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TECHNICAL CONSIDERATIONS FOR PPE DECONTAMINATION

STRUCTURAL FIRE FIGHTING GARMENTS AND ASSOCIATED PPE

MARCH 2014

1. INTRODUCTION

This document has been prepared by Industrial Decontamination Services Pty Ltd (IDS) to detail the various technical considerations that must be addressed when establishing a whole of life garment management program for fire fighting garments and associated personal protective equipment (PPE). IDS are considered to be the leading provider of PPE decontamination and management services in Australia with proven processes and measurable results. Accordingly this document details the critical considerations for PPE management that can be used by fire fighting organisations to benchmark their own PPE management programs.

2. GARMENT CONSTRUCTION

Fire fighting PPE is built to various Australian and international standards to perform the task of protecting the wearer from injury in the process of fighting a fire or carrying out other duties required of an emergency services worker. In order to achieve the level of protection required manufacturers must use a range of materials and garment designs that in combination result in a high performance garment that is very difficult to clean or decontaminate without resulting damage to one or all of the components.

Laundry damage is almost certain when the cleaning is performed by commercial laundry providers. Commercial laundry providers are not proficient in the identification and removal of contamination nor are their processes flexible enough to adjust for each type of garment they process as they are volume based. The industries approach to contaminated specialized garments is the same as for hospital linen or cotton drill work wear. This process relies on extreme heat, aggressive chemicals and rigorous mechanical agitation to remove bacteria and contamination from the items being washed. While this process will result in a “clean” garment, the likelihood of garment damage is certain. Repeated exposures to these processes will result in reduced garment performance and a shortened garment life.

Likely damage can include the following:

- Reduced performance of the outer shell of garments due to fibre degradation.
- Damage to the breathability of the garment barriers. Often the micro pores of the garment will open up with aggressive laundering resulting in permeation of contaminants and liquids or vapour through a damaged liner.
- Damage to stitching, Velcro, elastic and tape.
- Shrinkage or reshaping of the garment, knee pads, cuffs etc.
- Colour fading of high vis components.
- Delamination of lettering and tape.
- Reduced garment life.

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3. TECHNICAL CONSIDERATIONS FOR LAUNDRY

Over a period of 15 years IDS has addressed the issues of in laundry damage related to laundering of PPE. The resultant process ensures that garments and other item of PPE returned to fire fighters are free of contamination, are clean and hygienic and will still provide the intended levels of protection required of a new garment. IDS has coupled this unique decontamination process with a whole of life garment management system that ensures secure and timely servicing from all locations. Key considerations are detailed below.

3:1 MANAGING CONTAMINATION

In the performance of their duties fire fighters will come into contact with a vast array of contaminants. Even these highly trained professionals will not always be able to identify exactly what contamination they have been exposed to during the emergency event. Accordingly it would be unrealistic to expect that they will be able to accurately advise the launderer of what contamination is present on the PPE when it is sent for decontamination. This raises two primary issues for launderers.

The first issue is that many garment management programs provide for a two level laundering program. Some laundry programs for firefighting PPE have a base level wash for “non-contaminated PPE” and a heavy wash for “contaminated PPE”. The base level wash has been adopted as a means of reducing damage caused in the heavy wash through commercial laundries and also as a means of providing a cheaper option for laundry for those garments that are considered to be free of contamination. As explained, without conducting extensive testing on individual items of PPE, a laundry cannot know with any degree of accuracy that an item is contaminated or not. By adopting a two level approach fire agencies are exposing their laundry provider’s staff, transport drivers, and others who handle the PPE to an array of unknown contaminants. This approach will also result in contaminated garments being returned to the fire fighter from the laundry provider. IDS has had to provide clean up services previously where garments have been laundered at a local laundry and have been returned to the fire fighter still affected by contamination.

The second issue is that when advised that a garment is contaminated the laundry industry’s approach is to attack the contamination with a very rigorous laundry program to bludgeon the contamination from the PPE item. The belief is that the rigorous process will be able to remove all contamination from any item. In addition to the damage this approach will cause the PPE as detailed earlier, this process will not remove all contamination and in fact in some cases will permanently embed contaminants into the PPE.

IDS agrees that it is prudent to assume that every item of PPE may be contaminated. This is reflected in the risk management measures we have established for each step in our process from the point of collection to the point of decontamination. IDS has spent a great deal of time to establish processes that firstly identify the various types of contamination and then processes for dealing with each type. Unlike the laundry industry we understand that there will need to be different processes used for different contaminants. This is the main difference between the IDS and the commercial laundry industry’s wash processes. The IDS process has a series of processes to identify contaminants and is flexible enough to adapt to deal with the various types of contamination we encounter whereas the commercial laundry treats all contaminants as one and the same.

3:2 PROTECTION OF TRANSPORT AND LAUNDRY WORKERS

A key element of safe PPE processing is safe transport and handling for contaminated PPE. Packaging must be such that all personal required to handle contaminated PPE are not exposed. Packaging must be sufficient to withstand the manual handling that occurs during transit and the types of contaminants that are likely.

Laundry workers must also be protected from exposures when the PPE arrives at the plant for processing. The laundry industry has traditionally addressed this issue through transporting and handling the PPE in dissolvable

plastic bags. Laundry staff will then load the PPE in the bag into washing machinery so that they do not handle the goods at any time. While this method does provide some risk mitigation, the dissolvable bags often dissolve in transit when loaded with wet PPE resulting in loose items of PPE arriving at the laundry. This method also prevents any pre-treatment of contamination which IDS feels is essential to a successful outcome.

As per the comments above regarding contamination, IDS believes that in order to be able to wash contaminated PPE correctly each item must be pre-treated prior to washing in a machine. This requires PPE to be removed from the transport bag prior to washing. This is the point of greatest exposure for laundry workers and accordingly IDS has established a process where all items are opened in a controlled environment before being assessed for the type of contaminants present and the appropriate treatment process. Obviously in addition to the controlled opening process adequate PPE is provided for staff performing this step of the process.

This is a key difference between “laundry services” and “decontamination services”. Fire agencies must differentiate between the two processes when setting up their garment management programs.

3:3 MIXED LOADING

A common problem with commercial laundries is cross contamination. Because all garments are processed in continuous batch washers or in large pocket washers using recovered rinse water etc. the soils, grease or chemical removed from heavily soiled garments or contaminated garments often move through the system and redeposit on other laundry items. The industry has come up with chemicals to help reduce re-deposition, however in the case of some contaminants including particulate such as asbestos, these chemicals will not entirely prevent cross contamination.

In order to safely prevent cross contamination, PPE items must be treated individually. Volume based laundries cannot do this. Successful decontamination requires small load sizes and no mixed loading. Fire agencies must specify that their garments are processed individually to avoid this problem.

3:4 TEMPERATURE VERSUS CHEMICAL SANITISATION

Washing temperatures are critical when processing fire garments. Australian standards for laundries require temperatures above 74^{o}C for several minutes in order to affect a sanitary result. Unfortunately at these temperatures fire garments will suffer significant damage. Based on the combined technical specifications from manufacturers of the various materials and components that go into modern fire ensembles, and IDS testing, the maximum temperatures for washing to avoid damage should not exceed 48^{o}C. At these temperatures bacteria kill will not be achieved unless other methods of bacterial decontamination are used.

This requires the introduction of high cost sanitisers, launderers need to ensure that they avoid those sanitizers that will cause additional chemical damage to the PPE such as chlorine based, alkaline, acid or hydroxide based chemicals. Because of the cost and the potential side effects of these chemicals they are not commonly used in large batch washing processes. Therefore in order to utilize these chemicals successfully and cost effectively laundries must use small batch washing techniques.

Fire agencies must specify that their PPE is processed under 45oC and that sanitizers are used to achieve satisfactory bacterial levels.

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3:5 PH VERSUS SURFACTANT CLEANERS

Hand in hand with high temperatures for commercial laundry comes high pH laundry detergents of around 9.8pH and above. For linen based products these are excellent. They are low cost, they provide bacterial kill and excellent soil removal they are easily rinsed out of linen and they are sewage friendly. High pH chemical are also more effective at higher temperatures which results in laundries increasing wash temperatures to improve yields and their cents per kg cost. Many steam heated laundries operate at above 85^{o}C in order to maximize their detergent action.

High pH is extremely damaging for many of the components of a fire ensemble. The main effect is oxidization of the reflective tape, heat seal lettering, fading of the outer fabric, fibre damage and deterioration of stitching. Kevlar stitching in particular is badly affected by caustic or high pH chemical. The alternative to using high pH is to use better quality surfactant based cleaners. These work on the surface tension to separate soils from fabric and are mostly of moderate pH levels. Unfortunately these surfactant detergents are extremely expensive when compared to caustic based detergents. The chemicals used by IDS cost $24.00 per litre compared to $2.60 per litre for a caustic liquid detergent.

Fire agencies should consult the manufacturers of their garments to identify the maximum pH for their range of PPE.

3:6 IONIC AND CATIONIC DETERGENTS

Successful removal of particulate material including asbestos is critical in decontamination of fire garments. In addition to the use of high quality surfactant based detergents which separate solid matter through reducing surface tension, consideration must be given to the static charge of the chemicals used. IDS has developed significant intellectual property around chemical formulations and ionization. We have found that using the correct combination of charged chemical with certain surfactants provides excellent results.

3:7 MECHANICAL ACTION

Providing mechanical action is the basic function of a washing machine and a useful tool in improving cleaning outcomes for linen. Basically the harder you throw the laundry load around through the heated detergent, the better the clean. Unfortunately in regard to fire garments, mechanical action is often the cause of damage in the laundry presenting as torn joints where liners meet outers, twist damage to garments, missing press stud fixtures, broken plastic buckles etc.

Off the shelf laundering machines have a limited range of adjustment and so it is difficult to set rotation speeds, and to bring rotation into the wash when required. IDS have been able to modify controllers on our machinery that allow us to fully control and vary the rotation speed, when the rotation stops and starts in the cycle etc. this level of control allows us to limit mechanical action and achieve our result through other less aggressive means.

3:8 DRYING METHODS

The majority of damage caused in laundry is during drying cycles. The two main commercial methods of drying are the tumble dryer that rotates garments while blowing hot air through the drying drum, and tunnel drying where the hung garments are transported on a conveyer chain through a tunnel with hot air blowing on them. In both methods hot air is used and the basis of the system is the hotter the air the faster the drying time. Considering that these systems where set up for linen based products, the temperatures are set accordingly. Most tumble dryers operate at between 70^{o}C and 95^{o}C while tunnel dryers are usually set above 90^{o}C.

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Dry heat at this temperature will cause significant shrinkage and damage to all of the components of a fire ensemble. These set temperatures will also fluctuate significantly during the drying cycle and can cause fabric shock which deteriorates the fabric of the garment. Furthermore other items of PPE including boots, flash hoods, gloves neck protectors and single layered wild lands fire apparel will all be damaged at these temperatures.

Fire agencies should insist that all of their PPE is dried using a dehumidification process. Dehumidification does not rely on heat and rapid air movement to evaporate water from the garments. A dehumidifier is usually a sealed cupboard or a room. Wet garments and PPE are hung or placed on racks and placed in the room. Warm dry air is blown gently into the room which causes moisture on the garments to evaporate into the dry air. The moisture laden air is then extracted and dried in the dehumidifier before being recycled back into the room. In this process there is minimal heat of 40^{o}C or less, relative humidity of 10%rH and there is no mechanical action which will occur in other drying methods.

4. LIFECYCLE MANAGEMENT REQUIREMENTS

The major benefit for any fire agency of establishing a whole of life garment management program is the level to which their liability can be managed and mitigated. Other benefits include cost and loss management resulting in opportunities to upgrade the PPE provided. The laundering process as detailed above is a significant factor in the success of a whole of life garment management program but it is not the only major consideration when fire agencies are setting up their own systems. A number of other major factors as detailed below are as important as the laundering process and will ensure that the maximum value is gained from the initial purchase of firefighting PPE.

4:1 THROUGH LIFE TESTING AND INSPECTION

Periodic compulsory inspections ensure that minor damage to PPE is identified and corrected before it becomes irreparable or before it results in injury to the wearer. By carrying out through life inspections the fire agencies are also demonstrating due diligence in their efforts to protect fire fighters and maintain the integrity of the PPE provided. The fire fighter should carry out their own inspections on a regular basis to ensure that the PPE is providing a suitable level of protection; however a formal inspection at least annually or following each use is advised.

IDS regularly identify damaged PPE that can be cheaply repaired during the laundry cycle. Most of this damage could compromise the protection provided by the PPE and would lead to total garment failure if left unrepaired. Through life testing is key to maximizing the life of the PPE.

4:2 REPAIRS

Carrying out repairs is an obvious requirement for the whole of life garment management program. The issue with repairs however is that there are usually no guidelines set by the manufacturer or fire agency for launderers to work to. IDS recommends that a set of requirements be provided for laundering providers covering the following.

- Beyond economic repair (BER) guidelines. Usually relates to a percentage of the value of the replacement item. I.e. PPE will be replaced if the repair is more than 65% of the cost of a new item. This will help prevent old and out of date PPE from being returned to active use.
- Maximum life of an item be advised and no repairs be carried out after that period. This will remove redundant PPE from use.
- Repairs must be authorized by the manufacturer. I.e. the laundry provider must be authorized to carry out the repairs or all repairs must go back to the manufacturer. This ensures that all repairs return the item to the original level of protection.

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- All repairs would need to be recorded and added to the database for that particular item of PPE.
- All repairs must be carried out using original materials. Therefore it would be a requirement placed upon the manufacturer to support the repairer with sufficient stock of spares for the life of the program.

4:3 SERVICING TIMEFRAMES

The recommended laundry processes outlined above are longer than ordinary commercial processes however for any whole of life garment management program to be fully effective these processes represent the minimum requirement. PPE can be processed in a normal laundry in around 3-6 hours from start to finish. To carry out the process detailed above will take between 24 to 36 hours mainly due to the preparation time required and the drying processes used. When establishing their program fire agencies need to consider this additional turnaround time and ensure that each fire fighter or area office has back up or pool PPE at their disposal. An extra day or two in turnaround time for proper decontamination is a small price to pay for the long term benefits but the extra time must be taken into consideration.

4:4 GARMENT TRACKING SYSTEMS.

A garment tracking system is compulsory for the whole of life garment management system. A suitable system will provide a range of benefits as follows.

- Historical data for review and future cost planning and management.
- Trend data for review purposes.
- Total cost information by a range of parameters as set by the client.
- Auto alert management to facilitate 12 monthly inspections.
- Batch or defect tracking and recall ability.
- Verifiable data for legal defenses, union discussions and negotiations etc.
- Individual item tracking.

Most of these systems will incorporate either RFID or bar code identification. The greatest benefit of a garment tracking system will be achieved when all items of PPE are included. There must also be a requirement for manufacturers to support the system by incorporating the RFID or bar code during manufacture.

4:5 GARMENT MANAGEMENT SERVICES VERSUS REPLACEMENT

Much of the PPE we use in industry is considered to be disposable. The main benefit of a whole of life garment management program when done properly is that better, more effective, more comfortable and more expensive PPE can be provided because with the system in place it is easy to achieve the maximum value from the items purchased. Some of the benefits include:

- Happier wearers and unions.
- Higher levels of safety and performance.
- Reduced overall costs.
- Fewer injuries and a reduced legal liability.
- Reduced waste.