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Methods of Decontamination after Chemical Incidents Summary Report

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Methods of Decontamination after Chemical Incidents Summary Reports

The Fire Experimental Unit (FEU) of the Home Office has been conducting research into the effectiveness of the various methods used by, and available to, fire brigades for decontaminating firefighters in chemical protective clothing following a chemical incident. The project was confined to primary decontamination - necessary to safely extricate the firefighter from protective clothing at the scene of the incident. No work was undertaken on secondary decontamination - necessary to make protective clothing safe to re-use.

PRELIMINARY WORK

The Brigade Questionnaire

In March 1992, a questionnaire was sent to all of the UK brigades, asking what kinds of chemical protective clothing they carried and on what vehicles, and what methods of decontamination they did or could employ at the scene of an incident. The questionnaire also asked what special equipment, if any, was carried and deployed, as well as other more general questions such as what happened to a chemical protective suit after primary decontamination. The findings of this questionnaire were published as FRDG Report 9/92.

Based on the findings of this questionnaire, the FEU purchased, for use in its trials, a range of chemical suits and decontamination equipment most widely used by brigades.

The Suits

It was decided to carry out trials using three different types of suit, each of a different material. These were:

- a non-coverall (BA outside) CPS suit, made of PVC (Figure 1a).
- a coverall suit, made of neoprene (Figure 1b).
- a gas-tight suit made of hyperlon/neoprene (hyperlon outer layer) (Figure 1c).

Figure 1a

Figure 1b

Figure 1c

The three Chemical Protection Suits used in the trials

The materials were chosen because they were seen to be the most widely used in the brigades. Also, all three types of suit were in use. All of these suits are designed to be worn with self-contained breathing apparatus (BA), although the two coverall suits also incorporate an airline entry point (hermetically sealed in the case of the gas-tight suit).

The Decontamination Methods

A list of decontamination methods was produced, based upon the responses to the questionnaire. These were methods which brigades indicated that they would use, as well as some which were developed or modified by the FEU to examine whether any improvement could thus be obtained.

The wet methods ranged from a 2,000 litre deluge, using one of the four portable shower units available, through water application from a main jet/spray branch, to hosereel guns using relatively little water. The firefighters were sometimes asked to rub those parts of their body they could reach, and sometimes asked to refrain from doing this. Some methods involved a decontamination operative scrubbing the suit with a brush, with or without a detergent, immediately followed by some form of water wash. A vacuum cleaner was used against a dry powder contaminant, both alone and with a subsequent water rinse.

The times allowed for decontamination were decided by one of two methods. These were:

- the time taken to deliver 2,000 litres of water; or
- a time (typically 5 minutes) agreed in discussions with brigades' personnel as being reasonable, (given the fact that at a real incident, there would be at least two firefighters to be decontaminated, and that it would probably be deemed undesirable to have to couple in an auxiliary airline once the firefighters' breathing apparatus air supply was exhausted).

THE DECONTAMINATION TRIALS

The Contaminants

It was decided at the outset that only safe dummy contaminants would be used in any trials undertaken. It was hoped that it would be possible to use dummy contaminants which would behave like a range of hazardous chemicals in the way in which they adhered to the suits. Ideally it should be possible to measure the amount of contaminant present on the suit before and after contamination.

It was finally decided to use fluorescein as the basis for all of the dummy contaminants. This material is a finely divided yellow powder, very small quantities of which show up under strong ultraviolet light, while being invisible to the eye in good daylight. Unfortunately, the amount of fluorescence from fluorescein is not a direct measure of the quantity of the powder present. Nevertheless, it was possible to get some measure of the amount removed during decontamination.

Four contaminants were developed, designed to represent different types of contaminant, and which would represent different degrees of difficulty to remove. These were:

- Talcum powder + 1.7% by weight fluorescein.
- Wallpaper paste + 1.7% by weight fluorescein.
- Vegetable (rape seed) oil + 2.0% by weight fluorescein.
- Golden syrup + 5% water + 2.0% by weight fluorescein.

The Trials Method

The underlying method remained the same throughout all trials, although the decontamination procedures tried varied widely. Basically, the procedure was designed to provide a 'before and after' assessment of the amount of contaminant on a suit to allow an assessment of the relative effectiveness of the decontamination methods to be made.

The contaminant was smeared on to the suit at selected sites, typically a total of 15, and viewed under ultraviolet light. The brightness, before and after decontamination, was estimated on a scale of 1 to 8, by comparison with a reference chart. Figure 2 shows typical 'before' and 'after' photographs, taken under ultraviolet light.

In each trial, the amount by which the contamination was reduced was assessed to give a 'reduced-by' value for each site. In order to summarise the results, these values were averaged to give an 'average reduced-by' value for each method, suit and contaminant combination. These values were further averaged for each method, to cover all suits and all contaminants, and these 'overall average reduced-by' values were used to rank the decontamination methods according to their relative overall effectiveness. These are listed in Table 1.

Figure 2 Typical before and after photographs under ultraviolet light

All of the decontamination trials, 276 in all, were performed at the FEU. Typically, each trial decontamination method was used 12 times (all 4 contaminants being used on all 3 suits). Brigades provided teams of 3 firefighters, each for a 2 day period, which proved sufficient to complete 12 trials with each team. The firefighters acted as subjects and decontamination operatives, where applicable, in turn.

Water Penetration

On a number of occasions, water penetrated the suit during decontamination:

- between the face seal and the BA facemask, or through the zip, in the case of the non-coverall suit.
- through the airline seal, or through the ankle/boot seal while kneeling, in the case of the coverall suit.
- Through the improperly closed zip in the case of the gas-tight suit.

The cause of this last leak turned out to be a poorly designed zip, making it impossible to tell whether the zip had effected a proper seal at its closure end. The manufacturers state that they have now changed their design and have replaced the old design zips, with a new, more positive, one.

Zip Trials

If a suit is heavily contaminated, firefighters may consider it pointless to try to decontaminate the whole suit. In such circumstances, they may concentrate on the zip area, to make it safe to extricate the firefighter from the suit.

Some trials were undertaken, spending the whole five minutes on the zip area alone:

- to see if the zip could be more effectively cleaned, and
- to find out whether it was possible to drive a contaminant from the outside of the zip, through to the inside.

These trials showed that it was possible to reduce the contamination on the outside of the zips to virtually the limits of the detection method. Also, only very slight traces (barely detectable) of contaminant were forced through the zips in two cases out of the fourteen such trials.

TRIALS RESULTS

The underlying conclusion of this work is that none of the decontamination methods tried was entirely successful in removing any of the safe dummy contaminants used. However, some methods appeared better than others.

Table 1 gives a list of the decontamination methods used, together with a brief description, and a performance figure - the 'average reduced-by' value - for each method. The higher this figure, the better the decontamination method.

Overall, it was found that methods which incorporated some element of scrubbing with detergent gave the best results: the more scrubbing the better, although there may be a limit beyond which the suit would be damaged; the stronger the detergent mix the better, although the strongest concentration used in this work was 25%.

There was no indication that the effectiveness of decontamination was related to the quantity of water used in the decontamination process. Generally, no matter what combination of scrubbing and detergent was adopted, methods using hosereels or main jet/spray branches out-performed the portable shower units, when used alone.

The portable shower units, when used to deliver 2,000 litres of water, without any scrubbing or detergent, gave the poorest results of all, except for the vacuum cleaner.

The vacuum cleaner appeared to be relatively ineffective against the dry powder contaminant (although it may prove invaluable for capturing and containing quantities of dry powder at an incident).

It proved impossible to effectively decontaminate a BA set when worn outside a chemical protection suit.

There may be occasions when it is desirable to use large amounts of water to dilute the contaminant being washed from the suits. However, when it is required to contain all decontamination run-off [the National River Authority's (NRA) preferred approach], methods which use smaller quantities of water may be preferred because of the problems involved in capturing and containing large volumes of water. At the other extreme, one method tried was a car-wash brush fed from a hosereel. This proved moderately effective and used only some 33 litres of water in 5 minutes. This is clearly an operational decision for the brigades and is outside the scope of this report. (There is a NRA/CACFOA Memorandum of Understanding covering this.)

While these trials were conducted using safe dummy contaminants, they have shown that there are materials which can be present on the surface of a suit without being detectable to the human eye in good daylight. Clearly, effective decontamination of used chemical protective clothing can be difficult to achieve. Even after a used suit has been cleaned, doubts must inevitably remain about whether it is still fit for use, depending largely on the chemicals to which it has been exposed.

For this reason, some brigades are considering pursuing a 'use once' policy in the future, possibly with suits of a polymer material. The chemists who have been consulted in this work all confirm that, at present, there is no way that a brigade can be certain that a used suit is uncontaminated, and undamaged, by exposure to chemicals. Also, it is unlikely that a simple test to ascertain this will become available in the near future.

The possibility of small traces of hazardous chemicals remaining on Chemical Protection Suits after an incident does constitute a hazard, but the question remains as to whether the risk is significant. This will depend on the chemicals encountered.

CONCLUSIONS

These trials have shown that it is impossible to be certain that all traces of a chemical have been removed from a chemical protection suit.

Nevertheless, some methods appear to be far better than others in reducing the amount of chemical present on the suit. Some brigades may find that the best of the methods described in this report offer significant improvements upon their present procedures.

The procedure adopted will have to take into account any requirement to contain water used in decontamination.

Brigades should also consider what action should be taken before a used suit can be considered fit for re-use. This will depend on the chemical encountered, and the history of the suit.

ACKNOWLEDGEMENTS

The FEU is grateful to the firefighters from 22 brigades who participated in these trials

Further details of this work are published in:

FRDG Report 9/92 - An assessment of Brigade Responses to the Chemical Decontamination Questionnaire

FRDG Report 9/94 - An Assessment of Fire Service Methods for Chemical Decontamination

TABLE 1 METHODS RANKED IN ORDER OF EFFECTIVENESS		
Method	**Method summary**	**Overall average reduction**
29	Strong detergent scrub (25% Beep, 5 mins) and Aadver Full shower (1.7 mins, 2000 litres)	5.6
28	Strong detergent scrub (25% Beep, 3 mins) and Aadver Full shower (1.7 mins 2000 litres)	5.1
26	Hot detergent scrub (2.5% Beep, 60°C, 3 Mins) and Galena hosereel (2 mins, 10 bar, 208 litres)	5.0
27	Hot detergent scrub (2.5% Beep, 60°C, 3 mins) and Aadver Full shower (1.7 mins, 2000 litres)	5.0
19	Scrub with detergent (2.5% Beep, 4 mins) then Galena hosereel (5 bar, 1 min, 80 litres)	4.7
25	Scrub with detergent (2.5% Beep, 3 mins) then Galena main jet (3 bar, 2 mins, 370 litres)	4.7
17	Scrub with detergent (2.5% Beep for 3 mins) then Aadver Full shower (5 bar, 2000 litres) - not rubbing	4.4
9	Angus Superfog hosereel only (10 bar, 5 mins, 330 litres) - rubbing	4.2
18	Scrub with detergent (2.5% Beep for 3 mins) then Aadver Primary shower (5 bar, 2 mins, 470 litres) - not rubbing	4.2
12	Car wash brush with 3 soap pellets (4 bar, 5 mins, 33 litres)	3.8
11	Alternate scrub and Galena hosereel (30 secs water, 1 min scrub, 5 mins, 132 litres) - no detergent	3.8
14	Galena main jet (3 bar, 5 mins, 925 litres) - rubbing - no detergent	3.8
5	Hughes 300 shower (5 bar, 2000 litres) - rubbing - no detergent	3.7
16	Aadver Full shower with induced detergent - no rubbing (15 sec water, 15 sec detergent, 80 sec water)	3.5
10	Galena hosereel (10 bar, 5 mins, 530 litres) - rubbing - no detergent	3.5
13	Car wash brush (4 bar, 150 litres) - no detergent	3.3
8	Aadver Full shower - rubbing - no detergent (7 bar, 2000 litres)	3.3
2	Aadver Full shower - rubbing - no detergent (5 bar, 2000 litres)	3.2
1	Aadver Full shower - no rubbing - no detergent (5 bar, 2000 litres)	3.1
3	Aadver Primary shower - rubbing - no detergent (5 bar, 2000 litres)	3.1
6	Hughes 75 shower - no rubbing - no detergent (5 bar, 2000 litres)	2.7
24	Vacuum with brush (4 mins) - hosereel rinse (1 min, 60 litres)	2.8
23	Vacuum with cone (4 mins) - hosereel rinse (1 min, 60 litres)	2.5
21	Vacuum with brush (5 mins)	1.5
22	Vacuum with cone (5 mins)	1.4

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