



Feel the heat

As protective clothing has improved, firefighters can theoretically get deeper into a fire and remain there for longer periods of time before they feel the heat and realise they should retreat. Is this a good thing or a bad thing? Has, in effect, protective gear become too effective? *Fire & Rescue* approached a number of experts to ask the question – here are their thoughts.

Deputy Chief Bruce Ziegler, Park Forest Fire Department, Park Forest, IL (USA)

The relative effectiveness of personal protective ensembles has seen a marked increase for firefighting personnel in recent years. The firefighter is better protected than they have ever been – but at what cost? While we at the Park Forest Fire Department have not experienced any injuries related to this effectiveness; we have experienced incidents of super heated turnout clothing (without injury to date).

We have a live fire training facility available in our community, one that is also used by the local Junior College for practical aspects of the basic firefighter training class. This increased efficiency has resulted in changes to how we train firefighters; a number of years ago when we mandated the use of firefighting hoods we began to move away from using the process of feeling the heat and turning towards a more commonsense approach to fire attack. Now we are focusing more on reading smoke, visual and mental clues indicating potential problems with heat and the other by-products of the fire. While we have made strides in this area, we still have a long way to go in our community, as well as the region at large.

Firefighters have been slow to adapt to this process, especially older firefighters who came of age under different tactical and cultural circumstances. Younger firefighters, seem to more readily adapt to this line of thinking over the years. Despite evidence and policy to the contrary, many firefighters inside and outside of our department find it difficult to give up these previous techniques, resulting in the potential for near misses and injuries. Until we overcome the gap in updated training, and the “take-on-all-risks mentality” as well, history will continue to repeat itself despite technological advances.

Has PPE become too effective to the detriment of firefighting?

In my personal opinion it has yet to become as effective as it can and should be; but the technology has exceeded the training and culture present in much of today's fire service.

Until the fire service as a whole can overcome the outdated thinking and the techniques of our past, the potential for injury will remain. I have always been a firm believer in the fact that once you are taught to use a tool, you should become an expert in the use of that tool – and this should include your PPE. It is not the fault of the tool, but poor application of this tool on our part. As they say; don't blame the tool, blame the carpenter.



Mike Allen & Kirk Owen: TenCate Protective Fabrics – Emergency Response

The answer is an emphatic “no”. Historically, the leading cause of death among firefighters is sudden cardiac arrest. However, I was surprised to learn that over the last 30 years this number has actually dropped by 1/3 among US firefighters¹.

Of the more than 1 million firefighters in the US in 2008, 36

suffered from sudden cardiac death, and only a portion of these were heat stress related².

We at TenCate develops and manufactures products for firefighters around the globe and participates in standards committees that study the needs of end users. We also employ experienced firefighters to help with these efforts. Whether it is EN or NFPA or ISO, the standards take into account the specific activities and hazards that may be encountered by the firefighter.

Protective clothing has evolved significantly over the years. The changes started with the introduction of inherently flame resistant outershells (Nomex) and have continued to evolve today with outershells that have minimal integrity loss after exposure to heat and flame (PBO and PBI). Thermal and moisture barrier technology has also improved, and garment designers are incorporating lighter weight fabrics that take advantage of air gaps to provide additional heat insulation without increasing weight. Measures are being taken to evaluate the breathability and total heat loss of garments to indicate the impact on the firefighter.

All aspects of PPE have improved over the years, making it safer for firefighters to do their jobs. It would make little sense to have an SCBA that allows firefighters to work for periods in elevated thermal conditions wearing garments that do not provide adequate protection for their task, or should conditions worsen become brittle and begin to break open before they can escape.

The conditions can change rapidly and the thermal environment can overcome the protection provided by the ensemble. It is therefore, important that firefighters are trained to understand the conditions and to recognise when those conditions are deteriorating. It is far better to do this with training and an understanding of the environmental conditions than by using bare skin (such as ears) as a sensor, or fighting fires without SCBA.

The fatality rates and statistics were taken from the NFPA reports:

1. *Fire Fighter Fatalities in the US-2008, Fahey et al, June 2009.*
2. *What's Changed over the Past 30 years? Fahey et al, June 2007.*



Ian Moses, Personal Protective Equipment Manager, Grampian Fire Brigade, Aberdeen, Grampian (Scotland)

It's an interesting theory that because of the insulative qualities of firefighters tunics and trousers, that they expose themselves to higher levels of danger. It's almost as interesting as the other theory that garment weight has a serious impact on the physiological wellbeing of the wearer.

Firefighting is dangerous, always has been, always will be. Yes I know that we don't go to as many fires as we used to, but that has no bearing on the levels of protection that we should be giving to our personnel.

The training delivered today, particularly in hot fires, has never been better; firefighters not only get theoretical training, but visual and practical experience as well. The quality of incident risk assessments that are carried out are of the highest quality.

Older firefighters used to tell me how they used to use their ears as a warning system, that when they started to burn, they knew it was time to get out. That kind of statement delayed the issue of fire hoods for years. And I would hate to estimate the amount of face burns caused to firefighter over these years. In fact, one of the major US fire departments in a six-month period logged 229 head burns, and reduced this by 40% immediately they issued fire hoods to their firefighters.

The other thing that must be considered is the volume of fuel loading. A study carried out in the US identified that the typical fuel in a domestic bedroom has risen by at least 100%, so even though the amounts of fires have decreased, fire are burning hotter, and have even more materials to burn than ever before.

One should also remember that as a garment gets older it is subjected to more wear and tear. And depending on the initial performance levels of the garment you have purchased, the protective performance may deteriorate, so if you buy PPE that just passes the minimum requirement of the relevant standard, then you may find that after a relatively short period of time, that the performance has dropped below the required levels.

We introduced whole garments testing, both in the UK and USA, in 1995. Every year, we submit old garments for independent testing, so we can be confident that no matter what our firefighters may have to face, the PPE issued will do the job.

Firefighters are aware of the dangers they face, they are more brave and courageous than foolish and reckless, and whilst the thermal performance of current PPE is higher than ever before, I see that as a positive, long may that continue, and I do not believe that this encourages them to go further than they ever did before.



Ian Callaghan, PBI (UK)

First of all there is no such thing as overprotection. Although people have the perception that high levels of protection lead to heat stress, or a "boil-in-the-bag" situation, the most important factor is actually management. Management of time, of fire kit, and of firefighting.

If a firefighter spends 25-30 minutes in a burning building, they are going to feel the heat and collapse, so it is important that they know their limitations. Some may say that you can overprotect a firefighter. But no matter how hard a firefighter has trained and no matter how well he has read the situation, he may still find

PPE: FEELING THE HEAT

himself endangered in a one-off incident. So you simply cannot compromise on protection when it matters.

Then there's the management of fire garments. Some might argue that we should make compromises on protection because 80% of the time firefighters are not fighting fires, they are cutting people out of cars etc. But they have to be well-prepared for that other 20% when firefighters are in need of protection. We cannot afford to take risks with people's lives.

PPE is the last line of defence and therefore when you get to that point, when all training has gone out of the window and you're relying solely on your PPE, you have to make sure you are fully protected. You need to be aware of the limitations of your firesuit and if and when you do feel the heat, that is the time to get out.



Roger Startin, Joint MD of Bristol Uniforms (UK)

40 years ago the level of firefighter protection offered by shallow helmets and PVC "wetlegs" meant that firefighters used their body senses to feel the heat – principally around their ears and the fronts of their legs which had little protection. Today, specialist fabrics, when combined into highly effective technical composites, have transformed wearer safety and provide the most effective protection ever against flame lick, heat penetration and moisture ingress.

However, new designs have taken care to counter any potential loss of sensitivity to heat for the wearer, by changing the construction to reduce the impact of generated body heat which had become an issue during the late 1990s. Heat stress, the result of prolonged physical exertion, can be a contributory cause of heart failure and has become a major cause for concern in the USA.

In the UK, over the past 30 years, 30% of firefighter active duty fatalities were caused by heart attacks as compared with 45% in the US. On average, a US firefighter is clothed in protective garments 30% heavier than commonly now in use in the UK. Design changes, pioneered by Bristol seven years ago following major physiological trials, have been widely adopted across the industry to reduce garment weight and are generally regarded as having had a positive impact on wearer health and safety.

Fire authorities in the UK specify different levels of thermal protection but this can be achieved without a major impact on the effectiveness of heat stress minimisation. The process of moisture management inherent in state-of-the-art structural

garments provides increased air circulation inside the garment to improve breathability. Better release of both heat and sweat also improve comfort.

In the UK there is no empirical evidence to support the assertion that safety is compromised by modern garments, as current designs have maintained a balance between protection and safety. Lighter constructions maintain the levels of wearer protection from external factors whilst reducing the impact of internally generated heat and moisture. In addition, improved release of heated trapped moisture near to the skin can reduce physical discomfort. We believe that making PPE lighter has real benefits provided that the resulting ensembles fully meet the performance standards required by our customers.

Tim Dorsey, BS, EMT-P, Training Chief, West County EMS & Fire Protection District, Missouri (US)

Firefighting PPE levels have been enhanced dramatically over the last 30 years. From the days of aluminum helmets, rubber coats, charcoal air filters, and rubber hip boots to the present fully integrated, tested, and evaluated ensembles with self contained breathing apparatus that afford superior protection and comfort.

Some hypothesise that we are now overprotected, which may produce more unsafe conditions for firefighters because they cannot "feel the heat". I do not subscribe to this misnomer.

There are reasons that these protection levels and standards have increased – namely firefighter deaths and injuries and the byproducts/heat generation of modern combustible materials. I feel that these levels of protection will continue to increase due to science, technology, and the continual research to lengthen the life expectancy of firefighters and lessen their exposure to harmful unknown potential carcinogens and chemicals through the current levels of PPE.

A recent study by the Queensland (AU) Fire Rescue Service found these everyday exposures to the byproducts/chemicals of combustion and fire in a typical dwelling, to be present and measurable. The only issue is measuring the long-term effects of these exposures and their relationship to numerous cancers. Many states in the US have recognised this, and as a result legislated presumptive cancer workers compensation laws with the assistance and persistence of the International Association of Firefighters. Unfortunately, these are being fought against by some organisations.

Until these issues are solved and the life expectancy of firefighters is dramatically raised, the safety cocoon of firefighter structural PPE will continue to strive to become safer and more protective in the future.

Kevan Whitehead, Senior Technical Officer (retired) Greater Manchester Fire (UK)

The HM Government publication "Fire Service Operations – Incident Command" advises us that "in a highly calculated way, firefighters will take some risk to save saveable lives".

This philosophy was clearly illustrated (and recreated on a recent BBC Crimewatch TV programme) when a UK firefighter entered a dwelling house in an attempt to save the lives of a family trapped within a burning inferno.

It is estimated that the heat flux within the house was around 3,500 Kw achieving temperatures in excess of 500° C. The firefighter concerned received horrendous burns to over 50% of his body.

But for his fire kit, the burns would have been much more significant.

New York Fire Department undertakes CBRN program

The Fire Department of New York (FDNY), the largest fire department in the US, has selected Lion's MT94 CBRN protective ensemble to fit its mission-specific needs and to increase its response capabilities for technical rescue, patient rescue, decontamination and air monitoring. The revamped program provides FDNY's hazmat response teams with a more functional alternative than wearing traditional Level A suits to respond to such incidents.

It is expected that the advancements will significantly improve safety and decrease the physical impact on FDNY's first responders.

The MT94 is a one-piece ensemble designed to protect against some of the world's deadliest chemical and biological threats. It combines rugged Gore Chempak Ultra Barrier Fabric laminated to a Nomex outer textile to offer lightweight and comfortable multi-wear, multi-threat protection.

The MT94 is certified to NFPA 1994 Class 2, and NFPA 1992, and provides the highest level of protection in a Class 2 suit, blocking out high levels of CBRN agents that may be encountered in the "hot zone."



A very quick fireground calculation uses the following calculation to assess survival rates. 100 minus (age + % body burns) where the smaller the resulting number, the less likely the victim is to survive. Our firefighter was in his early 40s, thus with over 50% burns we substitute the figures of 100 minus (40 + 50) = 10. Just 10% more burns and it is unlikely he would have survived.

Furthermore, Dr Jim Marsden, in the *Fire Risk Management Journal* of June 2009, argued that as a result of changes to building construction and increased insulation in attempts to combat global warming, compartment fires were set to be come hotter and more hostile than those currently being encountered.

South Wales Fire & Rescue Service opt for lightweight carrying system

South Wales Fire and Rescue Service (SWFRS) has chosen Scott Health & Safety to provide 450 sets of its lightweight Advanced Carrying System (ACS) for Self Contained Breathing Apparatus. The ACS was selected by the Service following extensive consultation with its firefighters who trialled various different systems before deciding which best suited their requirements. Huw Jakeway, Assistant Chief Fire Officer South Wales Fire & Rescue Service, said: "The feedback from our firefighters demonstrated very clearly that the ACS was their preferred carrying system for SCBA." The selection of Scott's ACS system is the latest contract in a 20-year relationship between Scott Health & Safety and SWFRS.

Scott's new ACS has been developed following considerable research and investment and is significantly lighter than any other carrying system in its class. It is the only carrying system in the world that features the unique Thermoflex backplate which is moulded to fit the spine and back muscles providing the wearer with greater comfort, ease of movement and flexibility.

At the heart of the ACS is a simple, high performance and reliable two-stage pneumatic system which can be simply removed by rotating it 90° to disengage from the mounting. A new quick release cylinder connector has also been developed which allows the wearer to simply snap on and off a connection. Made of high quality stainless steel the quick release system can also be retro fitted to existing ACS systems.



So while compartment fires are set to become hotter, the philosophy to save life remains entrenched within the psyche of every firefighter in the world.

The argument to reduce/limit the effectiveness of the firefighters PPE is nothing short of nonsense. Allowing firefighters to "feel the heat" and burn could be classed as negligent and criminal!

H&S principles advise us that PPE should be seen as the last line of defence – ie when everything else goes wrong, it is the PPE which steps into the breach! It is argued that something is going wrong well before "the incident" and that PPE is becoming the first line of defence instead of the last.

Not too long ago, firefighters during their basic training were allowed to enter a controlled compartment fire with little or no PPE in order to experience the differences in heat at various heights and levels within the room.

As the heat "barrier" descended from ceiling towards the floor, rookie firefighters were forced to crouch and even lie below this hostile layer. Such "firemanship" was taught to all firefighters and in the 1945 publication *Manual of Firemanship*, we are told: "If the smoke is thick, the branchman should crawl along the landing or passage with his head and face well down... He should direct the branch onto the ceiling and should keep it moving"

By means of learning from the "manuals" and via simulated incidents, skills and knowledge were developed so firefighters could survive hostile fires with what now appears to be quite primitive PPE.

What has gone wrong? Why are our firefighters with state-of-the-art PPE getting into trouble when their forefathers were able to survive with simple woollen jackets and PVC over-trousers?

The advent of Health & Safety of Work Legislation and the overzealous interpretation of its intentions has meant that firefighters are now very unlikely to experience the descending heat barrier. They undertake their training in full PPE, which insulates them completely from the environment – they therefore believe they are indestructible. They do not crouch or crawl, they walk upright into the hottest parts of the room.

Significant advances in public fire safety, changes to upholstery regulations, better building regulations and fire engineering solutions all mean that there are less fires to go to. This also means there are less opportunities for rookies to learn their art.

The older, experienced firefighters who would adopt a mentorship role are retiring and taking their years of experience and knowledge with them.

The abandonment of the national examination structures means that young firefighters rarely, if ever, study training manuals like their predecessors did.

We are potentially going to be left with inexperienced, poorly educated and overly confident young firefighters who simply don't understand the environment they are operating in. They don't know what they don't know! Lambs to the slaughter maybe?

The answer is not to blame PPE – it saves their lives. The answer is to remember lessons of the past, properly train and educate firefighters. Train them about the conditions they will encounter. Train them about their PPE. Train them they are not indestructible.

Lt. David Belcher, Fire Prevention and Code Enforcement Specialist at Violet Twp. Fire Department, near Columbus, Ohio, and Vice President of the Ohio Society of Fire Service Instructors (US)

I believe the most important points regarding the firefighter's protective clothing ensemble are – firstly – that turnout gear (as

Tackling the burning issues...



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in protective clothing ensemble) is the last line of defence for firefighters, not the first. Secondly, this ensemble is designed for the "worst day of your life", when you find yourself in trouble that you were not planning for.

Newer materials sustain higher temperatures and their characteristics result in better moisture control, which leads to less fatigue and more comfort. Custom tailored fitting also allows us to do our job longer – and safer, in most circumstances.

So has the protective ensemble become too protective? The answer is "absolutely not". What is important is enhancing our training to ensure that all firefighters – from recruits to veterans – have the basic skills of fire behaviour and building construction. Additionally, a good and early ventilation technique is vitally important for the risk management part of our job.

Any deficit in a firefighter's knowledge in the above mentioned items contribute to a lack of necessary skills to utilise good situational awareness. In a nutshell, the main question is not about feeling the heat.

A contributing factor is the "macho" culture in our "boys" today, and it can lead many of us into trouble. To change this culture is of primary importance, and it is worth noting the National Fallen Firefighters Foundation's 16 Life Safety #1 statement: "Define and advocate the need for cultural change within the fire service relating to safety, incorporating leadership, management, supervision, accountability, and personal safety."

Traditionally the US fire service has always been slow for change, as encapsulated by our usual phrase of: "200 years of tradition... unchanged by progress." This doesn't apply to the firefighting protective ensemble however, which has changed substantially in my 28-year tenure in the service.



Philip Johnson, Managing Director, FlamePro (UK)

Writing as a designer and manufacturer of structural firefighting clothing this question is most pertinent since we have to put into practice the correct material requirements to meet the standards set out in BS EN 469:2005/AC:2006.

We therefore have a prime responsibility, under the UK's Personal Protective Equipment Regulations 2002, to protect the wearer of our products and ensure that such products meet all statutory requirements.

Firefighting clothing is classified as "complex" PPE, where the meaning of complex is; "PPE...intended to protect against mortal danger or against dangers that may seriously and irreversibly harm health, the immediate effects of which the designer assumes the

Lion secures Welsh PPE contract

Lion Apparel has been awarded the contract to supply structural firefighting suits to all three of the Welsh Fire and Rescue services (UK) as part of a total care managed service agreement.

Approximately 8,000 Pro-Tek Max Fire Suits designed to provide the highest standard of protection for firefighters and incorporating some unique new design innovations will be issued in April 2010.

The Pro-Tek Max suit incorporates a PBI Matrix 205 gm outer fabric, giving extremely high mechanical and thermal properties and a waterproof, breathable Crosstech Fireblocker moisture barrier. The garments also utilise a unique new proprietary lining system, developed by Lion, that uses a special wicking technology to remove moisture and heat from the body.

Mark Walker, Business Development Manager at Lion Apparel Systems, said:

"The three Welsh Chief Fire Officers have determined that the firefighters in Wales will be amongst the best protected in the world. They will be protected by state-of-the art PPE that will enhance operational duty without compromising personal protection."

The contract was awarded to Lion after an extensive evaluation and trial process that included garments from all of the main suppliers in the UK.

user cannot identify in sufficient time". The problem facing the designer of such products is to interpret this phrase correctly and act accordingly. This however raises the question: can firefighters identify the dangers in "sufficient time"? The HM Government publication "Fire Service Operations – Incident Command" advises that, "in a highly calculated way, firefighters will take some risk to save saveable lives" and it would seem therefore, that they can identify the dangers and act accordingly.

The question is, to what degree are they aware of the dangers they face? It is incumbent on designers and manufacturers of firefighting PPE to be sufficiently conversant with the materials they use in such a manner that they can offer the highest degree of protection available to ensure that their products comply with the relevant standards.

In practice, the market is continually striving to improve all the components used in the manufacture of PPE. The designers and manufacturers of endproducts have to balance the competing claims of all the component manufacturers with regard to performance, price, specifications, certifications and supply; and then design, manufacture and test the best performing finished product. One of the problems facing the designer is that of being able to understand the level of expertise in materials that purchasing officers have, and for them then to be able to make a properly informed decision. Most frequently, decision makers do not possess the level of expertise required to make decisions based on anything other than marketing, price and claimed performance which can lead to the purchase of products which are possibly over specified or not necessarily the best product for



HOT sensors to aid firefighters

Heat Observation Technology, or HOT system, is a safety technology that uses RFID, radio frequency identification, to read and monitor a firefighter's core body temperature.

The system is comprised of a sensor, transponder, and a reader. The sensor is placed on the temporal artery and reads the firefighter's skin temperature and estimates the core body temperature to within 0.01 degree Fahrenheit.

The temperature is then sent to a reader, either a PDA or a laptop, and will alert the holder if the firefighter's core body temperature is in dangerous levels. The firefighter can then be placed out of service and in rehab for active cooling.

The PDA contains the firefighter's personal medical history and contact information for easy access if needed by medical personnel. The range for the HOT system is approximately 300 yards in 360 degrees. Each PDA or laptop can contain up to 1,000 firefighters and their information.

The HOT system has been tested in several metro-Atlanta fire departments as well as being utilized in the Louisiana State University (LSU) Fire Institute's Recruit Academy. The system has been placed in helmets, SCBA masks, and headbands. With the sensors placed in helmet and mask, the firefighter can be monitored the entire duration of an emergency incident. The sensors are weather and impact-proof and have been thoroughly tested in fire ground conditions.

343 Technologies is comprised completely of career, on-duty firefighters. They found the system while researching tools and technology for RIT, Rapid Intervention Team, operations.

The President, Michael Bentley, contacted Hothead to inquire about possibilities in the fire service. Jay Buckalew, CEO/Founder of Hothead Technologies, was contacted and discussed testing the technology in fire ground operations. 343 Technologies tested the system and the results were remarkable. A partnership was formed and 343 Technologies began to assist Hothead in developing the fire version of the HOT system.

The HOT system made its initial mark on the American football world. Jay Buckalew developed the idea after suffering a syncopal episode from heat stress. He was working on a rooftop in Puerto Rico as a telecommunications engineer when he collapsed from overheating.

Jay decided that a technology was needed to monitor individual's core body temperature and help to prevent future heat stress related illnesses. He found that many football players suffered from this and several had died for overheating. He implemented the system and partnered with Schutt sports to bring the technology to the masses. Hothead has also partnered with the Sports Concussion Institute at UCLA.

343 Technologies and Hothead Technologies are continuing to bring the system to public safety, sports, and industrial companies worldwide. 343 is currently working with manufacturers to bring the system to larger markets such as countries in Europe.

Note: The members of 343 wanted to pay honor and tribute to their fallen brothers during the terrorist attack on September 11 by naming their company, a safety inspired company, 343 Technologies LLC. 343 is the number of firefighters that perished while responding to their last call on that fateful day.



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the required level of protection.

Health & Safety principles advise us that PPE should be seen as the last line of defence. To set against this it is argued that something is going wrong well before the incident and that PPE is becoming the first line of defence. Clearly there appears to be some confusion in this area and using safety first as the guiding principle, perhaps we should always provide the highest level of protective structural clothing possible in order to ensure firefighter safety for this type of PPE.



Alex McAllister, Lion Apparel (UK)

The level of protection offered to firefighters today is arguably better than for any other group of professionals. That's because for the last 20 years the focus of innovation and development has been to protect the firefighter from heat and flame. The introduction in Europe of the EN469 standard ensures protection from the most intense levels of fire and most quality structural gear performs well beyond the minimum standard required.

But therein lies the paradox – there is greater risk from overprotection when a firefighter isn't fighting a fire. That's because for at least 80% of the time they are either training or undertaking rescue or extrication tasks, where protection from heat and flame is unnecessary. For these situations there is a greater need for protection against heat stress, cutting, tearing and body fluids.

Firefighters now have the option of wearing protective clothing, such as USAR suits or wildfire coveralls, designed to meet the specific needs of the job at hand and minimise the risk of injury.

In the wake of 9/11, many rescue workers suffered exhaustion and heat stress because they were wearing structural firefighting suits when a USAR coverall would have been more appropriate for digging through mountains of rubble.

The Fire Service in the UK now takes a flexible approach rather than the "one size fits all" solution that comes from wearing full structural kit for every eventuality. Firefighters now have a choice of specialist PPE to complement structural ensembles.

So the key is to make the right choice of PPE for the job at hand. At Lion we are in advance stages of creating a single solution that would allow removal of layers to suit the task. This ensures the most appropriate protection relevant to the situation, whether an intense fire, road traffic accident or building collapse. It is only right to continue to develop the highest standards of PPE, but it must be flexible to be fit for a variety of purposes.

What do you think? Please send your comments to the Editor: am.knegt@hisdorset.com.