The Organisation for Emergency Services Management

THE JOIFF STANDARD

HANDBOOK

ON

PERSONAL PROTECTIVE EQUIPMENT (PPE)

to protect against

Heat and Flame

JOIFF In Partnership with

FULCRUM CONSULTANTS

JOIFF Handbook on Personal Protective Equipment (PPE) to protect against Heat and Flame

INDEX

DETAIL **PAGE**

EDITORS NOTE:
The attention of Readers is drawn to Appendix 1 which provides a number of suggested definitions to assist the Reader in their understanding of issues raised throughout this Handbook.

Produced by Fulcrum Consultants for JOIFF.

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INTRODUCTION

JOIFF Handbook

This Handbook has been drawn up to provide JOIFF Members with information and background detail to enable them to make informed decisions as to the most suitable type of PPE to provide for their personnel. Information is included to give Purchasers and Users of PPE a greater understanding of the reasons for using PPE, some of the issues relating to PPE, in particular to PPE to protect against heat and flame, and to highlight the importance of selecting the correct type of PPE based on the results of a risk assessment.

Role of PPE

The role of Personal Protective Equipment (PPE) is to allow personnel to work in environments where without the protection afforded by the PPE, they normally could not work. PPE also has the role of safeguarding personnel from accidental or unexpected exposure to hazards in emergency conditions. Heat protective PPE is the type of PPE used in situations where personnel are likely to be exposed to heat and/or flame. This type of PPE, which includes PPE for firefighting, should not burn, melt or disintegrate on exposure to flame for its lifetime and it should provide the required level of thermal protection consistent with the potential risk to which the wearer might be exposed.

PPE for firefighters has a dual function in that it must not only allow the firefighter to carry out the required work to deal with and mitigate an incident, but in situations where the firefighter is unable to achieve the objectives of attendance and to bring the incident under control, the PPE must also provide sufficient protection to allow the firefighter to escape without receiving unacceptable injury.

Most PPE, particularly PPE to protect against mortal danger, has failure levels far above the limit of exposures of human beings. On incident sites where PPE is being used, particularly sites where there are high level risks, it is important to ensure that proper and suitable safety procedures are in place, that there is effective management, command and control of each incident, and that as it is possible that medical attention will be needed it therefore should be readily available.

Responsibility to provide and use PPE

Under European Law, employers who fail to provide suitable PPE commit a criminal offence. In addition, if as a result of failure to provide suitable PPE, an employee suffers foreseeable injury and/or disease, the employer will be liable to the employee for damages for negligence.

Conversely if after instructions and necessary training, an employee fails or refuses to wear and maintain suitable PPE s/he too can be prosecuted and/or dismissed and if s/he is injured or suffers disease in consequence will probably lose all or certainly part of the damages that would be paid.

JOIFF believes that best Health and Safety practice should be followed because it is the correct thing to do not because the law says you should do it.

Disclaimer:

The information in this Handbook is intended to give guidance only. Its contents are not exhaustive nor are they intended to support the views or claims of any persons or Organisations. Neither JOIFF Ltd. nor its Secretariat Fulcrum Consultants assumes any responsibility for consequences resulting from the use of any information in this Handbook.

SECTION 1:

Introductory Comments:

In this, the first edition of the JOIFF Handbook on PPE, Section 1 covering Selection, Use, Care and Maintenance of PPE, deals primarily with protective clothing and gloves which only form part of a PPE ensemble. Subject to a risk assessment, for some exposures, other items of PPE may be required for head protection, foot protection and respiratory protection. Much of the information for protective clothing and gloves given in Section 1 is equally relevant to other items of PPE. If JOIFF identifies the need, the detail in this Handbook will be expanded in future editions to cover other types of PPE.

For any item of PPE, full information on all aspects should be sought from the Manufacturer/Supplier of the items of PPE concerned.

1.1 GUIDELINES ON SELECTION OF PPE:

The person who makes the Purchasing Decision for PPE is the person who sets the Organisation's parameters for protection of the persons who have to wear it. Therefore the decision-maker should have knowledge of the risks against which the PPE is supposed to protect and it is advisable that those who make the purchasing decision should receive training prior to purchasing, in order to ensure that an informed decision on purchase is reached.

Before selecting PPE, a Risk Assessment of the workplace should be carried out to

- identify the hazards,
- assess the risk and
- eliminate, remove or reduce the hazard.

Where a hazard cannot be eliminated, removed or reduced to an acceptable level, it is necessary to introduce controls to ensure the safety of personnel. If the safety of personnel still cannot be sufficiently ensured having done all that, only then should it be necessary to introduce PPE.

The employer has the ultimate responsibility for providing PPE that is fit for purpose and protects personnel whilst allowing them to carry out the work required in their workplace without unduly increasing the risk by the use of such PPE. The employer must balance issues such as safety, suitability, cost, goods and services expected from the supplier of the PPE and all other relevant factors before deciding on PPE that is suitable for their purpose whilst never forgetting that the decision being taken is to provide adequate and suitable protection for their employees whilst they are carrying out duties in their workplace.

Specifically with regard to PPE for firefighters, which falls into the category of PPE to protect against mortal danger, it is very important that the risk assessment ensures that selected PPE matches the tactics being used. This is particularly important when there is a change in style or design of PPE as happens for example when new PPE is purchased. Firefighters may believe that the new PPE will perform in the same manner as the PPE being replaced, which may not be the case taking into account the on-going developments in performance levels of materials and of techniques of design and construction of PPE in the market today. The PPE must always match the type of tactics being used by the firefighter and the command and control procedures in place.

It is vitally important that if an organisation wishes to make changes in their general tactics e.g. adopting a more aggressive firefighting strategy, they should always determine the changes in risk of injury and its impact on the protection provided by the organisation's PPE. This should be done by revisiting the organisation's risk assessment and changing procedures of training, tactics, command and control as appropriate.

Sample questions for the Selection Process

In the tables on the following pages of this Section are some questions which the purchaser might consider before making a decision to purchase PPE. Where indicated in the Tables, explanatory notes are included on pages following the Tables and these notes should be read in conjunction with the questions to gain a full understanding of the issues raised.

The questions in the tables do not cover everything that should be asked. Other questions based on local conditions and requirements should be added by the purchaser. Purchasers should not be reluctant to ask suppliers any questions that they wish in arriving at their final decision as to which PPE to buy. The supplier's ability to answer these questions may be influential in the final purchasing decision.

There are no universally correct or incorrect answers to the questions set out in the following pages. The relevant PASS/FAIL criteria for any answers given must be established by the purchaser as they should have a very big influence on the purchasing decision.

QUESTION	YES	NO
TABLE 1.1 RISK ASSESSMENT		
1.1.1 Have you identified the activities to be undertaken by the person(s) wearing the PPE, the likely duration of each activity and the working environments in which they will be exposed ?		
1.1.2 Have you identified a list of the hazards present ?		
1.1.3 Have you quantified the risks that would result from exposure to the hazards?		
1.1.4 Have you considered the protection provided by other control measures before the application of PPE ?		
1.1.4 Have you determined the level and extent of protection required from the PPE ?		
1.1.6 Have you matched potential exposures of persons who will wear the PPE with your Organisation's job practices, tactics, working and safety procedures ?		
1.1.7 Have you considered the frequency of use of the PPE to be chosen ?		
1.1.7 Have you considered the number of sets of PPE required by each person ? ***NOTE 1***		

TABLE 1.2 THE LEVEL OF PROTECTION REQUIRED		
1.2.1 Have you determined which parts of the body require protection ?		
1.2.2 Have you determined the level(s) of protection required for the relevant parts of the body ?		
1.2.3 Have you selected the type of PPE that offers the optimum combination of features and performance against the identified hazards requiring protection ?		

<table>
<tr><td colspan="2">TABLE 1.3 INFORMATION ON AVAILABLE PPE</td><td></td><td></td></tr>
<tr><td colspan="2">1.3.1 Have you carried out research to determine the range of products available ?</td><td></td><td></td></tr>
<tr><td rowspan="4">1.3.2 Have you established that the PPE that you are looking at is</td><td>1.3.2.1 suitable for its purpose ?</td><td></td><td></td></tr>
<tr><td>1.3.2.2 appropriate to the risk involved ?</td><td></td><td></td></tr>
<tr><td>1.3.2.3 capable of correct fitting on the persons who will wear it ?</td><td></td><td></td></tr>
<tr><td>1.3.2.4 effective in preventing or adequately controlling the risk without increasing overall risk ?</td><td></td><td></td></tr>
<tr><td colspan="2">1.3.3 Have you gathered information from comparable organisations using similar items of PPE for similar tasks ?</td><td></td><td></td></tr>
</table>

TABLE 1.4 STANDARDS AND CERTIFICATION		
1.4.1 Are there any legal or procedural requirements in your Country and / or Organisation that PPE must be certified to any particular standards ?		
1.4.2 Have you established the particular standards to which the PPE should be tested ?		
1.4.3 Have you matched performance properties in standards with the types of hazard identified in your own Risk Assessment ?		
1.4.4 Have you decided which certification, if any, will be acceptable to you ?		
1.4.5 Have you investigated which Test Houses are authorised and capable of testing to the standards that you require ?		
1.4.6 Have potential suppliers provided you with details from a recognised Test House on compliance with and certification to relevant standards of the products they propose to supply ?		

<table>
<tr><td colspan="2">TABLE 1.5 SIZING</td><td></td><td></td></tr>
<tr><td rowspan="3">1.5.1 Have you established</td><td>1.5.1.1 what sizes are available ?</td><td></td><td></td></tr>
<tr><td>1.5.1.2 what are regarded by the potential supplier as standard sizes and what are the costs of non standard sizes ?</td><td></td><td></td></tr>
<tr><td>1.5.1.3 what is the delivery time for standard and non-standard sizes ?</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="2">QUESTION</th><th>YES</th><th>NO</th></tr>
<tr><td colspan="2">TABLE 1.6 CONSPICUITY / IDENTIFICATION</td><td></td><td></td></tr>
<tr><td colspan="2">1.6.1 Does the PPE you will purchase require any special features for high visibility and/or identification e.g. reflective material, badging, rank markings etc. ?</td><td></td><td></td></tr>
<tr><td colspan="2">1.6.2 Are there any legal requirements on the type / amount of these features ? NOTE 2</td><td></td><td></td></tr>
<tr><td colspan="2">1.6.3 Can the proposed supplier of the PPE provide the type and level of conspicuity / identification required and have you established the cost ? NOTE 3</td><td></td><td></td></tr>
<tr><td rowspan="2">1.6.4 Has the proposed supplier of these items produced suitable certification to demonstrate</td><td>1.6.4.1 that the overall protective performance of the PPE will not be affected by the addition of such items ? NOTE 4</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>1.6.4.2 that what is proposed meets local regulatory requirements ?</td></tr>
</table>

<table>
<tr><th colspan="2">TABLE 1.7 PRACTICAL PERFORMANCE TESTS (Wearer Trials) NOTE 5</th><th></th><th></th></tr>
<tr><td rowspan="7">1.7.1 For the PPE being trialled, have you considered the</td><td>1.7.1.1 ease and speed of putting on (donning) and taking off (doffing) ?</td><td></td><td></td></tr>
<tr><td>1.7.1.2 ease and extent of adjustability ?</td><td></td><td></td></tr>
<tr><td>1.7.1.3 comfort / weight of each item of PPE in the ensemble ?</td><td></td><td></td></tr>
<tr><td>1.7.1.4 compatibility with each other of each of the items of PPE that you are considering purchasing?</td><td></td><td></td></tr>
<tr><td>1.7.1.5 compatibility of all other items of PPE that will form the PPE ensemble ?</td><td></td><td></td></tr>
<tr><td>1.7.1.6 ability to undertake all tasks expected without hindrance or difficulty ?</td><td></td><td></td></tr>
<tr><td>1.7.1.7 preservation of the protection in all working positions ?</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="2">TABLE 1.8 CARE AND MAINTENANCE OF THE PPE: NOTE 6</th><th></th><th></th></tr>
<tr><td colspan="2">1.8.1 Have you been made aware of requirements for cleaning, decontamination and disinfection of the PPE to be purchased ?</td><td></td><td></td></tr>
<tr><td colspan="2">1.8.2 Have you been made aware of the inspection and maintenance requirements for the PPE to be purchased ?</td><td></td><td></td></tr>
<tr><td colspan="2">1.8.3 Have you been made aware of the replacement requirements and costs for components for the PPE to be purchased ?</td><td></td><td></td></tr>
<tr><td rowspan="6">1.8.4 With regard to the expected lifetime of the PPE to be purchased, (NOTE 7) have you been made aware of</td><td>1.8.4.1 the parameters whereby the PPE continues to be safe to use ?</td><td></td><td></td></tr>
<tr><td>1.8.4.2 the expected lifetime period claimed by the potential supplier ?</td><td></td><td></td></tr>
<tr><td>1.8.4.3 how the potential supplier has arrived at the time given for the expected lifetime period ?</td><td></td><td></td></tr>
<tr><td>1.8.4.4 any testing programme that the supplier operates either by themselves or in conjunction with a testing laboratory, to help determine expected lifetime period of the PPE they supply ?</td><td></td><td></td></tr>
<tr><td>1.8.4.5 any obligations that you will have if the claimed expected lifetime period is to be achieved ?</td><td></td><td></td></tr>
<tr><td>1.8.4.6 what guarantees the potential supplier is giving if, having followed all obligations, the PPE does not last for the stated expected lifetime period ?</td><td></td><td></td></tr>
<tr><td colspan="2">1.8.5 Have you been made aware of the requirements for disposal of the PPE when it has outlived its use ?</td><td></td><td></td></tr>
</table>

QUESTION		YES	NO
TABLE 1.9 DELIVERY / GUARANTEE CONSIDERATIONS			
1.9.1 Are there any requirements from the proposed supplier for minimum quantities ? ***NOTE 8***			
1.9.2 Have you established	1.9.2.1 the proposed supplier's delivery time for the complete order ?		
	1.9.2.2 the proposed supplier's delivery time for parts and replacements when the items of PPE have been delivered and are in use ?		
	1.9.2.3 what support the proposed supplier will provide if the agreed delivery times for part or all of the order are not met ?		
	1.9.2.4 what is the time limit after which you can cancel the order without penalty if promised delivery times are not met ? ***NOTE 9***		
1.9.3 Are there any guarantees for replacement if there is a failure of part / all of the items of PPE supplied ?			
1.9.4 What costs do any guarantees offered cover ? ***NOTE 10***			
1.9.5 Is there a fixed time period after which the supplier will not supply parts and replacements	1.9.5.1 that are under guarantee ?		
	1.9.5.2 after any guarantee expires ?		

TABLE 1.10 THE COMPANY YOU ARE PROPOSING TO DEAL WITH ***NOTE 11***		
1.10.1 Is the Company legally established and registered under the Laws of the Country in which it is operating ?		
1.10.2 Has it the financial structure to operate its business and to fulfil its statutory requirements such as paying its taxes, paying its employees, its suppliers etc. ?		
1.10.3 Does it carry an adequate level of Insurance cover e.g. product liability, public liability and employers liability ?		
1.10.4 Has it the technical support needed to carry out its activities, support that is based on scientific fact and modern practice ?		
1.10.5 Are the products it sells approved by recognised Test Houses, does it offer guarantees and can proof of these approvals and guarantees be provided ?		
1.10.6 Is it approved to the relevant ISO quality standard or equivalent ?		
1.10.7 Can it provide you and those who will use the PPE with adequate and relevant training in its use, storage, care, maintenance and eventual disposal ?		
1.10.8 Have you seen a copy of the User Guide that is provided with the PPE ?		
1.10.9 Is the Sales person you are dealing with competent to role and knowledgeable about the goods and services being offered ?		
1.10.10 Are you comfortable in your dealings with this Company ?		

Notes relating to the above Tables.

NOTE 1. *1.1.7 Have you considered the number of sets of PPE required by each person ?*
Good practice requires that each person is issued with their own set of PPE. Subject to the type of PPE under consideration, a guide to the minimum number of sets per person is 3, the set that is being worn, the set that is being cleaned and a stand-by set in the event of an accident to the set being worn.

NOTE 2. *1.6.2 Are there any legal requirements on the type / amount of these features ?*
Many Countries have specific legislation and relevant Regulatory Agencies may have specific requirements for defined levels of conspicuity when used on roads, railways, aerodromes etc.

NOTE 3. *1.6.3 Can the proposed supplier of the PPE provide the type………*
Some suppliers may not supply PPE with the required items for conspicuity affixed and they may need to affixed by another Company. If the latter, you should establish the logistical and cost implications that this will have for you.

NOTE 4. *1.6.4 Will the additional items affect the performance characteristics…….*
No matter who affixes these items, you should seek from the supplier acceptable certification, preferably from a recognised Test House, that the overall protective performance of the PPE will not be affected by the addition of such items.

NOTE 5. *TABLE 1.7 PRACTICAL PERFORMANCE TESTS (Wearer Trials):*
These could be valuable in assessing the compatibility and ergonomic practicality of the complete PPE ensemble.

NOTE 6. *TABLE 1.8 CARE AND MAINTENANCE OF THE PPE:*
Questions in this Table need to be asked even if you are contracting out the care and maintenance of the PPE being purchased.

NOTE 7. *1.8.4 With regard to the expected lifetime of the PPE to be purchased, ……….*
What is generally regarded as the expected “lifetime” or “lifespan” of an item of PPE is the length of time from when the item is first put into service to the point where the user decides to withdraw the item from service based on whatever criteria that causes the decision to be made. The only way to accurately establish the “lifetime” of an item of PPE is to use that item for its lifetime the length of which will depend on the ageing process of the item. The ageing process is the changing of the product performance over time subject to exposures caused by a combination of several factors such as:

- exposures during use to, for example:
    - wear and tear,
    - visible and/or ultra-violet radiation,
    - high or low temperatures or to changing temperatures,
    - chemicals,
    - humidity,
    - biological agents such as bacteria, fungi, insects etc.,
    - mechanical action such as abrasion, flexing, pressure and strain,
    - contaminants such as dirt, oil, splashes of molten metal, etc.
- exposures during cleaning and maintenance and
- exposures during the processes of decontamination and disinfection.

By the nature of the use of PPE, exposures during the actual lifetime of an item will differ in real life, probably substantially, from User to User and from item to item. It is therefore impossible for a manufacturer or a test house to accurately predict the lifetime of items of PPE other than through such real life exposures, because they can never have sufficient control of the end-use situation to be able to make such a statement, particularly if levels of adequate protection cannot be determined solely by a visual inspection of the item of PPE in question. Manufacturers are therefore understandably reluctant to make such statements.

Indications of expected lifetime can be perceived as a basic safety requirement of an item of PPE and could also give some indication of value for money. These indication may be provided by for example a list of parameters drawn up by the manufacturer and/or a test house that the user/ purchaser should assess during the use of the PPE so as to be as sure as possible that it is withdrawn from use before its protective performance falls below the initial certification levels and/or claimed levels of protective performance.

However it is important that users/purchasers understand that any information given under this question can only be estimated, but even an educated estimate can be a useful indication as to the perception that a manufacturer has about the quality and expected durability of the items of PPE that s/he manufactures and wishes to supply to you.

NOTE 8. *1.9.1 Are there any requirements from the Supplier for minimum quantities ?*
Some suppliers require a commitment to minimum numbers of items before they will accept an order. You should establish at the outset whether or not the supplier is prepared to supply the quantities of both initial product and expected replacements that you require. If not, you should seriously question the value of continuing negotiations with this supplier.

NOTE 9. *1.9.3.2 what is the time limit after which you can cancel …….*
If you are expecting delivery of PPE that does not arrive within the time limit promised, in order not to compromise safety of your personnel, it is likely that you will incur costs in providing alternative PPE until the items ordered arrive. Will the proposed supplier contribute to this cost in the event of non-delivery within the time limit promised ?

The period during which delivery is promised should not be open ended and at a certain point you should be in a position to seek other suppliers without penalty to your Organisation and possibly also to seek compensation from the supplier for failure to meet his/her promised/committed obligations.

NOTE 10. *1.9.5 What costs do any guarantees offered cover ?*
Some guarantees may just cover the cost of the item to be replaced in which case the purchaser must pay for delivery and any work needed to fix the item in place.

NOTE 11. *TABLE 1.10 THE COMPANY YOU ARE PROPOSING TO DEAL WITH:*
When purchasing complete PPE ensembles it is likely that you will be dealing with a number of Companies each of which will supply different items that will make up the ensemble. The type of questions listed in this Table should be applied to each of the Companies with which you are dealing.

SECTION 1:

1.2 GUIDELINES ON USE of PPE:

After the selection of the PPE, a number of stages should be followed when introducing it into service to ensure its correct use.

Information from the Manufacturer
The manufacturer should provide detailed information with each item of PPE which should include specific instructions for storage, use, cleaning, maintenance, servicing and disinfection. The information should also provide guidance on what to look for when undertaking a visual inspection and may also include a note on the maximum number of maintenance/cleaning cycles after which it is recommended that withdrawal from use should be undertaken if withdrawal has not already occurred because of visual inspection outcomes. The information should also include detail on performance as recorded during technical tests, the significance of any markings and may include recommendations on suitable PPE accessories.

Record keeping
The only certain way to establish the protective status of materials from which items of PPE to protect against heat/flame are manufactured, is by means of fire testing which is always damaging and potentially totally destructive to the item being tested. This means that the item of PPE being tested cannot be put back into service and results from the testing will only give an indication of the protective condition of similar items of PPE in service that have been submitted to similar wear and exposures. In the overall management of PPE it is therefore essential to build a full life history for each item from manufacture to disposal so that a competent person can evaluate the on-going protective status of items of PPE without setting up a programme of laboratory testing. The availability of such records will also be an important part of any investigation of an incident involving items of PPE. As they are built up, these records will provide important information to any Organisation, so they should be held in a secure location.

Organisations should assign overall responsibility for record keeping to a person (persons) who has (have) been trained and can demonstrate competence in the use, care and maintenance of the PPE concerned, although it is likely that others e.g. the user, the person maintaining the items of PPE etc. will also have input into the records. Records should be checked by responsible management on a regular basis to ensure compliance with procedures.

It is important that the record keeping shows that the manufacturer's instructions are being followed and that if there are any deviations, the rationale for such deviation is recorded.

Record keeping should include at least the following:

- Selection process records – i.e. risk assessment outcome and its link to final choice.
- Specification of the PPE including the type of PPE obtained, when, where from, specification met, copy of any test certification, receipt of all necessary user information etc.
- The service history of the PPE which should include information such as
    - initial and subsequent storage conditions/location, date of issue to individuals, evidence of correct sizing choice.
    - Training in donning/doffing, using correctly in relation to hazards/tasks.
    - Record of manufacturer's user information having been issued and read by individual users.

- Use periods/conditions/locations/exposures to hazards.
- Records of cleaning and maintenance.

- Any problems arising from the use of the PPE.
- Recommendations as to performance of the PPE e.g. must/should/could be better in respect of some aspect of protection, design, fit, weight, durability etc.
- Withdrawal from use records – when/why/number of cleansing/maintenance cycles plus any incidents/accidents linked to extent/nature/location of use etc.

By implementing this type of record-keeping-based inspection programmes it is possible to build up a full life history of each item of PPE from receipt into storage or into immediate use through to withdrawal and disposal including the means of disposal.

To be fully effective, a recording/tracking system must be put in place from the time the item of PPE is new, but implementing such a system for PPE that is already in use without a recording/tracking system, will provide a partial history of the item from which something can be learnt and this is better than having no records.

Training
All those who purchase the PPE and those who use and maintain it, should be trained in its correct use and maintenance prior to it being introduced into active service. Such training should include at least the following:

- Information concerning limitations and capabilities of the PPE.
- What the PPE will protect from.
- What the PPE will not protect from.
- How to use/wear the PPE.
- What the effects are (if any) of long term use.
- The importance of complying with the manufacturers/suppliers instructions.
- How to store the PPE when not in use.
- Information concerning arrangements for cleaning, decontamination and disinfection..
- How to determine when the PPE is no longer fit for purpose.
- How to obtain replacements.

Routine examination
Each individual item of PPE should be examined on a regular basis during its lifetime. Routine examinations should include checks for at least the following:

- Soiling.
- Contamination from hazardous materials or biological agents.
  <u>NOTE:</u> Contamination may only be visually evident after a significant exposure, but as PPE can become contaminated during any exposure to hazardous materials including biological agents, examination is recommended after any exposure or suspected exposure.
- Damage (e.g. rips, tears, cuts, missing hardware and closing systems etc.).
- Damaged or missing accessories (reflective tapes, labelling etc.).
- Seams and/or damages at joins.
- Ongoing evaluation of system fit and interfaces/overlaps.

SECTION 1:

1.3 GUIDELINES ON CARE of PPE:

The information provided by the manufacturer for each item of PPE should include care instructions. Based on this information, the employer should determine the arrangements for care which should include as applicable procedures for cleaning, decontamination, disinfection and storage.

Cleaning
Good cleaning practice will ensure amongst other things, that:

- There is limited deterioration to any components of the PPE.
- Each item of PPE is visibly clean.
- Each item of PPE is hygienically clean.
- There are no unpleasant odours present.
- There are no residues of the cleaning products.
- If applicable, re-application of finishes/treatments is done according to the instructions of the supplier.

NOTE: When the performance/ operational life of the PPE is known to be significantly impaired by cleaning, this should be mentioned in the manufacturer's instructions.

Clear procedures should be established to set out amongst other things:

- The cleaning methods to be used.
- Who will carry out the cleaning.
- When items should be cleaned.
- Where items should be cleaned.
- Whether or not re-application of finishes/treatments is necessary and if so at what intervals and how it should be carried out.
  NOTE: Further information on finishes is included in Section 2.4 of this Handbook.
- Any recommendation from the Manufacturer on maximum number of washes.
  NOTE: The recording system referred to in Section 1.2 should include a tracking system which records the history of washing of the item(s) of PPE.

Washing Protective Garments
Garments to protect against heat and flame can be single or multilayered and many will have attachments such as zips, reflective tape, badging etc. Whilst the material from which a single layer protective garment or the outer layer of a multi-layer protective garment is made can normally be washed at high temperatures, inner layers and items affixed to the garments may not be able to withstand these high temperatures. So the correct decision on the best way to clean garments will usually be dictated by the item that is the most susceptible to damage by such temperatures and procedures.

The outer material of many of the garments used to protect against heat and flame is made from an aramid fibre. Aramid itself is not sensitive to boiling water, but agitation which takes place at the boil, especially over extended periods of time, can cause fabric shrinkage. This is because strong agitation causes the yarns and the fibres to move within the fabric and because the fibres have a relatively rough surface, the surfaces can interlock and such shrinkage can take place.

Taking all this into account, such garments to protect against heat and flame should be washed at temperatures no higher than 40°C to 60°C. Using higher temperatures may not bring any benefit and may simply contribute to overall energy consumption.

The washing cycle could be a main wash, spin and two rinses which will take in the region of 55 minutes. It is important to include these rinse cycles so that residual soap and detergents are adequately removed. Many kinds of detergent may be flammable and if left in the material as a concentrated deposit will support combustion.

In washing such clothing, it is usually recommended that a liquid detergent with a near-neutral pH, certainly not exceeding pH 9.0 be used. Liquids can be more easily handled than powdered soaps. If localised dirty oil stains are difficult to remove, they can be treated before putting into the washing machine with neat liquid soap applied to the locality of the stains and light rubbing to assist the action of the soap. It is known that particular attention must be given to pH of soaps used with garments in colours of navy blue, royal blue, greens and greys, and in these cases it is best to select soaps and detergents with pH of 8.0 or below.

Garments made with FR treated cotton and garments made with aramid materials should never be treated with any chlorine bleach or strong oxidising agent such as peroxide. Neither should caustic washing agents, alkalis, biological agents or fabric softeners be used.

Drying Protective Garments

Garments to protect against heat and flame should be dried by hanging in warm air. Tumble drying is not usually recommended because the temperature used in such drying is usually too high and also because excessive agitation can cause localised damage such as abrasion and in extreme cases, garment shrinkage. If a tumble dryer is to be used, it should be at temperatures of normally 60°C or up to 90°C at the most. The important factor in drying is not to overdry. It is better to give the garments a shorter drying cycle and remove them while still slightly damp than to remove them bone-dry. Drying by an industrial laundry method known as continuous tunnel drying, where garments are passed on coat hangers through a tunnel of hot air by means of a conveyor system is a good method of drying providing the temperature of the drying air is not excessively high.

Dry cleaning Protective Garments

Dry cleaning is usually carried out by an external contractor, therefore it is very important that clear and strict instructions are issued to the contractor on what can and what cannot be done to the protective garments.

Solvents are often used in dry cleaning and many of these are flammable. Flammable residues in PPE after cleaning can ignite in proximity to an ignition source, so such flammable solvents should not be used in dry cleaning clothing to protect against heat and flame.

Cleaning Firefighters Protective Gloves
Firefighters protective gloves are usually best cleaned by hand washing in warm water, squeezing the water from fingertips to wrist – do not twist – and drip drying with the fingers facing upwards. It is usually not recommended that firefighters protective gloves be machine washed, dry cleaned or ironed. They certainly should not be bleached.

Decontamination and disinfection
Decontamination, the removal of harmful chemicals and/or disinfection, the removal of biological agents, is required when there is a possibility that an item of PPE has come in contact with a hazardous substance. In order to avoid the risk of contamination by PPE both of individuals and of the environment, procedures for decontamination/disinfection should be put in place, where instructions for the removal, handling, segregation, storage, transportation, treatment and disposal of all PPE are clearly set out and understood.

Contamination of protective garments and gloves through exposure to body fluids/blood which could cause life threatening diseases is a particularly serious issue for emergency response personnel. Removal of such contaminants can be carried out by washing at temperatures of 95°C but washing at this temperature may damage or destroy parts of the garment/glove e.g. the moisture barrier. It can also be carried out by a procedure called “autoclaving” which is a steam treatment - but once again this procedure is at temperatures which could damage or destroy parts of the garment/glove. Probably the best method of disinfecting garments/gloves suspected of containing such fluids is to rinse them at a temperature of between 40°C to 60°C in a special chemical used for such disinfection. Prior to using any such chemical, it is important to ensure that the manufacturer of the garments/gloves approves of its use on his/her products.

Cleaning Firefighters Helmets
Firefighters helmets should be cleaned in accordance with the manufacturers recommendations as soon as possible after contamination or exposure to fuels or to any other hazardous materials. Bleach, any cleaning product containing chlorine, solvents or paint thinners should usually not be used as they may degrade the protective properties of the helmet components.

The outer shell of a firefighters helmet can usually be cleaned using a brush or sponge to wipe off contaminants, soot, or dirt in a sink filled with warm water mixed with mild detergent. Rinse with clean warm, soapy water. Wipe dry or air dry.

The Faceshield can be cleaned in a sink filled with warm water mixed with mild detergent, rinsed with clean water and dried with a soft sponge or cloth

Cleaning Firefighters protective boots
Firefighters boots should be cleaned in accordance with the manufacturers recommendations. Leather boots are usually cleaned by using an agent that conditions and provides water protection to the outer material and rubber boots are usually cleaned by hand washing in warm water with a small amount of mild detergent, rinsing with clean water and air drying.

Storage

Storage of PPE should be organised so that it remains hygienic and clean until it is required for use. The method of storage should not adversely affect the performance of the PPE.

Soiled PPE should be cleaned and dried before storage.

PPE should be stored in a clean, dry, well ventilated area at a temperature that will not cause damage to the protective properties of any of the materials in the PPE. Some items of PPE to protect against heat and flame, in particular protective garments, should be stored, ideally wrapped in black polythene bags or plastic sheets, in an environment where they are not exposed to ultraviolet light e.g. sunlight, fluorescent light tubes etc.

If the life cycle of the PPE is influenced by its storage, this must be indicated in the information from the manufacturer which should also indicate any specific storage requirements.

In summary, clear procedures should be established to set out amongst other things:

- Where the items of PPE should be stored.
- How the items of PPE should be stored
    - prior to use;
    - when in use and
    - when not in use.
- Any parameters recommended by the Manufacturer for the storage of the PPE e.g. humidity, temperature, time, light etc.

SECTION 1:

1.4 GUIDELINES ON MAINTENANCE of PPE:

The information provided by the manufacturer for each item of PPE should include maintenance instructions. Based on these instructions, the employer should determine the arrangements for maintaining the PPE and all parties involved, including all persons who will use the PPE should be so informed. Maintenance of PPE should only be performed by trained personnel who can demonstrate the relevant competencies to carry out this task.

Maintenance of PPE should include the following:

Inspections

Inspections are necessary to establish that the PPE is fit for purpose and therefore regular inspection of PPE is essential to ensure that it will provide the protection intended. Any elements of the PPE contaminated with hazardous materials or biological agents should be decontaminated/ disinfected before inspection is initiated. PPE should be inspected by a competent person who is familiar with the PPE and the types of wear and tear that could influence its performance.

An inspection programme should be drawn up for each type of PPE and should include an inspection schedule, list of elements to be inspected and the decisions and actions to be taken based on the inspection results. The decisions based on the inspection results should include:

- Is the PPE fit for service ?
- Is the PPE fit for limited use only ?
- Does the PPE require repair / adjustment ?
  NOTE: Alterations of items of PPE may affect the status of any certification of the item and so they should not be carried out without prior approval of the manufacturer and assurance from him/her that such alterations will not affect the certification status of the item(s) of PPE in question.
- Does the PPE require cleaning / decontamination / disinfection ?
- Should the PPE be removed from service and destroyed ?

Clear procedures should be established to set out amongst other things:

- The inspection criteria that should be applied.
- Who should carry out the inspections.
- How often and when inspections should be carried out.

Repairs and adjustments

PPE to protect against heat and/or flame should never be worn if damaged. Repairs and/or adjustments to PPE should only be carried out, following the manufacturers instructions, by competent individuals or organisations trained to do so. After repair/adjustment, the PPE should be inspected by a suitably competent person to ensure that the repair/adjustment has been carried out to an acceptable standard of workmanship and that the protective properties of the PPE are not affected.

Clear procedures should be established to set out amongst other things:

- The kind of repairs that are acceptable to be carried out on site by a competent person.
- The kind of repairs that should be carried out by the Manufacturer.
- Who will be responsible for overseeing the management of repairs.

Removal from service and ultimate disposal

PPE that is no longer fit for purpose must not re-enter service. A number of factors, in particular the effect on the environment, should be considered when disposing of PPE. The chosen method of disposal should not compromise the health and safety of anyone coming into contact with the contaminated PPE.

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

Clear procedures should be established to set out amongst other things:

- When the PPE should be disposed of.
- How the PPE should be disposed of ensuring no damage to the environment.

NOTE:

It is important that all aspects of care and maintenance of PPE be under the supervision of a competent person. In this context, a competent person may be defined as:

> *A person where, having regard to the task that s/he is required to perform, and taking account of the hazards to which the PPE may be exposed, the person possesses sufficient training, experience and knowledge appropriate to the nature of the work to be undertaken.*

SECTION 2: SUPPORTING DETAIL

2.1 ASSESSMENT OF RISK: RISK ASSESSMENT GUIDELINES

PPE is just one part of an overall Safety Management System (SMS) which must include hazard reduction and risk management and it should be chosen based on the protection of the user against the identified risks that are in the work place. Within an effective SMS, PPE should only be used when risks cannot be avoided or cannot be sufficiently limited by technical means of collective protection or by measures, methods or procedures of work organisation. To identify the correct type of PPE to use it is necessary to list the hazards a person may encounter during his/her work, estimate the likelihood of him/her being exposed to each of these hazards and estimate the possible consequences of such exposure.

To be in a position to make the proper decision as to exactly what is required, an understanding of both hazards potentially being faced and of PPE is very important. With regard to the types of exposures that might be experienced by emergency response personnel, the role of PPE is to protect them whilst enabling them to achieve the objectives of attendance at an incident and to safeguard them in the event of the need to escape. The PPE chosen must also allow the emergency responder to carry out his/her duties without undue stress being caused by the PPE.

To arrive at a decision on the most suitable type of PPE to use, it is necessary to carry out a risk assessment specifically about the choice of PPE. This type of the risk assessment is **not** a work place risk assessment, it is an assessment to ascertain the type of PPE required to protect personnel working in specific areas and it should be carried out within an overall SMS, not in place of it. PPE to protect against heat and flame is categorised as PPE to protect against mortal danger and in other risk assessments, possible exposure to mortal danger will probably be considered as unacceptable. Yet in terms of work place protection, such PPE cannot be regarded as unacceptable providing it is part of an overall SMS. The overall work place risk assessment must be used to identify what is acceptable and what is unacceptable, not the PPE risk assessment.

The Risk Assessment model below was developed specifically for choice of PPE for firefighters and it is simple to use. It is based on an annex of CEN Standard EN 469:2005 the European standard for protective clothing for firefighters. Whilst the model was developed specifically for exposures in firefighting, the principal it establishes can be adapted for other exposures. Other identified hazards can be added to the Table as appropriate to each workplace.

Risk assessment formula:

R = L x S where **R** = Risk.
L = Likelihood of the wearer being exposed to the hazard, and
S = Severity/consequences to the wearer if exposed to the hazard.

Values of "L" and "S"

Value	Likelihood	Severity / consequence	
0	Never	Nil	
1	Exceptional	Low	e.g. minor injury: small cuts; superficial burns etc.
2	Occasional	Moderate	e.g. major injury; broken bones; serious burns etc.
3	Very likely	High	e.g. life threatening
4	Always	Extreme	e.g. death

Hazard **Origin and type**	**Likelihood of being exposed to hazard (L)**	**Severity / Consequences if exposed to hazard (S)**	**Risk (total of L x S)**	**Control measures**
1. Thermal hazards				
a. Convective heat				
b. Radiant heat				
c. Conductive heat				
d. Flame				
e. Contact heat				
f. Molten metal/drops				
g. Burning embers				
h. Flashover				
2. Electrical hazards				
a. Electric arc				
b. Static electricity				
c. Electrical current, high voltage				
d. Low voltage				
3. Environmental hazards				
a. Ambient cold				
b. Ambient hot				
c. Cold surfaces				
d. Air Velocity - mechanical				
e. Air Velocity – wind				
f. Rain				
g. Splashes				
h. Working in water				
i. Falling in water				
4. Mechanical hazards				
a. Penetration				
b. Cut				
c. Abrasion				
d. Falling objects				
e. Impact				
f. Falling/slipping				
5. Non-visibility hazards				
a. Not being seen				
6.Biological/chemical hazards				
a. Liquid				
b. Contamination by body fluids				
c. Gas				
d. Smoke				
e. Radio activity				
7. Other hazards				
a. Physiological/heat stress				

The training, tactics and operational procedures of each organisation 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". This might therefore result in different outcomes in different organisations.

EXAMPLE of a risk assessment for PPE using the method shown.

Work place detail in this example.

Process operators are working in an area where there are large quantities of flammable liquids.

Suggested potential Exposures: (See risk assessment formula table above for values shown.)

- **Exposure to thermal hazards.**

In a workplace that is safe, the likelihood of such exposure is exceptional or occasional and if it happens, it will most probably be in emergency conditions such as a flash fire. Whilst a flash fire will produce convective, radiant, and possibly conductive and contact heat, the main risk to the operator will be flame. The possible consequences of exposure to flame could be extreme (death).

Risk total of this hazard is either exceptional (1) multiplied by extreme (4) = 4
or occasional (2) multiplied by extreme (4) = 8. *<u>See Table below</u>.

- **Exposure to environmental hazards.**

If working in a factory the likelihood of such exposure is exceptional (1) or occasional (2). In Summer there may be a risk of ambient hot, in Winter of ambient cold. The consequence of such exposure is low (discomfort/minor injury) (1). The risk total is 1 x 1 = 1.
or 2 x 1 = 2.

However if the operator is working outdoors, subject to location, the possibility of risk due to exposure to ambient cold or hot could be very likely (3). The consequences of such exposure will depend on the severity of the environment. In a very hot climate, the consequence could be heat stroke, in a very cold climate, the consequence could be hypothermia. Both of these conditions could be regarded as high (life threatening) (3). The risk total is 3 x 3 = 9. *<u>See Table below</u>.

There could be further risks under this category if the operator is working outdoors near water. The likelihood of falling in might be occasional (2) whereas the consequences could be high (life threatening) (3). The risk total is 2 x 3 = 6. *<u>See Table below</u>.

- **Exposure to mechanical hazards.**

In a workplace that is safe, the likelihood of such exposure is exceptional or occasional. But for example where the operator is located in an area where other work is being carried out overhead without fully effective safety procedures, the risk could be very likely (3), with moderate consequences (broken bones) (2). The risk total is 3 x 2 = 6. *<u>See Table below</u>.

In an unsafe environment where for example floors are not well maintained, the risk of slipping is also very likely (3) with moderate consequences (broken bones) (2).
The risk total is 3 x 2= 6. *<u>See Table below</u>.

Control measures.

Based on the results of this assessment, using the table below, the risk analysis for this scenario has given clear results and decisions can now be taken on effective control measures. Whilst this risk assessment model is primarily for the purpose of choosing PPE, basic safety protocols must still be regarded and so control measures must extend beyond PPE to overall work place safety.

Hazard Origin and type	Risk total of L x S)	Control measures
Exposure to thermal hazards		
Flame	**8**	Provide flame retardant clothing for operators.
		Provide sufficient number of fire extinguishers.
		Provide training in the use of fire extinguishers.
		Provide fire blankets near each work station.
		Provide training in the use of fire blankets.
Exposure to environmental hazards		
Ambient cold / hot	**9**	Implement procedures to control onset of heat stress / hypothermia (as applicable)
		Provide information and training for all personnel working in areas where such risks are likely.
		Ensure availability of suitable medical equipment / treatment in the event of such an occurrence.
Falling in water	**6**	Improve safety procedures to reduce risk.
		Provide operators with suitable buoyancy aids.
Exposure to mechanical hazards		
Falling objects	**6**	Improve safety procedures to reduce risk.
Falling/slipping.	**6**	Improve safety procedures to reduce risk.

Control Measures: Safety procedures:
It has been identified that there is considerable scope for improvement of safety procedures to make the work place safer. When these procedures have been put in place, a risk assessment after such measures have been taken should show major reductions in risk probabilities.

Control Measures: PPE requirements:
The greatest level of risk has been identified as exposure to environmental hazards – which for the purpose of this exercise is being taken as ambient cold – followed by exposure to flame and then an equal total of risk of exposure to falling in the water, falling objects and falling/slipping. Effective safety procedures could significantly reduce the risk of exposure to falling objects and slipping but may not significantly reduce the risk of exposures to ambient cold and to flame. The PPE chosen should therefore be PPE that is resistant to flame and to ambient cold as well as PPE in the event of falling in the water – known as buoyancy aids.

The relevant standard for clothing to protect against heat and flame in CEN is EN 531 and in ISO it is ISO 11612. One of the performance requirements in EN 531/ISO 11612 is that the material in the clothing must be resistant to flame, so clothing certified to EN 531 and/or ISO 11612 would appear to be the correct standard for the clothing to be chosen.

EN 342 is the European Standard for protective clothing ensembles and garments for protection against cold. The ideal choice therefore would be clothing certified to both EN 531 and EN 342. Another possibility is to choose clothing certified to EN 469 the European standard for protective clothing for firefighters, because such clothing is not only certified as flame resistant but it has high levels of thermal insulation such as are needed for protection against ambient cold. Design considerations for PPE for the purpose stated may be different to those for firefighting.

In most cases of possible exposure to high levels of risk, there may have to be a choice between comfort and the type, mix and levels of protection provided. Suppliers of PPE who realise the need for risk assessment procedures will be of great assistance in arriving at the correct decision.

Risk Assessment for suitability of PPE in use

In Section 1 of this Handbook, there are important guidelines to ensure that PPE gives an acceptable level of on-going protection throughout its lifetime by the implementation of procedures on care and maintenance by suitably competent persons. This applies not only to users whose Organisation owns the PPE that is used but also to users whose Organisations contract out the care and maintenance of the PPE. Contracting out the work of care and maintenance of PPE does not reduce the responsibilities of employers and employees to provide suitable PPE and to use, care and maintain it as specified, it means that third party Organisations are doing the work of care and maintenance and possibly replacement.

Achieving such control of PPE is somewhat more complex for PPE that is used in locations where users temporarily attend for a particular purpose e.g. when they attend a training course at recognised training establishments, when they are working for their employer at a place other than the main place of employment etc. The responsibilities of employers and employees with regard to PPE are not diminished in any way because a member of its Organisation is training/working in another location and in these circumstances, not only the employer and employee have responsibilities for the PPE, but also the training establishment/owners of the external site are now faced with their own responsibilities with regard to the PPE used as they have a duty of care to ensure the safety of all personnel using their facilities.

PPE in Training Establishments
Regular exposure to robust and/or specialist training in recognised training establishments is an important part of maintaining competencies of Emergency Services personnel who, due to the type of training they will be engaged in will require to use PPE. Some training establishments allow trainees to use the PPE issued by their employer during training. In these cases, before training commences, the employers of the trainees should have already satisfied themselves that such PPE is capable of providing the required levels of protection identified in their own Organisation’s risk assessment. They should also satisfy themselves that the exposures which their employees are likely to face in the training establishment are no higher than the levels of exposure identified in the Organisation’s risk assessment. The training establishment has an obligation of satisfying itself that the PPE being worn is capable of providing the required levels of protection identified in the risk assessment of the training establishment for the exposures of training. If the training is over a prolonged period, it is important that suitable arrangements for cleaning and inspecting the PPE regularly are implemented.

Other training establishments issue to trainees PPE which is owned and maintained by the training establishment. In these cases the training establishment has a responsibility to ensure that the PPE chosen is suitable for the likely exposures and that it is fit for purpose each time it is used. This puts obligations on them to implement on-going suitable and effective procedures for the care and maintenance of the PPE - as outlined in Section 1 of this Handbook - and in particular it is critical that persons who are competent in care and maintenance of PPE assess each item of PPE before **each** use. Before training commences, the training establishment must also ensure that trainees have the competence to work safely in the exposures to which they will be subjected because the levels of exposure may be higher than those to which the trainee is used to being exposed to in his/her own Organisation.

Any divergences in either scenario outlined above, should be resolved before training commences to ensure a safe place of work for the trainees.

SECTION 2: SUPPORTING DETAIL

2.2 BURNS

The Skin
The components of the skin can be divided into three primary layers - the epidermis which is the outermost layer, the dermis which is directly below the epidermis and the hypodermis, also called the subcutaneous fatty tissue, which consists of fat followed by muscle. The thickness of this fatty layer is affected by individual and anatomical differences which can vary substantially from person to person. These differences can play a major role in determining the degree of injury in a severe burn.

Pain and Skin Damage
In an incident involving heat and flame, four different levels of heat likely to cause burns are involved, the intensity of the heat source which is measured as "heat flux", the temperature of the surrounding air, the temperature of the PPE and the temperature of the skin. As heat transfers through the PPE worn, the temperature of the covered skin is raised and when the temperature of the skin reaches critical levels, pain and injury occur and damage called a "thermal burn" begins. Thermal burns to uncovered skin will occur very much quicker than to skin which is protected by PPE.

As every person's skin is different, the exact temperature at which damage begins varies from person to person and from one part of the body to another. A good general guideline is that pain is felt and injury begins at skin temperatures at around 44°C (111°F) and injury will continue for as long as the skin temperature remains above this temperature, removal of heat source notwithstanding. The rate of injury is roughly trebled for each °C increase above the threshold tissue temperature - for example, the damage rate at 50°C is in excess of 100 times that at 44° to 45°C

In general terms, there are three levels of burns:

Effects on Skin	*Skin Temperature*
First degree burns	44°C to 48°C (118°F)
Second degree burns	48°C to 55°C (131°F)
Instantaneous third degree burns	72°C (162°F)

- *1st degree burns* also referred to as "superficial burns" only involve the epidermis. The skin becomes red and painful but blistering will not occur. Severe sunburns are the most common form of first-degree burns. These types of burns usually heal well.
- *2nd degree burns* also referred to as "intermediate burns" occur when the entire epidermis is destroyed. These burns can be sub-divided into superficial and deep classifications. A superficial 2nd degree burn involves no damage to the dermis. The skin will be blistered, red and painful, with a moist look to it. A deep 2nd degree burn is when there is some damage to the dermis and the skin will be blistered with a pale white colour under the blisters. These burns require medical aid.
- *3rd degree burns* also referred to as "deep burns" involve all layers of skin with complete destruction of the dermis. The skin will not blister, but instead will be dry, grey and possibly leathery. There is usually no feeling because the nerves are damaged. There is little or no possibility for regeneration and such burns always require medical attention.

The rapid application of ice to an exposed area can prevent a blister by eliminating about one third of the burn damage.

Protective Clothing and Burns

The purpose of the materials used in heat protective clothing is that they must not support burning or melting nor must they continue to burn or decompose after a source of heat or combustion has been removed. Heat protective clothing should also act as a flame shield and provide insulation to slow down the passage of air at elevated temperatures through the clothing to the surface of the body. The type of material used and the number of layers in a garment assembly are critical to the type and level of protection afforded.

If a person is exposed to flame whilst wearing clothing that is not heat/flame protective and the clothing catches fire, purposeful escape action would almost certainly stop whilst frantic attempts are made to beat down the flames. The sufferer would then be subjected not only to any continuing thermal radiation from the heat source but also to flame engulfment from the burning garments.

Clothing manufactured from materials that will not be affected by exposure to high levels of heat and flame should be worn by persons likely to be exposed to such hazards. However, persons wearing such clothing should be made aware that protective clothing will generally show no damage at temperatures that will cause serious burn injuries to the body. Some heat resistant fabrics degrade at very high temperatures so for example a Firefighter can easily get burnt wearing the clothing that is there to protect him/her.

SECTION 2: SUPPORTING DETAIL

2.3 CERTIFICATION of PPE in the EUROPEAN UNION (EU)

Introduction

EU Health and Safety legislation requires all employers to ensure the safety and health of their workers and to take the necessary steps to remove risk from the work place - in other words, all workers have the right of a safe work place. This requirement includes Emergency Responders, whose work place might be potentially dangerous, but who nonetheless, like all other workers, are entitled to a safe place of work.

Where the risk cannot be removed from the work place by for example safety management systems including effective training, provision of the correct type of safety equipment etc. the employer is required, in consultation with his/her employees, to evaluate the risks that cannot be avoided and to provide employees with suitable PPE, to maintain it, and to train each person in its use, all free of charge.

European Directives on PPE

To be sold in the EU, PPE must comply with two Directives which are incorporated into the safety legislation of each Country in the EU. These Directives are –

- Directive 89/656/EEC "Minimum Health and Safety Requirements for the Use by Workers of PPE" – known as the PPE "Use Directive" which sets down minimum Health and Safety requirements for the use by Workers of PPE at the workplace and

- Directive 89/686/EEC "Approximation of the Laws of Member States relating to PPE" – known as the PPE "Product Directive" which specifies the procedures to be taken in the manufacture and certification of PPE.

The "Use Directive" sets out the obligations on Employers and Employees about the wearing and use of PPE in the Work Place under the general rule

"Personal Protective Equipment shall be used when the risks cannot be avoided or sufficiently limited by technical means of collective protection or by measures, methods or procedures of work organisation."

The "Product Directive" sets out the rules with regard to design, manufacture and certification of PPE that is to be sold within the EU and requires that all PPE must provide adequate protection against all risks encountered. The Directive brings together PPE covered into 3 distinct groups and whilst the Directive does not explicitly define these three groups into categories, it is common practice to use the terms category I, II and III respectively.

1. Category I is PPE of Simple Design and is PPE manufactured where the designer assumes that the user can assess the level of protection against the minimal risks concerned, the effects of which, when they are gradual, can be safely identified by the user in good time. Examples of PPE of simple design are gardening gloves, thimbles, sunglasses, gloves for domestic washing etc.

2. Category II is PPE that is neither simple nor complex but is there by implication and is referred to as PPE of Intermediate Design. This type of PPE does not fall into either of the other two categories and is intended to provide an intermediate level of protection.

3. Category III is PPE of Complex Design and is PPE intended to protect against mortal danger or against dangers that may seriously and irreversibly harm the health, the immediate effects of which the designer assumes the user cannot identify in sufficient time. Examples of PPE of complex design are PPE for firefighters, diving suits, PPE for protection when using chain saws etc.

PPE designed and manufactured for private use to provide protection against adverse atmospheric conditions, damp, water and heat which are neither exceptional nor extreme, does not fall within the scope of the Directive. However PPE designed and manufactured for professional use in these conditions does fall under the Directive. This means that for example it is not a requirement that a garment to protect against rain purchased by a person for their own use shall have to pass through the certification process and carry CE marking, whereas if the garment is purchased by an employer for the use of employees during their work, it is a requirement to follow the CE marking procedure.

The Product Directive lists essential safety requirements for PPE which are sometimes referred to as the “Basic Safety Requirements”. The European Standards Organisation (CEN) is responsible for drawing up relevant standards for test methods and product performance for PPE, mainly category II and category III PPE, which are intended to provide compliance with the Basic Safety Requirements of the Directive for the item of PPE concerned. Compliance can also be demonstrated by providing a technical file based on the user’s risk assessment to the notified body who will evaluate whether or not the Basic Safety Requirements for that particular use are met.

Certification
Test Houses who wish their certification to be recognised as verifying compliance by the product with the Basic Safety Requirements of the Product Directive must register Nationally and if their quality and other systems meet minimum requirements they become known as Notified Bodies whose certificates of test and conformity will be recognised throughout the EU. This allows a free movement of goods throughout the EU without any national barriers to trade based on performance requirements.

CE marking
Before being paced on the market or put into service, items of PPE that are certified by a Notified Body as meeting the Basic Safety Requirements of the Product Directive must have a CE Mark affixed before being placed on the market and/or put into service. When the Directive was initially agreed by the EU Member States, it was required that the CE mark be followed by the last two figures of the year in which the marking had been affixed, but an amendment to the Directive in 1993 withdrew this requirement. However in case of category III PPE, the identification number of the Notified Body that carried out production control (see Table 2.3.1 below) must follow the CE mark.

The CE marking symbol symbolises conformity to all provisions of the relevant directives and it is prohibited to affix other marks, e.g. the manufacturer’s logo or a voluntary quality mark, which overlaps and may be confused with the CE mark. The CE mark shall usually be affixed to the product, however in exceptional circumstances, where conditions do not permit its fixing, e.g.

where the minimum dimensions of the CE marking cannot be respected or where it cannot be ensured that the CE marking is visibly, legibly and indelibly affixed, the CE marking must be affixed to the smallest commercially available packaging intended for the end user.

Manufacturers information

The information supplied by the manufacturer constitutes a fundamental element in order to judge the conformity of an item of PPE. It is considered to be an integral part of the PPE to which it refers and when undertaking the EC-type examination, the Notified Body is required to check the information which must be precise and comprehensible in terms of content and ability to understand. The information supplied must be delivered in paper form to users with each unit of PPE put on the market. For some types of PPE e.g. earplugs or specified protective gloves that are sometimes supplied in dispenser boxes, the instructions for use can be affixed to the boxes or provided with each unit.

The information that is required to be provided must include amongst other detail,

- the name and address of the manufacturer and/or his authorised representative established in the EU;
- instructions on storage, use, cleaning, maintenance, servicing and disinfection;
- performance as recorded during technical tests to check the levels or classes of protection provided by the PPE in question;
- the obsolescence deadline or period of obsolescence of the PPE or certain of its components,

and this information must be provided at least in the official language(s) of the EU Member State of destination.

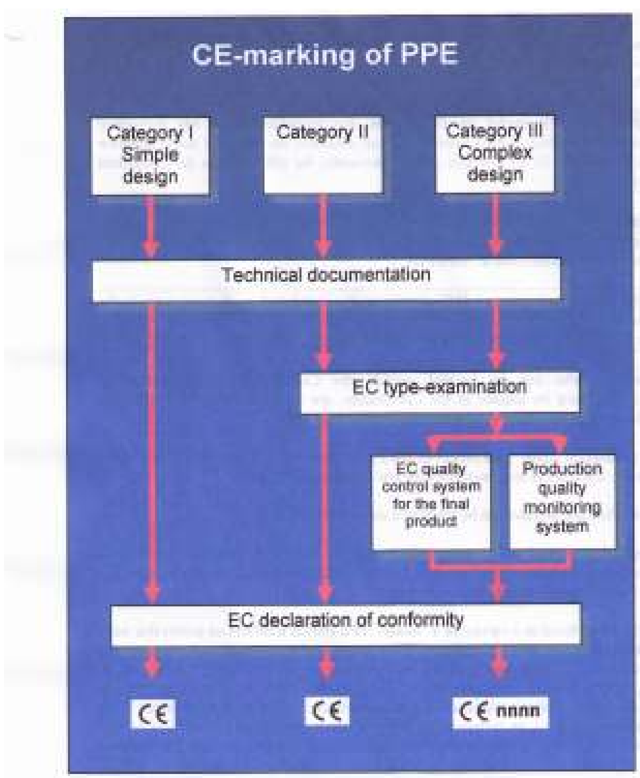

Table 2.3.1: CE Conformity – Certification Process

SECTION 2: SUPPORTING DETAIL

2.4 CLOTHING TO PROTECT AGAINST HEAT AND FLAME:

EDITOR'S NOTE:
This Section of the Handbook deals with protective work wear and firefighters' protective clothing that is used to protect persons working in environments where there are hazards of flammable materials, in particular, flammable liquids and gases, and to environments to which emergency responders might be exposed in firefighting and rescue activities. Clothing to protect persons whose work place includes hazards such as welding, molten metal splash, working in proximity to open flames such as furnaces etc. is not specifically dealt with in this Section, although much of the detail hereunder is also relevant to such clothing.

Introduction.

When material is exposed to heat and flame, it responds in a number of ways depending on the type and properties of the material. It can break open (a phenomenon caused by heat shrinkage), melt, drip, char (the formation of a carbonaceous residue as a result of incomplete combustion), shrink, ignite etc. Protective clothing designed to protect the user during exposure to heat and flame uses special materials to reduce or eliminate the possibilities of one or more of these responses taking place.

Clothing to protect against heat and flame can be single or multi-layered. The more layers that there are in a material/clothing assembly, the thicker and heavier it generally becomes and therefore the more protective is the assembly. The type and level of protection provided by an assembly is dependent on the types of materials in an assembly and what each material is designed to do.

The fit of a heat/flame protective garment plays an important part in the protection of the wearer. In general, the looser the garment, the more protection it gives because of the air space between the clothing and the skin providing insulation and thermal protection. Clothing that is tight fitting reduces the air insulation and in the event of an exposure to flames, can result in more severe burns than loose fitting clothing.

Protective Work Wear to protect against heat and flame.

Limited Flame Spread materials
In the 1990s, when the various CEN (European Standards Organisation) standards relating to clothing to protect against heat and flame were being developed, difficulties were encountered in agreeing effective definitions of the terms "F.R.", "fire resistant", flame resistant", "flame retardant" etc. as used to describe some materials used in such protective clothing. So the new term "limited flame spread materials" was adopted and the standard EN 533:1997 covering such materials was approved. EN 533 is now in the final stages of its revision to become an ISO (International Standards Organisation) standard entitled ISO 14116 "Protective clothing — Protection against heat and flame — Limited flame spread materials, material assemblies and clothing". Throughout this Section of the Handbook, there are references to F.R. materials i.e. F.R. treated materials and inherently F.R. materials. Whilst the correct current title for such materials is "limited flame spread materials", because this description is not in widespread use at present the reference "F.R." is used. In all cases in the Handbook, this reference means limited flame spread materials.

Personnel working in environments where they may be exposed to hazards that could cause burn injuries should be protected by wearing F.R. clothing. Clothing that does not have this F.R. property can burn on exposure to an ignition source and will continue to burn even after the source of ignition has been removed.

The choice of materials for use in the manufacture of F.R. protective work wear falls into three categories:

- materials that have been given an F.R. treatment,
- materials that are inherently F.R. and
- materials that are mixtures of inherently F.R. fibres.

F.R. treated materials
The preferred choices of materials to which an F.R. treatment is given are cellulosic materials such as cotton and viscose. The F.R. treatment is applied to the fibre and/or material by the manufacturer's proprietary system of application. This treatment can comprise at least 30% of the finished material weight. Manufacturers of such treatments claim that when garments are cared for and maintained following the manufacturer's instructions throughout their useful life, the material's F.R. properties will last for the expected lifetime of the garment.

Inherently F.R. materials
These materials are synthetic materials where the F.R. properties are built into the chemistry of the materials and therefore cannot be chemically or physically changed, which means that the F.R. properties will remain in the material for its lifetime and they will not degrade. As well as providing these F.R. properties for the lifetime of the material, physical properties such as strength and abrasion resistance are generally much higher in these materials than in F.R. treated materials.

Materials that are mixtures
Manufacturers have developed mixtures of inherently F.R. fibres so as to reduce the cost of the material and to achieve a better balance of properties - some inherently F.R. fibres are much cheaper than others. Another reason for mixing the fibres into such materials is to provide the protective features of the synthetic fibre and the comfort of the natural fibre.

Comparison between FR treated materials and inherently FR materials
<u>Weight of material.</u>
To provide equivalent levels of protection against heat and flame, the weight of any F.R. treated material when compared to a synthetic counterpart may need to be higher.

<u>Exposure to flame:</u>
Exposure to flame in the workplace can be from a small localised exposure right up to a condition of flame engulfment. On exposure to flame, some manufacturers of F.R. treatments claim that the gases that are given off by the F.R. treatment chemically interfere with the combustion process whilst others claim that their F.R. treatments react by the F.R. chemical causing accelerated charring of the fabric which reduces the ability of the fabric to support combustion. To achieve full potential from this process, maintaining the continuing cleanliness of the F.R. fabric is very important.

Tests of clothing manufactured in F.R. treated materials on a full size manikin test rig replicate flame engulfment and show that at temperatures of 140°C to 150°C the F.R. chemical is flashed off as a vapour and condenses to form a dense, dark smoke leaving behind a material which is now like normal cotton or viscose and which will continue to burn. As flash fire conditions vary between 200°C and 900°C it can be concluded that these treated materials are a risk under extreme conditions.

Comparative testing of similar clothing manufactured in inherently F.R. materials shows that it provides protection throughout the burning time and there is little after-burn damage and with a para-aramid content, shrinkage is at a minimum. Not all exposures of F.R. work wear in actual usage will be to complete engulfment in flame but knowing that this happens must be a factor in considering the safety of the product for use as Work Wear where engulfment is possible.

Lifespan of treatment.

Under certain conditions, all F.R. treated materials will lose their treatment. If wear and exposure conditions of the workwear can be controlled, the protective condition of such garments can be tracked and when subjected to testing, some indication of the diminution of protection by the loss of the F.R. treatment due to such wear and exposures can be estimated. However, such testing requires destruction of the test sample and so the results can only give an indication of the condition of other garments in the test batch.

Manufacturers of F.R. treated materials usually use the number of washes as the controlling factor for the lifetime of a garment. Washing and wear life may reduce the amount of F.R. chemical thus reducing the F.R. properties of the material. Workwear gets wet from water not only by exposure to cleaning, but also from the user sweating whilst wearing the garment, exposure to weather conditions etc. and these must be considered at least as a partial wash or soaking. So it is impossible to track the actual levels of remaining resistance to heat and flame in these garments.

On the other hand, what is inherent cannot be removed and therefore the FR properties claimed by the manufacturer of inherent F.R. materials lasts for the lifetime of the material and the uncertainties outlined for the levels of protection in F.R. treated materials does not exist.

All materials including inherently FR materials may eventually become thinner as a result of abrasion during wear and use and this will result in reduced resistance to heat penetration.

Badging

It is not unusual for work wear to have corporate/departmental/individual identification in the form of some type of badges or other items affixed to garments. Badging or other items affixed to protective work wear to protect against heat and flame should be kept to the absolute minimum and only such items manufactured from non flammable materials at levels of performance which do not in any way reduce the overall protective performance of the protective work wear should be used. If a badge is required for whatever reason on heat/flame protective work wear, it is preferable to position it on the inside of the garment or on an inside part of a collar which is folded over. This means that the badge is protected from exposures by the outer material.

Protective Clothing for Firefighting

Material Assembly
In Firefighting operations, the clothing should protect the user against possible flame impingement, high air temperatures, radiant heat and accidental contact with chemicals, whilst allowing the user to carry out his/her duties without undue stress being caused by the clothing. In firefighters intervention clothing, such protection will only be achieved, bearing in mind current technology, by the use of a multilayered garment i.e. a series of materials each with its own special protective properties, combined in a material assembly and manufactured as a garment.

Typically, protective clothing for firefighters is made with four primary materials sewn together in a material combination:

- An outer material referred to as "outer shell". The outer shell is a strong material with high-heat and flame resistance and certain chemical resistance, to provide initial protection against exposure to heat, flame, abrasion etc.
- A moisture barrier, to reduce the amount of water from the environment that might penetrate to the inside of the garment. The moisture barrier is bonded to a woven or non-woven substrate to give it strength and durability or it may be bonded to the inner side of the outer shell.
  NOTE: This latter type of construction i.e. bonding to the inner side of the outer shell, whilst cheaper to manufacture, can reduce the durability of the whole garment because the moisture barrier may be much more easily punctured or torn thus allowing water penetration. This type of damage is almost impossible to repair.
- A thermal interlining, a material designed to slow down the passage of heat from the outside to the inside of the garment.
- An innermost lining, to protect the materials in the thermal barrier and to give comfort and an extra layer of protection to the User.

The required levels of protection can be achieved by either a series of one or more garments worn over each other, or by a single garment utilising the 4 layered material assembly. Whatever system is used, it is important that the levels of protection on the upper and lower body are the same unless a risk assessment indicates otherwise e.g. there may be some situations where a higher level of protection might be required for the upper body.

Anti wicking
Many manufacturers of Firefighters multilayered clothing include what is called an anti-wicking barrier in the jacket and trousers. This is a material used to prevent the transfer of liquid from outside the garment to inside the garment at or around the edges of the clothing. It is included either as part of an interlining at the edge part of a moisture barrier or as the edge part of an innermost lining e.g. at the end of the sleeves, the trouser legs or bottom of a jacket. It is important that where fitted, such materials should at least meet the same protective requirements against flame spread and heat transfer and resistance to water penetration as the rest of the garment in which it is fitted.

Inspection of layers
To allow for inspection of each of the layers of a multi-layered garment, some manufacturers of firefighters garments provide a facility to gain access to the inner layers. This can be some form of “inspection trap” such as a wide pocket which can be opened and sealed relatively easily. Another method is that a main seam is not sewn. Open seams can have potentially very dangerous outcomes such as materials getting caught up, or flames and other hazardous agents coming in contact with and attacking inner layers or the development of what is known as the “chimney effect” which is where the smoke and flames are drawn into the various layers of the garment due to differences in air density between the layers of the garment and the fire environment. Whatever is the system used to allow such inspection, care should be taken that such a facility in no way reduces the protective performance of the garment.

Repellent finish on outer materials
Many heat/flame protective garments are provided with a special finish on the outer layer to provide water and/or fuel and/or chemical repellence properties. One of the problems with some of these treatments is that whilst the finish does provide water/fuel/ chemical run off it may offer only limited stain protection which makes the garment more difficult to clean and stains that do occur on the outer surface may trapped within the fibres of the garment. In other cases, these finishes wear off with use but garments can be re-treated. It is recommended that garments with this treatment be re-retreated after each washing cycle, particularly in cases where there is an uncontrolled recording/tracking system. With a proper tracking system in place, some manufacturers recommend that re-treatment should take place after 5 or 10 washes although others say that the effect of the treatment starts to diminish after as few as two washes.

During re-treatment of multi-layered garments such as firefighters garments, not only does the outer material get the finish, but also all the other layers of the garment. This will effect the moisture management of the garment, as every layer will now be water repellent.

During re-treatment, all stains that have not been previously washed out on any layer of the garment will become locked in. For fire and heat protective clothing, stain is a major problem if it is flammable. The stain, as a chemical or biological contaminant is also a big problem but it can often be neutralised if not removed. Stains on a garment that are not hazardous do not cause any problems other than visual issues when the garment is of a colour where the stains are visible.

Reflective outer surface
Some protective clothing for firefighters is manufactured with an outer material with a reflective surface, usually an aluminised fabric. The protective property of a reflective surface is its ability to reflect intense radiant heat and it will provide this protection provided that the surface is kept free from dirt and other contaminants. This type of clothing is difficult to store and maintain and it can be hot and uncomfortable to wear. When the outer surface becomes damaged for whatever reason e.g. cracking during storage, reduction in reflective shine through wear, smoke etc., it loses its ability to reflect heat. Well designed clothing with a reflective outer surface that is manufactured by a quality manufacturer can provide excellent levels of protection if it is properly maintained and it will continue to provide protection against convective heat, molten materials, contact heat etc. even if the surface is damaged.

Outerwear/Underwear

The most important and fundamental rule in specifying heat/flame resistant clothing is that the different layers of heat/flame resistant materials from which the clothing is manufactured must be able to provide sufficient protection to the skin underneath and, if underwear that is not heat/flame resistant is being worn directly underneath the clothing, to that underwear. Therefore the risk assessment on which the decision to purchase the heat/flame resistant clothing is made and which takes account of potential exposures must ensure that the heat/flame resistant materials in the clothing chosen are of sufficient density and thickness to resist the heat penetration and heat transfer to the skin and/or to the materials underneath which possible exposures could produce.

In general terms, this requirement can be satisfied by one of two choices.

The first choice is to specify outerwear garments, if necessary garments manufactured from multi-layer materials or a multi layer clothing assembly, which will give the protective performance levels required by the risk assessment to protect against the hazard envisaged. This outerwear must be manufactured entirely from heat/flame resistant materials. If this choice is made, then clothing such as underwear, shirts and trousers etc. that are not manufactured from heat/flame resistant materials may be worn underneath. As such a clothing assembly, the total thermal performance will be enhanced, however the total weight of this assembly could affect basic comfort and heat retention and cause build up the core body temperature of the person wearing the garments. So the potential hazard of heat stress during work activity due to the level of thermal insulation of the various sets of garments must be taken into account in the risk assessment.

The second choice is to specify a protective clothing assembly comprising outerwear and underwear which are manufactured totally from heat/flame resistant materials in such a way that all layers from the skin to the outermost material of the outerwear are fully heat/flame resistant and together they are designed to meet the thermal performance requirements of the risk assessment. A major advantage of this choice is that the clothing assembly is likely to be lighter, more comfortable and will cause less heat build up inside than that in the first choice, because calculation of the required levels of protection takes into account all layers of clothing used, not just the outer layer. However with this second choice, because it involves the wearing of an assembly of several garments e.g. outerwear, shirt and trousers and underwear, procedures must be established to ensure that all wearers are wearing the specified combination of all garments when entering a hazardous environment.

Regardless of which choice is taken, no other garment should be worn over the chosen outer garment for any purpose e.g. to provide protection against rain and weather conditions, clothing to provide conspicuity etc. This is because if for whatever reason, garments that are worn over heat/flame protective garments should catch fire and support burning because they are not manufactured from materials with any/or sufficient properties of heat/flame resistance, it is very likely that early burns to the unprotected face will occur and progressively involve the rest of the body.

General properties

Consistent quality
Manufacturers of protective clothing should be able to demonstrate their ability to continually manufacture items of clothing to a particular standard. In Europe, this is a legal requirement for any manufacturer who supplies PPE. Acceptance of this ability is given to manufacturers whose procedures and methods of operation are certified to ISO 9000, the International Standard for Quality which gives a guarantee of consistency of manufacture. However it must be remembered that ISO 9000 certification does not guarantee that products are good or will perform as required, only that products are made to a consistent level of quality which does not vary and that this can be demonstrated.

Material strength
High strength fibres should be included in the make up of materials used in the manufacture of garments to protect against heat and flame, to reduce or prevent the possibility of degradation of fabric, which is measured by what is called "tear strength". This degradation can be caused by a number of reasons, including exposure to ultra violet weathering. For fabrics to be used in garments to provide protection against heat and flame, it is important to include suitable mixtures of fibre to provide protection against "break-open" a phenomenon caused by heat shrinkage.

Level of protection
A balance must be struck between the level of protection required from the clothing and the comfort of the user because the heat capacity of a material i.e. the amount of heat that it can absorb, is very much related to the weight of the material. So reducing the weight of material(s) in the garment will inevitably reduce the level of protection provided. This is particularly critical in single layer garments. Some newer materials are very strong at very light weights but at these lighter weights questions must be asked about the level of protection against thermal transfer – in other words whilst the material might provide an excellent flame shield, at the lighter weight, will it also provide the required resistance to slow down the transfer of heat from outside to inside the garment ?

The most important input in establishing the types and level of protection required, must be from a user risk assessment. It must always be remembered that the use of PPE must be accompanied by safety management systems including training, fitness, command and control, ready availability of medical attention etc.

SECTION 2: SUPPORTING DETAIL

2.5 COMFORT, SWEAT and BREATHABILITY

Introduction
Although it may be perceived that protection should be the main purpose of PPE, the demands of comfort when wearing PPE cannot be separated as they are critical to the ability of the Wearer to work whilst wearing the PPE. In practice there is always an interaction between protection and comfort and in general terms, particularly with PPE to protect against heat and flame, the more protective an item of PPE is, the less comfortable it will be and vice versa. The difficulty is to find the right balance between the demands of the two.

Comfort
Scientifically we are comfortable when a balance occurs between the heat we lose and the heat we produce. Non-scientifically, when we are comfortable, we usually don't think about it, when we are uncomfortable, we are aware of it.

The comfort of PPE when worn is influenced by many factors including work and climactic conditions, the touch, construction, weight and finish of any material next to the skin, the design and appearance of the item, the sizing and fit of the item and the weight of the item. Comfort is further influenced by the ability of the person wearing the PPE to work i.e. does the PPE restrict movement, bending, climbing etc. and also the perceived ability of the PPE to allow breathability.

Breathability
One of the normal functions of the body is to produce sweat when necessary to keep the body's core temperature at normal levels. The evaporation of the water produced by sweating is the most effective way to cool the body due to the latent heat of evaporation of water. Under conditions of high heat stress or high workloads, secreting sweat that is allowed evaporate in contact with the skin is the major mechanism by which the body can lose heat.

Breathability indicates the flow of heat and moisture from the skin to the environment and it relates to the transmission of water vapour through a material to the outside environment. The purpose of using "breathable" materials in PPE is to allow transfer of this moisture vapour from the body to the outside. The less a material resists the transfer of moisture vapour the more breathable it is said to be.

Moisture barriers
The nature and purpose of PPE is that it should form a shield between the body and the risks from which it is intended to protect the wearer. Part of the protection provided by this shielding action must be to prevent liquids from entering the PPE. Clothing therefore may have a moisture barrier the sole purpose of which is to prevent the passage of liquid water from outside the clothing to inside. Moisture barriers are not intelligent however, so they will also prevent the passage of liquid water from inside PPE to the outside.

Some moisture barriers are claimed to be breathable and under conditions of low levels of exertion, moisture barriers may carry out this function and therefore add to the comfort of wear. However it is the nature of the work of an emergency responder that considerable exertion is required which in turn causes the body to sweat sometimes at very high rates – 2 litres or more over a 20 minute period is not uncommon. The amount of sweat produced at these volumes is far too great to allow any moisture barrier to remove the liquid in the form of water vapour, so the water from the sweat remains on the body or in the PPE. Sweating which does not evaporate in contact with the skin does not contribute to heat loss.

Water in protective clothing

Moisture within PPE will increase in temperature as the outside temperatures increase due to the Firefighter getting closer to the intensity of the fire or through flashover. When the moisture inside the clothing is heated to temperatures in excess of 44ºC, burns can occur to the body – see Section 2.2 of this Handbook.

The outer shell of Firefighters protective clothing may have a liquid repellent treatment as discussed in Section 2.4 of the Handbook. If a moisture barrier is also fitted, the garment could be very highly resistant to water entry. However in conditions of firefighting and/or inclement weather, it can be difficult to prevent water from entering the garment through the neck and wrist openings and even highly water resistant garments can allow some water to pass through if exposed to high pressure hoses. So build up of water inside the clothing takes place due to sweat which cannot evaporate added to by water entering the garment.

Water transfers heat very much faster than air. When water is added to a material system it gives the system a greater mass which therefore absorbs more heat and performs as a better thermal barrier. The volume of moisture in clothing tends to mask the thermal environment around the Firefighter as it stores heat energy within the clothing. However, at a certain point, the higher heat conductivity due to the presence of water will be dominant and will have a negative effect on heat transfer. So what the wearer believes is a very protective garment can in an instant turn into a lethal hazard. This is particularly dangerous when dealing with compressed protective clothing, because in fire fighting environments, whilst the water within the clothing may initially provide the extra thermal protection mentioned, particularly when body movement is not excessive, when the Firefighter bends, kneels etc. and compresses the clothing, this hot moisture could cause serious burns or even scalding.

Sweat Management

If sweat cannot be evaporated from the body, the next best thing is for it to be taken from the body by a material that has the ability to “wick”. Wicking is the ability to move moisture within a material without actually absorbing it - also known as hydrophilic. The skin is hydrophobic i.e. it has little or no ability to absorb water, which is why sweat which does not evaporate will remain in liquid form on the skin or drip off. If the liquid sweat is absorbed by, for example, very light close fitting underwear with good wicking properties, it will be distributed over the whole fabric surface and will evaporate quickly. This can be very cooling, however the transport of the evaporated moisture should not be hindered by the outer layers of clothing and therefore it is very important that these have a good water vapour permeability to transport the water vapour evaporated from the underwear to the environment as quickly as possible.

Safety of personnel at Incidents

When an Emergency Responder is working at a high rate of exertion, s/he is being exposed to the potentially lethal hazard of heat exhaustion. Even protective clothing that is claimed to be breathable will not assist in reducing increases in core body temperatures. Safety of personnel in such conditions cannot be provided solely by PPE and must be assured by safety management systems which should include amongst other features:

- ensuring the continuing fitness of the Firefighter;
- training in realistic conditions before an actual incident takes place;
- ensuring that the firefighter is not over-exposed to the incident;
  NOTE: This includes planning of work/rest schedules, specifying acceptable total duration of exposure and other safety measures.
- ensuring that as soon as the firefighter leaves the hot incident, his/her clothing is opened up to allow heat retained in the clothing and other items of PPE to escape and air to flow in to assist in cooling down the body;
- ensuring that there are plenty of suitable liquids available to re-hydrate the firefighters;
- ensuring that systems are in place to assist and if necessary rescue firefighters who might get into difficulties at an incident and
- ensuring that medical assistance is available if needed.

SECTION 2: SUPPORTING DETAIL

2.6 CONSPICUITY

Introduction
Seeing takes place when the eye detects the reflected light of any item and the optic nerve transports the information to the brain where the message is perceived and recognised. Only when recognition of the situation has occurred is a person able to react. In situations where there are potential risks by not seeing, it is important that recognition takes place in time to react appropriately. When this happens, the object is conspicuous.

Conspicuity is something that has a high visual impact that brings it to immediate attention. The most conspicuous feature is contrast, as human recognition works by distinguishing objects from their environment. When an item stands out due to colour and brightness, the human eye will be able to detect it quickly and precisely. Also, the size of an object is important in creating attention. The larger it is, the easier it will be noticed as the visual system is stimulated by clearly defined shapes, especially when the visual pattern is already known. Movement is also a key factor in conspicuity – even low contrast objects can be discerned against a background if they are moving.

During the day when there is light, colour providing contrast to the environment plays a major role in establishing conspicuity. However because most information is gathered from the light reflected by the surroundings, orientation during the night without light or in very limited light conditions becomes a very critical issue. In darkness, persons are deprived of most of the messages taken in during the day so the main task in promoting conspicuity at night is to provide brightness.

Conspicuity and PPE
In many work place conditions, any person wearing PPE should be easily and readily seen at all times. This is particularly important when working in areas where there is a likelihood of being hit by a vehicle when unseen e.g. in road traffic incidents, in environments with poor visibility where colleagues will want to keep in contact e.g. smoke filled areas during a fire and in situations where the wearer may be injured and immobile and colleagues are attempting rescue and they should be able to find him/her quickly.

Conspicuity of persons is usually achieved by using particular types of material either as the main material from which the garment is manufactured or by using tape or patches affixed to items of PPE. In both conditions, design considerations must include the placement of the materials that are to provide conspicuity as they must support the recognition of the person as a human shape.

Other considerations must include the risk when working in daylight or darkness and that whilst working, people are in motion, are bending or squatting and at all times, they must still be conspicuous. To provide necessary contrast, the amount of the material in the PPE must be of sufficient size and brightness to compete successfully with any coloured backgrounds or dark environments that might be partially illuminated by other light sources. In other words the high visibility materials should be applied to attract the attention of the human eye.

There are a number of different types of high visibility materials:

- Retro-reflective material. This is material that reflects incoming light back to the light source. It is achieved in material by special technologies which produce special shaped surfaces, such as repeated micro-spheres or micro-prisms. Retro-reflective materials illuminated by a light-source e.g. from the headlights of vehicles, creates contrast, brightness and recognisable shape. Optimised placement of retro- reflective materials ensures the recognition of a person as a human being in visually complex environments. This material can be affected by soiling and washing where minute particles of dirt and other substances collect on the retro-reflective material and block the reflective properties.

- Fluorescent material provides light that results from the interaction of light and matter e.g. the interaction of light from the sun or moon with the atmosphere, clouds, water, or dust and other particulates. Fluorescence is caused by special colour pigments converting ultra violet light into visible light of outstanding brightness. This is important during daytime as the rural and urban environments are dominated by the colours grey, brown, green and blue. Fluorescent colours, especially fluorescent yellow, orange and red are rare in both of these environments and provide enhanced contrast and brightness compared to the other colours as they will not be found in conventional backgrounds.

- Phosphorescent material is material which has the property of absorbing certain rays such as ultra-violet rays and releasing it slowly and continuously in the form of glowing light for a period of time after the material has ceased to be exposed to these rays. In other words it provides the light it has stored even in conditions where there is no light from which to reflect.

High visibility material on PPE
High visibility material should be used to create contrast with the background. This is important for daytime, but particularly so for night visibility. Higher visibility is achieved not only by increasing the amount of material, but also by placing the material both horizontally and vertically.

For PPE to protect against heat and flame, the outer material of any item of PPE should not be flammable, nor should any material or other items affixed to an item of PPE be flammable or reduce the protective performance of the PPE.

SECTION 2: SUPPORTING DETAIL

2.7 ELECTRICAL HAZARDS AND PROTECTIVE WORK WEAR

Static Electricity

When electricity is present on the surface of an insulted or non-conductive body and it is trapped or prevented from escaping, it is termed static electricity. Static electricity may appear as the result of motions that involve the separation or pulling apart of contacting surfaces usually of dissimilar substances one of which must be a poor conductor of electricity. A static charge that exists can be removed or allowed to dissipate itself.

Static electricity in PPE - in clothing in particular - can cause the clothing to be uncomfortable to wear and can be potentially dangerous in explosive atmospheres. Protective work wear garments to be worn in areas where there is a likelihood of build up of static charges should have anti-static properties throughout, including the seams. Such protection can be provided by fabrics with surface conductive metal fibres included in the fabrics of the clothing or the more modern anti-static protection which includes core conducting fibres usually made from polyester or polyamide with a conductive core of carbon or metal. By utilising these fibres, the fabric is given the ability to absorb the electrical charge by a mechanism called induction and to transport it to the atmosphere.

Although fabrics and garments containing anti-static fibres may substantially reduce static electricity generated by fabric-to-fabric friction and may also reduce the contribution of clothing to the static charge build up in the body, they do not eliminate body charges. Energy stored in the body poses a much greater hazard than static charges built up in clothing, because the body is made almost entirely of water and electrolytes and can store up to 40 mJ of energy. Other factors such as environmental humidity can also have an influence on the level of risk.

<u>Static that affects comfort:</u>

All textile fibres develop static electricity. Static electricity in clothing causes a tendency of fabrics to cling to the body and increases the speed of soiling because of electrical attraction of dirt particles. Sparks and minor shocks can be experienced whilst wearing items of clothing that have built up static charges when making contact with another object that will conduct the charge. This phenomenon of build up and of discharge is more likely to occur when in dry atmospheres.

<u>Static protection in explosive environments:</u>

The development of an electrical charge may not be a potential fire or explosion hazard in itself as certain conditions must be present for static electricity to become a source of ignition. The first line of defence against static discharge in explosive environments should be to connect the body to the ground so that when a charge is generated the electrons can flow out of or into the body and garment without doing any harm. The most effective grounding procedure is to discharge static from the body by wearing a wristlet connected to a ground source. Additional protection should be provided by wearing conductive - anti-static - footwear to minimise the accumulation of electrostatic charges and to allow their dissipation. However, even wearing anti-static footwear does not guarantee adequate protection against electric shock if for example, the sole of the footwear is contaminated or any internal insulation apart from ordinary socks is inserted between the Wearer's foot and the insole.

Anti-static protection for personnel should be considered separately for each high-risk area to be entered, as conditions may change from location to location. The electrical properties of all PPE to be used in such risk areas should be checked at regular intervals.

Electric Arc

Electric Arcs occur due to lightening and heavy electrical equipment, switchgears and transformers and normally generate a much higher level of energy than flash fires but for a much shorter period. The intense heat energy of an electric arc can generate temperatures of about 13,000°C, more than twice the temperature of the sun's surface. A person in the vicinity of such an accident has a very high risk of receiving severe second and third degree body burns. An electric arc produces electric shock, force and a great deal of thermal energy, possibly as high as 90% radiant energy - this compares to a "normal" thermal effect which has a mix of around 50% convective/50% radiant energy. This means that in an electric arc event, serious skin damage and burns can be caused without there being any flame.

A comparison of some characteristics of an electric arc event and a potentially dangerous incident involving flame is as follows:

Exposure Element	Electric Arc	Flame
Exposure time in secs.	0.01 to > 1	1 to 15
Total Incident Energy in cal/cm²	1 to > 100	1 to 30
Ratio of Energy Radiant / Convective	90/10	50/50

The risks of an electric arc event to humans are:

- Electrocution – in an electric arc, this usually will result in death.
- Clothing igniting or melting – exposure to electric arc or flame caused by an electric arc can rapidly exceed human tissue tolerance and cause 2nd and 3rd degree burns which are potentially fatal.
- Blast - the sudden release of energy which can generate shock waves and project debris similar in intensity to an explosion.

Actions that can be taken to reduce the risk of injury and death from electric arc events are to upgrade working practices - PPE never replaces safe operating practice - and avoid working live.

<u>PPE to protect against electric arc:</u>

Based on an organisation's risk assessment, the issue of the correct type of PPE will increase the chance of survival when a person is exposed to an electric arc event and gain escape time for the victim. A multi-layered heat and flame resisting garment is likely to give the best protection as more air is entrapped than in single layered garments. Alternatively, several garments worn on top of the other, all made from heat and flame resistant materials will be required.

Clothing to protect against and electric arc event must:

- provide permanent flame resistance,
- not melt or ignite and continue to burn,
- resist break open during electric arc exposure and
- insulate the wearer from heat.

Ordinary everyday clothing is usually made from cotton, viscose, wool, polyester, acrylic, nylon etc. and these garments should not be used when there is a risk of exposure to electric arc events, as the fabrics can ignite and continue to burn or melt on the body or lack the mechanical strength to resist the blast, increasing the extent of burn and other injury to the Wearer.

SECTION 2: SUPPORTING DETAIL

2.8 GLOVES TO PROTECT AGAINST HEAT AND FLAME

Design of protective gloves

Protective gloves, like all items of PPE, should be designed and manufactured so that in the foreseeable conditions of use for which they are intended, the user can perform the hazard related activity normally whilst enjoying appropriate protection at the highest possible level. Some of the features that all protective gloves should incorporate include the following:

- The materials from which gloves should be made should be innocuous i.e. they should provide protection without harm to the user. This means that glove materials, degradation products, incorporated substances, seams and edges and particularly those parts of the gloves in close contact with the user's hands should not harm the user's health and hygiene.
- The pH value for gloves should be as close as possible to neutrality and note should also be taken of the chromium content of materials used if this is applicable.
- When the glove construction includes seams, the material and strength of the seams shall be such that the overall performance of the glove is not significantly decreased.

Gloves to protect against heat and flame may be provided with safety cuffs or with wristlets constructed of flame retardant knitted materials designed to close around the wearer's wrist to prevent particles from getting into the glove through the cuff, or with gauntlets that extend up and protect the forearm, sometimes to as far as the elbow. The appropriate design should be based on the type of protection required.

Properties of protective gloves

Some of the protective properties for which gloves to protect against heat and flame might be chosen based on a risk assessment include:

- mechanical protection i.e. resistance to cuts, puncture, abrasion and tear,
- resistance to heat degradation,
- resistance to exposure to contact heat, flame, radiant heat and if applicable
- resistance to small and large splashes of molten metal.

For the type of risks to which Emergency Responders are likely to be exposed, protection against penetration by water and/or chemicals will need to be considered and subject to the risk assessment, it may be advisable to include a moisture barrier in the gloves. If protection from chemical risks is identified as a requirement, the potential for a chemical reaction between the chemicals that the wearer may be exposed to and the constituents of the glove including the proposed moisture barrier may also need to be reviewed.

It must be remembered that in most cases, the chemical protective properties of all PPE likely to be exposed to heat and flame, including gloves, are designed for accidental limited exposures – if there is a risk that exposures could be to more than just accidental limited exposure, serious consideration must be given to using suitable chemical protective PPE specially designed for this purpose.

<u>NOTE:</u> Decontamination/disinfection of any PPE exposed to or suspected of being exposed to chemicals/biological agents must always take place before the PPE is used again or put in storage. In some instances, decontamination/disinfection may not be practicable and replacement will be necessary, also ensuring the safe disposal of the contaminated PPE.

Glove functions
The protective properties of gloves to protect against heat and flame are of course important but a balance with other glove functions must be made by the manufacturer and agreed by the purchaser based on his/her risk assessment to allow the operator to carry out his/her work whilst wearing them. The most important of these other functions are:

- *Dexterity*, which is the ability of the wearer to manipulate objects and control his/her hands in the desired manner. A glove should allow as much dexterity as possible whilst still providing the required level(s) of protection. Dexterity in gloves is affected by factors including
    - the correct fit,
    - the thickness of the glove material,
    - the elasticity of the glove,
    - the deformability of the glove and
    - how it can be impaired by overly stiff or bulky materials required for physical and other forms of protection.

- *Tactility*, which is the ability of the glove wearer to sense objects by touch. Tactility in gloves is affected by factors including:
    - the thickness of the glove,
    - the presence of liners in the glove,
    - the glove surface characteristics, and
    - the properties of any coating material on the glove.

- *Grip*, which is the ability of the glove wearer to exert pressure on an object when holding it. Good grip in gloves allows the wearer to hold heavy objects in different orientations. Grip in gloves is affected by factors including:
    - the type of treatment on the glove surface,
    - the type of object being grasped and
    - the presence of any wetness or other substances.

SECTION 2: SUPPORTING DETAIL

2.9 HEAT STRESS

Human body's thermoregulatory mechanism
Humans have a complex thermoregulatory mechanism which keeps the temperature deep inside the body, known as the core body temperature, within a very narrow range around the "normal" value of about 37°C. Variations of about 1°C from this normal value are common in everyday life. Upward variations of about 2°C decrease both physical and mental performance and are often seen during more extreme activities and in illness. In general terms, upper variations of 3°C to 4ºC or more are rare under normal circumstances and usually require medical intervention to prevent irreversible deterioration and death. Notwithstanding these parameters, it is not unusual that the core body temperature of persons engaged in activities of high exertion e.g. firefighting, regularly rises as high as 40° to 42°C. These levels equate to those of some athletes e.g. the core temperature of a marathon runner who is competing robustly.

Under conditions of high heat stress or high work loads, the major mechanism by which the body can lose heat is by secreting sweat which is allowed to evaporate in contact with the body. Sweat which does not evaporate does not contribute to heat loss.

Exposure to heat
Some of the main disorders arising from exposure to heat can be classified into categories of increasing severity and build up of core body temperature. If allowed to continue untreated, the Heat Stress disorder becomes more severe and enters a higher category. These categories, in ascending order, include:

- *Heat oedema,* which may cause transient ankle swelling during acclimatisation to heat.
- *Heat cramps,* which may cause painful muscle spasm in the presence of salt deficiency.
- *Prickly heat,* which is the name given to a fine, superficial skin rash associated with excessive sweating and which most frequently arises in covered areas of skin.
- *Heat hyperventilation,* which can arise as a result of abnormally deep or rapid breathing in the heat, especially where respiratory protective equipment is being worn.
- *Heat syncope,* which is a simple faint as a result of reduced effective circulating blood volume.
- *Heat exhaustion,* which results from a combination of thermal and cardiovascular strain and produces a condition of irritability, tiredness and stumbling, with poor control and co-ordination, rapid and perhaps weak pulse and shallow, rapid respiration. Dehydration or, less commonly, salt deficiency, may contribute to the onset of heat exhaustion, which may in turn, predispose to the onset of heat hyperpyrexia or to other accidents.
- *Heat hyperpyrexia (heat stroke),* which is a potentially fatal condition occurring when body core temperature is raised above 40ºC. Its onset may be sudden, being indicated by collapse of the individual who will often, but not invariably, have a hot, red, dry skin. The conscious level is likely to be impaired and the pulse is rapid and weak. The condition results from a failure of the body's thermoregulatory mechanism to match the body's cooling requirements and if the individual is not removed from the heat and actively cooled, brain damage or death can arise from the elevated tissue temperatures.

The human body can adapt to some extent to regular exposure to heat. This physiological adaptation is called acclimatisation and after a period of acclimatisation, the same activity will produce fewer cardiovascular demands. The person will sweat more efficiently causing better evaporative cooling and thus will more easily be able to maintain normal body temperatures. It is naturally better to condition persons likely to be exposed to Heat Stress on a regular basis so that when exposed, the effects are not as severe. Fitness, particularly of persons who are regularly exposed to such large increases in core body temperature, is a very important feature in control of heat stress. Physical training and heat acclimatisation can be useful for both heat dissipation and/ or heat storage capability leading to better bodily adjustments, increased sweating sensitivity, more appropriate blood flow distribution, reduced cardiac strain, reduced blood pressure and reduced rate of perceived exertion.

Heat stress - Individuals differ

Heat Stress manifests itself in different ways and its effects are likely to differ from person to person and incident to incident based on factors such as:

- Physical factors e.g. age; sex; weight; body build and fitness; body composition - fat, muscle, blood volume etc.; biological rhythms e.g. time of day; menstrual cycle; sleep deprivation, tolerance to heat etc.
- Medical factors e.g. prone to attacks of loss of consciousness, fits or faints; mental illness; diabetes or any general medical condition; disease of the heart or blood vessels, including high blood pressure; chest disease, e.g. asthma; skin disease etc.
- Human factors e.g. taking drugs, either prescription or non prescription; frequency and type of exercise level if any; alcohol consumption; smoking.

Heat Stress and PPE

One of the functions of the human body is to sweat in order to keep the body core temperature at normal levels. PPE should not contribute to risk or indeed constitute a risk in itself, however any PPE worn, in particular protective clothing, will restrict the ability of secreted sweat to evaporate. The major thermal consequence of wearing PPE, in particular of wearing protective clothing, is that the garment or garments inevitably prevent the loss of metabolic heat from the wearer's body through the natural process of evaporation of sweat. The thicker and heavier the clothing worn, the greater will be the restriction on the body's natural cooling system. As the core body temperature rises, more sweat will be secreted and the sweat that cannot evaporate naturally will remain within the clothing and the inside of the clothing will become wetter.

It is unrealistic to expect that problems of Heat Stress can be reduced or eliminated solely by the design, weight, breathability and/or type of PPE used. PPE is just one of many factors that must be considered when seeking ways to reduce potential injury or death from Heat Stress.

Heat Stress and Firefighters

Because of the nature of the activities of firefighters and the probability of regular exposure to extreme physical and mental stress which will result in higher than normal core body temperatures and amounts of sweat, Heat Stress must be regarded as an on-going serious but inevitable health risk for firefighters and steps must be taken to reduce the risk of exposure to it. It is most unlikely that this risk can be completely removed.

The decision-making process is critical to Safety, particularly when in dangerous life threatening situations, conditions to which firefighters may be regularly exposed. As mentioned above, very small increases in core body temperature will lead to the onset of heat stress and from the Firefighters' point of view, perhaps the most serious aspects of this stress are the degradation of decision-making abilities and reaction times. This can result in injury or death to the Firefighter or to others and/or to unnecessary levels of damage to property and the environment.

In general terms, the form of heat stress that most firefighters experience is heat exhaustion due to them being committed and re-committed to firefighting and rescue work until the incident is resolved. Research indicates that the maximum time that a fit person should spend under intense exertion is in the region of 20 minutes. This is because a normal person absorbs about 1 litre of liquid in one hour through the cells in the different digestive organs. The body can be trained to be able to absorb more and some athletes such as marathon runners train specifically to do this. A person working in an intensely active environment will produce at least 2 litres of sweat in 20 to 30 minutes, but only about 0.5 litre can be replaced in the same time. If the person drinks more, this will be transformed rapidly into urine and will be lost for the organism. Therefore, a person subjected to such environments may have problems of dehydration, which may impair his/her performance unless s/he rests for in the region of at least 60 to 90 minutes to allow his/her organism to take up the liquid that was lost.

In situations of firefighting and rescue, a good measure of the potential length of exposure is the capacity of a nominal 30 minute Breathing Apparatus - if the person is working hard they will breathe out the air in one of these sets during a 12 to 15 minute period at which time they will have to withdraw anyway. In circumstances other than emergency response, for safety reasons, the person should not be re-committed until the core body temperature has cooled. However this rule tends not to be used where firefighters are concerned because by the nature of their work they have to be recommitted, on many occasions more than once. This is one of the very important reasons that health monitoring of firefighters is so important as is the need for firefighters to drink enough liquids before, during and after an incident.

In order to cool down the body, sweat has to evaporate as freely as possible, therefore, the time to bring the core temperature down to normal will depend on the evaporation rate. At incidents that are prolonged, a protected rest area should be provided where firefighters may rest and cool down after a period of high levels of physical activity. Where such a protected rest area is provided, the firefighter should remove his/her protective clothing and dress down to his/her underwear to accelerate the rate of evaporation.

Heat Stress and PPE for Firefighters

Most protective clothing for firefighters is specifically designed to reduce the transfer of heat from the incident to the body. In general terms, reducing the thickness of the clothing worn reduces the amount of metabolic heat retained, but it also reduces the level of protection provided and the level of risk of exposure may be increased. The correct balance between acceptable levels of comfort and protection can be difficult to achieve as so many factors must be taken into account. For example in temperatures such as are experienced in many Countries at various times of the year, exposure to cold is one of the risks that must be addressed and PPE providing a high level of insulation is chosen to ensure that firefighters are kept warm. But with high levels of physical work, this type of PPE will result in a quicker build up of core body temperature with the resultant risk of heat stress.

The choice of protective clothing for firefighters must be a compromise between the level of retention of metabolic heat and the protection required. The firefighter must always be properly protected against the risks that will be encountered so before any final choice of protective clothing is made, a detailed risk assessment, in which Heat Stress must be one of the risks taken into account, should be carried out. This choice must inevitably be linked to the tactics to be used in tackling an incident and to the enforcement of a strict system of Command and Control, not only at the time of incident, but throughout all the activities of the firefighter.

Coping with Heat Stress is not only related to balancing the protective abilities of PPE with the potential exposures and the duration of these exposures, but it is also very much dependant on the physical and aerobic fitness, experience, conditioning, mental attitude etc. of the firefighter. This is primarily an operational problem that must be resolved by risk assessment and work practices which must incorporate ongoing training, physical fitness, acclimatisation to heat and medical screening to ensure that the physical and mental condition of each firefighter is such that s/he is continually capable of dealing with what for most others, would be unacceptably extreme conditions of work. Firefighters who by their physical and/or mental condition at the time of an incident are not capable of withstanding the inevitable effects of Heat Stress must not be allowed become involved in what is likely to be a stressful incident.

Treatment of Heat Stress

The essential treatment of heat disorders other than a simple faint, is to reduce the body temperature. If, during prolonged heat exposure, sweat losses are replaced with large quantities of water it is possible to lower the sodium concentration in the blood. However using coolant alone to reduce heat stress may not be good – when coolant is applied, peripheral blood vessels in the skin can contract which will usually increase body temperature.

The importance of having suitable medical supervision and aid available at the scene of every incident where it is suspected that heat stress may occur cannot be overemphasised.

SECTION 2: SUPPORTING DETAIL

2.10 MANIKIN TESTING

Manikin is the technical term for an anatomically-formed model which is able to simulate and/or measure certain human functions. For PPE to protect against heat and flame, there are a number of Test Houses around the World which have Manikins that are used to test the effects of wearing different types of clothing and other items of PPE on the human body.

One of the best known of these is Du Pont's Thermo-Man® life-size instrumented test manikins, located in the USA and Switzerland. Thermo-Man® is designed to assess the fire-resistant properties of different fabrics and garments under realistic conditions of flame engulfment. It incorporates in excess of 120 thermal sensors at representative locations on its body which continually sample and pass the information to a special computer while Thermo-Man®, dressed in protective clothing, is exposed to a controlled propane flash fire. After an exposure, the computer prints out a "map" of the heat input received by the various body areas, which makes it possible to estimate which parts of the human body would have suffered 2nd and 3rd degree burns in such a flash fire if that particular type of clothing ensemble had been worn.

RALPH is the name of the manikin in BTTG, England, which is used to carry out similar tests and recently BTTG introduced a sister manikin to RALPH, this one, in female form, called SOPHIE. The original RALPH manikin has been updated and the new RALPH and SOPHIE are designed to assess the effectiveness of complete PPE ensembles in providing an adequate level of protection for the entire body of the firefighter under conditions of flame engulfment. To achieve this, the manikin has a higher concentration of sensors at PPE interfaces such as wrists, head and waist and Breathing Apparatus will also be assessed on the manikins.

HENRY is a life-sized manikin located in EMPA, St. Gallen, Switzerland which, like Thermo-Man®, RALPH and SOPHIE, is used to assess flame and heat protective clothing. HENRY has the added advantage of being able to include gloves and shoes in the tests although the evaluation of their protective efficiency is limited. By removing 2 sensors from HENRY's head region and replacing them with a burette, it is possible to analyse the combustion gas in the face region.

The computers to which manikins such as Thermo-Man®, RALPH, SOPHIE and HENRY are connected predict firefighter burn injuries when exposed to flame and can measure the protective performance of a variety of garments and clothing systems under realistic flash fire conditions in a manner that will allow factors such as garment construction, fabric weight, material type, garment style and fit and the impact of outerwear and undergarments to be taken into account. The information provided by this type of test can be a used to analyse properties of items of clothing when exposed to flame such as design and fit of the garments, shrinking behaviour, quality of the seams, fire behaviour of components like closure systems, retro reflective tape etc.

The purpose of such manikin testing is not to establish a standard design of a garment that will predict that there will be no burn injuries. One of its most useful functions is to allow comparisons to be made in a way that garment "A" can be directly compared with garment "B" under identical conditions. Comparisons can be made between different types of clothing design, construction, finish, etc. to improve levels of protection and to highlight weak areas in the design and content of garments. Other factors that might vary from manufacturer to manufacturer are e.g. length of legs, sleeves, height of collar, length of jacket etc. and the manikin flame engulfment test will give valuable information on the effects of these differences as well as seeing how different types and mixes of materials used in garments perform.

The manikin forms of these test rigs are built to similar sizes and shapes and so will not be able to predict effects that some persons might face during an incident i.e. those whose body measurements do not correspond to the measurement of the manikin because they are taller, shorter, overweight and “bulging” in places where the manikin is not etc. Manikin testing clearly identifies that in an ideal situation each firefighter should be individually measured for his/her own protective clothing in order to maximise protection.

It is important to point out that as there is currently no agreed International standard for such manikins, there are differences between each manikin around the World and so where comparisons are being made between different types/designs of garment, such testing should all be carried out on the same manikin.

As with all laboratory tests, these results cannot be taken in isolation and are not the only factors that should be taken into account in the overall evaluation of items of PPE, in particular of protective clothing. In an actual flashover situation, the heat protection of a garment is mostly due to air layers between the textile layers and the skin so body shape and fit of the protective garments will have a major impact on what will happen in such actual exposures e.g. if the garment is too tight around the waist, there will be a greater risk of burns in this region.

Another manikin located in EMPA, Switzerland, that is providing a growing amount of valuable information to manufacturers and users of clothing to protect against heat and flame is SAM, the Sweating, Agile, Thermal Manikin. SAM is an anatomically-formed manikin with the body dimensions of an average male adult, having limbs which can be moved and the ability to sweat. SAM simulates the heat loss, sweat production and realistic movements of the human body.

Distributed over SAM’s entire body surface, sweat outlets are supplied by a reservoir containing distilled water. Using internal microvalves, both vapour and liquid sweating can be simulated either over the whole body or over chosen body parts, with variable sweat rates corresponding to a person undergoing various workloads. Joints at the shoulders, elbows, hips and knees permit SAM to be articulated. The wrists and ankles are connected to external drive assemblies, which can move through various curves under computer control. Based on kinetic data, realistic movements for walking, climbing and running can be programmed for the measurements, with variable speeds up to 3 km/h. With the manikin positioned in a climatic chamber, environmental conditions such as temperature, humidity, wind, rain and radiation can be defined.

In real life situations, many factors other than the protective ensemble being worn will contribute to the survival or otherwise of a person exposed to a flash fire, factors such as fitness, mental attitude, age, training etc. so it is difficult to effectively translate the information gained from such testing into relevant information for the firefighter on the fire ground.

Tests such as those carried out on manikins cannot remove from the end user their ultimate responsibility – they must make the final choice of PPE to be used.

SECTION 2: SUPPORTING DETAIL

2.11 PERSONAL SAFETY

Employers have an obligation to ensure a safe work place for all their employees. In the work places of emergency services personnel during operational incidents this may not always be possible as their work place i.e. the site of an incident, may become hazardous due to unexpected occurrences. So particularly for firefighters and other emergency services personnel, efforts must be directed towards making each individual as safe as is reasonably practicable. This approach is known as the "Safe Person Concept".

Both the Organisation and the individual have responsibilities in achieving this status and some of the factors that should be taken into account include:

- The importance of maintaining a level of personal physical fitness.
    - This requires an understanding of the physical demands that are likely to be experienced during an emergency incident and how personal fitness improves operational effectiveness and health and safety and aims at promoting long term health and well being.
- The knowledge and understanding of the components of the PPE issued.
    - Different types of PPE provide protection for different parts of the body. It is important for users to have an understanding of the various features of the PPE issued.
- The awareness of Safety considerations to be taken into account when wearing and using PPE.
    - This includes the correct procedures for donning (putting on) and doffing (taking off) PPE, the limitations of the level of protection that the PPE provides, procedures to be adopted when PPE is contaminated, the potential for heat stress when using PPE etc.
- The knowledge of the necessary care and maintenance of PPE issued.
    - This includes being aware of inspection procedure before and after use, maintenance intervals, when PPE should be discarded etc.
- The necessity of having strict Health and Safety procedures at all stages of an Incident.

SECTION 2: SUPPORTING DETAIL

2.12 PRACTICAL PERFORMANCE TESTS

Some basic ergonomic features of PPE may be checked in simple practical tests. The practice of carrying out ergonomic assessments should verify that no major deficiencies in PPE exist and can lead to improvements in it. There are some simple questions on which to base development of practical performance tests suitable for particular Organisations.

NOTE: The detail in this Section of the Handbook is based on the relevant section of EN 340:2003 the CEN standard for General Requirements for Protective Clothing. The principles of EN 340 should be applied to the complete ensemble of PPE that is worn, not just the clothing. Particular attention should be paid to interfaces between different items of PPE.

Assessment questions

1. Is the PPE free from any sharp or hard edges, protruding wire ends, rough surfaces or other items on the inner or outer surface of the items of PPE that are likely to cause harm to the user or others?

   PPE should be inspected manually and visually to ensure no harmful features exist.

2. Is it possible to put on and take off the PPE without difficulty?

   The following points should be considered:

   - The ease of putting on and removing the PPE with or without assistance as is appropriate for the type of PPE.
   - The PPE is not too tight for comfort and deep breathing is not restricted and there is no blood flow restriction.
   - The PPE design at e.g. the armholes and crotch are appropriately proportioned and positioned.

3. Can the closures, adjusters and restraint systems be operated without difficulty?

   The following points should be considered:

   - The adequacy of the range of adjustments available.
   - The ease of operation and the security of closures and adjusters.
   - Whether the closures, adjusters and restraint systems appear strong enough to withstand the forces to which they are likely to be exposed during body movements and the tasks for which the PPE is intended.

4. Does the PPE cover the body area intended to be protected and is coverage maintained during movements ?

The following points should be considered:

- The adequacy of coverage of any specified protection zones by protective material or special constructions.
- Is coverage maintained during movements as extreme as it is anticipated a user would make ?

5. Can the following movements be carried out without difficulty?

   - Standing, sitting, walking, running and stair climbing.
   - Raising both hands above the head.
   - Bending over and picking up a small object such as a pencil.
   - Other movements specific to the job(s) to be undertaken in the work place of the Purchaser.

   The following points should be considered:

   - The arms and legs of the protective clothing should not be so long that they interfere with hand and foot movements.
   - The protective clothing should not be so loose that it flaps about or moves independently and inconveniently.
   - There should not be points at which unexpected and unintended gaps open up between or within components of the PPE, particularly at the interfaces at the neck, hands and feet.
   - There should not be any unreasonable restriction of movement at any joint.

6. Are the items of PPE compatible with each other ?

   The following points should be considered:

   - Each item of PPE that is normally worn as part of an ensemble should be compatible with representative examples of the rest of that ensemble.
   - Putting on and removing items of PPE such as gloves and boots should be possible without difficulty.

Grounds for concluding a product is unacceptable
The following are obvious reasons for concluding an item of PPE is unacceptable and not fit for use:

- Subjects it should fit cannot wear one or more items of the PPE for whatever reason(s).
- The closure system of the PPE does not remain secure when in use.
- The PPE does not stay in place when in use.
- A vital function such as breathing is compromised.
- It is impossible to carry out simple tasks.
- Movements that are essential to the work to be carried out are prevented.
- A subject refuses to continue the assessment due to pain or other reason(s).
- Items of the PPE ensemble are incompatible with each other.
- It is not possible to use equipment that is essential to be used to perform the work whilst wearing the PPE.

SECTION 2: SUPPORTING DETAIL

2.13 SIZING FOR PPE TO PROTECT AGAINST HEAT AND FLAME

Protective Clothing

Clothing to protect against Heat and Flame is most usually over-clothing and it should be designed to be of generous fit. Loose fitting garments contain more air than tight fitting garments and therefore provide a greater level of thermal protection.

European Standard EN 340:2003 "Protective clothing General requirements" deals with sizing of protective clothing to be sold in the European Union. It proposes an extremely effective and uncomplicated system which designates just 3 sizing parameters which are required for establishing the size of protective garment required - chest or bust girth, waist girth and height.

This system has been successfully used in Europe for many years and removes a great deal of the work and associated costs of providing detailed individual measurements. This system has proven that such detailed measurements are not required unless this is a choice of the Purchaser. It should be remembered that protective clothing is not usually tailored clothing and is used on most occasions as over-clothing.

EN 340:2003 Body dimensions for sizing protective clothing

No	Protective clothing	Control dimensions
1	Jacket. Coat. Vest	Chest/bust girth and height
2	Trousers	Waist girth and height
3	Coverall	Chest/bust girth and height
4	Aprons	Waist or chest/bust girth and height
5	Protective equipment (e.g. knee pads, back protectors etc.)	Chest/bust or waist girth or height or body weight or waist to waist over the shoulder length

EN 340:2003 does not rule out detailed individual measurement and indicates that the manufacturer can also designate additional measurements, e.g. the arm length, the inside leg length or the hip girth for women's garments. The standard identifies the parts of the body from where such measurements shall be taken and states that normal underclothing shall be worn for the measurement. It further states that the sizing intervals should ensure that a good fit is achievable on the majority of users and that there is specification of the degree of adjustment that is provided to ensure that the fit of the protective clothing is adequate on the range of users each size is intended to fit. The proportions and the dimensions of the protective clothing should reflect the needs of the users in the environments where it is to be used, with the clothing to be worn with it and performing the normal tasks for which it is intended.

Protective gloves

Sizing of gloves is not as simple as the system described above for sizing protective clothing. The manufacturer of protective gloves should provide a sizing system which specifies the range of wearer hand dimensions in terms of wrist and hand circumference and hand length or other end user hand dimensions that can be measured that is accommodated by each respective size. The sizing system should take into account the application of the glove and the relative fit preferred for that application. The purchaser should ensure that an adequate range of sizes of gloves are provided by the manufacturer/supplier to ensure that the protection of the hands of all persons likely to use the gloves is not compromised by a poor system of sizing and/or an inadequate range of sizes.

Protective footwear
Footwear that is too loose or too tight will affect mobility and performance. The manufacturer of protective footwear should provide a sizing system which specifies the range of wearer foot dimensions and the sizing system should take into account the application of the footwear and the relative fit preferred for that application. Based on the risk assessment, there may be a requirement for special types of socks to be worn under the protective footwear which could result in larger sizes of footwear than normally used being required. The purchaser should ensure that an adequate range of sizes of footwear are provided by the manufacturer/supplier to ensure that the protection of the feet of all persons likely to use the footwear is not compromised by a poor system of sizing and/or an inadequate range of sizes.

Users should ensure that their footwear adequately fits by assessing their ability to perform tasks while wearing the footwear. Users should initially be fitted with the appropriate size footwear by checking their feet dimensions against manufacturer's recommendations, but they may have to measure and/or try on different sizes to find the “best” fitting footwear.

Protective helmets
Badly fitting helmets can seriously affect balance and it can be dangerous for a person when engaged in hazardous activities to wear a helmet that does not fit correctly. So care must be taken to ensure that all users are correctly protected by helmets that fit.

Protective helmets for firefighters usually have a retention system which allows adjustment to secure the helmet in position on the head and is intended to provide improved comfort. A chinstrap is an optional part of a retention system which helps ensure that the helmet is correctly maintained in place.

The use of an adjustable retention system is regarded by some manufacturers as providing a “universal fit” for all and the user is responsible for adjusting to suit. However adjustable retention systems of some helmets have been found to be inadequate for heads that might be smaller or larger than what are regarded as “normal” head sizes. To cater for these for this, some manufacturers of helmets provide more than one size helmet.

As with protective gloves and footwear, the purchaser should ensure that an adequate range of sizes covered by the helmet and its retention system are provided by the manufacturer/supplier to ensure that the protection of the head of all persons likely to use the helmets is not compromised by a poor system of sizing and/or an inadequate range of sizes.

Users should ensure that their helmet adequately fits by assessing their ability to perform tasks while wearing the helmet.

Respiratory protective equipment (RPE)
The main requirement in sizing RPE is to ensure a correct fit for each user. Firefighters normally use full face masks which fall into the category of tight fitting facepieces. The performance of these type of facepieces relies heavily on the quality of fit of the facepiece to the wearer’s face. An inadequate fit will significantly reduce the protection provided to the wearer.

To ensure effective protection for each person using RPE, it is crucial to have a good mask fit for each person. This is achieved through regular face fit testing which is a method for checking that a tight fitting facepiece matches the person's facial features and seals adequately to the wearer’s face.

Face fit testing is also useful for checking that a wearer can put on a respirator facepiece correctly. Correct fitting of the facepiece at all times is vital to prevent exposure.

For RPE to be suitable it must be matched to the job, the environment, the anticipated exposure level and the wearer. As people come in all sorts of shapes and sizes it is unlikely that one particular type or size of RPE facepiece will fit everyone. Employers need to ensure that the make, model, type, material and size of facepiece that their employees wear, when successfully fit tested, is made available for use and is maintained in a clean and efficient state. If an employee wears more than one type of tight fitting facepiece then each type of facepiece should be subjected to fit testing.

The performance of tight-fitting facepieces depends on achieving a good contact between the wearer's skin and the face seal of the facepiece. Inadequate fit will significantly reduce the protection provided to the wearer. Any reduction in protection can put the RPE wearer's life in danger or may lead to immediate or long-term ill health.

It is vital to emphasise that facepiece fit testing is not intended to assess the extent of protection afforded by the RPE on a daily basis in the workplace or to assess the quality of maintenance of the wearer's own RPE. Face fit testing is not the same as RPE performance testing. Performance testing includes thorough examination and testing by a competent person.

SECTION 2: SUPPORTING DETAIL

2.14 STANDARDS

A product standard is a document established by consensus, specifying nationally recognised or internationally agreed properties for manufactured goods. Specific product standards define a series of performance levels, in which a higher number corresponds to a higher performance. Standards provide uniformity of approach to design and testing on the part of manufacturers. Standards for PPE contain a series of laboratory tests to establish that the material being used in the item of PPE concerned will meet the minimum performance requirements set for the intended use of the PPE. These requirements could include performance when for example exposed to a source of radiant, convective and/or contact heat and/or flame, when exposed to chemical splash, the tear strength of the material, its tensile strength, etc. etc.

Standards are not intended to replicate work place hazards but are developed to provide a means of testing to specified performance requirements. On many occasions this results in a cobbling together of a number of different performance characteristics for which there are reproducible test methods. Many standards do not provide the comprehensive mix of protective properties that are required in the Work Place and indeed some of them are positively deficient.

Every end-use is different, and no test method can fully replicate them. In particular, combinations of hazards are not usually considered in test standards and therefore there can be no guarantee that an item of PPE which rates highly in any test method will be able to provide adequate protection on the job in the work place. Thus, PPE should be selected with a full appreciation of the conditions and tasks related to the end-user process, taking account of the risk(s) involved and of the data supplied by the manufacturer in relation to the performance of the item of PPE against the hazard(s) in question.

In many tests, the levels of exposure to which PPE may be subjected without damage are far higher than those to which the human body can be exposed, so it is important, in particular when dealing with PPE to protect against mortal danger, that only persons properly trained in techniques to deal with the hazards to which they are likely to be exposed and with knowledge of the proper selection, fit, use, care and limitations of the PPE supplied, should use it.

Because PPE is tested and certified to the stated Standard for the PPE concerned does not necessarily mean that it is safe and suitable for purpose. It is important that purchasers and users make themselves aware of the content of the standard concerned and the performance characteristics to which the product has been tested.

In the context of PPE, there are three main standards-making bodies in the World:

- In Europe, CEN, whose Members comprise the National Standards Bodies of the Countries in the European Union and the European Free Trade Association. EU Member Countries must accept CEN Standards as National Standards without any alteration.
- In the USA, ANSI is the American National Standards Institute which co-ordinates the voluntary consensus standards development system. Standards are developed by more than 20 Government Agencies e.g. Food and Drugs Administration (FDA), Department of Defence (DOD) and more than 400 private sector standards developers scientific organisations, trade associations and standards development membership organisations e.g. ASTM, NFPA.
- Internationally, ISO, the International Standards Organisation, whose Members are National Standards Bodies from all over the World.

Each of the three aforementioned standards making bodies develops its own standards for new PPE to protect against heat and flame. Unfortunately, on many occasions, there are divergences in test methods and minimum levels of performance between standards for the same items of PPE from each Body, so users are left in a quandary as to what performance levels they should use. The answer, as emphasised throughout this Handbook, should be established by user risk assessment to ascertain the levels of protection that are required for the work to be carried out in the user's workplace.

Under best health and safety practice – and under European Union Law - the responsibility for the choice of PPE to protect workers against foreseeable risks during the task(s) to be carried out falls squarely on the shoulders of the employer who is required to carry out a risk assessment of the work place. If protection is not provided by the PPE for one or more of the risks that have been identified in the risk assessment and these risks are not removed from the work place of the employee, then the decision on the type of PPE to purchase is not complete.

Standards only specify minimum levels of performance and users must rely on their own risk assessments to identify the specific hazards involved and the levels of performance required in their own work place and they should make their specific requirements known to the manufacturers of the particular item(s) of PPE before they purchase.

If purchasers and users are going to rely on compliance with standards to provide PPE that is suitable in the workplace, the risk assessments made should be compared with the performance requirements of the standard concerned to ensure that they are relevant. The real "expert" when user safety is at stake is not the standards-maker, it should be the user. The user should be dictating what happens in the committees writing and revising standards because ultimately the user is left with paying the bill for compliance or for legal damages when PPE is found in an accident to be non-compliant.

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List of Standards for PPE for Firefighters

Note: The standard used should be the most recent edition.

Item of PPE	Standard Number		
	CEN	**NFPA**	**ISO**
Head Protection			
Helmet	EN 443	NFPA 1971	None
Fire Hood	EN 13911	NFPA 1971	None
Face Protection			
Faceshield &Visors for Firefighters	EN 14458		None
Body Protection			
Work Wear / Station Wear	EN 531	NFPA 1975	ISO 11612
Wildland Clothing		NFPA 1977	ISO 15384
Firefighters Clothing	EN 469	NFPA 1971	ISO 11613
Firefighters Reflective Clothing	EN 1486	NFPA 1976	ISO 15538
Hand Protection			
Firefighters Gloves	EN 659	NFPA 1971	ISO 15383
Foot Protection			
Firefighters Boots	EN 15090	NFPA 1971	None
Respiratory Protection			
Face masks	EN 136 Class 3	NFPA 1981	None
SCBA	EN 137	NFPA 1981	None

APPENDIX 1 SOME SUGGESTED DEFINITIONS RELEVANT TO PPE TO PROTECT AGAINST HEAT AND FLAME.

Abrasion resistance test:
- mechanical test for materials that attempts to simulate the durability of fabric when subject to wear.

Accessory:
- optional part of an item of PPE which is removable without the use of tools.
- accessories (in the context of Protective Clothing)
  - non fabric items forming part of or optional extras in a garment e.g. metal or plastic buttons or fasteners etc. (See Hardware).

Aramids:
- family of polymers with inherent protective properties useful in heat and flame protection.

Body:
- all parts of the human including head, hands, arms, legs, feet and torso.

i. - upper body protective garment
   garment designed to protect the body from above the waist line extending to the neck/shoulder including the arm and wrist but excluding the hand.

ii. - lower body protective garment
   garment designed to protect the body from below the waist line including the legs and ankles but excluding the feet.
   <u>NOTE</u>: The waist line is the horizontal line marking the level of the top of the hip bones.

Break-open:
- formation of a hole in material caused by material shrinkage during thermal exposure.

Breathing Apparatus:

i. - equipment which enables the wearer to breath independently of the ambient atmosphere.

ii. Compressed air breathing apparatus:
   - equipment which is not self contained and in which the wearer is supplied with breathable air from a source of compressed air. Abbreviation: CABA.

iii. Positive pressure SCBA:
   - self contained breathing apparatus in which the pressure inside the facepiece remains positive during inhalation and exhalation.

iv. Self contained breathing apparatus:
   - equipment which is self contained, where the breathing gas supply is carried by the wearer. Abbreviation: SCBA.

Burn Injury:

i. - burn damage which occurs at various levels of depth within human tissue and is categorised as 1st, 2nd and 3rd degree burns.

ii. Predicted burn injury:
   - measurement used in the manikin flash fire testing of clothing which is the sum of the areas represented by the sensors with predicted 2$^{nd.}$ and 3rd degree burn injury.

CEN:
- the European Committee for Standardisation. Its Members are the National Standards Bodies of States in the EU and the European Free Trade Association (EFTA).

Char:
- formation of a carbonaceous residue as a result of incomplete combustion.

Closure system:
- method of fastening the openings in a garment including combinations of more than one method of achieving a secure closure. Note : This term does not cover seams.

Clothing assembly:
- series of outer and under garments to be worn together.

Clothing ensemble:
- combination of two or more garments that collectively provide protection to the body.

Coat – protective coat:
- outer garment covering the body from the neck to below the knees, including the arms.

Component:
- any material, part or sub-assembly used in the construction of an item of PPE.

Component assembly:
- combination of all materials of a multi-layer garment presented exactly as the finished garment construction.

Coverall – protective coverall
- one piece garment that completely covers the Wearer's torso, arms and legs.

Cuff:
- finished edge of the sleeve opening.

Doffing:
- taking off clothing or anything worn.

Donning:
- putting on clothing or anything worn.

Fabric / Fabric component:
- any pliable, natural or synthetic material(s) or combination thereof, made by weaving, felting, forming or knitting.

Facepiece:
- component of SCBA and/or a respirator that at least covers the wearer's nose, mouth and eyes.

Filter:
- device which removes specific contaminants from the atmosphere passing through it.

Fire Hood:
- see below under "hood"

Firefighters' gloves:
i. - specific gloves providing protection for the Firefighters hands and wrists.
ii. Gauntlet:
  - circular, flared, or otherwise expanded part of the glove that extends beyond the opening of the glove body to cover the wrist area.
iii. Glove body:
  - the part of the glove that extends from the tip of the fingers to approx. 25 mm. beyond the wrist crease.

iv. Wristlet:
- circular, close fitting part of the glove, usually made from knitted material, that extends beyond the opening of the glove body to cover the wrist area.

Firefighters' PPE:
- specific items of PPE providing full body protection for the Firefighter. This term includes suitable respiratory protective equipment.

Firefighters' protective clothing:
- specific garments providing protection for the Firefighters upper and lower torso, neck, arms and legs but excluding the head, hands and feet.

Flame resistant material (also referred to as F.R. material and material of limited flame spread)
- term used to describe a material that resists combustion or is self extinguishing after removal of an external source of ignition.

Flame retardant treatment:
- treatment which is added topically to fibres and fabrics with the aim of reducing the flammability of the Material. F.R. treatment is self extinguishing.

Flash fire
- sudden large scale flame or heat blast at extremely high temperatures.

Flashover:
- rapid escalation of a fire resulting in a sudden large scale flame or heat blast at extremely high temperatures with accompanying pressure waves that can destroy building structures.

Garment
- single item of clothing which may consist of single or multiple layers.

Goggles:
- device used to provide limited eye protection.

Hazard:
i. -something with the potential to cause harm.
ii. -potential injury and/or damage that could occur to an individual in a particular situation.

Hardware:
- non-fabric items used in protective clothing including those made of plastic or metal, e.g. fasteners, rank markings, buttons, zippers. (See Accessories)

Heat Flux:
- thermal intensity indicated by the amount of energy transmitted per unit area and per unit time.

Helmet:
i. - headgear worn to protect the head e.g. from falling objects.
ii. Brim:
- ridge protruding outwards from the basic shape of the helmet shell forming its lower edge.
iii. Chinstrap:
- type of retention system which passes underneath the wearer's chin and which helps to ensure that the helmet is correctly maintained in place.

iv. Earflaps:
- integral part or accessory of the helmet which protect the ears of the wearer.

v. Facepiece fixing:
- system enabling a facepiece of a respiratory protective device to be fixed to the helmet in such a way that correct sealing around the face is achievable.

vi. Neck guard - also known as neck curtain:
- integral part of or accessory for a helmet which protects the back of the neck from water or other liquids, materials and from radiant heat.

vii. Helmet shell:
- component which gives the helmet its general shape and on which may be fixed various accessories.

High visibility clothing:
- warning clothing intended to provide conspicuity at all times.

Hood:
i. - item of PPE made from textile which covers the head and neck. Certain types of hood may also cover the shoulders.
ii. - Fire Hood:
- balaclava style garment worn directly in contact with the head to protect exposed parts of the head and neck that are not covered by protective clothing, breathing apparatus and helmet.
iii.- Fire Hood Yoke:
the area of the Fire Hood interfacing with the protective clothing that covers the upper torso.

Hydrophilic:
- can readily absorb water/moisture.

Hydrophobic:
- has little or no ability to absorb water/moisture.

Ignition:
- initiation of combustion.

Inherent Flame Resistance:
- flame resistance that derives from the combination of chemical components which are an inseparable part of the fibre from which a fabric is manufactured.

Innermost lining:
- innermost face of a component assembly closest to the wearer's skin. Where the innermost lining forms part of a material combination, the material combination shall be regarded as the innermost lining.

Integral part of an item of PPE:
- part which cannot be removed from an item of PPE without the use of tools.

Interface Area:
- area of the body where items of PPE meet and/or overlap.

Interface Component:
- item(s) designed to provide limited protection to interface areas.

Interlining:
- layer between the outermost layer and the innermost lining in a multilayer garment.

ISO:
- the International Standards Organisation.

Material assembly:
- two or more separate layers of the same or different materials.
Note: A material assembly test specimen represents or is taken from the various layers in a single garment or in a series of garments in a clothing system, assembled in equal size and in the order of use.

Material combination:
- material produced from a series of separate layers, intimately combined prior to the garment manufacturing stage, for example a quilted material.

Moisture barrier:
- part of the component assembly of a protective garment which prevents the transfer of liquids.
Note: Moisture barriers might not prevent the passage of some chemical, biological or radioactive agents and appropriate PPE should be provided to protect the Wearer in such incidents.

Multilayer clothing assembly:
- series of layers of garments arranged in the order as worn. It may contain multilayer materials, material combinations or separate layers of clothing material in single or multiple layers.

NFPA:
- the National Fire Protection Association (USA).

Notified Body
- a testing laboratory, sometimes known as Test House, approved by a member state of the European Union responsible for the execution of the certification procedures referred to in European Directive 89/686/EEC on the approximation of the laws of the Member States relating to Personal Protective Equipment.

Outer material:
- outermost material of which the item of clothing is made.

Overboots: (in the context of Protective Clothing)
- single or multiple layers of material covering the footwear to provide protection against specific hazards. Certain types of overboots used for this purpose may also cover parts of the legs and/or ankles.

Padding:
- materials which serve to dampen shock impact energy and/or comfort materials which serve to improve the comfort for the wearer.

Personal Protective Equipment - (PPE):
- equipment which is intended to be worn or held by a person at work and which protects them against risks to their health or safety, and any addition or accessory designed to meet that objective.

Reflective protective clothing:
- protective clothing relying on the ability of the outer material to reflect radiant heat.

Retention system:
- means of securing an item of PPE in the correct position on the body.

Risk:
- the product of *probability* of the occurrence of a hazard in a particular situation and he *consequences* or extent of harm to the individual to be expected from the hazard.

Seam:
i. - any method of permanent fastening between two or more pieces of material.
ii. Main Seams
- Seams that are necessary for the integrity of the garment.

Shrinkage:
- decrease in one or more dimensions of an object or material.

Station Wear
i. - sometimes known as Work Wear or Protective Work Wear.
ii - garments that are intended to be worn by persons at their work place. They can be protective garments or garments designed to give a corporate or sectional identity or both.
iii - protective station wear / work wear has properties to protect against exposure to hazards in the work place that have been identified by a risk assessment.

Suit – protective suit
- upper and lower garment worn together that completely covers the Wearer's torso, arms and legs.

Thermal Barrier:
- part of the component assembly of a protective garment designed to provide thermal protection.

Thermal protection:
- property characterising overall protective performance of an item of PPE in reducing transfer of heat.

Thermal Protection Index (TPI):
- total thermal energy which results in heat transmitted through a material at a level to just cause a second degree burn in human tissue.

Thermal Threshold Index (TTI):
- term used in testing materials to indicate the time in seconds for the heat transmitted through a material to begin to cause second degree burns in human tissue.

Torso:
- trunk of the human body
- human body without arms legs and head.

Trim
- term used in North America to refer to high visibility material

Wicking
- the ability of certain materials to convey liquid by capillary action.
Anti-wicking barrier:
- material used to prevent the transfer of liquid from outside a garment to inside the garment, usually in addition to or replacing part of the moisture barrier at the edge(s).

Work Wear
- sometimes known as Station Wear. See definition under Station Wear above.

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APPENDIX 2 SECTION INDEX

APPENDIX 3 ABOUT JOIFF

J O I F F

The Organisation for Emergency Services Management

The overall aim of JOIFF is to work to improve standards of safety and of the working environment in those sectors in which its members operate. Full Membership of JOIFF is open to any organisation that has nominated personnel as emergency responders who provide cover to industrial/commercial organisations. Corporate Membership is open to Organisations which do not fully comply with the requirements for full membership but who wish to support JOIFF. The member is represented in JOIFF by nominated personnel.

Membership of JOIFF offers the following:

1. Shared Learning: JOIFF aims to fill the information vacuum that exists in the Industrial/ Commercial Sectors represented by its members, by sharing valuable information through its email cascade amongst all its membership and to work to ensure that members benefit from the misfortunes of some to ensure that the same mistakes are not repeated. An archive of all this information is available to Members for reference purposes through a password system, on the JOIFF website.

2. Accredited Training: Through its Training Standards Committee, JOIFF has developed a series of training courses/programmes which it has accredited. Courses/programmes are carried out at JOIFF approved training establishments and in modular form on company sites under the supervision of JOIFF approved instructors. All Courses must be consistent with the agreed JOIFF syllabi, site and instructor requirements.

3. Information dissemination:
JOIFF publishes a quarterly newsletter called The Catalyst which can be downloaded from the JOIFF website. JOIFF organises seminars, conferences and workshops on subjects of interest to JOIFF Members. The members section of the JOIFF website is regularly updated with matters of interest to Members.

4. Technical Advisory Group:
JOIFF participates in advising Governments and other organisations on policy making matters that effect its members with a view to improving standards of safety and of the working environment in Industry worldwide.

JOIFF welcomes applications for Full and Corporate Membership.

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