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THE CRITICAL THICKNESS OF A FOAM BLANKET

by

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Summary

The minimum thickness of a foam blanket necessary to seal the surface of a petrol fire has been determined for a range of foam properties. It is shown that stiff foams, such as are often produced by aircraft crash tenders, when applied to the surface of burning petrol produce a blanket several times thicker than is necessary to seal the surfaces. This suggests that an investigation of the techniques of applying foam to aircraft crash fires could be usefully directed towards methods of obtaining a coherent blanket nearer to the critical thickness.

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1. Introduction

The requirements of foam and foam-producing equipment vary with the type of risk to be protected. The aircraft crash fire is a difficult problem in that only a limited supply of agent is available and a large spill fire must be controlled as rapidly as possible if there is to be a chance of saving life. The most economic use must therefore be made of the extinguishing agent; this also applies to other types of fire but in none of them is it so critical.

One factor affecting the speed with which a flammable liquid fire can be controlled with foam is the minimum thickness of the foam layer necessary to seal the surface and an investigation of this part of the problem has been made.

2. Factors affecting the time taken to control a fire with foam

If it is assumed that there is little destruction of foam during the extinction process provided it is applied at rates reasonably above the critical, then the time taken to cover the fire with foam will depend on the liquid rate of application and the liquid content of the foam blanket per unit area. Thus when foam of expansion E is applied at a rate of R gal. of liquid/ft^2/min. and the foam blanket formed is of thickness x, then the time, t, taken to cover the surface will be given by

$$t \propto \frac{x}{R\,E} \qquad \dots\dots\dots\dots\dots(1)$$

When foam is applied gently to the surface of a flammable liquid fire the thickness of the foam blanket is governed by the physical properties of the foam, being proportional to the product of critical shear stress (S) and expansion (E):-

$$x \propto S \times E \qquad \dots\dots\dots\dots\dots(2)$$

Under these conditions the time taken for the foam to cover the surface is given by substitution in (1):-

$$t \propto \frac{S}{R} \qquad \dots\dots\dots\dots\dots(3)$$

Now results of fire tests$^{(1)}$ in which foams of varying properties were applied to petrol fires at rates of at least twice the critical rate of application can be correlated by the equation

$$T = A + \frac{BS}{R} \qquad \dots\dots\dots\dots\dots(4)$$

where A and B are constants
and T is the time taken to extinguish the fire.

It can be seen that providing the rate of application is reasonably above the critical rate, the time taken to extinguish the fire area is dependent upon the physical properties of the foam, insofar as they affect the thickness of the foam blanket, and not upon the fundamental requirements of the foam in its effectiveness in sealing the petrol surface and preventing the vaporization of fuel. A knowledge of the minimum thickness of the foam blanket required to seal the liquid surface, would be useful in determining to what extent an investigation of methods of applying foam more efficiently could be fruitful.

3. Experimental procedure

To determine the critical thickness of the foam blanket a foam layer was applied as evenly as possible to petrol burning in a tray 30 in. x 7½ in. The foam was applied through an applicator having a $7\frac{3}{4}$ in. wide outlet slit. The depth of this slit could be varied to suit the foam flow rate and the foam characteristics so as to ensure an even distribution of foam across its width. The applicator could be traversed along the tray by means of a simple electrically-powered gearbox and chain mechanism, as shown in Plate 1. The tray was fitted with corrugated sides, to prevent the foam blanket being dragged along by the applicator.

The foam was produced by a laboratory foam generator from a 3 per cent solution of a protein compound, and experiments were made over a range of expansions and critical shear stresses. For a foam of given characteristics, the rate of application was adjusted so that the blanket formed was just sufficient to seal the surface without any of the pockets of vapour that formed under the foam blanket breaking through it. The corrugated sides of the tray meant that there was always an edge fire which was a convenient igniting source for any vapour that did break through.

The test criterion was visual and on this depended the accuracy of the estimation of the critical depth.

4. Experimental results

The results of these experiments are shown plotted in Fig. 1.

5. Discussion of results

Fig. 1 shows that the critical thickness depends on critical shear stress. Stiffer foams can seal the petrol surface with appreciably thinner blankets than can fluid foams; increasing the critical shear stress from 0.5 lb/ft^2 (240 $dyne/cm^2$) to 2.5 lb/ft^2 (1200 $dyne/cm^2$) reduces the critical blanket thickness measured in terms of the liquid content of the foam from 0.13 to 0.05 in. of liquid.

There appears to be a better correlation between SE and the critical thickness (Fig. 2) than between S alone and critical thickness. Now SE is proportional to the specific surface of the foam per unit volume of water and this has been shown(2) to be related to foam stability under certain conditions.

Fig. 3 shows the normal thickness of a foam blanket obtained during extinction of a free surface petrol fire,(1) for three liquid rates of application, and how these are related to the critical thickness. The ratio of the thickness normally applied to the critical thickness increases as the critical shear stress increases. For a foam of critical shear stress 2.0 lb/ft^2 (960 $dyne/cm^2$), typical of a current crash tender, there can be a ratio of more than 10 : 1 between the water used and the water needed in terms of the critical blanket thickness. It is only for a low critical shear stress and a low rate of application that this ratio can be reduced to about 2. A blanket thicker than the critical will always be necessary to allow for drainage, so that some caution is necessary in applying these conclusions too directly.

6. Conclusions

These experiments suggest that improvement in aircraft crash fire fighting might best be achieved by improved application techniques which would allow a coherent foam blanket nearer to the critical thickness to be formed.

References

(1) NASH, P. Recent research on foam in the United Kingdom - to be published.

(2) THOMAS, P.H. The absorption of radiant heat by fire fighting foam. J. Appl. Chem. 9. May, 1959.

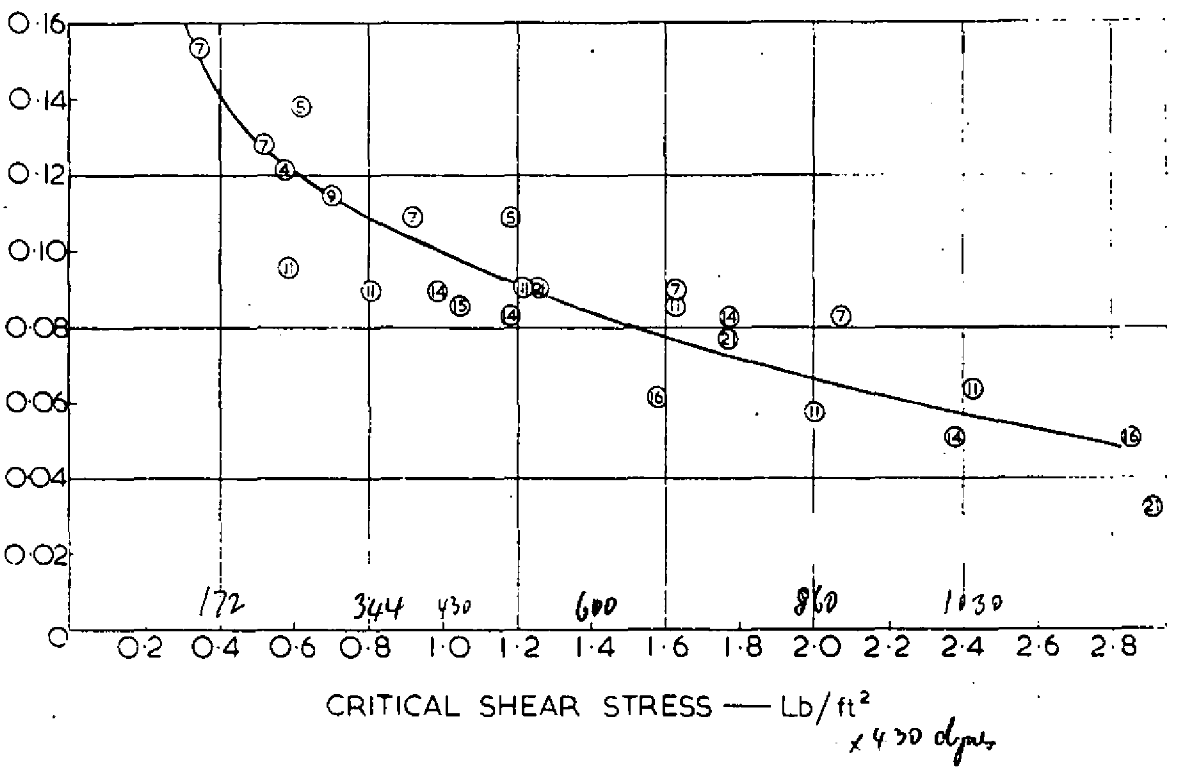

FIG. 1. CRITICAL THICKNESS OF A FOAM LAYER TO SEAL BURNING PETROL

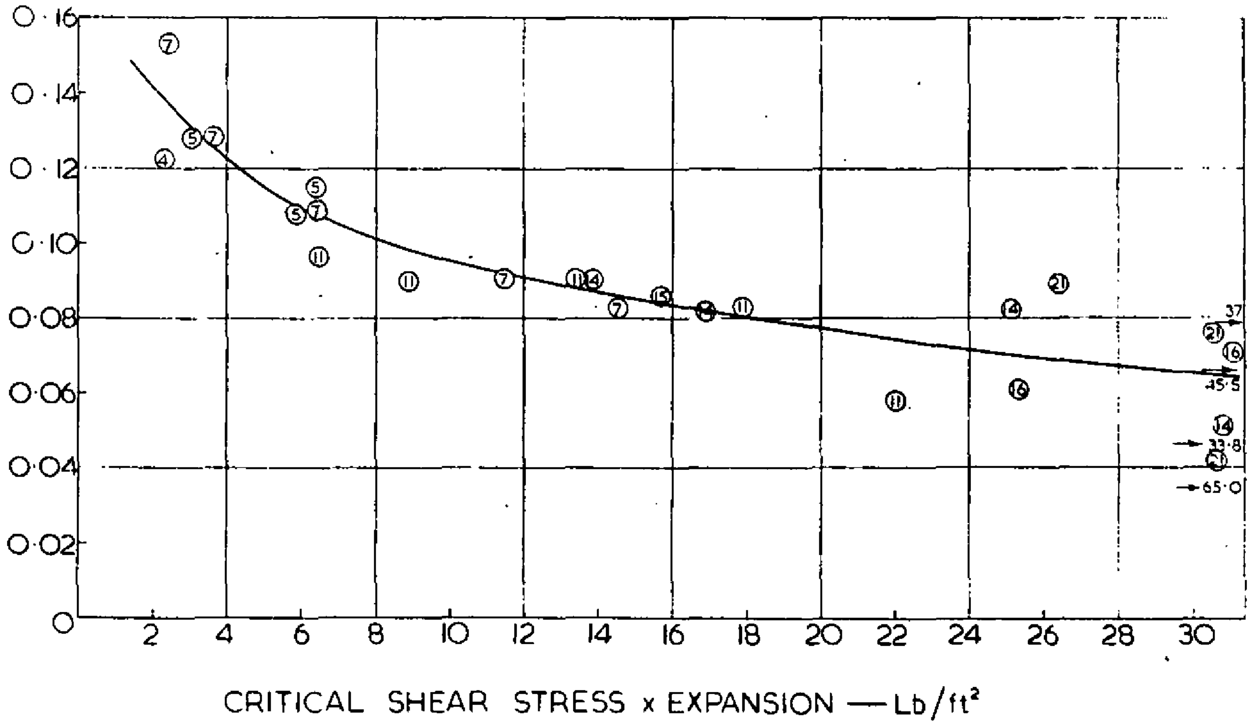

FIG. 2. CRITICAL THICKNESS OF A FOAM LAYER TO SEAL BURNING PETROL

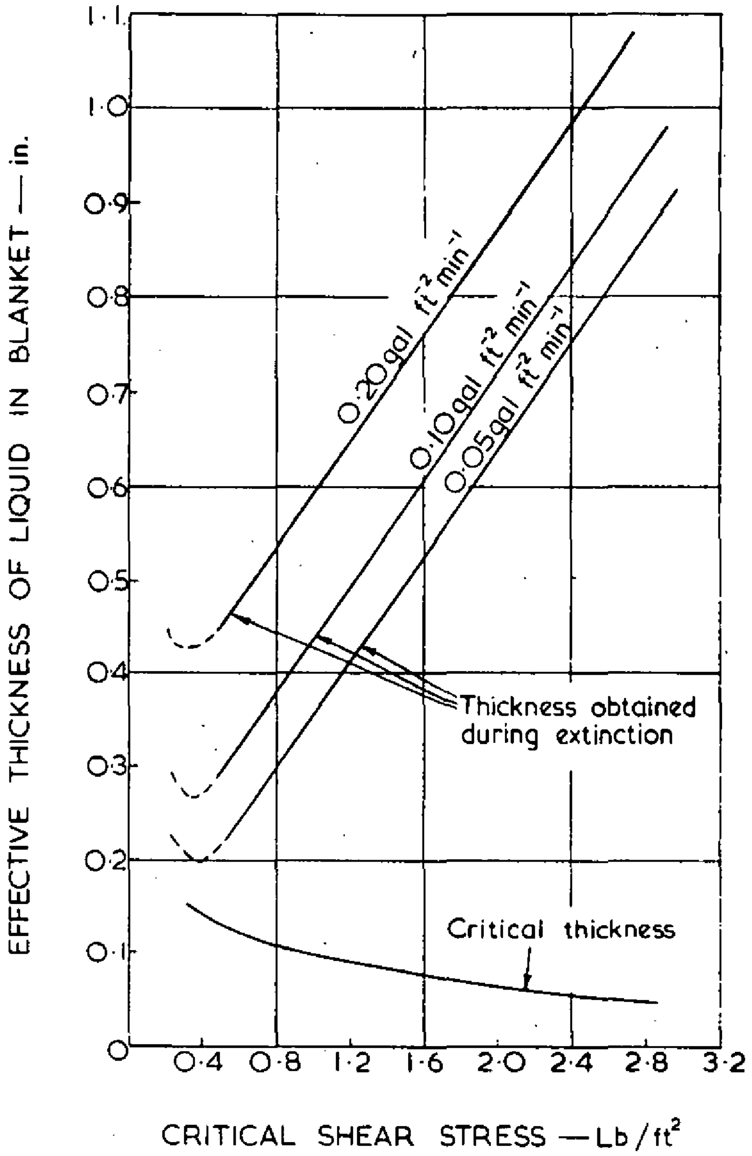

FIG. 3. COMPARISON BETWEEN CRITICAL THICKNESS AND NORMAL THICKNESS

FOAM SPREADING APPARATUS

PLATE 1