (tt ≥ 6s, tt ≥ 10s, tt ≥ 14s)

Heat resistance ISO 17493
Temp/Shrinkage
— ≥ 160 °C/ >8 %, ≥ 260 °C and ≥ 260 °C both >5 %
— (≥ 180 °C, ≥ 260 °C and ≥ 260 °C all >5 %)
Thread resistance ≥ 260 °C Abrasion (EN 388) level 3 or 4</td></tr>
</table>

