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Vulnerability of oil contaminated fire retardant overalls

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Vulnerability of oil contaminated fire retardant overalls

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Overalls become oil-contaminated very rapidly in many work situations, particularly offshore, in some cases within one day. From time to time, there are significant hydrocarbon fires offshore (eg on the Rough Platform). There is evidence that frequent washing reduces the fire retardant properties of some materials, thereby increasing personal risk to persons and compromising their safety in a fire.

Secondly, there is a problem with fires in the laundries offshore. Because of the large potential for escalation of fires offshore, the reduction of fuel loading and the prevention of ignition sources must remain a high priority. The presence of possibly flammable, oil-contaminated overalls with potential for self-heating exacerbates this problem.

Therefore, an experimental trial has been commissioned to investigate the possible degradation of the fire performance of fire protective overalls. This began with, a review of national standards to identify a suitable measure of fire performance that can be used to measure possible loss of protection after laundering.

This in turn was used to establish a test procedure to allow the comparison of new fire retardant material with laundered material, both stained and clean.

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EXECUTIVE SUMMARY

Objectives

Fire protective overalls are standard equipment used by workers in the offshore oil and gas industry. There is evidence that frequent washing will remove the fire retardant properties of some materials thereby increasing the risk to people in a fire. This is known and accounted for but overalls can become stained with oil or grease very rapidly in engineering work situations, in some cases within one day. Offshore laundries collect and wash a large number of these stained overalls and the associated fire risks have not been assessed.

An experimental investigation has been performed to identify the extent of any hazard from fire protective overalls being contaminated with hydrocarbon oil and the ease with which it can be removed.

Main Findings

It is clear that once contaminated with flammable / combustible oils, fire protective overalls cease to offer protection from fire spread. This study has shown that even trace amounts of oil left after washing can render an overalls' fire protective properties moot.

Contamination with hydrocarbon oils does not appear to have permanently damaged the performance of fire protective overalls, as this can be regained by additional washing. Tests performed on used fire protective overalls indicate that the majority of these still retain their flame retardant properties.

Since it has been shown that even flame retardant clothing will burn when contaminated, laundries have to be considered as areas of high potential fuel load.

Recommendations

1. Wherever practicable, avoid contaminating fire protective clothing with flammable / combustible liquids. If disposable outer coveralls are used to protect a reusable coverall, ensure that they are also flame retardant.

2. When contamination is unavoidable, replace the soiled clothing as soon as practicable and take additional precautions if personnel are exposed to ignition sources.

3. Treat contaminated fire protective clothing as a potential fire risk and keep it in metal containers as per HSG 140 The Safe Use and Handling of Flammable Liquids.

4. Launder fire protective clothing at the highest temperature recommended by the manufacturer, but do not exceed this temperature or use more aggressive cleaning agents.

5. Fire protective clothing should not be used beyond the manufacturers recommended number of washes

6. Do not assume that fire protective clothing will always self-extinguish and make other provision available for extinguishing flame.

1 INTRODUCTION

Overalls become oil-contaminated very rapidly in many work situations, particularly offshore, in some cases within one day. From time to time, there are significant hydrocarbon fires offshore (e.g. on the Rough Platform). There is evidence that frequent washing reduces the fire retardant properties of some materials, thereby increasing personal risk to persons and compromising their safety in a fire.

Secondly, there is a problem with fires in the laundries offshore. Because of the large potential for escalation of fires offshore, the reduction of fuel loading and the prevention of ignition sources must remain a high priority. The presence of possibly flammable, oil-contaminated overalls with potential for self-heating exacerbates this problem.

Therefore, an experimental trial has been commissioned to investigate the possible degradation of the fire performance of fire protective overalls. This began with, a review of national standards to identify a suitable measure of fire performance that can be used to measure possible loss of protection after laundering.

This in turn was used to establish a test procedure to allow the comparison of new fire retardant material with laundered material, both stained and clean.

2 STANDARDS

As might be expected for personal protective equipment, fire protective clothing is well certified by national standards. There are a number of standards on fire protective clothing where the fire performance depends upon the degree of protection required for specific purposes.

Some of the current standards are listed in Table 2-1. (1)

Table 2-1 List of standards applicable to heat and flame protective clothing

EN ISO 11611: 2007	Protective clothing for use in welding and allied processes
BS EN ISO 11612: 2008	Protective clothing- Clothing to protect against heat and flame
BS ISO 14116: 2008	Protective clothing- Protection against heat and flame- Limited flame spread materials, material assemblies and clothing
BS EN 469:2005	Protective clothing for firefighters- Performance requirements for protective clothing for firefighting
BS EN ISO 14460:1999	Protective clothing for automobile racing drivers- Protection against heat and flame. Performance requirements and test methods

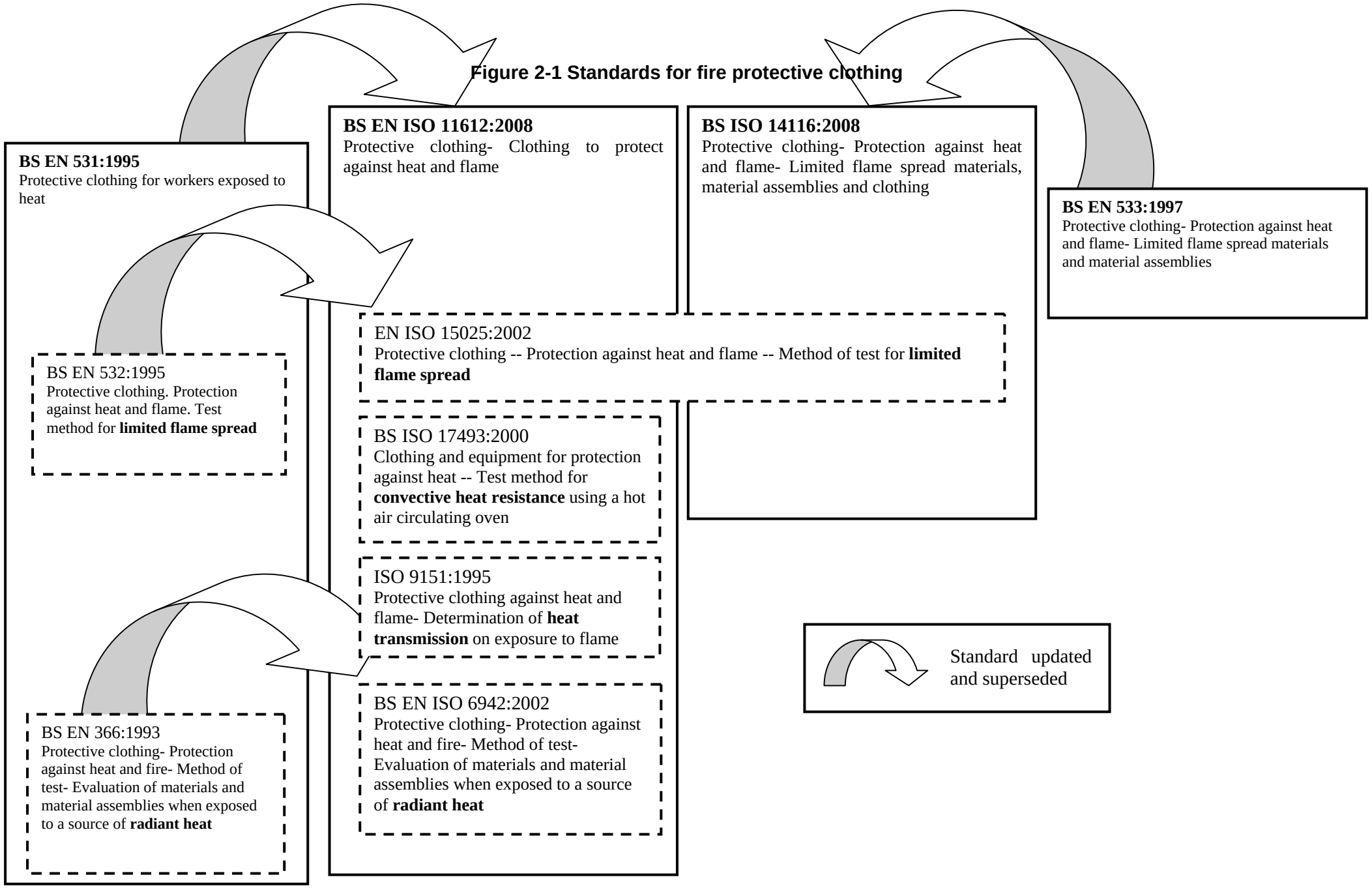
The most applicable standards for most offshore platform workers are BS EN ISO 11612 and BS ISO 14116, which are intended to define a threshold fire performance required. Each of these defines the pass/fail criteria that fire protective clothing need to conform to, in order to carry the CE marking.

The tests that BS EN ISO 11612 and BS ISO 14116 use to judge the performance of clothing are specified in other standards. BS ISO 14116 only specifies a flame spread limit, as measured by EN ISO 15025; but as well as this BS EN ISO 11612 also specifies the performance of clothing against BS ISO 17493 (heat resistance), ISO 9151 (convective heat) and BS EN ISO 6942 (radiant heat).

These standards have been updated in recent years and current fire protective overalls may have been designed according to previous standards. However, there is very little difference between the current standards and the previous ones.

Both BS EN ISO 11612 and BS ISO 14116 specify that the material samples should be washed before testing. The manufacturer specifies the number of times that an overall may be washed. It should be washed in accordance with the manufacturers instructions to the maximum number of washes specified or, in their absence, washed 5 times before testing.

Figure 2-1 Standards for fire protective clothing



3 EXPERIMENTAL

The property that has been chosen to investigate is flame retardancy. This complicated process involves both the transfer of heat from the flame to the material as well as the thermal degradation and evolution of volatiles from the material. Most fire protective clothing use ordinary textile material and treat it with impregnated chemicals, which make the cloth harder to ignite.

EN ISO 15025: 2002 “Protective clothing - Protection against heat and flame - Method of test for limited flame spread” specifies the method for testing flame retardancy against the performance criteria specified in BS EN ISO 11612:2008. Method B involves suspending a sample piece of material (200 mm by 160 mm) vertically and exposing the bottom edge to a small momentum jet flame for a 10 second duration.

To successfully pass the test, the cloth must self extinguish within 2 seconds and the burning must not reach either the top or edge of the sample. Furthermore, the sample must not be perforated by holes or produce flaming debris, which may spread the fire.

After some initial tests of a ‘Carrington Flameshield’ (cotton 400 gm^{-2}) type material stained with oil, it became clear that contamination by flammable oils rendered the fire retardant properties ineffective. Therefore, a test programme was devised to investigate if laundering successfully restored the fire performance of the material. This consisted of testing samples of the cloth after 7, 14, 21 and 28 cycles of staining with motor oil and grease then washing in accordance with the manufacturers instructions. For consistency, three samples were tested at each data point. The selected type of overall for this test was made of ‘Flameshield’-treated 100 % cotton and had been certified for 25 washes by the manufacturer.

Since the ‘Flameshield’ overalls are certified for 25 washes, it is expected that they will show some decrease in flame retardancy over their lifetime and for comparative purposes a programme of tests of identical samples of material which have not been stained was performed. This allowed a baseline of performance to be drawn.

Because the aim of the experimental programme is to measure performance degradation, the most severe testing regime has been selected. Therefore, the flame was applied to the bottom edge of the vertically orientated, un-hemmed sample. The average time to self-extinguishing as well as the length of burning were recorded.

After the results of this programme showed a drop in fire performance of ‘Flameshield’ type overalls, the programme was repeated using ‘Dale Antiflame’ (cotton 310 gm^{-2}) overalls. The manufacturer does not specify a maximum number of washes and these are more prevalent offshore.

4 RESULTS

4.1 IGNITION TESTS ON OILY CLOTHING

A small number of tests were undertaken using differing levels of oil contamination on samples of new, unwashed, 'Flameshield' flame retardant overalls.

In the first test, a standard sized sample was soaked in oil for approximately 1 minute, after which it was hung vertically and allowed to drain for 3½ hours. After this period, it was still visibly oily.

The oily sample was mounted on the test frame and the standard flame applied for 10 s. The sample ignited and burnt vigorously until it was extinguished using a fire extinguisher.

Following this test, a second was undertaken, but in this instance, the sample was sprayed liberally with the lubricating oil, WD40, after which it was allowed to dry for 2-3 hours.

Application of the standard pilot flame for 10 s again resulted in the ignition of the sample of new overall and vigorous burning until extinguished with a fire extinguisher.

The third investigative test involved rubbing a sample of new unwashed fabric on an oily tray. As this resulted in a patchy coating on the sample, it was rubbed together to more evenly spread the contamination.

On application of the pilot flame, it was noted that the specimen burnt after removal of the ignition source but that the flame did not spread and burning was largely confined to oily areas. When the flame was applied to areas with a lesser contamination, burning only continued for about 5 s after removal of the flame.

These tests would suggest that even new flame retardant overalls are capable of burning when contaminated with visible quantities of oil. The level required for vigorous burning appears to be sufficient to soak the fibres, rather than merely discolour them.

On this basis, it is suspected that if overalls had been subject to repeated washing, possibly decreasing their flame retardancy, then the addition of even a small quantity of oil may lead to a situation whereby they are able to support combustion.

4.2 IGNITION TESTS ON LAUNDERED 'FLAMESHIELD' OVERALLS

Test pieces of the sample material were cut from an unused overall and the edges were hemmed to prevent fraying during washing. Three of these pieces were tested immediately and the rest were split into the contaminated and uncontaminated experimental trials. The samples for contamination were dipped into a tray of motor oil and then hung to allow excess oil to drain. A central strip approximately 25 mm wide was then painted with lubricating grease. This process was repeated before each wash.

The two trials were kept separate but were both laundered in the same machine at the same conditions. The machine was set to a 60 °C wash on half loading. After the use of soap powder left residues of powder un-dissolved, 75 ml of 'Fairy' brand washing liquid was used to maintain a consistent concentration. This was in agreement with manufacturers' instructions.

The time to self-extinguishing and the burn length are recorded in Table 4.2-1 and 4.2-2 along with the data spread.

Table 4.2-1 'Flameshield' times to self-extinguishing

	Burn time (s)							
	Washed				*Stained and washed*			
Washes	*Data*			*Mean*	*Data*			*Mean*
0	0	0	0	0				
7	0	0	2	0.67	28	34	38	33.33
14	3	1	0	1.33	7	81	58	48.67
21	0	0	0	0	33	137	76	82
28	0	0	0	0	36	48	61	48.33

Table 4.2-2 'Flameshield' burn lengths

	Burn length (mm)							
	Washed				*Stained and washed*			
Washes	*Data*			*Mean*	*Data*			*Mean*
0	50	24	43	39				
7	53	62	65	60	200	200	200	200
14	82	47	55	61.3	113	200	200	171
21	8	14	14	12	200	200	200	200
28	25	14	10	16.3	200	200	200	200

As can be seen from the burning times, the process of staining and washing the overalls has a dramatic effect upon their fire protective properties. Once the burning reaches the upper edge of the sample, the burning time becomes more dependent on the orientation of the sample than its properties. Since the samples are 200 mm long, burn lengths in excess of this are impossible.

The series of tests performed on the unstained samples shows that this effect is due to the oil treatments rather than the washing process. A follow up experiment was performed to attempt to determine whether the decrease in fire performance was due to permanent damage to the fire retardant treatments of the cloth or due to trace amounts of oily residues not being removed during the single washing cycle following each contamination. The results are in Tables 4.2-3 and 4.2-4.

Table 4.2-3 'Flameshield' times to self-extinguishing

	Burn time (s)			
	Stained and washed 7 times then washed clean 7 times			
Washes	***Data***			***Mean***
14	1	3	1	1.67

Table 4.2-4 'Flameshield' burn lengths

	Burn length (mm)			
	Stained and washed 7 times then washed clean 7 times			
Washes	***Data***			***Mean***
14	70	77	72	73

As can be seen from the data above, although the fire performance of the 'Flameshield' material is degraded by the staining, additional washing returns its performance to a level approximately equal to the samples that were washed clean.

4.3 IGNITION TESTS ON LAUNDERED 'ANTIFLAME' OVERALLS

After the tests on the 'Flameshield' overalls revealed an issue with stained overalls, a second series was performed using a different type of textile. The 'Antiflame' material is widely used offshore and uses a different type of treatment to achieve its fire retardancy but is still impregnated on 100 % cotton allowing a comparison to be made with the first experimental series.

To aid this comparison, the same conditions were used as before. This included the staining materials and methods; the same washing temperatures, times, detergent and quantities; as well as testing after the same number of washes.

Again, the test EN ISO 15025 was performed and the same characteristics were measured; hence, the time to self-extinguishing and the burn length are recorded in Tables 4.3-1 and 4.3-2.

Table 4.3-1 'Antiflame' times to self-extinguishing

Washes	*Burn time (s)*							
	Washed				*Stained and washed*			
	Data			*Mean*	*Data*			*Mean*
0	0	0	0	0	0	0	0	0
7	3	1	1	1.67	43	71	30	48
14	4	2	4	3.33	40	7	7	18

Table 4.3-2 'Antiflame' burn length

Washes	*Burn length (mm)*							
	Washed				*Stained and washed*			
	Data			*Mean*	*Data*			*Mean*
0	118	108	93	106.33	118	108	93	106.33
7	156	120	140	138.67	200	200	200	200
14	161	145	161	155.67	200	200	198	199.33

The same trends as for 'Flameshield' treated cotton appear to be present in this series. After only seven washes, the burn time of the contaminated / washed samples averages over 40 seconds indicating that if the test were performed on a larger piece of material it may continue to burn. The performance improves slightly with subsequent washing but the burn lengths show that contamination is still present in all samples. A photograph of one of the samples tested after 14 cycles of staining and washing shows clearly the difference between the burn marks of the cloth and the oil in Figure 4.3-1.

Figure 4.3-1 ‘Antiflame’ sample after 14 cycles of staining and washing

4.4 TESTS ON USED OVERALLS FROM PLATFORMS

When it became apparent that there could be an issue with the failure of fire retardancy of fire protective clothing, a number of used overalls were taken from offshore platforms and subjected to the EN ISO 15025 method B test. Of the 7 overalls tested, 6 passed the test, self-extinguishing within 3 seconds but one did not and continued to burn for a minute.

Table 4.4-1 Used overalls' times to self-extinguishing

Sample	*Burn time (s)*			
	Data			*Mean*
A	0	2	0	0.67
B	0	0	0	0
C	0	1	0	0.33
D	82	58	49	63
E	2	2	0	1.33
F	2	1	1	1.33
G	1	1	1	1

The overall that failed the test was dressed on a mannequin and set on fire in a cold, humid environment under strong ventilation (see Figure 4.4-1). The material was resistant to ignition but eventually caught. The flame self extinguished with a few tens of seconds but the material continued to char for several minutes.

Figure 4.4-1 Used overall D during flaming and charring combustion

As a comparison, the ‘Antiflame’ overall used in the EN ISO 15025 tests previously was lightly stained by rubbing against a tray of diesel and also dressed on a mannequin and tested in the same environment as above. The diesel had dried and was not visible on the cloth at the time of the test.

The stained areas burned quickly but the fire did not spread into uncontaminated areas and the overall subsequently self-extinguished (see Figure 4.4-2).

Figure 4.4-2 New ‘Antiflame’ overall with light diesel contamination on mannequin before and after test

5 CONCLUSIONS

It is clear that once contaminated with flammable / combustible oils, fire protective overalls cease to offer protection from fire spread. The fire retardant treatments protect the fabric of the clothing from a small flame but do not prevent the oil from burning on its surface and the heat generated is sufficient to overcome the flame retardant treatment on the material and to burn the fabric.

Once the flame spreads beyond the stained area, the heat from the combustion decreases and the protective treatments prevent the fabric from contributing to the available fuel, essentially extinguishing the fire. This may prevent flame spread outside the contaminated area but could still allow localised burns to the wearer.

Washing can degrade these protective treatments and this has been taken into account by industry standards and manufacturers. However, this is not necessarily carried over into the work situation meaning excessively washed, flame-retardant overalls could be in circulation.

It would also appear that the effect of contamination on flame retardant overalls has been completely missed. This study has shown that even trace amounts of oil left after washing can render an overalls' fire protective properties moot.

Such contamination with hydrocarbon oils does not appear to permanently damage the performance of fire protective overalls, but only to render them combustible while the contamination is present. Additional washing can remove contamination, reinstating the flame retardant properties. Tests performed on used fire protective overalls indicate that the majority of these still retain their flame retardant properties.

The obvious solution when coming into proximity with oil or grease would be to use disposable coveralls over fire protective clothing to keep the oil away from the fibres and maintain the protection. Unfortunately, previous work at HSL (2) has shown that unless the disposable overall is fire retardant itself, it tends to melt and spread the fire, compromising the fire protective clothing underneath.

Since it has been shown that even flame retardant clothing will burn when contaminated, laundries have to be considered as areas of high potential fuel load. HSG 140 The Safe Use and Handling of Flammable Liquids (3), recommend cloths and clothing contaminated by flammable liquids are stored in metal containers. Similar precautions should be taken for oil stained overalls.

The tests on the full-scale mannequins proved more difficult to ignite indicating that temperature, humidity and airflow may be strong influencing factors along with the degree / type of contamination.

6 RECOMMENDATIONS

1. Wherever practicable, avoid contaminating fire protective clothing with flammable / combustible liquids. If disposable outer coveralls are used to protect a reusable coverall, ensure that they are also flame retardant.

2. When contamination is unavoidable, replace the soiled clothing as soon as practicable and take additional precautions if personnel are exposed to ignition sources.

3. Treat contaminated fire protective clothing as a potential fire risk and keep it in metal containers as per HSG 140 The Safe Use and Handling of Flammable Liquids.

4. Launder fire protective clothing at the highest temperature recommended by the manufacturer, but do not exceed this temperature or use more aggressive cleaning agents.

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6. Do not assume that fire protective clothing will always self-extinguish and make other provision available for extinguishing flame.

7 REFERENCES

(1) Standards

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BS EN 469:2005 “Protective clothing for firefighters- Performance requirements for protective clothing for firefighting”

BS EN ISO 14460:1999 “Protective clothing for automobile racing drivers- Protection against heat and flame. Performance requirements and test methods”

(2) R Mogridge, N Baxter, F Courtney-Clarke, N Vaughan; *Flammability of Coveralls for Offshore Use,* HSL/2007/25

(3) HSG 140 The Safe Use and Handling of Flammable Liquids

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