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Future Firefighter Concept – Phase 1

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Executive summary

This report provides the key findings from the research commissioned by Home Office (HO) Commissioning to support the National Fire Chiefs Council (NFCC) Fire and Rescue Service Personal Protective Equipment (PPE) / Clothing Committee in understanding what PPE and workwear (station-wear) will be required by the future firefighter to meet emerging future challenges.

All Fire and Rescue Services (FRS) ¹ across the United Kingdom (UK) were approached by Dstl to nominate end users (firefighters) and other relevant personnel² to participate in a series of semi-structured interviews. Dstl also engaged with FRS working groups and other accredited organisations to enable the most comprehensive collection of user observations and future requirements in the timeframe available³. The subsequent user observations recorded do not represent the views or technical assessment of Dstl.

The qualitative data collected was analysed to draw out the key insights that would most effectively inform the future direction of Science and Technology (S&T) required to develop the future firefighter PPE concept.

From the eight overarching themes⁴ identified, it was noticeable that wearability and standardisation of PPE and workwear received the greatest number of comments from the participants. The multiple wearability issues perceived by all parties within the increasingly diverse community held back some operational staff from completing their duties in the most effective way possible. The lack of standardisation across the UK FRSs in relation to the current PPE and workwear and the accompanying maintenance processes additionally impacted on the firefighter's confidence in their physical safety and psychological wellbeing.

The changing role of the firefighter and emerging threat landscape underlined the fact that the current structural PPE and workwear will also not be able to provide enough adaptability to cope with possible future incidents.

To address these findings it is proposed that during the development phase of the Future Firefighter Concept (FFC) the following should be considered⁵:

- Implementation of a layered system that is flexible enough to adequately address all the requirements of firefighters faced with the growing diversity of operational activities.
- Utilisation of materials that incorporate additional protection against 'on the horizon' threats such as electric car fires, knife attacks.
- Identify and adopt materials that are more durable to augment the confidence of the wearer.

¹ [List of UK fire and rescue services \(nationalfirechiefs.org.uk\)](http://nationalfirechiefs.org.uk)

² Contact made through NFCC PPE committee regional representatives.

³ October to December 2022.

⁴ Compatibility, Contaminants, Durability, Identification, Integration, Protection, Standardisation, Wearability.

⁵ Further recommendations not specific to S&T requirements are provided at the end of the document.

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- Ensuring that helmets / fire hoods are adaptable enough to suit the broadening range of requirements highlighted by the end users and which can be dismantled easily to ensure robust removal of contaminants.
- Creation of a system that can be universally used across all of the UK FRSs. This will address the inconsistencies across suppliers by;
 - Ensuring that the design is visually gender neutral except where on religious, health (pregnancy/menopause etc.) or specific gender related protection requirements (additional protection across female breast area) grounds.
 - Ensuring that it is adaptable enough to meet all the protected characteristics of the user community.
 - Enabling the development of a concept where bespoke elements can be built into it to support those with disabilities and health related requirements.
 - Ensuring that it is easily recognisable to the public and incorporates UK National branding on the garments.
 - Working with relevant standard bodies to ensure the requirements are incorporated into future iterations of standards and there is universal clarity concerning the certification required.
 - Creating a shared platform / collaboration space where users can access guidance on the tolerances of their PPE and workwear, where training guidance is available on how to use the kit and which provides an opportunity to provide feedback about any clothing issues.
 - Engaging with the user community during a FFC development and testing phase, to provide them with an opportunity to provide feedback on the suitability of the system. Iterative workshops would support this engagement.
 - Considering the integration of monitoring devices such as GPS, biometric measurement and communication without increasing cognitive burden to enhance the protection of the firefighter when natural senses can no longer be relied upon.

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1 Introduction

1.1 Background

The National Fire Chiefs Council (NFCC) Fire and Rescue Service (FRS) Personal Protective Equipment (PPE) / Clothing Committee has recognised that the role of the FRS is continually evolving. Firefighters in the future will not only have to continue to tackle fires but will also be required to complete other activities including responding to other types of emergencies, such as technical rescues, assisting partner agencies including the Ambulance Service with medical emergencies and supporting community safety. The role of the future firefighter is also being influenced by strategic changes such as global warming where the increase in wildfires⁶ has been highlighted as a likely consequence. The UK Fire Service also strives to be an inclusive employer, encouraging applicants from diverse communities⁷. The PPE and workwear systems therefore needs to encompass within its future design, elements that address these factors to ensure that it is fit for purpose.

1.2 The problem

There is currently some disparity across the fifty three FRSs (twelve regions within the UK) in terms of the products available to the end user. This is influenced by each service having to work within its own budgetary constraints to identify and procure PPE and workwear. This has resulted in a reduction in the standardisation of available products across the country with no one governing body having oversight and responsibility for ensuring that all the components procured are applicable in the face of emerging threats. Moreover, the growing diversification of the workforce has meant that some of the components available are not adaptable enough to address some of the issues raised by the end users themselves.

Dstl were commissioned by the Home Office (HO) to complete an independent review of user observations in relation to the current firefighter PPE⁸ and workwear⁹ to support the development of a Future Firefighter Concept (FFC) that could provide all FRSs with a standardised system that delivers the appropriate protection, is flexible across a range of activities and is inclusive.

⁶<https://www.forestresearch.gov.uk/research/climate-change-impacts/forest-fires-and-climate-change/#:~:text=The%20changing%20climate%20with%20warmer,and%20forests%20in%20sensitive%20areas-10/03/2023>.

⁷ In 2020/21, a study was conducted by Dstl to identify the challenges facing UK Fire & Rescue Services in a changing future socio-politico-economic landscape in the UK. This work identified 17 challenges, which were believed to be the main challenges facing the services in the next 15 to 20 years. This study also looked to identify similarities with a study conducted for the National Police Chiefs Council (NPCC) [1] [2].

⁸ Structural firefighting PPE in scope – Fire tunic, rescue jacket, over trousers, fire boots (leather/rubber), insoles/foot beds, fire hood, gloves.

⁹ Workwear in scope – jacket, fleece/sweatshirt, shirt/T-shirt/polo-shirt, trousers, head wear (cap or winter hat etc.).

2 Phase 1

2.1 Approach:

Data Collection – All FRSs across the UK were approached by Dstl to nominate end users (firefighters) and other relevant personnel¹⁰ to participate in a series of semi-structured interviews¹¹. Contact with the FRSs was coordinated through eleven¹² regional representatives. Dstl also engaged with the Fire Brigades Union, Fire Officers Association, Women in the Fire Service, Asian Fire Service Association, Fire and Rescue Service Association and the NFCC Strategic Leads to enable the most comprehensive collection of information pertaining to the current firefighter PPE and workwear as well as the user requirements for the future firefighter. The semi-structured interviews took place virtually using Microsoft Teams to encourage attendance especially for those on operational duty.

Analysis - Following the collection of the data, all of the anonymised comments were analysed using thematic analysis¹³ to draw out the key insights.

2.2 Key Insights

Themes

Analysis¹⁴ of the qualitative information provided by the interviewees in relation to the current PPE and workwear components identified eight key overarching themes across all of the brands currently in service. The following table provides an overview of the themes which have been colour coded to aid reference to the information available in Appendix A which provides a sample of the more detailed data that was recorded during the interviews.

¹⁰ Contact made through NFCC PPE committee regional representatives.

¹¹ A semi-structured interview is a qualitative research method that combines a pre-determined set of open questions (questions that prompt discussion) with the opportunity for the interviewer to explore particular themes or responses further. https://know.fife.scot/__data/assets/pdf_file/0028/177607/KnowHow-Semistructured-interviews.pdf

¹² There are 12 regions according to the NFCC, but during the interview process Northern Ireland was incorporated in the North West Region interviews

¹³ Thematic analysis is a method of analysing qualitative data. It is usually applied to a set of texts, such as an interview or transcripts. The researcher closely examines the data to identify common themes – topics, ideas and patterns of meaning that come up repeatedly - <https://www.scribbr.com/methodology/thematic-analysis/#:~:text=Thematic%20analysis%20is%20a%20method.meaning%20that%20come%20up%20repeatedly.>

¹⁴ During the thematic analysis phase comments were categorised by sentiment – positive, negative to enable a more robust understanding of the available content.

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Table 1: Overarching themes identified from the interviews with end users.

Theme	Description
Compatibility	How well the PPE and workwear works as a system.
Contaminants	Contamination issues – exposure during an incident or relating to the laundering process.
Durability	The robustness of the components during operational use / and level of resilience following any laundering processes.
Identification	Public as well as individual firefighter perception. Includes local and UK National branding.
Integration	Assimilation of PPE / workwear with the carriage of other items such as breathing apparatus.
Protection	The level of protection offered by an item of PPE / workwear and any issues associated with this.
Standardisation	Any information relating to the lack of standardisation across the UK including the supply, firefighters experiences of public perception etc.
Wearability	Any issues affecting the comfort of the wearer of the PPE or workwear. This incorporates a number of sub themes such as dexterity, number of pockets, fit/sizing options.

The information was broken down into percentages to illustrate the proportion of comments that were raised most frequently by the interviewees (Figure 1.). Results identified that wearability followed by standardisation elicited the greatest number of comments.

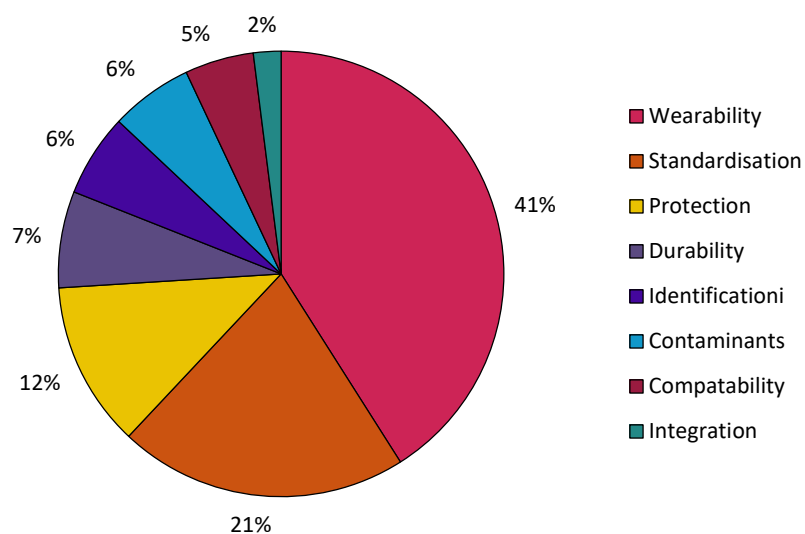


Figure 1: Percentage breakdown of all of the comments recorded for PPE and workwear within each of the overarching themes.

Further analysis of the overarching themes identified the following;

2.2.1 *The current size profile used for PPE and workwear is not adaptable enough to meet the user requirements of a diversifying FRS workforce.*

Throughout the interviews, multiple examples were given by the end user in relation to the inappropriate sizing of the components of PPE and workwear. This was attributed to, and exacerbated by, several factors. In relation to the sizing of firefighters for PPE, different methods were employed across the regions some of which utilised bespoke measuring of the individual whilst others offered a more limited ready-to-wear range of standard sizes and lengths. This lack of standard practice when fitting firefighters alongside the use of stock items, led to issues with the wearability of the PPE. It should be noted that comments concerning the size and subsequent issues relating to poorly fitting garments were not limited to any one particular gender or protected characteristics group although it was evident, from the information obtained, that female firefighters appeared to experience the greatest number of issues when trying to match garments to their body size.

Concerning workwear, several sizing issues were highlighted the majority of which impacted on the wearability of the clothing. Many of the garments offered to the end user were off-the-shelf items, which led to a limited and inflexible range being available across the workforce. In some cases, the end users stated that if they chose the size they would normally wear it did not translate well into the workwear available. Several comments were also made by the female firefighters that suggested that the modern uniform did not reflect the changing shape of this group particularly in relation to the trousers, with waistbands being very tight compared to the more generous proportions of the rest of the garment.

“The female shape is not like it was in the classic 1940’s movies. Women in today’s fire service are fitter with different waist / hip ratios so the manufacturers need to size accordingly”

There was also limited flexibility across some of the FRSs in terms of sizing and adaptability for users going through the menopause or pregnancy, with items such as the trousers having no flexibility designed into the garment to maximise comfort.

Interviewees highlighted that the shoe and boot lengths and widths were in some cases also inadequate and not always gender specific meaning that foot beds/shoe inserts etc. had to be used to compensate for the poor fit.

Although more about the integrity of the garment, many interviewees stated that shrinkage due to the laundering of the components of the PPE, impacted on the fit and therefore manoeuvrability of the wearer, something that was not always considered when the initial fitting was completed. Some of the firefighters stated that the shrinkage appeared to be greater than the 3% tolerance¹⁵ allowed. It should be noted that on one of the manufacturer’s websites it is stated that if structural PPE is fitted too tightly it will impact

¹⁵ BS EN 469:2020, 6.2.5 ‘Dimensional change’.

the airflow around the wearer creating additional heat stress [27] thereby increasing the health and safety risk to the wearer.

Poorly fitting gloves, due to the lack of appropriate sizing, caused issues when firefighters had to handle equipment or work on ladders as often dexterity was effected. It was highlighted that on occasion the length of the cuff of the glove was not compatible with the length of the tunic, which led to burning and injury.

Finally, the design and length of the braces on the PPE leggings, if not adjusted appropriately at the fitting stage, meant that female firefighters had to use methods to compensate for the sizing issues such as crossing the braces at the front to stop them falling down or sewing and stapling them together to keep them in place. Male firefighters also stated that sometimes the braces stretched and so had similar issues with the sizing, although this in part was due to the lack of robustness of the item.

2.2.2 *The current available PPE and workwear is not flexible enough to meet the requirements of the evolving user community.*

Although it was reported that many of the FRSs had taken steps to embrace inclusivity when procuring PPE and workwear, a number of individuals still stated that their individual requirements had not been catered for which left them feeling undervalued and vulnerable both psychologically and physically. Some of the factors that attributed to this included;

- **Long procurement times for bespoke items** – In several instances individuals stated that if they required bespoke items due to cultural, religious, ethnicity, disability, age or gender requirements, the lengthy procurement time restricted what they were able to do operationally and meant that they were using whatever PPE was available until they received their requested bespoke items. Women frequently reported longer wait times for the delivery of their garments.
- **Lack of diversity in the available PPE and workwear components (examples) –**
 - **Maternity wear** – As previously discussed, in some FRSs no provision had been made for females going through pregnancy in terms of the availability of the workwear garments, with some individuals having to purchase their own.
 - **Menopause** – Female respondents stated that no allowance had been made for individuals going through the menopause concerning both flexibility of the sizing and fastenings or the thermal qualities of the materials used.
 - **Hijabs** – It was reported that some FRSs were having to do their own research into identifying the most appropriate design (thermal quality, fit etc.) of the hijabs required by their staff as there did not appear to be a universal provider for this garment.
 - **Sikh headwear** – Although it was articulated that positive steps were being taken to include different faiths in the services, members of the Sikh faith

are still unable to attend operational incidents due to the lack of a headwear solution becoming available.

- **Individuals with health conditions or impairments** – Although few comments were raised in relation to the issues faced by colleagues with health conditions or impairments, the information available reported that the current choices of helmets and visors and other PPE components could not be readily altered to accommodate firefighters who had suffered injuries. Examples of injuries included the loss of sight in one eye and missing fingers, which resulted in a reduction in their ability to work in the operational environment due to no solution becoming available.
- **Neurodiversity** - Feedback was provided concerning the lack of support provided in the design of PPE for anyone with Neurodiversity where the current PPE is not able to negate issues such as the impact of sensory overload. The feel of certain materials on the skin, the thermal burden from PPE may have an additional burden on neurodiverse staff within the FRS.
- **Other** – It was reported that items of PPE were not always compatible with hearing aids or when wearing glasses.
- **Gender specific PPE and workwear** – Manufacturers did provide a varying degree of gender specific garments but these did not always meet the requirements of the user community. Feedback additionally stated that sometimes the garments were visibly identifiable as gender specific, which for those transitioning through gender reassignment made them feel uncomfortable. There was also some discussion about changing the design of garments to have non-gender specific fasteners to champion inclusion. Female users indicated that a more gender-neutral uniform would enhance the feeling of inclusion within the wider FRS community. In addition it should be noted that in some cases female firefighters did not feel that they were involved in the consultation process concerning the acquisition of new kit which resulted in issues such as pockets being removed from certain garments. This led to them having to carry sanitary towels in their hands or in bags when preparing to attend an incident, which further reinforced feelings of separation from the majority of the group.
- **Lack of information about the regulations concerning the protection afforded by the PPE for female firefighters** – It was unclear to many of the interviewees as to whether the female PPE, in particular the tunic, provided enough protection around the areas (chest and lower abdomen) thought to be vulnerable to ongoing heat exposure. Some participants stated that the policy in their service was that females must only wear the female kit whilst other FRS participants stated that they were free to choose to wear male or female garments. This led to a lack of clarity in terms of the level of protection being provided if women were wearing male garments, which was sometimes due to the poor fit of the female garments available. The consequence of this was noticeable uneasiness as to the risk that wearing male garments carried. The opinion on this subject varied between interviews with some groups stating that there was robust

research in this area whilst other groups suggested that more research was required.

- **Lack of standardisation** – The lack of standardisation not only across the FRSs but also within the user community, was identified as one of the reasons that attributed to the perpetuation of feelings of exclusivity and in some cases isolation.
- For some parts of the FRS community short sleeve workwear shirts are not appropriate (modesty beliefs). Long sleeved alternatives can be ordered however; due to them being visually distinct, this led to feelings of exclusion from the rest of the service.

2.2.3 *There is some disparity across the UK concerning training for the fitting, and subsequent usage, of PPE.*

During the interviews, it became evident that FRSs across the UK adopt different approaches when fitting personnel with their structural PPE. Typically, the fitting was completed by representatives of the manufacturers or stores personnel who had received some training or guidance in how to measure the user. However, a number of individuals reported that they were asked to try on available new and /or second hand in-service PPE without being measured so the fit was not always optimum. This highlights the lack of standardisation across the UK in terms of the training and methods adopted. Many services also did not offer recurring fitting opportunities to their staff, which in some cases was felt to be detrimental to the wellbeing as well as the health of the individual.

Training for the end users on how to use their PPE was reported to be variable with some interviewees stating that it was very limited or non-existent. The training that was available was provided through a variety of forums including initial training courses, on-boarding days, e-learning or posters and leaflets. All of this highlights the variance in practices across the regions.

2.2.4 *Lack of confidence in the safety of the components of the current PPE.*

Several emerging themes were identified following the collation and analysis of the information;

- It was reported by many of the interviewees that they did not feel that they had been provided with adequate information or training in the correct management of their PPE. Although initial training was provided for most of the new recruits, little or no refresher training was offered to maintain knowledge.
- In some cases, firefighters had reported that their PPE items had been returned looking visibly dirty which led them to question whether contaminants had been effectively removed during the laundering process. However, there was no mechanism in place to raise any queries apart from speaking to their local managers, which in some cases left individuals feeling uneasy and in consequence continuing to utilise items that they were not confident with.

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- Ripped tunics and over trousers were returned with patch repairs and due to the limited information available concerning the impact of these alterations on the integrity of the garments; firefighters were unclear as to their protection status.
- Inconsistencies across suppliers in terms of the garments durability and protection regulations left users unsure as to whether the manufacturer of the brand they were using afforded the right level of protection to the individual, something that the use of a universally available kit across the UK could address.
- The use of off the shelf garments for workwear and rescue jacket left the users questioning whether they were suitable in relation to the environments they were exposed to. This was exacerbated by the fact that garments such as the wicking t-shirts which were designed to remove sweat from the body, often did not appear to do this and held odours which made them unpleasant to wear despite washing attempts.
- Due to the cuffs on the tunic as well as the structural gloves not being waterproof, the absorption of water during incidents had resulted in steam burns. A compatibility issue between the tunic collar and fire hood was also raised. Some of the fire hoods were shorter on the neck than others creating a gap between the tunic collar and fire hood allowing embers or sparks to make contact with the wearer's neck.

2.2.5 *There are inconsistencies in identity and public perception.*

The public's perception of the fire service evoked a lot of discussion with some of the interviewees indicating that the current PPE and workwear was adequate in its ability to identify who the user was and uphold the professional status of the service and wearer. However, multiple service personnel felt that the lack of standardisation across the UK in terms of the design, quality, makeup and branding of PPE and workwear components meant that the public did not always understand who they were and what their role was. The themes that emerged from these specific discussions included;

- **Lack of clarity around firefighter role** –
 - Due to the inconsistency in the types of clothing used when attending incidents other than structural fires such as rescue jackets and / or High - Vis jackets, some reported that they had been mistaken as road workers or other emergency service workers. If the fire engine was not visible then the public was not always sure whether they were the right people to approach.
 - It was reported that in a few cases where the fire service was co-located with police forces that the firefighters were using items of police uniform (trousers) to supplement their kit which made some feel more vulnerable to attack if they were separated from colleagues when attending a community incident, especially within a metropolitan area. They also felt that the wrong signage might influence the reassurance and current engagement they have nurtured with their local communities.
- **Identity** – Multiple interviewees expressed the desire for greater uniformity of PPE and workwear in the future and suggested that the FFC should be developed to provide a visually similar system for all FRSs across the UK. This would ensure

that all service personnel felt valued whether in a more rural or metropolitan conurbation and provide a more cohesive public interface, reinforcing the collective bond across the service.

- **Multi-service incidents** – In some circumstances visual differences in each of the FRSs PPE and workwear led to confusion on the incident ground especially concerning cross border events. The key differences between services included the rescue jacket and helmet colour. Services frequently use the colour of helmets as identification of rank however; interviewees stated that not all services use the same colours for ranks. End users reported that this has caused confusion when trying to identify the incident commander during a large-scale response not only for the firefighters but also for other emergency services.
- **Branding** – It became apparent that across the regions the branding on clothing was inconsistent. The consensus was that branding should be consistent across all FRSs with all garments exhibiting similar lettering formats, symbols and badges although each should still retain the specific emblems for the individual FRSs.

2.2.6 *The current structural PPE is not agile enough to cope with the growing diversity of emerging threats.*

As previously discussed, the role of the firefighter is changing. Structural fire incidents only take up a small proportion of the incidents that require a response. Currently the structural PPE offers appropriate protection to the wearer when dealing with these structural fires and intense fire situations. However, wearers when dealing with other types of incidents such as road traffic collisions, find them heavy, too warm and not agile enough with the current system putting excess burden upon the wearer in some scenarios.

Many articulated the need for a more layered system where the layers could be added or removed to suit the incident being faced. This would help reduce heat exhaustion, a likely scenario due to the impact of climate change. It would also discourage firefighters from unzipping or rolling down their tunics, which has previously led to exposure to injury and contaminants.

Several users highlighted that if they were moved to a UK wide integrated layered system that unless the system is designed to deliver a lighter layered solution, any additional heavier garments could create problems concerning the carriage and storage of multiple items on appliances.

2.2.7 *The evolving role of the future firefighter will require the development of a more responsive and resilient PPE and workwear system.*

During the interviews, participants were asked to provide their thoughts on how their role might change in the next 5 – 10 year timeframe and, during the development of the FFC, what considerations should be taken into account to address these potential changes. As with any future predictions, some found this quite difficult to answer. However, several themes emerged, all of which will help direct the thinking used to develop future PPE and workwear system solutions;

- Due to the rapidly evolving nature of future technologies, protection against any fires and hazards associated with these will require newer materials that are more protective. For instance, electric vehicle fires already occur and are known to throw out toxic waste. It is unclear as to whether current PPE can protect the firefighter against exposure to these toxic substances.
- Occupational health monitoring will need to adapt to monitor exposure to these newer emerging hazards.
- The rapid uptake of autonomous vehicles and robotics may expose firefighters to a new set of scenarios where injuries may become a hazard due to the unfamiliar movement of mechanical components creating stab or slash injuries.
- The impact of climate change is already changing the environment. Increases in wildfire and flooding incidents will therefore need to be considered when designing the FFC.
- Assailants are more frequently utilising chemicals in their attacks on others. In addition to this, there is the changing global threat from international state and non-state actors engaging in the use of nefarious acts. Understanding this evolving threat will support the development of materials and equipment required to ensure appropriate protection.
- Although already something faced by the current firefighter, incidents in high-rise buildings are likely to increase. Although there is not likely to be a personal system solution that could address this, the interviewees said this should still be considered when developing an understanding of the future threat landscape.
- Terrorism and attacks on emergency services workers are concerns facing the fire service now and may increase in the future. The FFC should therefore investigate stab vest technologies to address knife attacks¹⁶.
- Future firefighter PPE and workwear will need to integrate more efficiently with Global Positioning Systems and biometric measurement technologies to afford the user with greater protection.

2.2.8 *The potential use of wearable sensors and physiological monitoring to enhance the protection of the future firefighter.*

Although the investigation of wearable sensors and physiological monitoring was out of scope for this work, a theme emerged around the level of protection modern PPE now offers firefighters. Several comments were made that it does not allow firefighters to rely on their natural senses to understand when a situation might be increasing in terms of escalating risk. Supplementing or replacing the natural senses of the body with science and technology could be a possible way forward. Wearable sensors could be added or integrated to future PPE to relay live environmental information as well as physiological monitoring for firefighters within a scene. The Home Office Centre for Applied Science

¹⁶ This was highlighted on several occasions, by the end users.

and Technology (CAST), which integrated with Dstl, completed a scoping study as part of a project on wearable technology for the emergency services. This study generated a number of requirements for these technologies and identified which requirements overlapped between emergency services. The study also sought engagement from industry and academia in developing an integrated system[3].

2.2.9 *The maintenance of PPE and workwear is inconsistent across the UK.*

The maintenance of structural firefighting PPE and workwear varies across the services/regions. Some services had a fully managed service where the supplier managed the maintenance of all of the PPE items. Others services had partially managed services. Although there has been a move to adopt electronic systems that tag and keep track of the number of wash cycles for each item of PPE, some services are still relying on paper records.

A consistent theme was that firefighters have to rely on third party contractors to ensure the PPE is returned in a clean and ready to use condition which generated some uncertainty for the user when items were returned with repairs or 'looked dirty'. This doubt could be negated if firefighters had access to information concerning guidance around the repair and laundering process but in almost all cases, they did not.

The cleaning and maintenance of helmets was also inconsistent across FRSs with some stations being provided with machines whilst others relied on the user hand washing them. Many of the interviewees highlighted the difficulty in ensuring that the helmet was clean and free of contaminants due to the design of some of the helmets preventing them from dismantling the inner structure.

Many users were required to wash their workwear at home, which raised the issue of whether contaminants from the items infiltrated their other personal items something that therefore should be considered when deciding the FFC and the processes that support it.

2.2.10 *There is a lack of standardisation concerning the selection and procurement of PPE and workwear across the FRSs, which has led to variances in the quality of the items available to all users.*

Due to the decentralisation of budgets, each FRS has the responsibility of gathering its own PPE and workwear requirements, identifying possible suppliers and then procuring the items required. Interviewees did not always feel that consultation during the requirements capture phase was comprehensive enough. This resulted in some design features being removed or added which in some cases detrimentally affected the user. For example, several users highlighted that pockets were in the wrong place preventing easy access to items or were removed altogether, which made the transport of particular items more difficult.

Some FRSs were impacted by budgetary constraints, which the users felt had caused the acquisition of poorer quality or uncomfortable items (especially boots and shoes) which instigated an increase in occupational health referrals in order to request better quality items.

2.2.11 The lack of uniformity in the standards adopted.

Currently there are multiple British, European and International standards applicable to each of different aspects of PPE. Each individual piece of PPE has at least one standard describing the testing and specifications that should be met in accordance with that standard. In many cases, one piece of equipment is subject to both a British Standard (BS) and an International standard (ISO). Alongside this, there are several overarching standards for the procurement and maintenance of PPE, which opens up the potential risk of confusion concerning which standards, should be employed by FRSS.

Table 2: List of relevant product standards.

	CEN	ISO
Helmet	BS EN 443:2008 [4]	ISO 11999-5:2015 [5]
Hood	BS EN 13911:2017 [6]	ISO 11999-9:2016 [7]
Tunic/trouser	BS EN 469:2020 [8]	ISO 11999-3:2015 [9]
Fire Gloves	BS EN 659:2003 +A1: 2008 [10]	ISO 11999-4:2015 [11]
Fire Boots	BS EN 15090:2012 [12]	ISO 11999-6:2016 [13]
Rescue Jacket	BS EN 16689:2017[14]	BS ISO 18639-3:2018[15]
	BS EN ISO 15384:2020 +A1:2021 [16] (Wildland)	
Hi Visibility	BS EN ISO 20471 [17]	
Rescue Gloves	Various glove standards: EN 388:2016 [18], 407 [29], 420:2003 [19] NB. Proposed draft revision EN 659 now includes rescue and wildland gloves	BS ISO 18639-4:2018 [20]
Wildland firefighting	BS EN ISO 15384: 2020 +A1:2021 [16]	ISO 16073:2020 parts 1- 10[21], [22]
Cleaning and Maintenance	BS 8617:2019 [23]	ISO 23616:2022 [24]
Selection, Use, Care and Maintenance (SUCAM)	EN 14560:2003 [25]	ISO 21808:2021 [26]

The British Standard (BS 8617:2019) and International Standard (ISO 23616:2022) for Cleaning, Inspection and Repair of PPE both provide clear and specific procedures for the upkeep of PPE. However, small discrepancies between the procedures recommended, such as the BS categorising items as “Hard” and “Soft” while the ISO does not, causes uncertainty. Many of the standards for items of PPE advise that cleaning should be carried out as per manufacturer’s instructions, which may not always be consistent with procedures outlined in BS 8617:2019 and ISO 23616:2022. In rare cases,

the BS and the ISO for a piece of equipment may differ. In one instance, BS 469:2020 presents an acceptable post laundering dimensional change of firefighting clothing as $\leq \pm 3\%$, whereas ISO 11999-3:2015 presents an acceptable change of $\leq 5\%$.

Many end users are concerned that standardised processes are not being applied to laundering and as such remain uncertain as to the sufficient removal of contaminants.

3 Conclusions

This review has provided an opportunity to reach out to a broad and diverse community of people working across the FRSs. The consequence of the activities completed has been the identification of a number of themes with potential opportunities and enablers that can be exploited to ensure that the future firefighter is working in a fully inclusive work environment where individuals are suitably equipped to protect both themselves and the wider community against emerging future threats;

- There are numerous PPE and workwear suppliers across the UK who provide and maintain the garments used by the services. Compliance to contracted services is managed at a local level.
- The end users intimated that decentralised budgets have put constraints on the services who may not have the funding available to acquire the highest quality and most diverse PPE and workwear on the market.
- The lack of standardisation across the UK FRSs in relation to the current PPE and workwear and the appropriateness of the maintenance process is impacting on the firefighter's confidence in their physical safety and psychological wellbeing.
- The multiple wearability issues experienced by all parties within the increasingly diverse community, if not addressed, will continue to frustrate and hold back operational staff from completing their duties in the most effective way possible.
- The changing role of the firefighter and emerging threat landscape has underlined the fact that the traditional structural PPE and workwear will soon no longer be agile enough or optimised to cope with all eventualities.
- There is inconsistency in the training available for both the fitters of the garments and the end users' themselves which has led to sizing and, in consequence, wearability and protection concerns.
- Most firefighters expressed a desire to be seen as part of the wider UK Fire Service community but differences in the UK National identity and branding affected this feeling of unity.
- The British Standards relating to structural firefighting PPE state that manufacturers should provide the maintenance and laundering information/regulations for their garments or products but it proved to be difficult to locate this information on some of the manufacturer websites. No other central repository was available to check these details

4 Recommendations

The evidence gathered during this review encompassed the physical (the person as well as the environment), social and cognitive factors that will need to be considered when developing the FFC. Utilising the findings of this report will ensure that the most appropriate S&T is adopted during the concept development phase.

When preparing for the development of the FFC for PPE and workwear, consideration should be given to the following;

1. Development of a Systems Requirement Document that initially specifies what requirements are compulsory for the development of a FFC.
2. Implementation of a layered system that is flexible enough to adequately address all the requirements of firefighters faced with the growing diversity of operational activities.
3. Utilisation of materials that incorporate additional protection against 'on the horizon' threats such as electric car fires, knife attacks.
4. Identification and adoption of materials that are more durable to augment the confidence of the wearer.
5. Ensuring that helmets / fire hoods are adaptable enough to suit the broadening range of requirements highlighted by the end users and which can be dismantled easily to ensure robust removal of contaminants.
6. Creation of a system that can be universally used across all of the UK FRSs. This will address the inconsistencies across suppliers by;
 - a. Ensuring that the design is visually gender neutral.
 - b. Ensuring that it is adaptable enough to meet all the protected characteristics of the user community.
 - c. Enabling the development of a concept where bespoke elements can be built into it to support those with disabilities and health related requirements.
 - d. Ensuring that it is easily recognisable to the public and incorporates UK National branding on the garments.
 - e. Working with relevant standard bodies to ensure the requirements are incorporated into future iterations of standards and there is universal clarity concerning the certification required.
 - f. Creating a shared platform / collaboration space where users can access guidance on the tolerances of their PPE and workwear, where training guidance is available on how to use the kit and which provides an opportunity to provide feedback about any clothing issues.

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- g. Engaging with the user community during a FFC development and testing phase, to provide them with an opportunity to provide feedback on the suitability of the system. Iterative workshops would support this engagement.
- h. Considering the integration of monitoring devices such as GPS, biometric measurement and communication without increasing cognitive burden to enhance the protection of the firefighter when natural senses can no longer be relied upon.

To support the ongoing delivery and maintenance of the FFC;

- 7. Develop and endorse a centralised governing body that has the authority to coordinate UK wide procurement and maintenance of PPE and workwear. This will secure standardisation and compliance.
- 8. Ensure that users are kept informed of any future changes to PPE and workwear.
- 9. Provide initial bespoke measuring facilities for all users when they are being fitted for future garments. Put in place regular fitting checks to ensure that firefighters have ongoing access to appropriate clothing.
- 10. Provide training for those completing the fitting checks to encourage standardisation of the service across the fire service.

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Glossary

Semi-structured interview

These are conducted conversationally with one or more respondents at a time and employ a blend of closed and open ended questions along with follow up questions [28].

Structural PPE

The items of personal protective equipment a Firefighter is issued with for their role. Designed for structural firefighting.

Workwear

The uniform items of clothing also known as station-wear that operational and non-operational staff within the Fire and Rescue Service wear.

List of abbreviations

CAST	Centre for Applied Science and Technology
FFC	Future Firefighter Concept
FRS	Fire and Rescue Service
HO	Home Office
NFCC	National Fire Chiefs Council
PPE	Personal Protective Equipment
S&T	Science and Technology
UK	United Kingdom

APPENDIX A **Snapshot of individual component information**

The interviews gave end users the opportunity to discuss the structural PPE as individual components and as a system. The following sections provides a snapshot of the comments made in relation to each individual component.

Tunic

Common consensus was that the fire tunics are good for structural fires however, they are not always suitable for the alternative incidents that firefighters are now facing more frequently. Variations in the design of tunics were dependent on the manufacturer of the tunic and included additional protection such as elbow pads built into the jacket and pocket positioning and availability. Design variations influenced the opinions of the end user on the suitability of the garment overall, however the collective opinion was that the current tunics have improved when compared to the earlier versions.



Figure 1: Positive and negative comments relating to the tunic.

Rescue Jacket

The consensus in relation to the rescue jacket was that, despite some size / fit issues, it was a good alternative to the fire tunic. End users liked having the flexibility to choose whether to wear the rescue jacket or structural tunic in non-structural fire incidents. The rescue jacket is a thinner High-Vis type jacket with full-length sleeves that can be worn, instead of the fire tunic, at road traffic collisions or railway incidents. The rescue jacket has not been adopted by all fire services with some services having only recently introduced it. This led to mixed and sometimes limited discussions on this garment within the sessions.

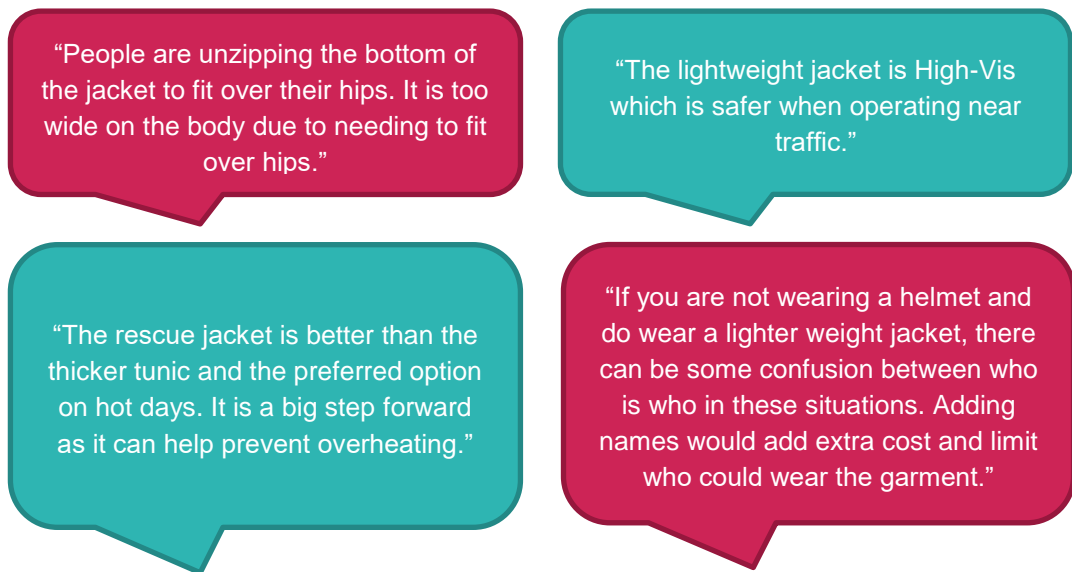


Figure 2: Positive and negative comments relating to the rescue jacket.

Over trousers

Generally, end users stated that the over trousers provided good protection when attending structural fires. Issues with this garment arise from the variety of incidents now faced by firefighters, where the heavyweight and protective characteristics of the over trousers caused heat stress and wearability issues. Styles were dependent on the manufacturer and variations included the placement of knee padding, the braces placement, and the availability of sizes.



Figure 3: Positive and negative comments relating to the over trousers.

Leather Fire Boots

Despite some issues, leather boots were more highly regarded than the alternatives (e.g. rubber). Female firefighters reported more issues with the fit of the boots such as the width being unsuitable. The desire for standardisation was a common theme across services with many highlighting that local budgetary constraints influenced the quality of the boots provided.



Figure 4: Positive and negative comments relating to the leather fire boots.

Rubber Fire Boots

The information collated highlighted that rubber fire boots were useful when attending floods but were painful to wear, were inflexible and did not look smart as they could not be polished.

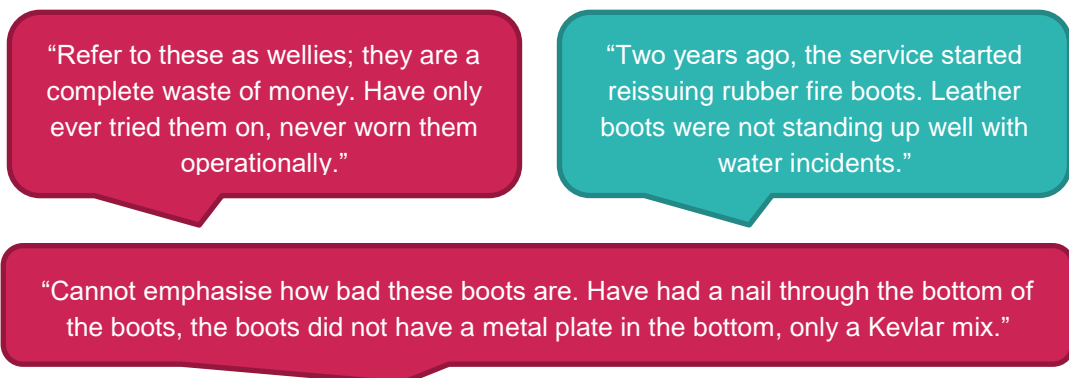


Figure 5: Positive and negative comments relating to the rubber fire boots

Fire/flash hood

There are currently numerous styles of fire/flash hoods in circulation throughout the UK. A number of services are reviewing their current garments and trialling new particulate-blocking hoods. Feedback from interviews highlighted the lack of standardisation in terms of laundering, protection, contamination, fit and thermal value.



Figure 6: Positive and negative comments relating to the fire / flash hood.

Fire Helmet

An overarching theme concerning the fire helmets was the risk of ongoing contamination. End users consistently commented on how pivotal it was to protect the head and neck from contaminants, and how they felt that current cleaning processes for helmets were inadequate. Variations in the design of helmets were manufacturer dependent. MSA Gallet provide two options for the outer shell size, whilst Rosenbauer provide one which end users felt did not cover the range of sizes required despite both styles having an adjustable inner cradle to allow individualisation in terms of fitting.

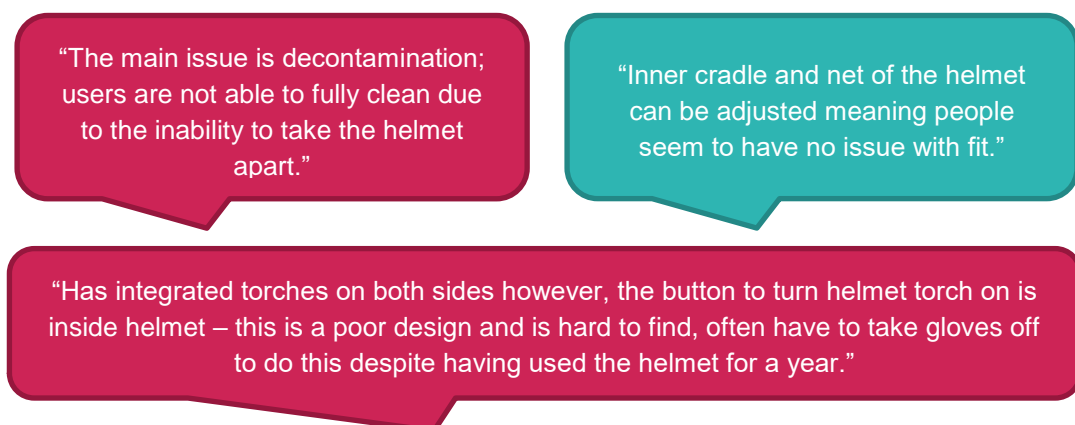


Figure 7: Positive and negative comments relating to the fire helmet.

Structural Gloves

End users reported that the level of dexterity provided was to be expected for the thickness of structural gloves. However, it was highlighted that alternative designs should be considered to enhance manoeuvrability. Ill-fitting gloves were increasing health and safety concerns with gloves reportedly being caught in equipment. Individuals would prefer gloves with the same protective qualities, but that fit better and enable better dexterity.

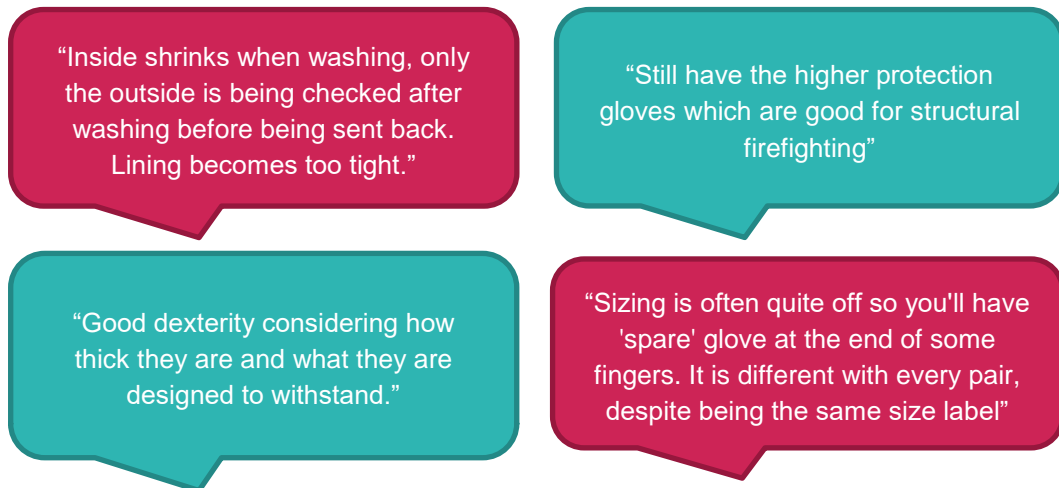


Figure 8: Positive and negative comments relating to the structural gloves.

General Purpose Gloves

There is no standardisation across UK Fire Services concerning general purpose gloves. Comments pertaining to fit and protection were highlighted but generally, the gloves did not create much discussion.



Figure 9: Positive and negative comments relating to the general purpose gloves.

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APPENDIX B In Service PPE and materials used in construction

Dstl have collated the in-service items of PPE in order to understand the types of materials used in the construction.

Table 3: A table to show in-service items of PPE and materials in their construction.

Equipment		Materials					
Equipment Type	Manufacturer/Product name	PBI	Aramids (KEVLAR, NOMEX, etc.)	Viscose	Leather	PFAS	Others
Structural Tunic	Bristol Uniforms Ltd					ePTFE	Gore-Tex® moisture barrier AND Axion thermal liner
	Ballyclare Ltd (Yorkshire)						Anti-Static fabric
	Ballyclare Ltd (Wales)						Anti-Static fabric
	MSA Bristol B-Tech						No information available
	MSA Bristol XFlex					ePTFE	Crosstech® Black AND Thermal Barrier quilted to a Nomex® filament lining
	Flame Pro- Valiant					ePTFE	OR Tough Plus OR AV9400 OR Core FX WITH ePTFE Moisture barrier
Rescue Jackets	Bristol USAR/Technical Rescue Jacket					ePTFE	OR TechsAlexandra 250HV OR Gore Shannon 11 AND moisture barrier
Over Trousers	MSA Bristol B-Tech						No information available

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Equipment		Materials					
	MSA Bristol X-flex					ePTFE	Crosstech® Black AND Thermal Barrier quilted to a Nomex® filament lining
	Flame Pro- Valiant					ePTFE	OR Tough Plus OR AV9400 OR Core FX
Fire Boots	Bristol Jolly 9005-GA Goretex boot					ePTFE	Rubber toecap cover AND Aluminium toecap AND Rubber
	Haix Fire Hero 3.0					ePTFE	CROSSTECH lining AND Fibre Reinforced toe cap AND Rubber Sole
Fire hood	Flamepro flash hood						
	Flamepro Particulate flash hood						Jersey Knit
	MSA BRISTOLHOOD1						
	MSA BRISTOLHOOD2						Carbonised Fibre
	MSA BRISTOLHOOD5						
	Eagle Fire Hoods						OR Carbon X OR Laminate OR Stedair Prevent
Structural Gloves	Granqvists Fire Grip 3.0					ePTFE	Porelle moisture barrier
	Holik Cheyenne					ePTFE	Porelle FR AND Palm Reinforced
	Blazemaster Pro-Fit MKVI V2						Goatskin Limited Info
	Fire Master 3					ePTFE	
	VIMPEX FX-1					ePTFE	

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Equipment		Materials					
	SEIZ XF-S					ePTFE	SEIZ heat absorber AND fiberglass AND Crosstech membrane
	MSA Bristol Structural Gloves					ePTFE	
Rescue Gloves	VIMPEX EX-1						
Fire Helmets	Rosenbauer HERO Titan						Limited information available
	Rosenbauer HERO H30						Limited information available
	MSA Bristol GALLET F1XF						Thermoplastics and Modacrylics

Materials marked in orange are used as a standard material, materials marked in yellow are available options for the piece of PPE (procurement can decide upon PPE features that can include these materials)

APPENDIX C Laundering and standards

Table 2 contains the BS EN and ISO standards associated with the manufacturer of structural firefighting PPE. Dstl have reviewed these standards for any reference to laundering or maintenance of garments and this is shown in the table also.

Table 4: BSI, EN or ISO standard shown with the item of PPE the standard relates to along with reference to laundering or maintenance.

Standards	Standard Focus	Laundering information
ISO 11999-3: 2015 (4.21.1)	Tunic/Trousers	The materials of the outer garment assembly, when tested in accordance with ISO 5077 using the pre-treatment by laundering or dry cleaning as specified in 4.15.2, shall give a dimensional change $\leq 5\%$.
BS EN 469: 2005 (6.2.5)		
BS EN 13911: 2017 (5.2.)	Hood	
ISO 11999-9:2016 (5.2.)		
BS EN 659:2003 +A1: 2008 (6.: BS EN 420 4.4.)	Fire Gloves	As a pre-treatment for testing: PPE is tested after 5 cycles of cleaning under the manufacturer's instructions OR Max number of cleaning cycles as dictated by manufacturer
ISO 11999-4: 2015 (5.4.1)		
BS EN 16689:2017	Rescue Jacket	
BS ISO 18639-3:2018 (5.2.1.)		
BS EN ISO 15384:2020 +A1:2021 (5.3.)		
BS EN ISO 20471:2013 (7.5.1)	Hi-Vis	
EN 388:2016, 407, 420:2003 (BS EN 420:2003 (4.4.))	Rescue Gloves	

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Standards	Standard Focus	Laundering information
BS ISO 18639-4:2018 (5.3.1.)	Wildland Firefighting	
BS EN ISO 15384: 2020 +A1:2021 (5.3.)		
ISO 16073:2023 parts 1-10 (5.2.)		
BS EN 443:2008 (7. g. V.)	Helmet	These standards either dictate that manufacturers must provide information on cleaning/disinfecting OR that cleaning/disinfecting should be carried out as per manufacturer's instructions
BS EN 15090:2012 (9.1.d)	Fire Boots	
ISO 11999-6: 2016 (9.1.d.6.)		
BS 8617:2019	Cleaning and Maintenance	These standards provide direct information on the care, cleaning and maintenance of equipment
ISO 23616:2022		
EN 14560:2003	Selection, Use, Care and Maintenance (SUCAM)	
ISO 21808:2021		
ISO 11999-5: 2015 (4.1.9)	Helmet	"All materials shall be unimpaired after cleaning and disinfection by the agents and procedures specified in the information provided by the manufacturer."

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