Technical Report

ISO/TR 21808

Third edition
2024-01

Best practices on the selection and use of personal protective equipment (PPE) designed to provide protection for firefighters

Meilleures pratiques 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
ISO/TR 21808:2024(en)

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Published in Switzerland

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

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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 third edition cancels and replaces the second edition (ISO/TR 21808:2021), which has been technically revised and completely rewritten.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 best practices document for PPE with the goal to evaluate and reduce the hazards and potential health risks associated with firefighting. This selection and use, 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 best practices document goes through the various steps and considerations such as risk assessment, compatibility, testing, 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 and Annex F provide importance guidance information.

The selection of appropriate PPE for heat and flame are based on your own risk assessment and procurement documents.

In the past 10 years, the world has experienced a rise in temperature due to climate change. As a result of this temperature rising, firefighters are facing the danger of heat stress, heat stroke and other fatal heat sicknesses. Many fire departments have begun considering heat stress management, taking into account the rising temperature and hot and humid climates, and have established new firefighting strategies, including tactics, training, equipment, and organization. Although some countries are placing more emphasis on heat and flame protection, the increased frequency and danger of heat stress and heat stroke incidents are estimated to result from the heavier and thicker PPE required. The risk of these newly generated risks, including dangerous heat stress/stroke, can not be underestimated. Risk assessments of firefighters' PPE(s) are to include the risks associated with heavier and thicker PPE(s) under various environmental conditions.

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. ISO 23616 is used 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, consider the consistency of this document.

Best practices on the selection and use of personal protective equipment (PPE) designed to provide protection for firefighters

1 Scope

This document sets out the best practices for the selection and use 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 bullet lists, these lists are provided for guidance only and they are not exhaustive.

Cleaning, inspection and repair of firefighters' personal protective equipment (including care and maintenance) are covered by ISO 23616.

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/TR 19591 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://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]

Note 1 to entry: See ISO 23616 for further information

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
contaminant
undesirable solid, liquid, gaseous or particulate hazardous substance such as

a) products of combustion (e.g. soot),

b) body fluids,

c) infectious micro-organisms, and

d) chemicals (e.g. asbestos or respirable fibres, flammable, corrosive, carcinogenic, mutagenic, toxic or sensitizing substances)

Note 1 to entry: Same definition with ISO 23616

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
ergonomics
scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance

[SOURCE: ISO 26800:2011, 2.2, modified — The note has been omitted.]

3.10
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.

3.11
maintenance
the act of preserving PPE from loss or *deterioration* (3.7) and includes procedures for inspection, repair and ultimate removal from service, see ISO 23616 for further information

Note 1 to entry: See ISO 23616 for further information

3.12
risk
probability of a specific undesired event (e.g. injury) occurring so that a hazard is realized

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

3.13
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

3.14
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

3.15
use
application of PPE including its limitations

4 General

4.1 Responsibility of procedure development

Fire services develop procedures for selection and use (of SUCAM) for firefighters' PPE.

NOTE 1 ISO 23616 is a companion to this document which describes detail requirement of cleaning, inspection, and repair.

NOTE 2 ISO/TS 16975-1 is also a companion to this document which describes SUCAM of RPD.

NOTE 3 ISO/TR 18690 is an additional companion to this document which describes SUCAM of occupational footwear and other personal protective equipment offering foot and leg protection.

4.2 Ergonomics

Ergonomics for firefighting organizations is a matter of ergonomic approach that firefighters are to consider when conducting activities, and the main purpose is to reduce the burden on humans.

The following items are to be taken into consideration.

The firefighting organization are to evaluate the compatibility and ergonomics of PPE by practical performance tests. In addition, the wearers are to try on and evaluate as necessary. Testing is to be performed by firefighting organizations, manufacturers or other competent organization.

Practical performance tests are conducted in accordance with ISO/TS 20141, Annex B and other applicable standards.

When conducting trial fitting by the wearer, the following items are considered:

— ease and time required for donning and doffing;

— ease of adjustment and adjustable range;

— comfort and weight tolerance;

— compatibility with other PPE to be used at the same time;

— whether or not all the expected tasks can be carried out without problems;

— protection against all postures during the work;

— identification of risks associated with attaching accessories to PPE.

NOTE Consider the location (e.g. in high risk areas) and material (e.g. flame retardant) of the accessories.

4.3 Compatibility

4.3.1 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 1 below shows the interactivity with the various parts of PPE, with in addition underwear.

Table 1 — 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

Table 1 *(continued)*

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

4.3.2 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.

4.3.3 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.

4.3.4 Chemical protection compatibility

The chemical thermal protective properties of the outer layer 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 negatively 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.

5 Selection

5.1 General

On the procurement process of PPE, emergency response organizations are to select appropriate PPE based on risk assessment. For this purpose, emergency response organizations are to identify the scope of activity, area of activity and required level of protection, after that, determine appropriate PPE range based on purpose and performance information of PPE. In addition, incidental information on PPE (compatibility information, maintenance service information on CIR, information on SDGs, etc.) is to be examined to determine the optimal PPE within the selected range.

Therefore, emergency response organizations are to develop procedures and plans, etc. for making selections, and implement the PPE procurement process including feedback information to purchasing process summarized in Clause 6.

5.2 Selection for PPE procurement

5.2.1 Identification of activity scope

Identifying the scope of activity is an important factor in determining PPE. Emergency response organization are to identify the purpose of the activities so that firefighters are adequately protected from the risks they face during their activities and that their activities are not limited by the excessive performance of the PPE. It also leads correct understanding of the unprotected areas, which can ensure safe activities. Therefore, in procurement, it is necessary to assume an appropriate scope of activities and perform the following steps.

The scope of activities is to be specified in consideration of the following conditions. However, these are not limited to

— what kind of activity and act in which working area is to be considered,

— what kind of environment is to be considered (geographical climate, environment at the actual place of activity (high working place, closed space, gassed place, densely built area, etc.)), and

— duration of work (how often) at each place.

The scope of activities are to be established appropriately, meeting the objective.

5.2.2 Risk assessment for procurement

The risk assessment of PPE selection is to include the following points:

— check the working activity scope, area and environment using PPE;

— alternative actions to mitigate risks (e.g. mitigation measures in place prior to applying PPE, consideration of organizational knowledge and other organizations experience, training, and understanding of other management measures);

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

— list of hazards covered with

  — thermal hazards: high temperature and heat flux (e.g. convection, radiation, mixing of heat types), contact heat, work environment, etc.,

  — thermal hazard: low temperature, working environment and/or temperature of the work object (low temperature, cryogenic temperature, etc.),

  — chemicals: phases of chemicals (e.g. gases, liquids, particulates or solids) and which chemicals or mixtures (e.g. acids/bases, organic solvents, gasoline, chlorine, etc.) , pollutants (e.g. asbestos) and combustion residues (e.g. smoke, particulates, etc.),

  — biological: viral, bacterial, and other biological risks,

  — mechanical: wear, cutting, vibration, flying objects, etc.,

  — other hazards (e.g. noise, electrical hazards, falls, flashes, etc.);

— assessment of the risks arising from the use of PPE (frequency and duration of PPE use);

— risk quantification;

— identification of protection level of PPE and the scope of protection;

— identification of whether the attachment of accessories to protective clothing increases the risk.

EXAMPLE When a badge is attached, a convex part is formed on the surface of the protective suit, and molten splashes (droplets) are easily adhered to.

— Feedback from knowledge of accidents, injuries and causes

NOTE Several risk assessment models are available to determine the level of risk associated with a task. Annex A lists literature on risk assessment.

5.2.3 Identification of minimum protection levels that fit to the scope of activities

The level of protection of PPE for the work to be covered is to be determined, including the following:

— identification of body parts that require protection;

— identification of the protective performance required of PPE (for the target body part);

— confirmation of the existence of standards or test methods that stipulate the necessary protective performance.

Other evaluations, depending on the risks involved in the operation, may be necessary to determine the choice, such as the following evaluation items:

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

— evaluation of whether previously used PPE meets standards (any problems or concerns that may have been caused by these, such as comfort, incidents, or inappropriate use));

— identify compatibility issues and requirements for PPE items.

5.2.4 Collect information on PPE that can be procured

Firefighting organizations are to collect information on the acquisition of PPE, including the following:

— conducting market research to determine available products;

— collecting information from suppliers on PPE performance and handling, including compliance information;

— gathering information on PPE use cases used in similar operations;

— check compatibility between all PPEs used simultaneously.

NOTE The following are examples of other matters that may be necessary to gather information on obtaining PPE:

— education for users at the time of procurement (including education provided by third parties);

— post-procurement services;

— quality assurance system up to delivery;

— requirements for washing, sanitizing and decontamination;

— requirements for inspection and repair;

— requirements and costs for replacement of parts;

— delivery times for standard and special sizes;

— size availability;

— supplier inventory;

— availability of supplier's stock;

— inventory needs of users;

— means of delivery to wearer after procurement;

— safe disposal methods for PPE;

— assessment of the impact of additional labelling, such as company name, on performance.

If multiple PPEs are provided by the firefighting organization for different tasks, the firefighting organization may have the PPE wearer select the PPE after providing appropriate training to the PPE wearer. This selection of PPE by the PPE wearer is based on a risk assessment conducted by the fire service organization or a risk assessment by the PPE wearer based on the conditions of use.

5.2.5 Collection of information on compatibility

When PPE is worn in a task, physical or performance compatibility between multiple PPE and the environment in which they are worn may be an issue.

This means that each item of PPE used may not be compatible with each other or may interfere with each other. When collecting information on the compatibility of items of PPE, the following is considered:

— interfaces: physical interference between the items of PPE is not to limit operation or compromise protection in the intended operation;

— performance: all PPE used simultaneously is to have a minimum protective performance for the purpose of protection, and the weakest item of PPE is to provide sufficient level of performance and protection;

— protective performance is reviewed based on the reequipments from a chemical, heat and flame and mechanical perspective;

— conditions of use: not only is the PPE to be operational for the intended operation, but it is to also be usable for the local climatic conditions (humidity, temperature, rain, etc.) as well as the length of time the PPE will be worn and the environment in which the wearer will be using it.

When using PPE containing child devices, the compatibility of the interface between the PPE and external devices is also to be considered.

Fire service organizations are to obtain information on compatibility (e.g. results of practical performance tests as defined in ISO/TS 20141) from their suppliers. Since the information provided by suppliers may not be sufficient for the actual activities and conditions of the activities, fire-fighting organizations are to ensure the compatibility of the above three requirements, including evaluation by trial fitting with the PPE to be used.

5.3 Evaluation by trial fitting for selection

The firefighting organization is to evaluate the compatibility and ergonomics of PPE by practical performance tests. In addition, the wearers are to try on the PPE and evaluate as necessary. Testing is to be performed by firefighting organizations, manufacturers or other competent organization.

Practical performance tests are to be conducted in accordance with ISO/TS 20141, this document and other applicable standards.

When conducting trial fitting by the wearer, the following items are considered:

— ease and time required for donning and doffing;

— ease of adjustment and adjustable range;

— comfort and weight tolerance;

— compatibility with other PPE to be used at the same time;

— whether or not all the expected tasks can be carried out without problems;

— protection against all postures during the work;

— identification of risks associated with attaching accessories to PPE.

NOTE Consider the location (e.g. in high risk areas) and material (e.g. flame retardant) of the accessories.

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), and

— identify compatibility issues and requirements of PPE items.

5.4 Provision of information for purchase by PPE manufacturers

Manufacturers are to provide basic performance information on PPE to fire service organizations as selection considerations for procurement. In addition to this, the compatibility of the equipment, sustainability of the product (e.g. energy reduction, recycling, use of materials with low environmental impact, etc.), simulation results of manikin tests, etc. are to be provided to the fire service organization as additional considerations.

NOTE 1 The standard for PPE compatibility is ISO/TS 20141. There are other standards that are considered parallel to product standards, such as ISO 11999-2, ISO 15384.

NOTE 2 ISO/Guide 64 and ISO/Guide 82 are standards on sustainability of PPE. This document defines the developer of the product standard as the primary user, but provides guidelines that is to be widely applied in the process of manufacturing the product. Therefore, information is provided as reference information for this document.

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).

7 Use

7.1 Start using PPE

7.1.1 Training before use

The firefighting organization is to conduct training to ensure proper use of the equipment, taking into account the equipment to be used, the area of operation, the environment, tactics, etc. The training is to be conducted in a manner that is appropriate to the organization's needs.

Information on individual pieces of equipment is available from the information provided by the manufacturer, but for the use of multiple pieces of equipment at the same time, the fire service organization is to take the initiative to determine the necessary training and provide training to fire fighters with the appropriate information and appropriate implementers.

For CIR of PPE, necessary training is to be conducted to operationalize the implementation method developed based on ISO 23616. For example, this includes cleaning, inspection, and repair of PPE as well as retirement of PPE that is no longer suitable for use.

Furthermore, it is desirable that these trainings are properly and continuously conducted, and that they are repeated and appropriately for long-term users in order to maintain and stimulate their understanding.

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 adjust 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.

7.1.2 Record keeping

The purpose of recording training prior to use is to

— record that the firefighting organization has conducted training not only on the use of individual PPE but also on the risks associated with the combination of PPE to ensure that the selected PPE can be used appropriately, and

— in the event of an accident, this record is intended to provide feedback on the adequacy of the training prior to the start of PPE use.

Record the content of the training (classroom and practical), when it was conducted (initial and periodic), who conducted it and who received it.

7.2 Use in duty

7.2.1 Routine inspection

The contents of the routine inspection in ISO 23616:—, 5.1 are carried out as maintenance in use.

7.2.2 Risk assessment for the scope of activities at the time of mobilization

A risk assessment is conducted based on the activities anticipated at the time of each mobilization.

Itemize the items to be considered when conducting the risk assessment (may be taken from Annex A).

One method of risk assessment is given Annex A.

7.2.3 Identification of protection required during the activity

Based on the results of the risk assessment, the appropriate protection for the activity is to be identified. Confirm in 5.2.4 that the scope of protection and protective performance of the PPE owned is applicable to the expected scope of activities at the time of individual mobilization.

7.2.4 Selection of PPE

Select PPE that meets the identified protective performance. If more than one PPE is possessed, select the appropriate equipment for the activity based on the results of the risk assessment. If there is no choice of PPE, alternative means is to be considered if the PPE to be used is not suitable for the activity based on the results of risk assessment.

7.2.5 Other consideration

If there is no PPE to be selected in 5.2.4, it is desirable not only to consider alternative means but also to provide feedback to the PPE procurement process (5.2.1 Identification of scope (including content) of activities).

7.3 Care and maintenance of PPE after use

The PPE used must be cared for and maintained. Detailed procedures and considerations for care and maintenance are specified in ISO 23616. Detailed procedures for cleaning, inspection, and documentation are based on ISO 23616.

7.4 Record of use

Record of use is maintained by fire organizations.

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,

— storage, and

— problems arising from the use of the PPE.

These records are made readily available to the current user.

7.5 Storage

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

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.

— To be used and are awaiting disposal.

8 Manufacturer information

8.1 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).

8.2 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, and

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

Annex A
(informative)

Risk assessment

A.1 Overview

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.

In the past 10 years, the world has experienced a rise in temperature due to climate change. As a result of this temperature rising, firefighters are facing the danger of heat stress, heat stroke and other fatal heat sicknesses in higher occurrence probability. Strengthening the protection capability against high temperature heat and flame sometimes introduces thicker and heavier PPE(s) that could cause higher probability of heat stress and/or heat stroke. Thus, the emergency response organizations is not to underestimate possibilities of heat stress/stroke.

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 best practice

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.

Reassessment

After assessing the risks, a 'reassessment' is to be conducted to evaluate how the implemented 'Control Measures' have resulted in risk mitigation. The processes used in the reassessment is to be the same as those used in the initial risk assessment. Sometimes, the control measures may induce another risk, which is defined as a 'counter-risk'. For example, a control measure to mitigate a certain risk may require a heavier helmet than the current one, which may increase the likelihood of heat stress and/or heat stroke. Therefore, the reassessment is to include an assessment of the counter-risk. The procedures for assessing counter-risk is also to include L, S, and R assessments. After the reassessment, it may be determined that the 'Control Measures' are not feasible for mitigating the risks.

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**	**Responsible 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											
d Low voltage <1 000											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control measures**	**L**	**S**	**R**	**Outcome from action**	**Responsible officer**	**Timeline**	**Priority**
— 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											
h Pressure											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control measures**	**L**	**S**	**R**	**Outcome from action**	**Responsible officer**	**Timeline**	**Priority**
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											
j Contamination by body fluids											
k Smoke											

Table A.1 *(continued)*

ASSESSMENT OF RISK					REASSESSMENT						
Hazard **Origin and type**	**L**	**S**	**R**	**Control measures**	**L**	**S**	**R**	**Outcome from action**	**Responsible officer**	**Timeline**	**Priority**
l Airborne particles											
9 Other hazards											
a Getting lost											

EXAMPLE

Hazard: A particle is flying and hit to unprotected area of firefighter's helmet.

L: Likelihood: 2 – This incident has not been observed often and the unprotected area of the helmet is less than 5 % of the entire area of the helmet.

S: Severity: 4 – If a particle hit the unprotected area of the helmet, the wearer would be heavily injured or could be fatal.

R: Risk: 8

Control Measure

Prepare a new helmet without unprotected area. The weight of the prepared helmet increases from 0,8 kg to 1,5 kg.

Reassessment of the control measure:

L: Likelihood: 2 – Unchanged

S: Severity: 1 – The new helmet can protect the wearer very well.

R: Risk: 2

Reassessment of the counter-risk

The new heavy helmet induces more heat stress/stroke.

L: Likelihood: 4 – Firefighters often suffered heat stress/stroke with the heavier helmet[1)].

S: Severity: 4 – Heat stress and/or heat stroke may induce serous sickness, even fatal.

R: Risk: 16

Result of reassessment:

Reassessment of the control measure: 2

Reassessment of the counter-risk: 16

2 + 16 = 18.

Feasible study of the risk assessment:

The original risk indexed 8 and the risk of the reassessment is 18. The risk reassessment is greater than the original risk that means the control measure is dangerous solution, or the control measure of a heavier helmet is **NOT FEASIBLE**. Therefore, the emergency response organizations is to find another control measure.

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.

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.

1) "Firefighting helmets: heaviness and thermal burden" by Joo-Yong Lee, Yutaka Tochihara, a presentation in ISO/TC94/SC14 Tokyo Meeting in Feb., 2023.

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 (see 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

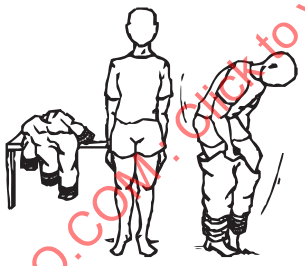
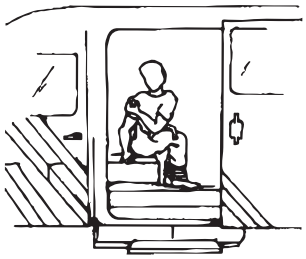
Number Test Item	Test item activity	Goal of test item	Performance in
1	**a. Donning in a workplace environment:** On a signal don the garments, in front of the test wearer on a table, as fast as possible, so that a good fit is achieved with all closures closed. 	The goal of this test item is to measure 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)*

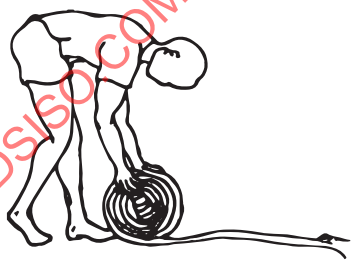
Number Test Item	Test item activity	Goal of test item	Performance in
	On a signal sprinting over 50 m as fast as possible. Time in seconds will be registered. 	The goal of this test item is to measure the load of the clothing on running	s
3	**Hose unrolling:** Test wearers walk and roll the hose in his 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)*

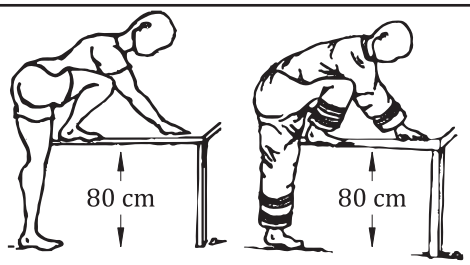
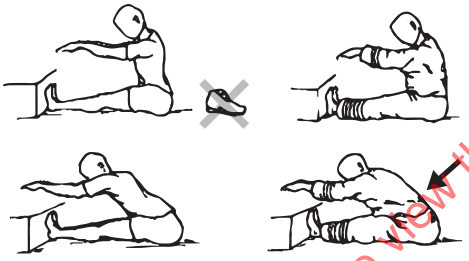
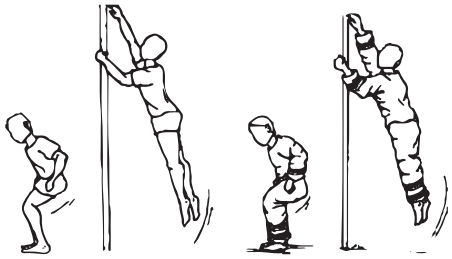
Number Test Item	Test item activity	Goal of test item	Performance in
			
6	**Sit-and-reach:** This test involves sitting on the floor with legs stretched out straight ahead. Shoes are removed. The soles of the feet are placed flat against the box. Both knees are locked and pressed flat to the floor. 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)*

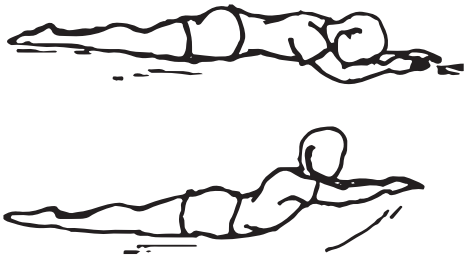
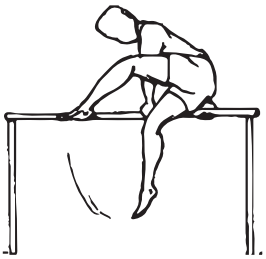
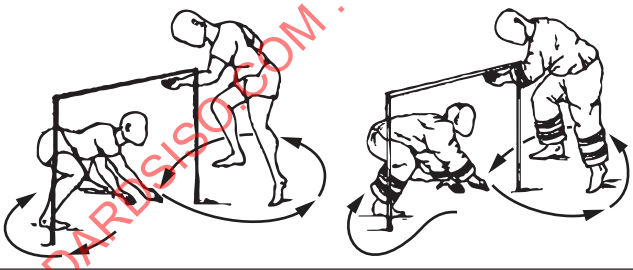
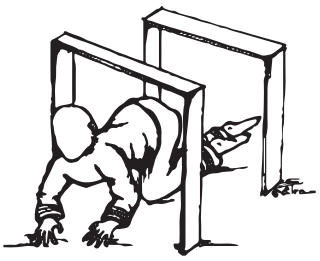
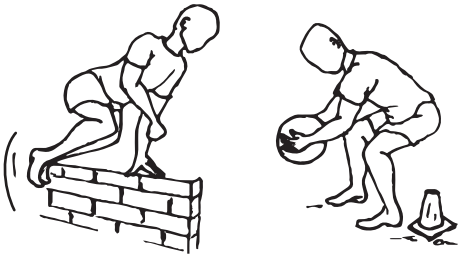
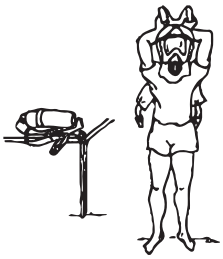
Number Test Item	Test item activity	Goal of test item	Performance in
	Lifting up the torso, lying on the belly with both legs and feet on the ground. The arms are stretched besides the body. Distance between ground and chin will be measured in cm. After practicing several times this test clement will 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
12	**Obstacle course:**		

Table B.1 *(continued)*

Number Test Item	Test item activity	Goal of test item	Performance in
	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. 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)[88], 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[2)].

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[3)]. 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[4)] (see specific parameters in Table B.2).

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)[89], thermal comfort, and humidity sensation will be measured. Besides that test wearers were requested to fill in the relevant questions of the questionnaire.

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

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

4) 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.

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	Flame resistance coverall
	(ISO 15025 Limited Flame spread test and ISO 9150 small molten metal splash)	(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)
Aluminium, Iron and steel works	Molten metal splash and contact heat	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

Table C.1 *(continued)*

Type of activity	Main hazard (test method)	Suggested protective clothing (product standard)
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	(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	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 c. Petro-chemical worker d. Pharmaceutical raw material production	Convective heat, radiant heat and flame engulfment (ISO 15025 Limited Flame spread test, ISO 9151 convective heat test, ISO 6942 radiant heat test, ISO 13506-1 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
Firefighting	Intense heat and flame Flashover in fire-fighting	

Table C.1 *(continued)*

Type of activity	Main hazard (test method)	Suggested protective clothing (product standard)
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 13506-1 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 13506-1 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 kW, 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 subclause will start with the product standards followed by the test methods (see Tables D.1 to D.4)

Table D.1 — Firefighter product specification

<table>
<tr><th>Standard</th><th>Standard title (summarised)</th><th>Required tests</th><th>Highlights of description of limits or pass/fail criteria</th></tr>
<tr><td rowspan="15">EN 469:2020</td><td rowspan="15">Protective clothing for firefighters- Performance requirements for protective clothing for firefighting</td><td rowspan="15">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>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	Level 2
Contact heat	
not required	250 °C for 10 sec ISO 12127-1
Radiant heat ISO 6942 Method B (20 kW/m^2)	
$RHTI_{24}$≥10, $RHTI_{24-12}$≥3;	$RHTI_{24}$≥18, $RHTI_{24-12}$≥4
Convective heat ISO 9151 (80 kW/m^2)	
HTI_{24}≥9, HTI_{24-12}≥3;	HTI_{24}≥13, HTI_{24-12}≥4;

</td></tr>
<tr><td></td></tr>
<tr><td>Water/vapour
— Water penetration- Y1 < 20 kPa or Y2 ≥ 20 kPa with moisture barrier</td></tr>
<tr><td>— 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>Chemical (ISO 6530) 80 % repellency
— Sulfuric Acid , 30 %, Xylene</td></tr>
<tr><td>Mechanical
— Tensile ≥ 450 N fabric, ≥ 225 N structural seams
— Tear strength ≥ 30 N.</td></tr>
<tr><td>Others
— Dimensional change :
Woven ≤ +/- 3 % ,
Non-woven ≤ +/- 5 %
— Visibility
— Thermal manikin (optional) ISO 13506-1:—
— 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. 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.	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 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

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
			Thermal Resistance ISO 11092 < 0,055 m^2K/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 %
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 $RHTI_{24}$ ≥ 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	Limited flame test (ISO 15025) method A Index 3 of SO 14116), Convective Heat

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria		
		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	$HTI_{24} \geq 9,0$		
		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 — extinguishing fires from the outside of the structure	$HTI_{24-12} \geq 3,0$ Radiant heat ISO 6942, 20 kW/m^2 RHTI $_{24} \geq 10$ s RHTI $_{24-12} \geq 3$ 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

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria		
		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 100 mm	
			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
			Contact heat (Tested dry and wet)	ISO 12127-1 55 kPa on knee 14 kPa on shoulder 180 °C for both	ISO 12127-155 kPa on knee 14 kPa on shoulder 260 °C for both
			Dimensional Change (Shrinkage after 5 cleaning cycles)	ISO 5077 ≤ +/- 3 % in both directions	
			Resistance to penetration by liquid chemicals (NaOH, HCI, H2SO4, O-xylene)	ISO 6530 Level C1 No penetration Repellency >80 %,	Level C2 ISO 13944 Proc. C no penetration 1 hr
			Resistance to water penetration	EN 20811 hydro pressure at 0,98 kPa/min < 20 kPa	EN 20811 hydro pressure at 5,9 kPa/min ≥175 kPa
			Water vapour Resistance	ISO 11092 ≤40 m^2 Pa/W ASTM F168, Part C THL ≥200 W/m^2	ISO 11092 ≤30 m^2 Pa/W ASTM F168, Part C THL ≥300 W/m^2
			Surface Wetting (water absorption)	EN 24920 Spray Rating ≥4	
ISO 16073-3	*Ensemble for wildland see for clothing ISO 15384*				
ISO 18639-3:2017	*Fire fighting for technical rescue operation*	Similar to the European but split in to two different activities:	Requirements common to both RTC and USAR		
		RTC – Road Traffic Crash USAR — Urban Search and Rescue	Limited flame test (ISO 15025) method A Index 3 of ISO 14116), Tensile strength for fabric and seam ≥450 N, non-woven ≥360 N Tear ≥ 25 N Dimensional change: respectively for woven and non-woven: ≤3 % and ≤5 % shrinkage		
			Abrasion >20 000 cycles using ISO 12947-2 (Martindale)		

Table D.1 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
			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
			Contact Heat ISO 12127-1 at 100 °C, performance levels are: ≥ 15 s

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 is to 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 % 260 °C shrink >10 %	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, 12 kPa, ≥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 is to 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>
</table>

Table D.2 *(continued)*

<table>
<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><th>Performance level</th><th>Heat transfer t_{24}
s</th></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>
<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</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)</td></tr>
</table>

Table D.2 *(continued)*

			— (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 ≥ 14 s, tt ≥ 14 s — (tt ≥ 6 s, tt ≥ 10 s, tt ≥ 14 s)
			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 Cut (ISO 13997) Level B, C, D (Level A or ≥4 N) Tear (EN 388) Level 2, ≥40 N or 3 (Level 2 or 3) Puncture (EN 388) ≥60 N ≥90 N ≥120 N (Level 2 or 3) Water penetration (ISO 811) 7 kPa No drops all levels (level 1 & 2 no drops, not for level 3) Chemical (ISO 13994) — no penetration for 1 hr for level 3
ISO 16073-4:2019	*Wildland firefighting personal protective equipment —Gloves*		Limited Flamespread: Index 3 Convective ISO 9151 (40 kW): HTI_{24} ≥ 9 , HTI_{24-12} ≥3 Radiant ISO 6942, Met. B : $RHTI_{24}$ ≥11, $RHTI_{24-12}$ ≥ 4 Contact ISO 12127-1 at 250 °C: tt≥ 6 s Thread resistance : 260 °C
			Heat resistance using ISO 17493 at 180 °C no shrinkage >5 % Abrasion (EN 388: level 3 Cut EN 388 (ISO 13997): A Tear (EN 388): level 2 (>25 N) Puncture (EN 388) : level 2 (>60 N)

Table D.2 *(continued)*

ISO 18639-4:2018	*PPE ensembles for firefighters undertaking specialist rescue activities — Part 4: Glove*	This standard provides the principles that govern the development of incident type and/or hazard specific test methods and minimum performance requirements for protective gloves for firefighters while engaged in specialist rescue activities, e.g. 6.2 Road Traffic Crash, (RTC) and 6.3 Urban Search & Rescue, (USAR).	Limited Flamespread Index 3 (only RTC) Convective ISO 9151 (40 kW) HTI_{24} ≥ 9, HTI24-12≥ 3
			Radiant ISO 6942, Met. B $RHTI_{24}$ ≥ 7, only for RTC Contact ISO 12127-1 at 250 °C: : tt≥ 6 s (only RTC) Heat resistance using ISO 17493 at 180 °C no shrinkage >5 % (only RTC) Abrasion (EN 388) : level 2 (RTC) or 3(USAR) Cut (ISO 13997) : ≥13 N , none for RTC Tear (EN 388): Level 2, none for RTC
			Chemical (ISO 13994): no penetration for 1 hr for RTC only

Table D.3 — Industrial/professional product specifications

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
ISO 14116:2015	*Limited flame spread materials and material assemblies*	This standard specifies the performance requirements for limited flame spread properties of materials and material assemblies used in protective clothing. A classification system is given for materials and material assemblies tested according to ISO 15025 "Protective clothing. Protection against flame — Test method for limited flame spread", before and after a standard cleaning procedure	To pass the test, depending on the Index 1,2,3 (min. to max. classification) they shall meet a before and after washing: — No flaming to top of specimen (Index 1-3)
			— No flaming or molten debris (Index 1-3) — Afterglow ≤ 2 s (Index1-3) — No hole formation (Index 2 or 3) — Afterflame ≤ 2 s (Index 3) A number of additional requirements design and physical properties of fabric and garment
		Letter A1 denotes materials passing the surface test (Method A) and A2 denotes materials passing the bottom edge test (Method B).	

Table D.3 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
ISO 11611:2015 (Under revision)	*Protective clothing for use in welding and allied processes*	This standard specifies test methods and general performance requirements for protective clothing for operators engaged in welding and allied processes with comparable risks. This type of protective clothing is intended to protect the wearer against small splashes of molten metal, short contact time with flame, and ultra violet radiation, and to be worn continuously for up to 8 h at ambient temperature	Garments are required to pass certain design and physical requirements, including electrical resistance. Garments / materials will be certified to the following: A (Limited Flame Spread) including Index 3 of ISO 14116 Impact Splatter (ISO 9150) with increasing the temperature by 40 K without ignition: — Class 1: at least 15 drops of molten metal — Class 2: at least 25 drops of molten metal Heat Transfer (Radiation ISO 6942) Using Method B, at a heat flux density of 20 kW/m^2,
			— Class 1: RHTI 24 ≥ 7 Class 2: RHTI 24 ≥ 16
ISO 11612 :2015	*Protective clothing — Clothing to protect against heat and flame — Minimum performance requirements*	This standard is applicable to protective clothing for workers exposed to heat. The clothing consists of garments made from material to protect specific parts of the body. Hoods and gaiters are included but all other types of protection for the head, hands and feet are excluded.	Garments are required to pass certain design and physical requirements Garments / materials will be certified to the following Code Letters — A (mandatory Index 3 of ISO 14116), — at least one of B, C, D or F): B (Convective heat ISO 9151) The transfer of heat through the material(s) by measuring the time for temperature to rise to level of pain (HTI 12) and 2nd degree burns
		This standard specifies the performance requirements and methods of test for the protective clothing materials and gives design recommendations for the clothing where necessary.	(HTI 24). The performance levels are: B1: 4 s ≤ HTI 24 < 10 s B2: 10 s ≤ HTI 24 < 20 s B3: HTI 24 ≥ 20 s C (Radiant heat)

Table D.3 *(continued)*

Standard	Standard title (summarised)	Required tests	Highlights of description of limits or pass/fail criteria
		Protective clothing complying with this standard is intended to protect workers against brief contact with flame and against at least one type of heat, The heat may be in the form of convective heat, radiant heat, large molten metal splashes or combination of these heat hazards.	The transfer of heat through the air onto and through the material(s). The test measures the time for temperature to rise to level of pain (RHTI12) and 2nd degree burns (RHTI24). The performance levels are: C1: 7 s ≤ RHTI 24 < 20 s C2: 20 s ≤ RHTI 24 < 50 s C3: 50 s ≤ RHTI 24 < 95 s
			C4: RHTI 24 ≥ 95 s D (Molten Aluminium Splash ISO 9185) Simulates Aluminium splash in foundries, but also bronze or molten mineral (Code Letter E is a similar test that covers iron, copper, etc.). The performance levels are: 100 g≤ D1 < 200 g
			200 g≤ D2 < 350 g D3 ≥350 g F (Contact Heat ISO 12127-1) Simulates accidental contact with hot surfaces. When tested at 250 °C, The performance levels are:
			5 s ≤ F1 < 10 s 10 ≤ F2 < 15 F3 ≥ 15 s
IEC 61482-2:2018	*Live working – protective clothing against the thermal hazards of an electric arc*	Garments shall be tested to either IEC/EN 61482-1-1 method B (open arc manikin test) or to IEC/EN 61482-1-2 (box arc garment test). They shall be tested to the same Arc rating or class as the front material or assembling. Only upper body garments (shirts, jackets, coverall torso) are tested.	Garments are required to pass certain design and physical requirements