TECHNICAL REPORT

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

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

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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	— Inherently FR shell; FR componentry
	— Heat resistance	— Level of dropping ad sagging
	— Heat insulation	— Increase in internal temperature
Protection mechanical & other	— Resistance to impacts	— Shock impacts (force, acceleration)
	— Resistance to crushing	— Penetration by blunt and sharp objects
	— Electrical insulation	— 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	— Weight
	— Activity	— Field test
	— Fitness	— Fatigue resistant
		— Movement of limbs and body
		— Transport
		— Training
		— Airtightness
Ergonomics	— Comfort	— Size
	— Environmental performance	— Visibility
		— Conversation
		— Breathing
		— Activities
		— Interference with other PPE
		— Abrasion with other PPE
Durability	— Comfort	— Comfort
	— Environmental	— Flame resistance
	— Performance	— Abrasion resistance
		— Weatherability
		— Aging of materials
Wash and care	— Cleaning	— Materials not affected by detergent
	— Decomposition and Manual	— 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