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THE EFFECT OF FOAM LIQUID CONCENTRATIONS ON FIRE PERFORMANCE ON LABORATORY FIRES

by

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SUMMARY

The effect of deterioration of foaming solutions of fluoroprotein and fluorochemical liquids has been simulated by dilution, and the consequent change in performance has been measured by means of the new 0.25 m^2 test fire described in FR Note No.1007. The results obtained are compared with earlier ones on the Defence Standard 42-3 fire of 0.28 m^2 area, over which the new fire is shown to have advantages.

KEY WORDS: Foam, laboratory, fire test, storage properties, fluorochemical, fluoroprotein.

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Department of the Environment and Fire Offices' Committee
Joint Fire Research Organization

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INTRODUCTION

Only meagre information is available on the keeping properties of foam liquids and this work was undertaken to illustrate how changes in the test methods, because they are more economical of laboratory time, will permit more extensive information to be obtained.

In a series of experiments to assess the storage properties of foam liquids[1,2] it was shown that a fire test conducted with the recommended concentration of foam liquid would not reveal deterioration until it had progressed to an unacceptable extent. This was overcome by testing the foam liquid at a number of concentrations to determine the minimum concentration required for optimum effectiveness. The resulting work load was unacceptably large, because between 6 and 10 experimental fires were required to assess each stored sample.

A new laboratory fire test for foam liquids has recently been developed[3] and it was thought that this new test might provide a more economical method of assessing storage samples. Experimental fires were therefore conducted with the new procedure, using two foam liquids at various concentrations. The results obtained were compared with those previously obtained using the original fire test, and foam liquids of the same groups.

The significant differences between the two fire tests are that the new test employs forceful application of the foam, as compared with gentle surface application in the original test, and also includes a burn-back test which the original test does not.

The two tests differ slightly in size, the original test employing 0.28 m^2 fires, and the new test 0.25 m^2 area fires; and these fire sizes are used to differentiate the two test methods in the remainder of this report.

EXPERIMENTAL METHODS

The 0.28 m^2 fires were conducted as described in UK Defence Standard 42-3[4] and Fire Research Note No.933[1]. The test uses petrol with a boiling range 62-68°C as fuel. A preburn time of 30 seconds is allowed. The foam is applied gently onto the fuel surface at 2.4 l/m^2-min.

The 0.25 m^2 fires were conducted as described in Fire Research Note No.1007[3] except that at the lower concentrations it was necessary to reduce the foam nozzle diameter from 7 mm to 5 mm, to allow the flow rate to be reduced to the desired value. Aviation gasoline was used as fuel. A preburn time of 1 minute was allowed. The foam was applied as a jet into the centre of the fire, for a total period of 3 minutes. A brass pot containing 1 litre of gasoline was then placed in the centre of the tray and ignited, and the time for the fire to re-cover the whole test area was measured.

MATERIALS USED

Fluorochemical foam liquid - A commercially available product manufactured in Belgium - Grade FC 200 normally used at 6 per cent concentration.

Fluoroprotein foam liquid - A commercially available product manufactured in UK, normally used at 4 per cent concentration.

EXPERIMENTAL RESULTS

Figures 1 and 2 show the results obtained on the 0.25 m^2 fires using fluorochemical and fluoroprotein foam respectively. Figures 3 and 4 compare the 90 per cent control times of the 0.25 m^2 fires with those of the 0.28 m^2 fires.

DISCUSSION

The deterioration of foam liquids in solution may be simulated by diluting the solutions to varying degrees and determining how the foam properties change with degree of dilution, as assessed by standard test methods. This approach is only valid if all the constituents of the foam liquid degrade in storage at the same rate, and are converted to inert end products. In practice deterioration in storage cannot be expected to follow such an uncomplicated course, and these dilution tests are consequently limited in value. Accepting this limitation, they give a simple and practical technique for obtaining information.

Different samples of foam liquids were used for the tests on the two test fires. The fluoroprotein foam liquids were from manufacturer A, while the fluorochemical foam liquids were from manufacturer B, one grade (FC 196) being used on the 0.28 m^2 fires, while another (FC 200) was used on the 0.25 m^2 fires. Some differences between the results on the two fire sizes may be attributable to differences in the foam liquid samples, but as the primary interest is in the shape of the curves obtained, the comparison of the two sets of results is justifiable.

Referring to the results using fluorochemical, shown in Fig.1, it can be seen that the the control and extinction times are not proportional to the concentration, and a dilution to almost 50 per cent of the recommended concentration was necessary before an unmistakable increase was observed. Figure 3, however, shows that the 0.25 m^2 fire gave a more pronounced response than did the 0.28 m^2 which required a dilution to 20 per cent of the recommended concentration before an unmistakable increase in the control time was observed.

Returning to Fig.1, the expansion and shear stress both fell progressively with increasing dilution, and the effect of a 20 per cent dilution would be unmistakably observed. The drainage time showed relatively little change with concentration. The burn-back time also showed relatively little change with concentration and therefore the 0.25 m^2 test has no apparent advantage over the 0.28 m^2 test because of the inclusion of a burn-back measurement when considering the deterioration of fluorochemical samples.

This is probably because the burn-back resistance of fluorochemical foam is largely influenced by its film forming property and only small amounts of fluorochemical are necessary to ensure film formation, and sufficient is provided by even a $1\frac{3}{4}$ per cent solution.

The results for the fluoroprotein foam shown in Fig.2 and Fig.4 show a similar increase in the dependence of the control time on concentrations, when the 0.25 m^2 fire is compared with the 0.28 m^2 fire, as was obtained with fluorochemical. A 35 per cent dilution would be unmistakably detected as compared with 55 per cent with the 0.28 m^2 fire. The burn-back time, and all three foam properties were highly dependent upon concentration and a 20 per cent dilution would be detected by any of these measurements.

The burn-back times obtained by these dilution tests may not be a valid model of actual storage deterioration. It is not improbable that the burn-back resistance is related to the total quantity of protein in the foam as a separate effect from its ability to foam. In storage the total quantity of protein will not change although its foaming properties may fall.

Another point of interest is that in the case of fluorochemical the control time and the extinction time both responded similarly to concentration and approximately 50 per cent dilution was required for an increase to be unmistakably detected. With the fluoroprotein the extinction time showed a greater dependence on concentration than did the control time and a 20 per cent dilution would be unmistakably detected.

We can conclude therefore that the new 0.25 m^2 fire test, which uses forceful application, is usefully more sensitive to concentration and should therefore be preferred for the assessment of the quality of storage samples, rather than the 0.28 m^2 fire test which uses gentle surface application. If control time, with the recommended concentration, is used alone as a basis for assessment even the 0.25 m^2 test may not reveal deterioration unless it exceeds 50 per cent. If, however, extinction time and foam properties are included as performance requirements a deterioration of 20 per cent is unlikely to pass undetected. It is, however, generally accepted that quality assessment must primarily be related to fire control and extinction and in the present state of knowledge it would be difficult to justify condemning stocks of foam liquid because of a change in foam properties if the product will still control and extinguish effectively.

For the routine assessment of storage samples a simple single test is required. The procedure of determining a concentration x control time curve is so demanding of time that it cannot be applied on the wide scale which is desirable.

A single concentration test using the new 0.25 m^2 fire provides a method which will just suffice. Deterioration up to 50 per cent may not be detected by the control time observation, but if the extinction and burn-back times, and the foam properties are also considered they will permit the recognition of samples which are showing changes and merit reappraisal after a further short period.

In addition to their purpose of selecting methods for the examination of storage samples, these tests also permit the evaluation of the 0.25 m^2 fire as a purchase control to ensure that new supplies have been prepared to the correct concentration, and they also provide information on the margin of safety in the foam liquid to allow for errors in proportioning, variation in the efficiency of branchpipes and some deterioration in storage.

As a purchase control tool the test has the same limitations as its use for storage assessment; the control and extinction times, at a single concentration, are not a reliable indication that the material has been prepared to the correct concentration, but the expansion and shear stress provide good guides for fluorochemical foam, while for the fluoroprotein the expansion, shear stress, drainage time and burn-back time all provide effective indices of concentration.

The safety margin can only be assessed from the concentration curves, and a test at a single concentration does not enable an assessment to be made. The test results in Fig.1 indicate that the fluorochemical sample had a concentration safety margin 50 per cent above that required to give good control and extinction, while Fig.2 indicates that the fluoroprotein sample had only a small margin of safety.

The tests also supported the claims for the simplicity, quickness, reliability and fuel economy of the 0.25 m^2 fire, described in FR Note No.1007.

CONCLUSIONS AND RECOMMENDATIONS

1. By using the new 0.25 m^2 fire test, described in Fire Research Note No 1007. for assessing the quality of stored samples of foam liquids, a test at a single concentration will suffice to reveal a serious degree of deterioration. The economy of this procedure will permit a more extensive monitoring of the keeping properties of foam liquids than does the current method requiring fire tests at a range of concentrations using the Defence Standard 42-3 laboratory fire.

2. Tests using the 0.25 m^2 fire, at a single concentration, will show whether the foam liquid is still effective, but the control time will not reveal the extent of any deterioration which has occurred, and this could be up to 50 per cent of the active ingredients.

3. If the extinction time and foam properties are also observed, adverse changes of a lesser degree will be noted, and deterioration exceeding 20 per cent is unlikely to pass undetected.

4. Even with this new fire, tests at a range of concentrations are required to obtain a close assessment of the extent of deterioration.

5. The new 0.25 m^2 fire test is not fully effective in verifying the quality of new deliveries of foam liquid, if only the 90 per cent control time is observed. The extinction time, the foam properties, and the burn-back time are also necessary to provide a trustworthy assessment.

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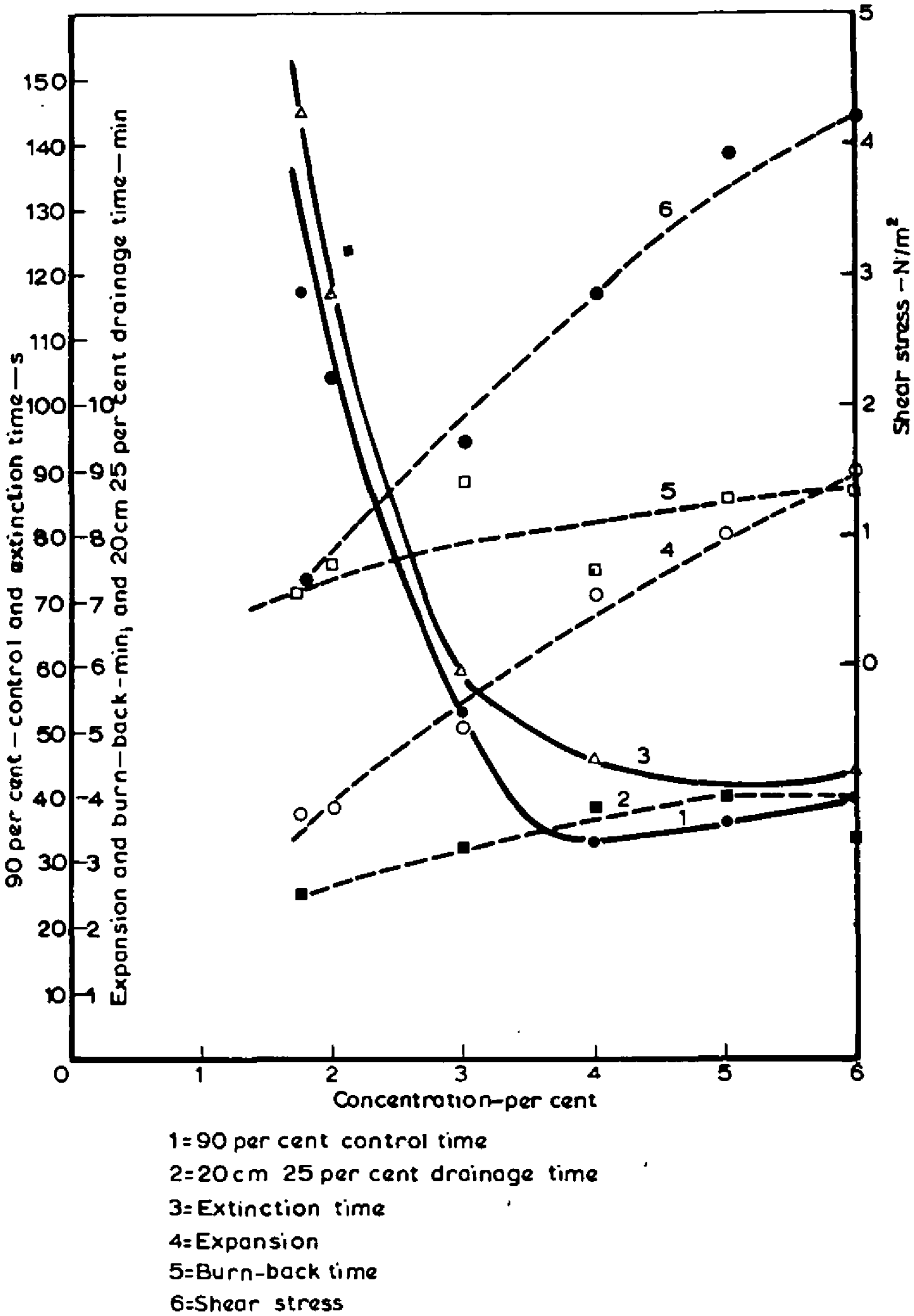
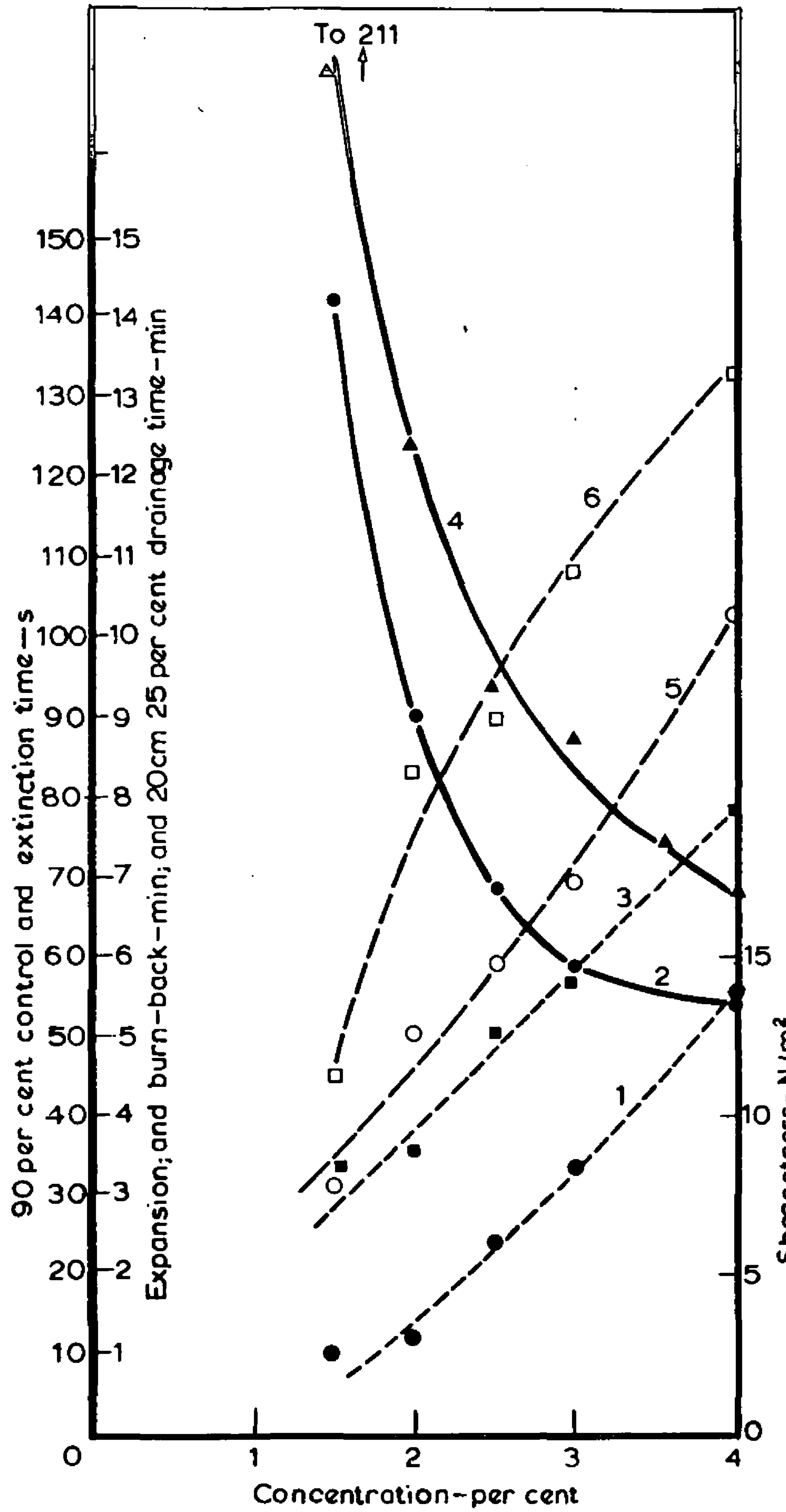


Figure1 0·25m^2 area petrol fires extinguished with fluorochemical foam applied at 3 ℓ/m^2-min and used with various concentrations



1= Shear stress

2= 90 per cent control time

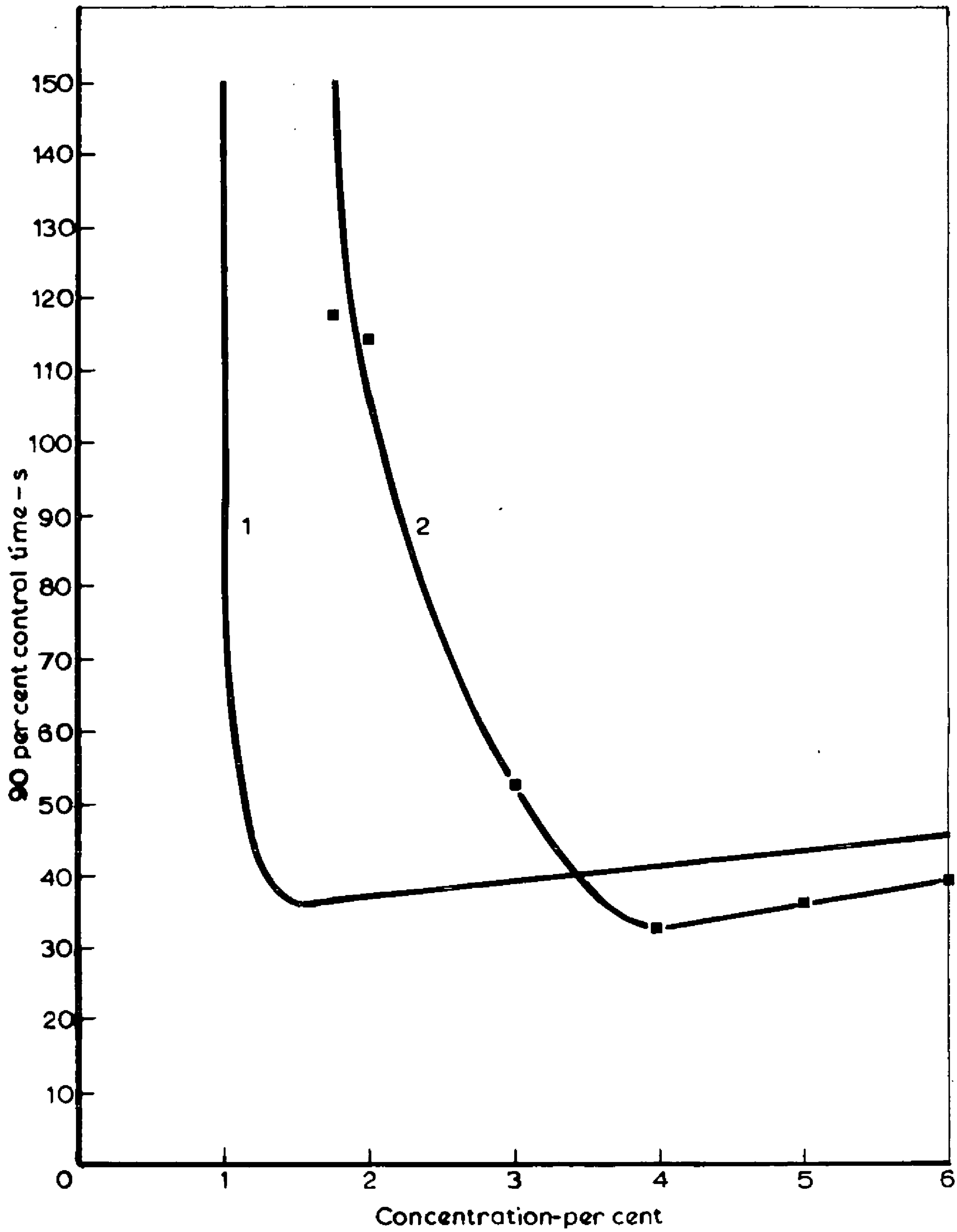
3=20cm 25 per cent drainage time

4=Extinction time

5= Expansion

6=Burn-back time

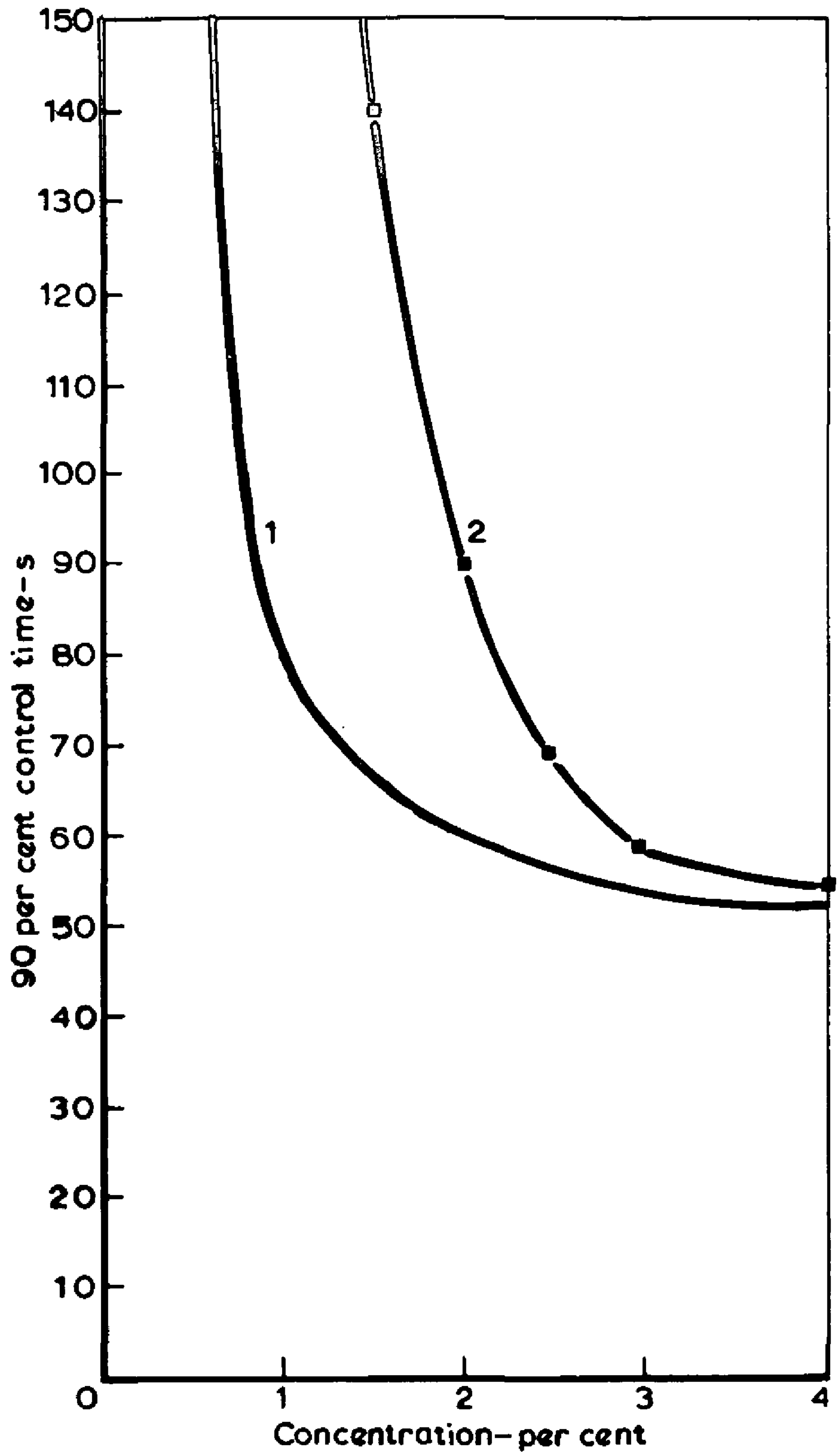
Figure 2 0·25m^2 area petrol fires extinguished with fluoroprotein foam applied at 3ℓ/m^2-min and used at various concentrations



1 = 0·28m² area fires of 62–68°C boiling point petrol – application rate = 2·4 ℓ/m²–min – gentle surface application – from Fire Research Note 933

2 = 0·25m² area fires of aviation gasoline – application rate 3 ℓ/m²–min forceful application

Figure 3 Comparison of 90 per cent control times of two laboratory fires using fluorochemical foam at various concentrations



1 = 0·28m² area fires of 62–68°C boiling range petrol – application rate = 2·4 ℓ/m²–min – gentle surface application – from Fire Research Note 933

2 = 0·25m² area fires of aviation gasoline application rate = 3 ℓ/m²–min forceful application

Figure 4 Comparison of 90 per cent control times of two laboratory fires using fluoroprotein foam at various concentrations

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