Decontamination of Firefighting PPE and Protective Clothing:

Evidential Approaches to Support Healthier Firefighters Today

scandecon

A proposal for routes to more effective decontamination with proven methodologies by James Jones

In the late 19th century, socially conscious leaders from the coal mining industry travelled to Belgium and Germany on a mission to discover how European mine workers and their families were more successful in avoiding occupational-related health problems than their British counterparts.

Many British coal miners and their families were suffering often severe side effects from exposure to coal dust and dirt. Washing the day's grime off in their bathtubs in front of the fire in their tiny homes meant high levels respiratory, cancers and other diseases. Miners were returning from the pit every day filthy dirty from their day's work thus exposing themselves and their loved ones to hazardous substances, damp and other dangers – contaminants from the workplace brought into the home.

In 1926, the first Pithead Baths were opened. It was this solution that those socially conscious industrialists learned was helping miners in Europe. They discovered that washing thoroughly straight after work, at the pit head, and leaving their dirty clothes there rather than taking them home significantly improved health outcomes.

Now, 100 years later, a similar pattern is emerging in the UK...

How Clean is Firefighters' PPE?

Those mine owners were incredibly forward thinking – creating separate 'dirty' and 'clean' zones to ensure cleanliness and areas free from contaminants thus preventing cross-contamination from dirty to clean clothing.

Now a century on, we are learning similar lessons to those early 20th century miners. Instead of filthy overalls; contaminated turnout kit and breathing apparatus has been proven to be hazardous and a significant contributary factor in increased incidences of cancers and other diseases in firefighters.

Regrettably, in contrast to some regions in Europe, the UK fire sector has been slow to react to the emerging science and growing evidence that contaminants left on clothing are contributing to poor health outcomes in the firefighting community. This is despite the important work carried out by Stec et al showing that UK firefighters are being exposed to polycyclic aromatic hydrocarbons (PAHs) during the course of their work – particularly during structural fire incidents and whilst hot fire training, but also when attending to car fires, outdoor burns and wildland fire incidents as well as post fire investigation and turnover work.

It is only since the 2022 declaration by the WHO that firefighting is a cancer risk occupation that the issue has been escalated to the importance it deserves.

Since then, there has been a flurry of activity in the UK, several excellent conferences have been held to raise awareness of the risk that contaminants pose with emotional pleas to the UK fire sector and its firefighters to take the risk seriously. The cost of continued exposure to contaminants and of not effectively cleaning kit is now clear in both the serving and retired firefighting community. It is a cost being borne not only in terms of health – both physically and mentally, but also financially. One serving firefighter, admirably using his own ongoing experience of battling cancer to raise awareness of the risk that contaminants pose, estimates the cost of his illness to his employer as being £500,000.

That's half a million pounds of taxpayers' money spent supporting one firefighter in one fire service. That we should support firefighters when suffering poor health due to occupational exposure to hazards is unquestionable. However, now there is ample evidence that occupational exposure to carcinogens and other hazards is causing disease, are we doing enough to properly decontaminate and clean PPE and equipment to ensure that the very equipment provided to protect is not in fact causing harm?

We Care for our Firefighters

The UK fire service is rightly regarded as being one of the best in the world. We are seen as leaders in many rescue fields such as vehicle extrication, Urban Search, Water and Technical Rescue.

We have serving firefighters and non-uniformed members of our sector representing the UK at the highest levels on committees, councils and standards bodies in Europe and internationally. We should be rightly proud of our status as global leaders in all aspects of fire safety, engineering and operational procedures.

Our Fire Service's excellence is abundantly illustrated by the relatively few operational deaths suffered – 33 in England since 1986.

Whilst every death is an avoidable tragedy, other nations regrettably suffer the sadness of far more operational fatalities than the UK. There is little doubt that on the face of it we look after our firefighters whilst at the incident or fireground. What though about the risk of exposure to hazardous contaminants, carcinogens and other poisons immediately post-fire and via contaminated clothing? On this measure, our record may not be as impressive.

Lessons from Abroad

Just as in the late 1800's with miners' health, it seems that we may be some way behind our European colleagues in terms of decontamination of structural firefighting clothing and cleanliness of breathing apparatus and other equipment.

Our research shows that markets such as Sweden, the wider Nordic region, The Netherlands, Belgium and other regions such as Slovenia are a long way ahead of the UK in their approach to firefighter decontamination and the importance that is placed on reduction of exposure to contaminants, decontamination and repeatable, consistent cleaning of fire kit.

An example can be found in Slovenia, where a private operator has run a highly efficient decontamination centre in Ljubljana for several years. Codex washes, repairs and launders approximately 20,000 firefighting suits, BA sets, boots, gloves and helmets per year, using a combination of conventional H2O and CO2 decontamination, all to very high levels of cleanliness and PAH removal.

This model of high quality and effective decontamination is repeated in territories that perhaps have more flexibility or control of their cleaning and laundry than we do in the UK. Countries such as Belgium, The Netherlands and France show examples of specialist private operators offering full H2O and CO2 decontamination services, providing their firefighters with consistently clean clothing and PPE with provable rates of contaminant removal.

Are we Constrained by the UK Market Structure?

Such is the market consolidation of PPE supply, maintenance and 'fully managed' contracts in the UK, most fire services are contractually limited in terms of washing procedures, the equipment and detergents used as well as methods of decontamination. There is very little habitual cleaning, laundering and decontamination 'on-station' in the UK with most of this work subcontracted to major workwear laundry operators or directly with the PPE manufacturers themselves.

The PPE manufacturers, laundry contractors and those fire services in leased and total care contracts are possibly limited in their ability and motivation to innovate in terms of decontamination. Garment manufacturers and laundry operators are, often by misconception, constrained in terms of detergent options, methods of cleaning and water temperatures. This is no wonder – it is only a few years since we have had to be truly concerned with decontamination as an issue. Providing turnout kit at the relatively low cost demanded by the UK market with all the certification, testing and durability requirements (correctly) imposed by standardisation is tough. To have to consider truly effective and provable decontamination within these constraints is an added level of complexity. It is though both important and possible.

Emerging evidence, knowhow and workable examples are now being offered to the UK by companies such as Vimpex, Hunters Apparel, Draeger and Rescue Intellitech, all of whom are proposing workable solutions to help fire services improve firefighter health through removal of contaminants.

Use our Knowledge and Resource

Customers of Vimpex Scandecon can benefit from the vast knowledge we have developed in the field of decontamination. There is no 'silver bullet' for the complex challenge of improving cleanliness of firefighting clothing and PPE. Great detergents will only perform with appropriate machinery, machine programming and correct dosing.

Our experienced team can assist with:

- Advice on progression from existing, embedded laundry processes.
- Input on optimisation within budgetary constraints.
- Provision of programmes specifically designed for professional washing machines.

See the process in action

Our network of European partners means we can provide your fire service with case studies and project experience from departments that have already implemented an optimal decontamination process.

Proof of Cleanliness

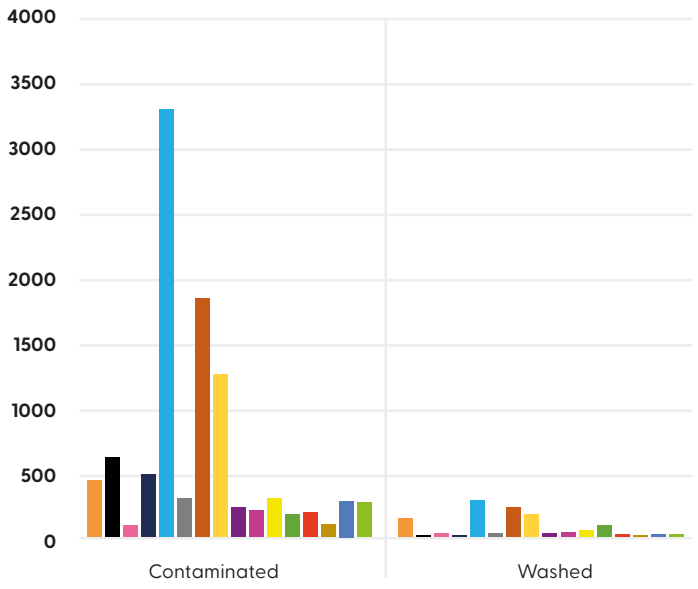
One question that is posed to us when presenting to Fire Services is, “How do we know that our current process is not clean using our existing processes?” The answer to this is - analyse it.

This is easier said than done, and even when PPE is being tested for PAH levels and other poisons, the approach, accuracy and method of analysis are in question. Whereas in Sweden, The Netherlands, Belgium and Finland , accurate test methods have been developed to accurately assess PAH levels before and after decontamination, evidence from the UK suggests that habitual analysis is not yet available. Stec’s excellent work includes analysis of PAHs, but it mainly focuses on proof of their presence – particularly on the body, with no investigation on removal or removal rates pre- and post-advanced laundry processes.

There is very little research on the effectiveness of laundering practices used by the firefighting community, particularly in relation to removing specific types of contaminants. We argue that the absence of locally available analysis at an appropriate cost and turnaround time means many of our 50 Fire and Rescue Services are each independently now looking for proof that current or proposed methods of decontamination are effective. This introduces the risk of inappropriate or inaccurate findings to either justify spend on equipment and processes which may or may not improve firefighter health or worse, delaying improvements to cleaning or doing nothing at all.

The UK desperately needs a centralised, independent testing authority to allow for audit and verification of decontamination efficacy, whether the decontamination is carried out by FRS, independent operators, or laundry contractors. We argue that this requirement should be a key requirement in any future amendments to or addition of a national annex to EN ISO 23616—Cleaning, inspection and repair of firefighters' personal protective equipment (PPE).

Levels of PAHs on the outer side of contaminated washable fabric gloves before and after washing at 60°C



	Contaminated	Washed
naphthalene	450	150
acenaphthylene	630	12
acenaphthene	90	28
fluorene	500	8
phenanthrene	3400	290
anthracene	310	29
fluoranthene	1900	230
pyrene	1300	180
benso(a)anthracene	230	35
kerosene	220	41
benso(b)fluoranthene	300	59
benso(k)fluoranthene	160	88
benso(a)pyrene	180	23
dibens(ah)anthracene	90	18
benso(ghi)perylene	290	23
indeno(123cd)pyren	280	23

*All data according to laboratory and full-scale washing tests at fire departments and independent accredited laboratories. PAH levels before and after washing of contaminated turnout kit shows reductions of 16 different PAHs. Analysis method - Gas chromotography and mass-specrometry.

Warranty, Care, Wear & Tear

"Current decontamination practices used for firefighter protective clothing have been shown to not be very effective."

This statement made last year by Girase et al. - well-respected authors on the subject has been reflected in the most recent version of NFPA, albeit based on arguably flawed assumptions around laundry methods and detergent types. NFPA 1851 acknowledges that the currently recommended 40°C may be unsuitable for acceptable removal rates. The majority of clothing manufacturers in the UK, however, continue to insist on a 40°C wash rather than 60°C - as used across much of Europe.

Whether this is due to environmental concerns over energy costs, an assumption that firefighting clothing can be cleaned effectively at 40°C or, simply habit is unknown. Fear for the useful lifetime of clothing seems to play a part, and it has been assumed that washing at higher temperatures can wear clothing more quickly than colder water.

We argue that, in fact, the inverse can be true. Clothing washed with dedicated 'gentle' programmes with ample water, at higher temperatures (60°C) and with specifically designed detergents can, in fact, extend the lifetime of clothing. Again - empirical evidence from Sweden, Norway, Germany, The Netherlands and Slovenia suggests that washing at 60°C does not increase the rate of wear or the need for more frequent replacement of structural firefighting clothing.

So, warmer washing temperatures – proven to significantly increase PAH removal rates is accepted in much of Europe, with one major difference – habitual reproofing to ensure continued waterproofness and chemical repellence. This difference means that in much of Europe, fire suits are not retired after a certain number of washes and are instead assessed by trained operatives for signs of wear and tear and continued chemical and water repellence.

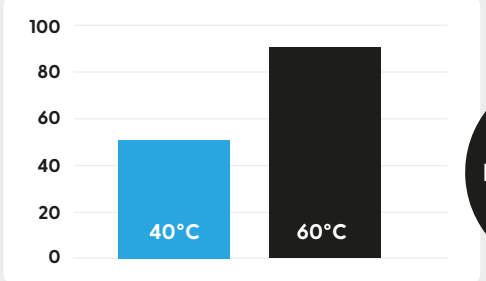
Recent excellent research commissioned by the NFCC included analysis of the structural integrity of fire kit after the UK's norm of 40 washes at 40°C shows that in terms of mechanical strength, thermal protection and capacity to mechanically protect the firefighter – 'retired' or 'end of life' fire clothing has in fact plenty of life left in it. What is worn down over time at all temperatures and washing methods by the mechanical and chemical action of laundering clothing is the liquid-repellent coating. US, European and ISO standards require water, hydrocarbon and acid run-off at a determined rate to ensure continued compliance and protection for the wearer. Whereas many international markets habitually re-proof their clothing every, say, 5 washes, in the UK, we do not. Leaving aside the ongoing, complex and far-reaching general debate around the use of PFAS (forever) chemicals, surely there is an exciting opportunity to consider lengthening the lifetime of UK turnout kit via reproofing?

With an acceptance of the necessity and efficacy of higher water temperatures, combined with a re-proofing culture, we could achieve a much cleaner fire kit with a longer useful life, thus lowering product lifetime costs and contributing to healthier firefighters.

The 60° difference

Because PAHs are oil and fat soluble, they become increasingly liquid with higher temperatures and thus easier to clean. Using even specialist detergents at 40°C removes 55% of contaminants. Washing at 60°C removes around 90%. That's a remarkable difference that can only be achieved with Lejon Kemi specialist chemicals, the correct machinery and wash programmes.

Comparison between standard industrial wash at 40°C and optimized wash at 60°C



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Routes to Effective Decontamination
Science and Culture

The UK fire sector is moving quickly to attempt to understand effective decontamination. Inevitably, mistakes are being made with some rushing to be seen to improve approaches to the challenge.

Much money is being spent on machinery, new techniques and methodologies, all with the laudable aim of improving employee health. Simply spending money is though not the answer. For example, adaptation to washing programmes to increase water volumes, amount of rinses, higher water temperatures and the use of specifically formulated detergents can work to significantly improve decontamination outcomes with relatively little capital investment.

As is often the case with complex challenges, there is no silver bullet. The challenge of improved decontamination needs to be attacked with a system-based approach. By this we mean carefully considering machinery (washing machines and PPE washers), detergents and washing programmes (time, temperature, mechanical agitation and water volumes). The system approach does not stop at the physical equipment and chemicals. Cultural change is vital to ensure permanent and truly effective decontamination. There is no room for stereotypical male attitudes to 'doing the laundry', excellent work by highly respected industry elders such as John Lord and Steven Burns who are raising awareness of the danger of contaminants is really helping drive this cultural change but more needs to be done.

We need to stop taking dirty kit home.

The UK's acceptance and willingness to trust the science, chemistry and the technicalities of decontamination, the way detergents work to break down dirt on clothing and distinct differences between cleaning methods, chemicals and equipment must be understood. Fire sector manufactures and suppliers must play their part in acting responsibly to ensure that marketing claims and their approach to 'selling the science' is truthful and accurate. Claims must be verifiable as well as being able to be easily understood by our customers.

It is only with evidence-based decision-making, backed with sound user knowledge and underpinned by permanent cultural change that better health outcomes for our firefighters can be achieved. Thankfully, these factors exist and are available to the UK fire sector now, meaning with careful thought, a sensible approach and with a trust and appreciation of the science, through reliable, repeatable and effective decontamination - we can contribute to Healthier Firefighters Today.

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