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## COMPATIBILITY OF FLUOROCHEMICAL AND PROTEIN FIRE-FIGHTING FOAMS

by

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SUMMARY

At the request of the Defence Materials Standardization Committee, laboratory tests have been made to provide information on the compatibility of fluorochemical and protein foams. The foams were applied gently to the surface of 0.28 $m^2$ (3 $ft^2$) fires of petrol having a boiling range of 62°C - 68°C. Experiments were made with foams made from mixtures of the two liquids in various proportions and with the two foams applied consecutively. No reduction in control and extinction performance was found when the two foam liquids were used together, but the protection from re-ignition and repropagation was reduced.

KEY WORDS: Foam, Protein, Fluorochemical, Compatibility.





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## INTRODUCTION

Fluorochemical foaming liquids are now available for the control of hydrocarbon fires. Protein foaming liquids are already in wide-spread use for this purpose and it can be foreseen that circumstances may arise where both types of foam could be used on the same fire. It is necessary to know whether, in such circumstances, the two foams will show any mutual interference.

## FOAM LIQUIDS USED IN THE INVESTIGATION

Fluorochemical - a commercially available synthetic foam liquid based on perfluorochemicals. (The grade used in the tests has now been superseded by an improved grade).

Protein - a commercially available foam liquid consisting of hydrolysed proteins and conforming to Defence Standard 42 - 3.

## EXPERIMENTAL PROCEDURE

The problem was investigated using 0.28 $m^2$ (3 $ft^2$) laboratory petrol fires as described in Defence Standard 42 - 3. In this method, foam with the desired physical properties is produced in a laboratory generator and applied to the test fire at a fixed rate of 0.04 $l/m^2 s$ (0.05 $gal/ft^2$ min) for a period of 4 minutes. The foam is applied gently to the surface of the burning fuel, which is a special grade of petrol with a narrow boiling range of 62°C - 68°C. A 30 seconds pre-burn time is allowed and the process of control and extinction is recorded by flame radiation measurements, while the liquid draining from the foam, during and following extinction, can be measured in a graduated tube into which it drains.

One series of tests investigated the effect on control time, extinction time, and fire drainage. Mixtures of the two foam liquids in various proportions were used to produce the foam, as well as each liquid separately.

A second series of tests investigated the effect on re-ignition and repropagation. The test fire was extinguished using foam made from each foam liquid; and foam made from mixtures of the two foam liquids in various proportions; and in one test the 4 minutes of foam application consisted of 2 minutes of fluorochemical foam followed by 2 minutes of protein foam. At fixed periods from the start of foam application in each test, the foam-covered fuel surface was tested by passing a lighted taper over the surface, just touching the foam. The occurrence of re-ignition was noted, whether it was sustained, and if so, the time for the foam blanket to be reduced to a scum and the time for full flaming to be re-established. Both these times were measured from the time of successful re-ignition.

## EXPERIMENTAL RESULTS

Table 1 records the measurements obtained in the first series of fires in which mixtures of the two foam liquids were used, and in which the drainage occurring during and after extinction was measured. Figure 1 depicts some of these data.

Table 2 records the observations on re-ignition obtained in the second series of fires.

## DISCUSSION

Referring to Fig 1 it can be seen that replacing 25 per cent of the fluorochemical foam liquid by protein foam liquid caused a marked reduction in the 25 per cent drainage time of the foam, but the control time, shear stress, and fire drainage were not substantially changed.

Replacing 25 per cent of the protein foam liquid with fluorochemical foam liquid had a very pronounced effect on all the observations. The 90 per cent control time was reduced from 107 s to 60 s, but was still higher than the 90 per cent control time for fluorochemical alone, which was 39 s. The shear stress was reduced to the low value obtained with fluorochemical foam alone. The 25 per cent drainage time was lower than for either of the two foam liquids used alone - 39 s as compared with 246 s for protein alone and 105 s for fluorochemical alone. This increased drainage rate was reflected in the fire drainage which was 60 per cent as compared with 16 per cent for protein alone and 31 per cent for fluorochemical alone.

Clearly the presence of a proportion of fluorochemical has a very adverse effect on the protein foam, causing it to lose water by drainage at a very high rate.

In the re-ignition and burnback tests, an examination of Table 2 shows that when fluorochemical and protein were used together, either as separate foams, or as foam produced from a mixture of the two liquids, re-ignition occurred in every case, at the first ignition test, 15 minutes from the start of foam application (11 minutes from completion of foam application). The foam was very rapidly destroyed and full flame was regained in less than one minute. This flash re-ignition and rapid repropagation would be a dangerous feature on a large spill fire. The mixed foams, although having a subtle change in appearance, did not collapse noticeably before re-ignition. In the test with protein foam alone, permanent re-ignition was only just obtained at 25 minutes.

In most of the tests, only 4 per cent solution of fluorochemical was used - to compare with the mixed solution foams - but as application was continued for a period of 4 minutes, extinction being obtained in less than 1 minute, the quantity applied was 2 - 3 times that which might be used in practice when application may stop when extinction is achieved.

A characteristic of fluorochemical is that the foam will transpose from an air foam to a petrol vapour foam which ignites and burns rapidly. In the test where protein foam was applied as a top layer above fluorochemical foam, re-ignition occurred as a flash over the whole surface, beneath the protein layer. In several places the fluorochemical foam had risen through the protein foam.

It should be noted that these tests all used $62^{\circ}C$ - $68^{\circ}C$ boiling range petrol and entirely different re-ignition and burnback properties may exist with other fuels such as kerosine.

These tests reveal the desirability of developing standard test methods for re-ignition and burnback properties of foams which will take account of the age of the foam, the type of fuel, the fuel temperature etc etc.

Although the mixed foams showed a substantial deterioration in burnback resistance all the test fires were effectively extinguished. In emergency, both types of foam could be used to contribute to extinction but at the cost of considerable deterioration in post control protection.

## CONCLUSIONS

1. When protein foam was applied to a petrol fire after fluorochemical foam had been used to extinguish it, the protection from re-ignition and repropagation was very much less than when either foam was used alone. The use of both foams on the same fire should therefore be avoided.

2. The method used is not flexible enough to study all the factors which may be involved in the phenomenon of compatibility. It is necessary to develop a method specifically for this purpose.

## Table 1

### EXTINCTION TESTS

$0.28\ m^2$ ($3\ ft^2$) Fires - Application Rate $0.04\ l/m^2\ s$ ($0.05\ gal/ft^2 min$) - for 4 min.

Fuel = Petrol Boiling Range $62^oC$ - $68^oC$

| Composition of Foam Liquid | Expansion | Shear Stress $N/m^2$ | 25 per cent Drainage Time min - s | 75 per cent Control Time s | 90 per cent Control Time s | Extinction Time s | Fire Drainage in 5 min. Per cent |
|---|---|---|---|---|---|---|---|
| 4 Per cent Protein | 9.9 | 36.0 | 4 - 6 | 83 | 107 | 169 | 15 |
| 4 Per cent Protein | 9.9 | 36.0 | 4 - 6 | 92 | 105 | 175 | 17 |
| 3 per cent Protein + 1 per cent Fluorochemical | 7.0 | 4.2 | 0 - 39 | 46 | 60 | 74 | 60 |
| 2 per cent Protein + 2 per cent Fluorochemical | 9.0 | 4.5 | 1 - 20 | 40 | 54 | 74 | 47 |
| 2 per cent Protein + 2 per cent Fluorochemical | 9.0 | 4.5 | 1 - 20 | 50 | 67 | 98 | 46 |
| 2 per cent Protein + 2 per cent Fluorochemical | 9.0 | 4.5 | 1 - 20 | 32.5 | 45 | 55 | 45 |
| 1 per cent Protein + 3 per cent Fluorochemical | 8.1 | 3.6 | 0 - 56 | 29 | 42 | 53 | - |
| 4 per cent Fluorochemical | 10.6 | 3.8 | 1 - 55 | 27 | 37 | 57 | 30 |
| 4 per cent Fluorochemical | 10.6 | 3.8 | 1 - 55 | 27 | 41 | 56 | 33 |

Table 2

RE-IGNITION TESTS

$0.28\ m^2$ ($3\ ft^2$) Fires - Application Rate $0.04\ l/m^2 s$ ($0.05\ gal/ft^2\ min$)

Fuel - Petrol Boiling Point $62^{\circ}C$ - $68^{\circ}C$

| Foam Liquid | Application time min | 15 min from start of foam application | | | 20 min from start of foam application | | | 25 min from start of foam application | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Re-ignition | Time to Destroy foam | Time to full flame | Re-ignition | Time to Destroy foam | Time to full flame | Re-ignition | Time to Destroy foam | Time to full flame |
| 4 per cent Protein | 4 | 30 s only* | - | - | Not Tested | - | - | Yes | 7 min | 7 min |
| 4 per cent Fluorochemical | 4 | 60 s only | - | - | Not Tested | - | - | 25 s only | - | - |
| 4 per cent Fluorochemical | 4 | 85 s only | - | - | Yes | 6 min | $6\frac{1}{2}$ min | | | |
| 6 per cent Fluorochemical | 4 | 55 s only | - | - | Not Tested | - | - | Yes | 2 min | 3 min |
| 4 per cent Fluorochemical<br>4 per cent Protein | 2<br>2 | Yes | 10 s | 25 s | | | | | | |
| 1 per cent Fluorochemical<br>+ 3 per cent Protein | 4 | Yes | 10 s | 40 s | | | | | | |
| 2 per cent Fluorochemical<br>+ 2 per cent Protein | 4 | Yes | 25 s | 45 s | | | | | | |
| 3 per cent Fluorochemical<br>+ 1 per cent Protein | 4 | Yes | 15 s | 60 s | | | | | | |

* Meaning that the re-ignition lasted for 30 s only, and the flame then went out.

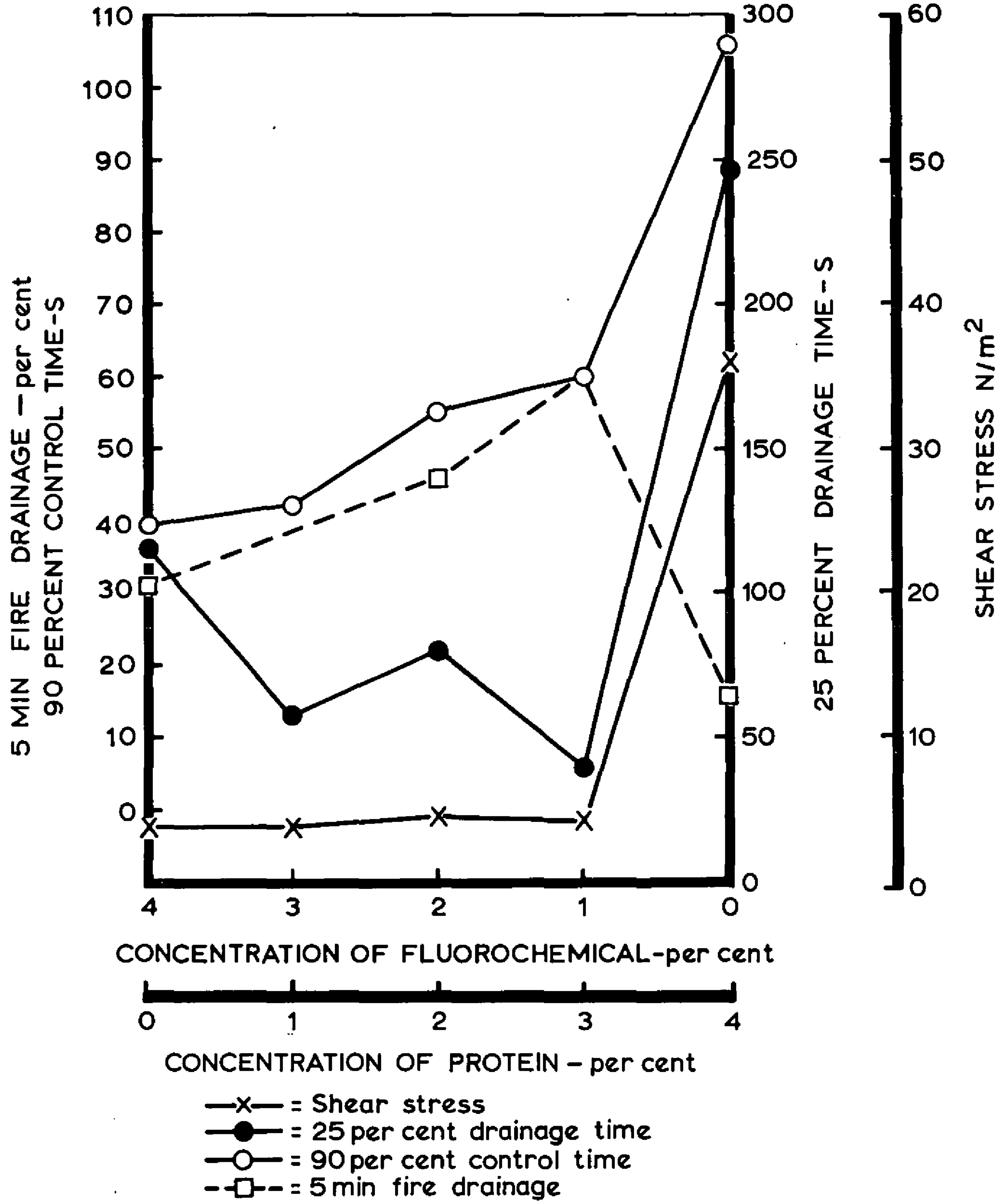


FIG.1 LABORATORY FIRE TESTS WITH FOAM MADE FROM MIXTURES OF PROTEIN AND FLUOROCHEMICAL LIQUIDS