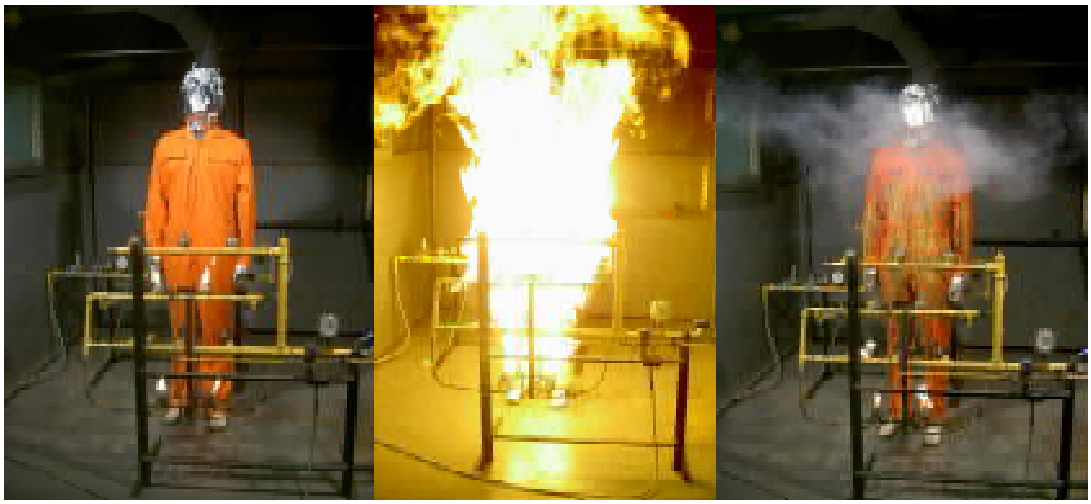
FlamePro®

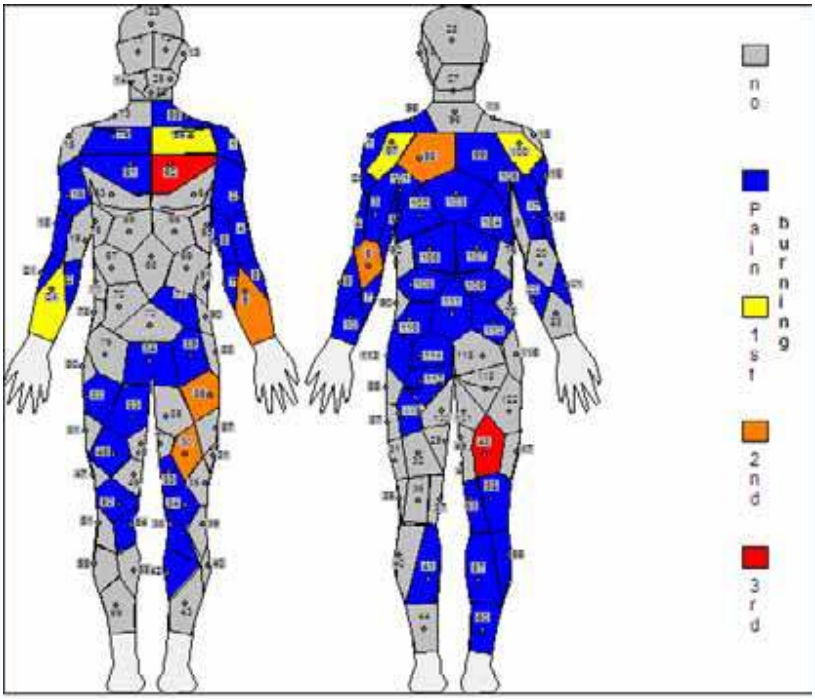
PPE (*Personal Protective Equipment*) at Work

Manikin Testing

FIRE TESTING
BTTG MANIKIN



We currently use the new manikin developed by the British Textile Technology Group, Fire Technology Services in which a manikin with a total of 132 sensors are distributed over the head, torso, arms and legs on the surface of the manikin to monitor the temperature. During a test the manikin is engulfed by flames from 12 burners, in 2 layers of 6 surrounding the manikin in a hexagonal pattern with the manikin in the centre giving a mean heat flux of 84kW/m² for an 8 second duration. From the temperatures recorded during the test **predictive** 'percentage burn injury' at Pain 1st, 2nd and 3rd degree levels is calculated. The various sensors reaching these thresholds and the percentage area of the body affected is plotted on a diagram of the manikin.

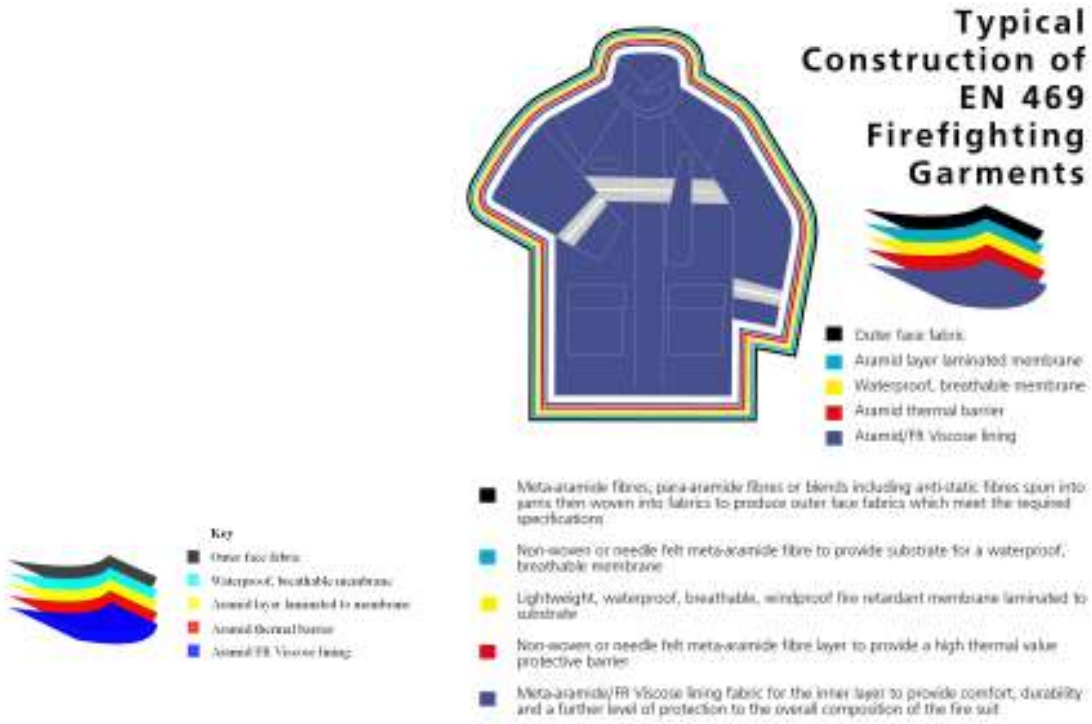


Level of burn Burn injury (%)
Pain 19.5
1st ° Burn 2.5
2nd ° Burn 16.3
3rd ° Burn 16.3

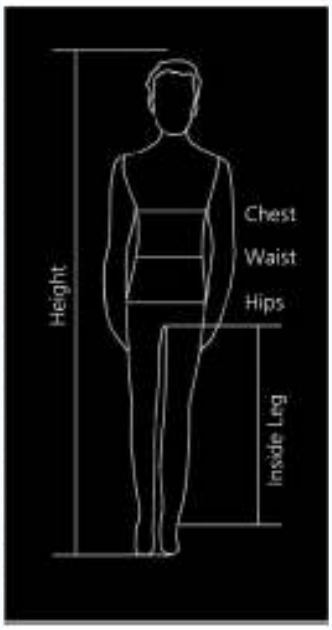
Burn injury diagram 10 Male manikin – firefighters garment test 1

Firefighting Garments to ISO EN469:2005

Garment Construction



Garment sizing



Garment design

The design of a firefighters garment should take into account factors such as size and fit. Because of the dichotomy between thermal protection from radiant heat and the need to alleviate heat build up from convective heat the garments should be designed in such a way that a positive air flow is generated to remove unwanted heat inside the garments. Provided air can permeate the inside of a garment, inside the non-air permeable moisture barrier a 'bellows' or 'chimney' effect can be created and it is therefore absolutely essential that the garments be relatively loose fitting, particularly around the hem of the jacket.

All garments worn in the workplace should be 'fit for purpose'. Good design is fundamental if the wearer is to feel comfortable whilst at the same time wearing garments that meet all essential PPE regulations. A reputable garment manufacturing company can offer designs from a wide range of models including bespoke modifications to existing designs or a complete design service from scratch. Distributors as a general rule can only offer 'off-the-shelf' products, this is not to say that such garments will be in any way inferior as regards quality and conformity but where they may suffer by comparison with a manufacturer is in selling only standard garments at a higher price, although generally being able to offer a stock item on demand. Garment design may be proscribed through type and end use but even in this area good design can still play an important role in the area of comfort.

Technical Files

The technical file relates to the style of garment, type of garment, code number of garment, illustration of garment and a size chart. The file will also contain specifications and test certificates (where relevant) for all fabrics, materials and components together with data relating to the manufacturer of all fabrics, materials and components. A copy of the relevant test certificate and the EC Type Examination certificate should also be included in the file.

End-user applications & Risk assessment

In the case of PPE the end use of the garment will be determined by the type of work being undertaken and how that work is to be performed. The type of conditions that relate to the work being carried out is dependent upon a number of factors most of which will be apparent in the nature of the job. However,

variable conditions such as weather, time of day, state of health and hours already worked or to be worked all play a bearing on how PPE is to be used.

Understanding Risk Assessment

I write as the Managing Director of a designer, manufacturer and distributor of PPE garments and ancillary products to attempt to clarify some misapprehensions about the role of risk assessment in the selection and use of PPE products.

Risk assessment is not something to be frightened about, it is in essence a relatively simple to understand process or series of processes designed to help to identify areas of potential risk to the workforce in your workplace. I use 'your' workplace since all workplaces differ in some respect or another and 'your workplace' is therefore specific.

The legal obligation placed on employers is one of 'duty of care' to the workforce employed under the relevant Health & Safety Regulations. The legal obligation placed upon the manufacturers of PPE is conformity to 'The Personal Protective Equipment Regulations 2002' (Statutory Instrument 2002 No. 1144). It can be seen therefore, that the obligations under these regulations mean that the users and suppliers of PPE must act in concert if the workforce is to be properly protected.

As a company, we take our legal responsibilities very seriously and therefore take all steps necessary to ensure that our products conform to the legislation currently in force for the products we sell. In many cases we design our own products, in these cases we ensure that our products conform to end user requirements. I other cases we supply products from 3rd party suppliers, in these cases we ensure that such products also conform to end user requirements.

As a matter of company policy we have always taken the view that the manufacturer of any form of PPE (as determined under the PPE Regulations 2002) is ultimately responsible for the products they sell and we are also of the view that, if there are any questions to be raised concerning suitability for use they should always be directed at such a manufacturer. As a company, we always ensure that users talk directly to manufacturers as a matter if principle. It may be worth bearing in mind that talking directly to any responsible manufacturer of PPE is the best way of being reassured that you are purchasing products that meet your requirements. As a PPE supplier we will provide you with any such contacts without obligation as an 'arms length' service.

It can be readily seen from the information above that dialogue between user and manufacturer/supplier is of primary importance. If your company is a member of JOIFF it would be a good idea to request a copy of the JOIFF Guidance Handbook on PPE to protect against Heat & Flame, even if the PPE you require is not for protection under that particular requirement. The Handbook provides guidelines to help you to assess the specific level of risk that your employees require; using the guidelines you can make your own assessment and then contact me for further information to assist you in locating the correct products for your needs.

Choice of materials and components

The choice of materials and components is very wide. Conformity to regulation is fundamental but within this constraint there are usually a number of competing products all meeting the standard. Once again, reputable garment manufacturers will generally choose products that have a good reputation in the market across a number of attributes; - quality, durability, performance, supply/service, technical back-up, after care, and value for money. Meeting the standard is only one element in choosing the best combination of properties required in the provision of the right product. The Specifier has to ask a number of questions in setting the criteria needed to meet the level of expectation intended; over what

time scale is it intended the PPE should perform, what type of care/laundering is to be applied, what is the inspection regime to be, over what length of time is the product to be stored and are full instructions included to cover the materials and components.

Quality assurance

In the case of garment manufacture to meet the PPE regulation the international standard for quality assurance is governed by certification to ISO9001.2000. It is always advisable to specify products from manufacturers who qualify for this standard and whose certification and audits are fully up to date.

Labeling/care/tracking

All garments must carry full details of the product (see Annex 7.1 below) including wash/care labels. It is of the utmost importance that strict attention is paid to the information contained in these labels and also in the information supplied by the manufacturer (see: 8.1 above). If such instructions are not followed correctly the garment may be rendered unfit for purpose and may not subsequently provide the level of protection for which it was first intended and certified. On a pragmatic note, it is also worth bearing in mind that if a garment is properly cared for it will, in all probability save money in the long run by extending its useable wearer lifespan.

Manufacturers guarantees

Most reputable manufacturers will give guarantees against the workmanship and quality of their garments. In such cases there is a tacit understanding that the materials and components used in the garment specified have been used to the suppliers recommendations and that care has been taken of the garments by the user as documented in labels and information provided. In some cases it may be necessary for the garment manufacturer to refer complaints to the OEM and ask for written tests or opinions to be supplied in the case of product failure or non-performance to certified standards.

Some types of fire or flame retardant fabrics

Flame retardant finishes

These finishes are applied to fibres which are not inherently flame retardant (FR). The fibres are spun and woven into fabrics, FR additives based on phosphazene derivatives and other commercial agents are applied to the woven fabrics as part of the finishing processes to produce an FR fabric. These additives, when applied to viscose rayon or cotton change the thermal properties of the fibres to produce a fire retardant finish. Viscose and cotton fibres are highly absorbent and so will accept high levels of the FR additives which are 'fixed' in the finishing processes to give good levels of durability.
Ignition takes place when the following conditions occur, as represented by the fire tetrahedron; fuel, oxidizer, heat and a chemical chain reaction, the removal of one or more of these components will cause combustion to cease.
'The cause of ignition is the flammable low molecular weight (of) substances evolved during the thermal decomposition process. The case of material ignition depends on the nature of the vapours and gases being formed. With cellulose one observes a high yield of the volatile thermal decomposition products, reaching 80-90%. The FR additives used must influence the combustion process so as to produce substances which do not support the flame. In an extreme case these retardants direct the pyrolysis process in such a way that the decomposition of cellulose during the combustion results in the formation of the end products, i.e. carbon, carbon dioxide and water before the formation of flammable products." *Journal of Thermal Analysis, Vol. 1. Thermal Properties of Flame Retardant Viscose Fibres* – B. Laszkiewicz and H. Struszczyk

Viscose Rayon

Viscose rayon was the first of the man-made fibres and was designed to be used as a substitute for cotton, silk and linen. The fibres are made from cotton or wood pulp which is rich in cellulose. They are processed and turned into pure cellulose which is then soaked in caustic soda and aged for 2 to 3 days under controlled temperature and humidity conditions. Liquid carbon disulphide is added which turns into cellulose xanthate, this is then dissolved in a weak solution of caustic soda and transformed into viscose. The viscose is then subject to further treatment by forcing filaments of the viscose through sulfuric acid which in turn forms pure regenerated cellulose filaments which can be spun to make filament yarns
When used in garments viscose rayon has good dye fastness and generally good resistance to uv, it possess good drape characteristics and heat conductivity and is therefore good for summer apparel. FR Viscose is widely used as a fibre blended with inherent FR fibres to reduce costs and improve the drape and feel of the woven fabric.

Cotton

Cotton has been used for hundreds of years and its properties are widely known and understood. There are many qualities and many blends which make a variety of fibres suitable for a wide range of applications. For the purposes of discussing FR workwear and protective clothing the fibre blends most appropriate to these end uses is polyester generally in blends of 70/30 CO/PES or high tenacity nylon 85/15 CO/PA or with higher cotton content. The polyester or nylon adds better durability and abrasion resistance, greater strength and improved wash/care properties. The high cotton content is necessary because of its absorbent properties which allow greater take-up of the FR additives. When compared with FR inherent fabrics cotton, polycotton and cotton/nylon are heavier by weight of fabric and have a tendency to a greater shrinkage rate. The fabrics are however, hard wearing with good strength characteristics, reasonable dye fastness and washing properties and are widely used in industrial workwear.
Some of the FR Cotton/Polycotton fabrics available are; - Proban®, Indura®, Flacavon and Pyrovatex®.
● Note: There are many so called FR products currently being manufactured in China and India, it's important that the provenance of such products is checked thoroughly to be certain they conform to the relevant standard.

Meta-aramid; Para-aramid

The Federal Trade Commission definition for aramid fiber is: A manufactured fiber in which the fiber-forming substance is a long-chain synthetic polyamide in which at least 85% of the amide linkages, (-CO-NH-) are attached directly to two aromatic rings.

These fibres are commonly known by a number of trade names: - (meta-aramid) Nomex, Kermel, PBI and Technora; (para-aramid) Kevlar and Twaron. They have high tenacity and elastic modulus with an ultra high molecular weight and are inherently fire retardant. Meta and para aramid fibres can be readily blended with each other to provide the desired range of properties required for woven fabrics. Fabrics made from blends of these fibres possess improved properties by comparison with other FR fabrics. They generally are relatively light weight and very hard wearing although they are very expensive i.e. from 200% - 400% more than Modacrylics - FR Cottons and not readily available as stock fabrics. Garments made from these fibres have excellent laundering properties with minimal shrinkage, good dye fastness and reasonable handle although care should be taken with prolonged exposure to direct sunlight for extended periods.

Modacrylic Yarns

Fibres are composed from modified acrylics where acrylic fibres are a type of plastic manufactured from 'long-chain synthetic polymers composed of at least 85% by weight of acrylonitrile units'. The acrylic fibres are modified by acrylonitrile in combination with other polymers. There are many methods of manufacture each a closely guarded process by individual manufacturers but all modacrylics have excellent flame resistance being difficult to ignite and self extinguishing when the flame source is removed. When used in garments fabrics woven from Modacrylic yarns exhibit good laundering properties with little or no shrinkage, they have good colour fastness and abrasion resilience but can be susceptible to piling when roughly rubbed. These yarns do not generally possess good abrasion resistance so cotton is added to improve yarn strength, the yarns are however provide good comfort values and have positive moisture regain making garments manufactured using modacrylics comfortable to wear. In workwear garments Modacrylic fabrics are generally heavier than those of the meta-aramid family but they do provide good, all-round properties. They are generally unsuitable for firefighting garments to EN469:2005. The leading brand for these types of fibres is Protex®

Moisture Barriers

The purpose of the moisture barrier is to provide protection against liquid water penetration through the outer fabric of the ensemble. I many instances these waterproof, breathable barriers also provide protection against some type of liquid chemical penetration and also the transmission of blood borne pathogens such as Hepatitis B and similar pathogens. The actual moisture barrier is a thin membrane, typically 10 – 20 micron which acts to prevent water molecules passing through but which allows the passage of water vapour to enable a degree of breathability. These membranes are relatively fragile and therefore need to be laminated to some form of carrier or substrate. This substrate can be a knitted, woven or non-woven structure and is composed from meta-aramid fibres. The resultant structure incorporates both a waterproof and thermal barrier to this layer of the composite structure of firefighting suits. Some well known brand names manufacturing moisture barriers are; - Goretex® Fireblocker®, Sympatex® Fireblocker®, Proline®, Stedfast® 4000.

Thermal Linings

The purpose of the thermal barrier is to protect the wearer from convective heat. Such barriers are generally water entangled non-wovens or needle felts although there are also woven layers incorporating Kevlar® strips or silicon bubbles to improve thermal protection. Regardless of the design of these barriers they are all constructed using meta-aramid or combinations including para-aramid. These barriers function by creating a high ratio of air to fibre and, because air is a poor conductor of heat they therefore provide good thermal insulation. The dichotomy attached to thermal insulation is that, whilst protecting the wearer from radiant heat these linings also act to retain heat generated by the human body. The amount of body heat generated fluctuates according to the work load being undertaken and during periods of high exertion this can equate to heat stress which in turn can have an adverse affect on individual performance (see: garment design) Some well known brand names are; - Freudenberg Fireblocker®, Proline®, Duflo®, Goretex® Airlock®.

Lining Materials

The final component in the composite structure of firefighting garments is a FR lining which is worn next to the inner clothing or in some cases skin. The linings provide another layer albeit of limited thermal value. Theses linings are lightweight woven fabrics made from meta-aramid fibres or blends incorporating FRViscose fibres generally in a 50/50 ratio. They provide a range of properties including; good abrasion resistance, good anti-pilling, good comfort i.e. soft to the touch and good drape plus their inherent FR properties, they may also incorporate anti-bacterial finishes. In the majority of cases these

linings are stitch bonded to the thermal barrier and this process gives additional strength to the thermal layer and also acts as an anchor in the finished construction of the garments.

Annexes

Fire protection

BS EN 531:1995*

References:
EN 340: Protective clothing – General requirements
EN 366: Protective clothing – Protection against heat and fire
EN 367:1992 Protective clothing – Protection against heat and flames
EN 373:1993 Protective clothing – Assessment of resistance of materials to molten metal splash
ISO 6330:1984 BS EN 26330:1994 Textiles – Domestic washing and drying procedures for textile testing.

Marking

In labels sewn into the garments the reference EN 531 is used together with a code letter suffix which identifies the protection level(s) as follows: A = Limited flame spread, B= Convective heat, C= Radiant heat, D= Molten aluminium splash, E= Molten iron splash; in addition each suffix (with the exception of A) carry performance levels indicated by a numeral after the code letter i.e. B1, C1 etc. In addition to this information the label must carry the manufacturers name or trade mark registered in the EEC, type designation or code, size designation in accordance with EN 340 and a pictogram marked accordingly. The label must also carry a pictogram(s) indicating wash/care treatment(s).

- This European Standard is applicable to protective clothing for industrial workers exposed to heat (excluding firefighters' and welders clothing.

BS EN 469:2005

References:
EN 340, Protective clothing – General requirements
EN 367, Protective clothing – Protection against heat and fire
EN 471:2003, High-visibility warning clothing for professional use – Test methods and requirements
EN 533:1997 Protective clothing – Protection against heat and flame – Limited flame spread materials and material assemblies
EN 20811, Textiles – determination of resistance to water penetration – Hydrostatic pressure test
EN 24920:1992, Textiles – Determination of resistance to surface wetting (spray test) of fabrics
EN 31092, Textiles – Determination of physiological properties – Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test) (ISO 11092:1993)
EN ISO 1421:1998 Rubber- 0r plastics – Determination of tensile strength and elongation at break (ISO 1421:1998)
EN ISO 4674-1:2003, Rubber- or plastics-coated fabrics – Determination of tear resistance – Part 1: Constant rate of tear methods (ISO 4674-1:2003)
EN ISO 6530:2005, Protective clothing – Protection against liquid chemicals – Test method for resistance of materials to penetration by liquids (ISO 6530:2005)
EN ISO 6942:2002, Protective clothing – Protection against heat and fire – Method of test: Evaluation of materials and material assemblies when exposed to a source of radiant heat (ISO 6942:2002)

EN ISO 13934-1:1999, Textiles – Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method (ISO 13934-1:1999)
EN ISO 13937-2:2000, Textiles – Teat properties of fabrics – Part 2: Determination of tear force of trouser shaped test specimens (Single tear method) (ISO 13937-2:2000)
EN ISO 15025:2002, Protective clothing – Protection against heat and flame – Method of test for limited flame spread (ISO 15025:2000)
ISO 5077, Textiles- Determination of dimensional change in washing and drying
ISO 7941, Commercial propane and butane – Analysis by gas chromatography
ISO 17493:2000, Clothing and equipment for protection against heat – Test method for convective heat resistance using a hot air circulating oven
CIE 54.2:2001, Retroreflection – Definition and measurement

Marking

7.1 Marking requirements shall be as specified in EN 340 and in this clause:
a) Name, trade mark or other means of identification of the manufacturer or his authorised representative
b) Designation for the product type, commercial name or code
c) Size designation according to clause 6 of EN 340: 1. Jacket = chest, height 2. Trousers waist and height
d) Number of the specific European Standard
e) Pictograms and level of performance (as pictogram below)
f) Care labeling, washing or cleaning instructions shall be given according to EN 23758 if applicable

7.2 Firefighters' protective clothing complying with this European Standard shall be marked with the number and date of this European Standard, i.e. EN 469:2005, on or adjacent to the pictogram attached to the garment.
7.3 If the requirements of this European Standard are met by the use of a combination of garments (see 4.4) this shall be declared on the labels of all pieces of the combination of the garments used and indicating that they shall be worn together.
7.4 The level of performance achieved, when tested in accordance with 6.2 (Heat transfer – Flame), 6.3 (Heat transfer – Radiation), 6.11 (Resistance to water penetration) and 6.12 (Water vapour resistance) shall be stated on the pictogram attached to the garment.
7.4.1 The pictogram shall be as given in Figure 1

EN469:2005
Xf1: Xr1: Y2: Z2

Information supplied by the manufacturer

8.1 Firefighters protective clothing shall be supplied to the customer with information written at least in the official language(s) of the state of destination.
The manufacturer shall add information about the use of integrated devices.
8.2 The information to be supplied by the manufacturer shall be as specified in EN340
8a) All information required in 7.2, a, b, e, f, g (as above)
8f) All main constituent materials of all layers of protective clothing shall be given

8g) Instructions for use as appropriate for the specific standard

- tests to be carried out by the wearer before use
- fitting; how to put on and off
- instructions concerning appropriate use of the product to minimise the risk of injury;
- limitations on use (e.g. temperature range etc.)
- instructions for storage and maintenance, with maximum periods between maintenance checks;
- complete instructions for cleaning and/or decontamination (e.g. cleaning temperatures, drying processes, pH value, mechanical action, maximum number of cleaning cycles;
- warning against problems likely to be encountered, e.g. domestic washing of contaminated clothing;
- details of additional items of protective clothing that need to be used to achieve the protection intended;
- information about any materials used in the product that may cause allergic responses or may be carcinogenic, toxic to reproduction or mutagenic;
- details of any significant ergonomic penalties of using the product such as a reduction in the field of vision, acuity of hearing or a risk of heat stress;
- instructions on how to recognise ageing and loss of performance in the product
- if helpful illustrations, part numbers etc. shall be added
- instructions concerning repair

8h) Reference to accessories and spare parts if relevant

8i) Type of packaging suitable for transport if relevant

8j) Instructions for recycling, safe destruction and disposal as relevant (e.g. mechanically disruption or incinerating the product)