Management and decontamination of Firefighters structural protective clothing and equipment.

JOHN HELGESEN
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Report by John Helgesen

2010 Churchill Fellow

The David Balfour Churchill Fellowship

To study

Methods used in the management and decontamination of Fire Fighters structural protective clothing and equipment

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Signed ……………………………………………………………

Dated……………………………

Page 2
TABLE OF CONTENTS

Introduction ........................................................................................................................................ 4
Acknowledgements .......................................................................................................................... 5
Executive summary .......................................................................................................................... 6
Recommendations - general ........................................................................................................... 8
Recommendations – ACTFB specific .............................................................................................. 9
Overview ......................................................................................................................................... 10
Study Program ................................................................................................................................ 12
Tokyo Fire Department .................................................................................................................. 13
Kobayashi Fire Protectives Co. Ltd ................................................................................................. 16
San Francisco Fire Department ...................................................................................................... 19
Los Angeles Fire Department ......................................................................................................... 21
Chicago Fire Department ............................................................................................................... 23
International Personal Protection Inc .......................................................................................... 27
International Association of Firefighters ....................................................................................... 31
New York- FDNY ........................................................................................................................... 33
London Fire Brigade ..................................................................................................................... 35
British Textile Technology Group .................................................................................................. 37
Conclusion ...................................................................................................................................... 39
INTRODUCTION

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This report is an observation of some of the world’s biggest and busiest Fire Departments/Brigades in the world and how they go about the management, decontamination and maintenance of Firefighters structural personnel protective clothing and equipment (PPC&E).

This study was bought about as a result of a need for a more consistent and user friendly procedure for minimizing the exposure of Firefighters to toxins and carcinogens that become embedded in the PPC&E as a result of firefighting activities, thus assisting the Fire Department in its duty of care in Firefighter health and well being.

This study does not differentiate between the type or construction of PPC.

At the initial inception for this study in 2008, only one document was available to provide an official guideline for Fire fighters, Fire Departments and Independent service providers (ISP’s) to make decisions on the condition of the PPC and its subsequent requirements to deem the garments fit for duty – NFPA1851, Standard on Selection, care and maintenance of Structural Fire Fighting Protective Ensembles, which is a guideline for all Fire departments in the USA.

In October, 2009 The International Standards Organization released ISO/TR21808:2009 Guidance on the selection, use, care and maintenance of Personnel Protective Equipment (PPE) designed to provide protection for Firefighters, as a guideline for all Fire departments around the world.

This study looks at the correlation between these documents and what actually happens within the Fire Departments and the effects logistically, financially and culturally upon the Fire fighters and the Fire Departments.
ACKNOWLEDGEMENTS

This study would not have been possible without the assistance of the following people and organizations.

Most importantly I would like to thank Mrs. Celia Balfour, widow of Senior Firefighter David Balfour of the ACT Fire Brigade and a colleague of mine who was tragically taken in the line of duty during the Victorian Bushfires in 2009.

Mrs. Balfour’s generosity in supporting the Winston Churchill Memorial Trust and donating a sponsored fellowship in David’s name is an honor for me to be the inaugural recipient.

Also I would like to thank the ACT Fire Brigade, especially Chief Officer Paul Swain and Deputy Chief Officer Conrad Barr for their support in allowing me the time to spend six weeks visiting Fire Departments across the world.

To my project referee Mr. Russell Shephard who mentored me and opened up so many doors around the world.

And of course the Winston Churchill Memorial Trust, ACT Branch for their support and assistance in ensuring my trip was the best it could be.

In thanking the following organizations I also thank the numerous people involved with them as it was a life changing experience to meet these people from different countries and cultures and be offered so much help along the way.

- Tokyo Fire Department
- Tokyo Fire Department International Liaison Section
- SanFrancisco Fire Department
- Los Angeles Fire Department
- Chicago Fire Department
- Lion Apparel – Chicago and Houston
- WS Darley co.
- Andy Oliver – GearWash
- Willemette Fire Department
- Northlake Fire Department
- Jeff & Grace Stull – International Personal Protection Inc.
- Houston Fire Department
- International Association of Fire Fighters (IAFF)
- FDNY
- Minerva Bunker Gear Cleaners
- London Fire Brigade
- Bristol Uniforms
- British Textiles Technology Group
- Bureau Veritas Solutions
EXECUTIVE SUMMARY

With the building industry becoming more reliant on synthetic materials and the increase in electrical equipment around the house, Firefighters are becoming more exposed to toxic and carcinogenic substances as a result of everyday fire fighting activities.

A study by the University of Cincinnati found that Firefighters have a 100% higher risk of developing testicular cancer, a 50% higher risk for multiple myeloma and non-Hodgkin’s lymphoma and a 28% increased risk for prostate cancer compared with non-firefighters.

In 2009 the International Standards Organization published ISO/TR21808:2009 Guidance on the selection, use, care and maintenance of Personnel Protective Equipment which is a baseline for all countries. In the USA most Fire Departments abide by the NFPA1851, Standard on Selection, care and maintenance of Structural Fire Fighting Protective Ensembles.

Whilst Fire Departments around the world have strict protocols in place to decontaminate PPC contaminated with blood borne pathogens, Asbestos or known chemicals, the management and decontamination of PPC after a “common” structure or vehicle fire is not considered for its potential risks to the Firefighter.

Contaminated PPC from fire fighting residue has not been generally considered as a potential health risk by Fire Departments although there have been scientific studies and analysis done by independent bodies to suggest otherwise.

It would appear that the logistical and financial imposition placed on Fire Departments across the board to conform to a nil contamination is too great, however there are systems utilized by some Fire Departments that greatly reduce the exposure to Firefighters.

A leasing arrangement as held between the London Fire Brigade and Bristol Uniforms would appear to be the best system, although this would not necessarily be economically viable for smaller Fire Departments. NFPA1851 in the USA gives a clear outline of firefighters and Fire departments responsibilities regarding the decontamination and maintenance of PPC and it is evident that the Fire Departments that follow these recommendations have a reduced likelihood of exposure to carcinogenics contained within the PPC.

Fire Departments throughout the USA have access to industrial style washing machines called Extractors, which have a multi stage cleaning cycle with predetermined settings for detergents, water temperature and spin cycle G forces to ensure the PPE is not damaged during washing. These Extractors are located at strategic stations throughout districts and used by the firefighters.

Annually the PPE is sent to an Independent Service Provider (ISP) for advanced annual cleaning, inspection and repairs as needed, in accordance with NFPA 1851.
The management and auditing of PPE is generally well done in the Fire Departments I visited in the USA. The Manager of the PPE Stores keeps all records of advanced cleaning and any repairs undertaken on the garment as well as its age and general condition. Replacement is carried out as required.

In Japan, the cleaning of PPE is conducted by Firefighters at the station by soaking in a tub and then scrubbing with brushes. There is very little consideration given to the contaminants contained within the PPE. Management of the PPE is conducted by the Station manager as the PPE is assigned to the station rather than the Firefighter. Replacement is carried out as required.

The London Fire Brigade (LFB) utilizes the Fully Managed Service (FMS) by Bristol Uniforms. This system works very well due to the dedicated service and facility provided by Bristol due to the size of the LFB. The contract between LFB and Bristol ensures that Bristol provide PPE that is clean and fully operational for the duration of the contract until 2018. Bristol Uniforms controls the management, tracking, cleaning and repairs for all PPE from head to toe.

Whilst there have been studies undertaken by a wide range of sources highlighting the potential toxins contained within PPE and the inherent health risks they pose to not only the firefighters but also the ISP’s, unless the contaminant is a known substance such as blood, asbestos or known chemical, Fire Departments do not have a consistent approach to the fire ground management and decontamination. This could be attributed to historical attitudes towards firefighting, a lack of awareness and education in the potential health risks and the financial implications required to consistently maintain a standard acceptable to the health and safety of firefighters.

It is entirely possible that the trend for increases in Firefighter cancers and other related health disorders may stabilize once the effects of new personnel protection practices become more commonplace for next several years; however, the increase in the number and types of contaminants found in structural fires and other incidents to which Firefighters now respond may present new hazards. The spread of toxins by contaminated clothing may become a subtle, insidious hazard capable of affecting Firefighter health.
RECOMMENDATIONS - GENERAL

- National bodies/unions to drive awareness campaigns similar to campaigns for HIV and asbestos
- Improved education of Firefighters in the effects of exposure to contaminated PPE and the importance of decontamination of PPC
- A consistent approach to post operations PPC management and decontamination, including, but not limited to:
  - Bagging and tagging of contaminated PPC.
  - Recording of incident and possible contamination.
  - Quality control of decontamination process.
- Dedicated PPC Manager to ensure auditable records are kept of PPC condition and age.
- Standards to reflect frequency of use as well as annual compulsory advanced cleaning and inspection
- Development of a recognised level of contamination for PPE and appropriate decontamination. An example could be:

<table>
<thead>
<tr>
<th>Description</th>
<th>Action required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Smoke, water, odour</td>
<td>Hang in ventilated dry area.</td>
</tr>
<tr>
<td>Level 2 Light particulate – dry</td>
<td>Vacuum or brush and hang in ventilated dry area</td>
</tr>
<tr>
<td>Level 3 Light particulate wet</td>
<td>Hose and brush. Hang in ventilated dry area</td>
</tr>
<tr>
<td>Level 4 Heavy dry or wet</td>
<td>Mechanical launder</td>
</tr>
<tr>
<td>Level 5 Blood, asbestos, chemical</td>
<td>Specialist launder by approved ISP</td>
</tr>
</tbody>
</table>
RECOMMENDATIONS – ACTFB SPECIFIC

In general the ACT Fire Brigade is well placed to adapt to improved management of PPC. Its current practices are sound yet not enforced. Therefore I offer these recommendations.

1. Greater emphasis placed through the chain of command on the condition of PPC. This can be achieved by regular inspections at the station by District Officers.

2. Position created for Officer in Charge of PPE. This position should sit within the Fire Brigade with sole responsibility for the tracking and auditing of PPC during its operational life.


4. Investigate the benefits of purchasing a number of extractors and creating an in house cleaning, inspection and management section for ALL PPC as opposed to outsourcing laundering of PPC.

5. Implement an education program to all ACTFB staff on the health risks involved with dirty PPC as well as a base recruit learning outcome.

6. Implementation of fire ground management for dirty PPC with level of decontamination to be determined on-site.

7. Implement tracking and recording process for all PPC.

8. Reinstate hanging storage capability at all fire stations.
OVERVIEW

In September 2010 I embarked on my Churchill Fellowship to look at world’s best practice in Management and Decontamination of Firefighters structural protective clothing and equipment. The six week study took me to Tokyo (Japan), San Francisco, Los Angeles, Chicago, Texas, Washington DC, New York (USA) and London and Manchester (UK).

My initial contact with all the Fire Departments I visited was by email to the Chiefs Department or to their International Liaison Department, outlining the nature of my study and areas of interest that they may be able to offer me. The replies were very cooperative in my request, however upon arrival at all of the Fire Departments, it became apparent very quickly that there really is very little knowledge or consideration given to the contamination of PPC&E and the effects on Firefighters health unless it is contaminated by blood, asbestos or a “known” chemical.

I was generally steered in the direction of the Hazardous Materials (HazMat) section and shown over the protective clothing and decontamination systems employed when dealing with a Hazmat incident.

Whilst I took interest in this area of the Fire Departments, it usually took a bit more explaining to my Department contacts to be shown what I was looking for.

For many years Fire Departments and Health organizations around the world have heavily promoted the dangers presented to Firefighters when contaminated with blood or bodily fluids and asbestos. As a result the strict decontamination regimes put in place for these contaminants ensure that the likelihood of Firefighters contracting any health conditions is almost nil.

If Firefighters are presented with a known chemical fire, appropriate measures are put in place to minimize exposure to chemicals and byproducts with the aid of technical data available to the Fire Departments for combating these incidents.

Fire fighters are continually exposed to a range of toxins as a result of incomplete combustion. As the building and manufacturing industry become more reliant on synthetic and composite materials, the risk to the Firefighters health becomes greater. It is more the case that all fires should be treated as Hazmat incidents.

Whilst Firefighters wear respiratory protection during firefighting, the dangers from these exposures are still present through the debris and contamination on the Firefighters PPC&E long after the Firefighters have left the fire ground.
Some of the more prominent contaminants Firefighters will be exposed to in a typical structure or vehicle fire include:

- Inorganic gases (hydrogen sulphide, hydrogen cyanide, nitrogen oxides)
- Acid gases (hydrochloric acid, sulphuric acid, nitric acid)
- Organic acids (formic acid, acetic acid)
- Aldehydes
- Chlorinated compounds (carbon tetrachloride and vinyl chloride)
- Hydrocarbons (benzene)
- Polynuclear aromatic compounds (PANs)
- Metals (barium, cadmium, chromium, lead, nickel, zinc)

Examples of fire contaminants

<table>
<thead>
<tr>
<th>Polychlorinated Biphenyl (PCBs)</th>
<th>Power transformers/capacitors</th>
<th>PCBs can produce dioxins which are toxic by inhalation and ingestion. PCBs also absorb through the skin. PCBs cause liver and pancreas.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power poles</td>
<td>Creosotes is toxic through inhalation and skin absorption. Causes cancer of skin, prostate, and testicles.</td>
</tr>
<tr>
<td></td>
<td>Railroad ties</td>
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<td></td>
<td>Treated wood or buildings</td>
<td></td>
</tr>
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<td></td>
<td>Lumber yards</td>
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<tr>
<td></td>
<td>Piers and docks</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical insulation</td>
<td>Variety of decomposition products including acrylonitrile, hydrogen cyanide, nitrogen oxides, hydrogen chloride, and benzene.</td>
</tr>
<tr>
<td></td>
<td>Plumbing</td>
<td>Various routes of toxicity through skin absorptions, inhalation or ingestion.</td>
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<tr>
<td></td>
<td>Furniture</td>
<td></td>
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<tr>
<td></td>
<td>Construction materials</td>
<td></td>
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<tr>
<td></td>
<td>Insulation and packaging</td>
<td></td>
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<td></td>
<td>Tools/toys</td>
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<td></td>
<td>Automobiles</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power transformers/capacitors</td>
<td>Televsions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air conditions</td>
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<tr>
<td></td>
<td>Carbonless copy paper</td>
<td></td>
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<tr>
<td></td>
<td>Hydraulic systems</td>
<td></td>
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<tr>
<td></td>
<td>Elevators</td>
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</tr>
<tr>
<td>Asbestos</td>
<td>Roofing and shingles</td>
<td>Principal hazard is inhalation of fibres’ (&lt;5 microns length) causes cancer. Asbestos fibres’ can be aerosolized from clothing and inspired or and ingested.</td>
</tr>
<tr>
<td></td>
<td>Acoustic ceiling tiles</td>
<td></td>
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<tr>
<td></td>
<td>Sprayed ceilings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old pipe insulation</td>
<td></td>
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<tr>
<td></td>
<td>Old octopus type furnaces</td>
<td></td>
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<tr>
<td></td>
<td>Pre-1975 drywall</td>
<td></td>
</tr>
<tr>
<td>Creosote</td>
<td></td>
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</table>

Jeff & Grace Stull, 1999
### STUDY PROGRAM

<table>
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<tr>
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<th>Location</th>
<th>Organizations/Companies</th>
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<tr>
<td>Sept 5 – 8, 2010</td>
<td>Japan</td>
<td>Tokyo</td>
<td>Tokyo Fire Department</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Kobayashi Protectives</td>
</tr>
<tr>
<td>Sept 9 – 10, 2010</td>
<td>USA</td>
<td>San Francisco</td>
<td>San Francisco Fire Dept.</td>
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<td>Sept 11 – 14, 2010</td>
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<td>Los Angeles Fire Dept.</td>
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<td>Chicago</td>
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<td>Northlake Fire Protection District</td>
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<td></td>
<td></td>
<td>Lion Totalcare Centre, Lion Apparel</td>
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<td>W.S. Darley co.</td>
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<td></td>
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<td></td>
<td>Gear Wash PPE Safety Services</td>
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<td>Sept 22 – 25, 2010</td>
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<td>Austin, Texas</td>
<td>International Personnel Protection</td>
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<td>Jeff &amp; Grace Stull</td>
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<td></td>
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<td>Houston, Texas</td>
<td>Houston Fire Department</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Lion Totalcare Centre, Lion Apparel</td>
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<td>Sept 26 – 29, 2010</td>
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<td>Washington DC</td>
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<td></td>
<td></td>
<td></td>
<td>Fire fighters (IAFF)</td>
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<tr>
<td>Sept 30 – Oct 7, 2010</td>
<td>USA</td>
<td>New York</td>
<td>New York Fire Department</td>
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<td></td>
<td></td>
<td></td>
<td>Minerva Bunker Gear Cleaners</td>
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<td>Oct 8 – 14, 2010</td>
<td>UK</td>
<td>London</td>
<td>London Fire Brigade</td>
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<td></td>
<td>Bureau Veritas Solutions</td>
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<td></td>
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<td>Bristol Uniforms Limited</td>
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<tr>
<td>Oct 15 – 17, 2010</td>
<td>UK</td>
<td>Manchester</td>
<td>British Textiles Technology Group</td>
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TOKYO FIRE DEPARTMENT

Tokyo Fire Department (TFD) is the largest Fire Department in the world with approximately 18,000 uniformed fire fighters (including paramedics) and 500 non-uniformed personnel.

My tour of the Tokyo Fire Department commenced with a visit of Kojimachi Fire Station and HQ of the 1st Fire District of the TFD. There are 10 Fire Districts and 80 Fire Stations in the TFD all having their own HQ and special operations groups as determined by their risks and exposures.

Upon arrival I was greeted by Mr. Noriaki Fujii, a Paramedic with the TFD who spoke very good English and had been given the task of being my guide and interpreter for the morning session. I was led upstairs into the HQ section and introduced to Battalion Chief Satoshi Andoh for the customary introductions and formalities before being taken downstairs to meet the Station Managers and fire fighters.

Here I was shown over their Personal protective clothing and the storage facilities. Firefighters are issued with one complete set of PPC comprising of:

- Helmet with built in hood
- Tunic
- Overpants
- Firefighting gloves
- Firefighting boots

Tokyo Firefighters do not have “ownership” of the protective clothing issued to them, it is assigned to the station that they belong to. If they are required to perform an out duty (work at a different station), they obtain another firefighters protective clothing from that station.

If a Firefighters protective clothing becomes dirty (contaminated) as a result of fire fighting activities, the gear is soaked in a tub of water for a period of time before being removed and washed on the engine bay floor with a bucket of soapy water and a broom then hosed off and hung up to dry. This will either take place as part of the oncoming shifts duties, or if the PPC is heavily contaminated they will clean it upon arrival back at station and use another Firefighters set of PPC.
The storage of the PPC is in a small dark room off to one side of the engine bay. All the PPC is hung up on peg racks, which allows the gear to breathe and reduces build up of contamination by allowing the gear to off gas. After my morning spent with the crew of the Kojimachi Fire Station, I was escorted to the Fire Technology and Safety Laboratory in Shibuya Ku.

This section is comprises of:

- Fire Technology Section
- Equipment Safety Section
- Hazardous Materials Identification Section
- Operational Safety Section

My main point of interest here was to look at the Hazardous Materials Identification Section and the Operational Safety Section.

The Hazardous Materials Identification Section is responsible for the identification of substances encountered at an incident, be it a Chemical, Biological, suicide or arson investigation. The Laboratory consists of a wide range of spectrometers, flame and photo ionizing detectors as well as the more traditional scientific test methods of glassware, reagents and burners.

This section works closely with the Operational Safety Section. It was with this section that I had an in depth conversation regarding the TFD’s approach to the management and decontamination of Fire fighters PPC.

Here I spoke to Lieutenant Caz Mishima with the assistance of Ms. Taka Nakamura from the International Liaison Section of the TFD.

The TFD have done considerable research in the area of atmospheric conditions after a fire for the safety of arson investigation and overhaul and salvage, however the contamination of the PPC is generally overlooked unless it is a “known” contamination from an identifiable source. I.e. a chemical plant or known Hazardous materials site, in which case fire fighting operations would be conducted in a less aggressive manner to minimize the risk of contamination.

Should PPC become contaminated as a result of a known contaminant including blood or bodily matter, it is disposed of and replaced. The cleaning of dirty PPC is generally at the discretion of the Fire fighters and cleaned very basically as described earlier in the section.

The replacement policy for PPC of the TFD is that the AI Special Firefighting PPC (black) is replaced every six years while the Rescue Units (orange) PPC is replaced
Management and decontamination of fire fighters structural protective clothing and equipment.

every 5 years, although based on frequency of use and condition of the PPC it may be replaced sooner, however with a Fire Department the size of Tokyo’s, the budget for PPC is limited.

FIGURE 1 PPE STORAGE AREA AT KOJIMACHI FIRE STATION

FIGURE 2 A1 SPECIALIST FIREFIGHTING (LEFT) RESCUE UNIT (RIGHT)
My next stop is to Kobayashi fire Protectives to meet with Mr. Jutaro Kobayashi. Mr Kobayashi is a 6th Generation CEO of the company which provides all the protective PPE to the Tokyo FD as well as several other Fire departments in Japan (approx. 60% of the market) as well as being the only authorised distributor in Tokyo of the ARAI fire helmet. Mr Kobayashi is also on the International Standards Organisation for PPE and is the leader of Working Group 2 - selection and use of Fire fighter PPE.

In Mr Kobayashi’s office is a range of PPC developed by his company for the different Fire Departments across Japan that he supplies. Mr Kobayashi explains the recent history of PPC in the Tokyo FD. Until 1999 Fire fighters wore aluminized neoprene PPC which do not absorb chemicals and moisture and have high heat reflective qualities. However for general fire fighting activities this clothing is not durable and retains a lot of body heat. Kyoto Fire Department still uses this type of PPC due to the high ratio of chemical factories located in the region. In 1999, The Tokyo FD adopted the International Standards Organisations recommendations for selection and use of Fire fighting PPC and changed to a PBI constructed PPC which is more durable and comfortable to wear but requires more frequent cleaning as the material does absorb chemicals and smoke.

Mr Kobayashi suggests that the PPC should be washed in a washing machine with a neutral (PH of 7) detergent before having the waterproofing properties reapplied and then ironed when dry.
FIGURE 3  JUTARO KOBAYASHI WITH AUTHOR

FIGURE 4  ALUMINIZED CLOSE PROXIMITY PPC
Management and decontamination of fire fighters structural protective clothing and equipment.

![FIGURE 5] PPC AS WORN BY TFD
SAN FRANCISCO FIRE DEPARTMENT

San Francisco Fire Department (SFFD) comprises of 1500 Firefighters in 42 stations protecting the city of San Francisco on a full time basis.

After meeting with my contacts with the SFFD and meeting Fire Chief Joanne Hayes-White, I am taken to the SFFD stores located on Treasure Island, which is situated between San Francisco and Oakland. This was once a Federal Facility used primarily by the Navy but is now used by the SFFD for training and stores. Here I met Dorothy Tuepel who gives me the run down on how the PPC is distributed, managed and inspected for damage and then cleaned and repaired.

She ensures that all personnel are educated and informed of their responsibilities when it comes to the care and maintenance of their PPC as well as running regular awareness and education programs for the Battalion Chiefs in their responsibilities for the health and wellbeing of the Firefighters.

SFFD Firefighters are issued with two sets of Turnout Gear, As set out in NFPA 1851 they are instructed in how to undertake basic decontamination, spot cleaning and conduct routine inspection and are required to submit their Tunic and over pants twice a year (one set per year) to Treasure Island in their own time usually when they are about to go on leave for 4 weeks for the annual inspection and clean, Dorothy then conducts an initial inspection of all garments and tags the garment for the Independent Service Provider(ISP) to repair. Any PPC that goes to the ISP is subjected to a full inspection, repaired and recorded in a master data base. The Firefighters then pick their gear up in their own time from Treasure Island.

Having spoken with the fire fighters at Station 38, Battalion 4, there is mixed attitudes towards the cleaning of PPC, most are comfortable with the SFFD policy of complying with the annual testing and cleaning, however with only six Fire stations in San Francisco having extractor facilities (washing machines), it is not convenient for them to take dirty PPC to these stations and wait for their gear to be washed so they only conduct a gross particulate clean with a brush and water at their own station.
Management and decontamination of fire fighters structural protective clothing and equipment.

FIGURE 6  RETIRED SFFD PPC

FIGURE 7  GARMENT LABEL FOR TRACKING
LOS ANGELES FIRE DEPARTMENT

My time with the Los Angeles Fire Department (LAFD) is hosted by Captain Dan Curry of the LAFD Risk Management Section. This section is responsible for the health and safety of Firefighters and investigates all incidents involving injury or death to Firefighters.

I visited Station 4, Div 1, Battalion 1 in central LA to see what the Firefighters and Captains attitude to the care and maintenance of PPC at a station level is.

LAFD issues their Firefighters with one set of PPC consisting of one Structural fire fighting tunic, one pair of overpants, one pair of bunker boots, gloves and helmet and obtain extra gear from guys who leave or retire; one set of operational gear I observed on the rack was literally shredded across the shoulders and upper arms, unfortunately my camera battery decided to die at that very moment! Wearing dirty, damaged gear is definitely a status symbol here.

The Station is fitted with a PPE Extractor machine, basically an industrial front loader washing machine with a two stage automatic chemical induction system designed specifically for PPE.

The Firefighters conduct a course particulate hose and scrub down of their gear weekly if required and then might use the Extractor a couple of times a year. When it comes to PPE inspection, which happens 2-3 times a year by the Battalion Chief, I was informed that the set of “new” gear from their locker is laid out for inspection! This makes it hard for the LAFD to justify purchasing more PPE because of the false image given to the condition of actual PPE.

LAFD on the Fire Station, do not believe in NFPA (National Fire Protection Agency), while management will say they take bits and pieces from the standards if it suits their needs. The NFPA is only a recommendation in the USA except for Texas where it is enforceable.
Management and decontamination of fire fighters structural protective clothing and equipment.

FIGURE 8  OPERATIONAL LAFD PPC READY FOR THE NEXT CALL

FIGURE 9  NEW LAFD PPC AT THE STORES
CHICAGO FIRE DEPARTMENT

Upon my arrival in Chicago I am met at the airport by Lieutenant Robert Delaney of the CFD Hazmat and Safety section. I spent a few days with Lieutenant Delaney visiting the Training Academy and the Hazmat stations.

After explaining my study, my itinerary for Chicago was quickly changed to accommodate my needs better.

The CFD is the second largest Fire department in the USA with over 4300 Firefighters. They issue their Firefighters with two sets of PPC, and are conversant in NFPA 1851. They conduct their own basic cleaning and routine inspections and send their PPC away once a year for its annual inspection to an ISP although it can be sent more often if a thorough clean is required.

Lion Apparel is the ISP for the Chicago Fire Department. I visited their facility and was taken through all the stages of the cleaning and testing as required in the NFPA.

Upon arrival, the PPC barcode is scanned and logged in the database, it is then dismantled, that is the moisture barrier is removed as well as the drag rescue device (DRD) from the outer shell, and the overpants moisture barrier is removed from the outer shell. All pieces are labelled so that the garment is assembled with matching components. Then the components are washed and dried following the manufacturers recommendations before undergoing a thorough inspection.

The moisture barriers are inspected for seam deterioration as well as wearing through. It is then subjected to a water pressure (hydrostatic) test at seven key points to ensure the membrane is watertight. And failures are patched and retested.

The outer shell is inspected for tears, heat damage and the condition of the reflective striping, Velcro and fasteners and repaired as required, based on the repair contract in place.

This contract states the ratio of costs to repair verses the age of the garment with each year of age reducing the repair cost before that item is retired from service.

Lion Apparel maintains a full database on all the garments and produces six monthly reports to the Battalion Chiefs for garments that require inspection or are nearing their expiry date of seven years of service.
I also visited the Wilmette Fire Dept. and Northlake Fire Dept. which are both situated just outside of Chicago. These District Fire Departments have approximately 100 Firefighters each and rely on municipal grants and fundraising to maintain their existence.

Annually a large portion of their budget is used in the purchase and maintenance of PPC. They each have a designated officer whose responsibility is to ensure that the departments maintain its PPC in accordance with the NFPA 1851. Their responsibilities include ensuring that all PPC is regularly maintained and annually inspected and cleaned as prescribed in the guideline, and records are kept relating to the exposures, cleaning and maintenance of each garment.

The stations are also equipped with Extractors so that the PPC can be effectively cleaned in house.

Whilst in Chicago I attended a course in Advanced Cleaning and Advanced Inspection of PPC. This was conducted by a company called Gear Wash who are an ISP from Milwaukee and are also accredited in the training of personnel in the NFPA 1851.

This course involved:

- An overview of NFPA 1851
  - Firefighters must perform routine cleaning and inspection
  - Authorised personnel to perform advanced cleaning and inspection of inner liners and outer shells
  - Testing of ensemble
  - Maintain records
  - Retire garments after 10 years from date of manufacture or as required.

- The different levels of PPE cleaning
  - Routine
    - Performed by end user after gear has been contaminated
  - Advanced
    - Performed at least once per year or when soiled
    - Use of appropriate machinery required
  - Specialized
    - Performed when chemicals, blood or asbestos come in contact with PPE.
    - Special chemicals & disinfectants needed.

- PPE Inspection
  - Routine Inspection
    - performed visually after each use by end user
  - Advanced inspection
- Performed annually or when routine inspection indicates problem
- Performed by qualified individuals
- Garments cleaned prior to inspection
- Garments dismantled and inspected
- Findings documented
  - Complete liner Inspection
    - Must be performed minimum of three years in service and annually after or when advanced inspection indicates problem
    - Performed by qualified individuals
    - Liner to be opened for inspection and testing of all layers of liner and moisture barrier
  - Trim retro-reflective evaluation
    - Use a flash light to compare brightness against a new piece of reflective trim.
    - Trim can lose fluorescence (daytime visibility) and still retain retro-reflective property.
- Record keeping
  - Person to whom element is issued.
  - Date and condition when issued.
  - Manufacturer, model name/design, ID/Lot/Serial #.
  - Month and year of manufacture.
  - Dates and results of advanced cleaning and inspection.
  - Reason for and who performed advanced cleaning.
  - Dates and description of repairs and by whom.
  - Date of retirement.
  - Date and method of disposal

Upon completion of this course the candidate is issued a certificate which recognises them as being qualified in advanced cleaning and inspection of PPE.
Management and decontamination of fire fighters structural protective clothing and equipment.

FIGURE 10  CFD PPC STORED IN GEAR ROOM

FIGURE 11  DIRTY PPC IN CHICAGO
INTERNATIONAL PERSONAL PROTECTION INC.

My next stop is Austin Texas, where I meet with Mr Jeff Stull (President) and his wife Grace (Vice President) from International Personal Protection Inc.

Jeff started out as an Officer in the U.S. Coast Guard where he attended Graduate School and received a degree in Chemical Engineering. After receiving his degree he moved to the office of Research and Development where he worked on the Personal Protection Program in the early 80’s which had response teams for chemical and oil spills. Most of the PPC was derived from whatever the military was using which for the best part was not providing adequate protection to the user. Jeff was instrumental in developing the Coastguards capability so much so, that they expanded their role from purely maritime to regular response and assisting the Environmental Protection Agency with remediation efforts. As the Coastguards firefighting roles expanded Jeff also got involved with improving the PPC for these tasks.

Jeff then took up a role with the Texas Research institute where he got involved in Government contract development, testing and R&D in clothing and equipment as well as certification and developing standards for PPC.

For the past 18 years, Jeff and Grace have run their own company- International Personal Protection Inc.; they have written countless papers, presented at conferences as well as submitted scientific evidence in court as to the effects of contamination as a result of firefighting activities. They also sit on various standards panels including those of the National Fire Protection Association (NFPA).

Jeff is regularly asked by Fire Departments to test PPC for levels of contamination. An example he spoke about was of some PPC which had been worn in an electrical store fire. Firefighters were concerned for the potential increased exposure to silicone, PCB’s and plasticisers. To achieve a quantifiable outcome three sets of PPC were used. One set was a new set not used at the fire, while sets worn at the fire were also used. One was washed and the other left unwashed to compare the levels of elements found in both sets of PPC.

These results usually refer to level for exposure, which can be respiratory based and have no relevance to skin contact where some chemicals are skin hazards. So Jeff is mindful to ensure that caveats’ and qualifications are placed on what he says as he cannot say definitively whether the levels of chemicals found in the results are harmful or safe.
In 1999, Jeff and Grace delivered a very comprehensive report to the U.S Fire Administration titled Research, Testing and Analysis on the Decontamination of Firefighting Protective Clothing and Equipment.

“Retired turnout coats, destructively evaluated using solvent extraction and gas chromatography with mass spectrometry for organic chemicals and digestion with atomic absorption for inorganic chemicals, showed a variety of hazardous chemical contaminants, some of which were present at relatively high concentrations. Several polycyclic aromatic hydrocarbons, known to be carcinogenic, were found in the used clothing”

Some Fire Departments (ACTFB included) have gone down the track of sampling head space for off gassing of Volatile Organic Compounds (VOCs) to determine levels of contamination and potential health risks, however, a lot of contamination is not volatile and thus will not be apparent. The biggest by-product of combustion is soot which consists of carbon particles. These carbon particles have a propensity to absorb chemicals which gets in the clothing and holds the “bad stuff” so the theory is that you get rid of the soot particles out of the clothing and you get rid of most of the residual persistent chemicals.

It can be suggested then that if contamination is allowed to dry on the PPC, then these soot particles containing carcinogenics can become airborne as dust and inhaled. The issue becomes the continual exposure to this dust.

A similarity to radiation can be used regarding exposure to these chemicals. Short term exposure will have very little effect on the Firefighters health, however continual exposure to the contaminated PPC increases the levels of contamination and places the Firefighter at a higher risk of illness.

We also spoke about the most appropriate type of PPC management is. There are three methods used by Fire Departments around the world.

- Single set – One set of PPC is issued with old or second hand PPC used when the main set of gear is not serviceable
- Two sets – Each Firefighter is issued two sets of Tunics and over pants to be rotated as required
- Leasing – The Fire Department enters into a lease arrangement with a manufacturer for the supply of PPC and ongoing cleaning and maintenance for a prescribed period, typically 6-7 years. The leasing company maintains a store of PPC as well as ensuring spare PPC is available on station.
Our next topic of discussion was the fire ground management of contaminated PPC.

The Fire ground can be categorised into two levels of exposure:

- Fire fighting exposure – Firefighters are involved in fire fighting, salvage and overhaul operations and become heavily contaminated with gross particulate fire residue.

- Fire ground proximity exposure – Firefighters are involved in fire ground support duties such as Incident control, BA control, Pump operators, where contamination is confined to smoke and dust.

Jeff believes that unless PPC is contaminated with a known chemical, asbestos or blood borne pathogens, the PPC will be worn or placed in the vehicle back to the station. There is merit in bagging dirty PPC at the fire ground to ensure some form of decontamination is performed on the PPC and to minimise the exposure to Firefighters of off-gassing whilst in the vehicle.

The decontamination of the PPC can then be determined by the level of visible contamination. Where gross contamination is evident then decontamination using detergent and water is required to remove the contaminant. If no contamination is visible but is evident from odour, then decontamination by airing in a ventilated room away from UV is sufficient.

For busy Fire Stations, where they are attending to fires every set of shifts, constant wet cleaning may not be practical as the availability of PPC is limited to personal issue unless there is a lease arrangement in place or a policy outlining the use of other Firefighters PPC as is the case in Tokyo. NFPA 1851 is clear in recommending that PPC is submitted for inspection annually however it does not specify that for PPC with a high volume use, it should be submitted more frequently to ensure compliance with manufacturers’ specifications.

The financial implication on the Fire Department then also becomes an issue as the PPC is limited to a set number of mechanical washes, typically 20-25 washes, assuming that the PPC is washed correctly before its protective qualities are compromised and requires replacement. At approximately $800 on average per tunic or over pants, the replacement costs will soon exhaust the Departments budget. The question is: at what price is the health and well being of Fire fighters?
FIGURE 12   LAFD TUNIC WITH MOLTEN ALUMINIUM DAMAGE
The International Association of Firefighters is a labor union representing professional Firefighters and Paramedics in the USA and Canada.

It was formed in 1918 and has its headquarters based in Washington, D.C. It has over 298,000 members in every State of the USA and Canada protecting 85% of the US population.

The IAFF mission is:

- To organize all fire fighters and emergency medical or rescue workers;
- To secure just compensation for their services and equitable settlement of their grievances;
- To promote as safe and healthy a working environment for fire fighters as is possible through modern technology;
- To promote the establishment of just and reasonable working conditions;
- To place the members of the Association on a higher plane of skill and efficiency;
- To promote harmonious relations between fire fighters and their employers;
- To encourage the formation of local unions, state and provincial associations and joint councils;
- To encourage the formation of sick and death benefit funds;
- To promote the research and treatment of burns and other related health problems common to fire fighters;
- To encourage the establishment of schools of instruction for imparting knowledge of modern and improved methods of fire fighting and prevention; and
- To cultivate friendship and fellowship among its members.

My main aim of visiting the IAFF was to meet and talk with Mr. Rich Duffy.

Mr. Duffy has been involved with worker occupational health and safety issues for over 38 years, the past 33 years at the IAFF, where he is the Assistant to the General President, responsible for the IAFF’s activities addressing occupational medicine, safety and health. He has been involved in numerous committees involving fire fighters’ and other workers’ safety and health, including those of the federal government, state governments, the National Fire Protection Association (NFPA), the American National Standards Institute (ANSI) and the International Standards Organization. He provides technical assistance on fire fighters health and safety issues and is internationally recognized as a fire fighters health and safety expert. He has authored numerous books, manuals and articles on worker occupational health and safety issues.

He has been actively involved in addressing protective clothing and equipment for workers. He served as the Chairman of the NFPA Technical Correlating Committee for Fire Service Protective Clothing and Equipment and as the Secretary of the NFPA Technical Committee for Career Fire Service Deployment and Organization. He also served as a member on the NFPA Fire Service Occupational Safety and Health Committee and the NFPA Technical Committee on Hazardous Materials Response.
Personnel. He directed the NASA/FEMA program Project FIRES (Firefighters Integrated Response Equipment System), which under the auspices of the IAFF continues to work towards the development of state-of-the-art protective clothing and equipment, including the management of the new IAFF initiative Project HEROES (Homeland Emergency Response Operational and Equipment Systems) and the new IAFF initiative addressing light weight pressure vessels for SCBAs.

Mr. Duffy is responsible for the coordination and technical aspects of the IAFF/IAFC Joint Wellness/Fitness Initiative for Fire Fighters, including the Wellness-Fitness Program, the Candidate Physical Ability Test Program, the Peer Fitness Trainer Certification Program and the recently released Fire Ground Survival Program. He has been directly responsible for IAFF efforts in addressing infectious diseases, including pandemic flu and proper personal protective equipment (PPE) recommendations.

Mr. Duffy holds Bachelor of Science degrees in environmental health and in business management and a Master of Science degree in occupational and environmental health sciences.

Like Mr. Jeff Stull, he has conducted numerous studies on the dangers of contaminated PPE and is a strong advocate for a better education of Fire fighters in consistent decontaminating programs.
NEW YORK - FDNY

The Fire Department New York or FDNY is the largest Fire Department in the USA. It consists of five boroughs – Manhattan, Queens, Staten Island, Bronx and Brooklyn with over 11,000 Firefighters.

I was interested to see how a Fire Department this big managed their PPC and what the attitude of the Department and the Firefighters at station level was towards the maintenance and decontamination of their PPC.

As was becoming more apparent, for the best part the PPC was only gross particulate cleaned on station occasionally and annually inspected and cleaned as per the NFPA 1851 Guidelines. FDNY Firefighters are issued with two sets of Tunics and Overpants, one helmet and one pair of bunker boots.

There is no fire-ground management of contaminated PPC unless it is contaminated in a known chemical or blood/bodily fluids, in which case it is bagged and dealt with at Minerva – an ISP or at the FDNY decontamination section.

Minerva Bunker Gear Cleaners is the largest facility in the USA devoted to PPC care and maintenance. They are fully NFPA 1851 compliant and recognized and authorized to carry out all repairs and alterations and retrofits to PPC from all major manufacturers.

Similar to Lion Apparel in Chicago, Minerva register all garments on a database and conduct cleaning, inspection and repairs as required on an annual basis. The database also allows the FDNY to budget for replacement PPC in the upcoming financial year to ensure that the Firefighters are not wearing out of date PPC.

FDNY also has its own PPC Decontamination Support Unit run by Captain William Horan; however this is only utilized for PPC contaminated with blood or bodily fluids, as well as laundering of bedding when infected with bed bugs.

This facility consists of six extractors housed within a stainless steel room for the sole purpose of decontaminating blood borne pathogens from PPC as well as two industrial washing machines for the laundering of bedding infested with bed bugs. This facility does not cater for annual care and maintenance of PPC however it could be utilized more efficiently (I believe) in conducting routine cleaning of PPC, given the frequency of response to fires that the FDNY attend.
Management and decontamination of fire fighters structural protective clothing and equipment.

FIGURE 13  MINERVA BUNKER GEAR CLEANERS FACILITY

FIGURE 14  FDNY DECONTAMINATION SUPPORT UNIT
LONDON FIRE BRIGADE

The London Fire Brigade is the fourth largest Fire Brigade in the world (Tokyo FD, FDNY and Paris Fire Brigade) with 5800 operational firefighters and 113 Fire stations.

The LFB respond to approximately 30,000 fires per year, making it one of the busiest fire departments in the world.

Unlike other Fire departments I have visited, the LFB have adopted the leasing arrangement for their PPC.

Bristol Uniforms provide over 70,000 individual pieces of protective clothing from head to toe including – helmets, flash hoods, tunics, gloves, overpants and boots

Under the fully managed service, Bristol leased structural firefighting garments to LFB for an eight year period from April 2010 with regular service and maintenance as part of an integrated and comprehensive managed service. This garment lifetime provision, which also covers replacement garments as older items reach the end of their service lives, ensures that every item of PPE will be regularly collected, inspected, repaired and washed. A computerised tracking and condition coding system identifies each item with its designated wearer and location ensuring swift and secure collection and return to its allocated fire station.

When Firefighters PPC becomes contaminated, upon return to their station it is sent away for cleaning and inspection and a replacement set of gear is taken from the station store. Bristol will then restock the station store with the appropriate garments.

Whilst this practice is the best system I have seen in minimising the exposure of Firefighters to off gassing, I was informed that the primary reason for this system dates back to the early days of the LFB when it was heavily influenced by the Royal Navy and its standards for pristine clothing.
Management and decontamination of fire fighters structural protective clothing and equipment.

FIGURE 15  LFB PPC DRYING AT BRISTOL UNIFORMS FACILITY

FIGURE 16  LFB PPC READY TO BE DISTRIBUTED TO THE STATIONS
BRITISH TEXTILE TECHNOLOGY GROUP

BTTG is based in the North of England. It was founded in 1989 by the merger of The Wool Industry Research Association and the Shirley Institute, organisations dating back to the 1920’s when England was the Cotton Capital of the world.

The Group has two operating companies:

**BTTG Testing and Certification** based in Manchester, specialises in the testing and certification of Personal Protective Equipment, geosynthetics, floor coverings and other construction products. It offers certification to EU directives and ISO directives.

**Shirley Technologies** based in Leeds, provides a broad range services to traditional apparel sector. It specialises in chemical testing and provides certification to the Oeko-tex scheme.

My interest here was to see how Fire fighters PPC is tested and whether BTTG had any evidence of performance differences in new PPC, clean, maintained PPC and contaminated PPC.

Unfortunately no comparative testing had been conducted due to the costs involved and who would fund the testing. However testing on new PPC to enable certification is quite exhaustive. These tests include:

- Radiant heat transfer
- Convective heat transfer
- Flammability
- Contact heat
- High visibility requirements
- Outer Shell Water resistance
- Inner liner Thermal resistance and Water vapour resistance
- Explosive atmosphere hazards
- Electrical hazards and electrostatic hazards
- Mechanical hazards – impact, cutting, entanglement
- Radiation hazards – ionising, non-ionising
- Chemical and biological hazards

The Manikin Fire Test is a specialty of BTTG Fire Technology Services. Their current test facility offers a male and female form of manikin – RALPH (Research Aim Longer Protection against Heat) and SOPHIE (System Objective Protection against Heat In Emergency). The technology enables these manikins to be dressed in all PPC&E (except footwear) that would typically be worn by a fire fighter.

The dressed manikins are subjected to full gas flame envelopment for a chosen length of time. The outcome is a burn injury prediction printout, a record of the location and duration of any visible ignition.
No sensors were placed in the head, hands or feet for this test.
CONCLUSION

Whilst my study was to look at world’s best practice in *Management and decontamination of Firefighters structural protective clothing and equipment*, it is apparent that some do it better than others but there is not a 100% complete package in my opinion.

The London Fire Brigades approach using the Fully Managed Service by Bristol Uniforms is the best system I witnessed, but I also acknowledge that system is not viable for smaller Fire Departments, however for smaller Fire Departments having a dedicated PPC Officer and in-house cleaning facilities appeared to work well.

Whilst all Fire Departments are slowly changing the culture of wearing dirty gear as a “badge of honour” there is definitely a lack of information available to the Firefighter as to the health risks posed to them through continual exposure to contaminated PPC, although the mention of Blood, bodily fluids or asbestos on PPC soon has them alerted to the potential health risks from these substances.

This would suggest that the Fire Departments are more concerned about their image in public than the health and well being of their Firefighters.

There are several sources readily available through the World Wide Web which draws attention to this topic and should be drawn upon to develop policy and procedures for Fire Departments around the world.

Suggested sites are:


One particular area that I believe can be improved very easily is the fire ground management of contaminated PPC.

- Bagging and tagging on scene,
- Not wearing dirty PPC back to the station,
- Not storing wet or dirty PPC in confined spaces (Bags),
- Not placing dirty SCBA sets in the cabin (if fitted to seats).

These are very simple procedures which have no cost implications on Fire Departments, yet can reduce the time that Firefighters are exposed to contaminants as well as reducing cross contamination of the vehicle for on coming shifts.

If nothing else, I hope that my study may go some way to raising the awareness of health risks facing Firefighters and that the Fire ground dangers do not follow us back to our families.