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THE EXTINCTION OF FLAMMABLE LIQUID FIRES BY DRY CHEMICAL EXTINGUISHING AGENTS - I. THE EFFECT OF PARTICLE SIZE

by

D. Hird and M. J. Gregsten

Summary

It is shown in this report that the efficiency of a dry chemical extinguishing agent with a sodium bicarbonate base depends largely on its specific surface. Chemicals intended for use as extinguishing agents should be ground as fine as possible, commensurate with maintaining good flow properties.

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Fire Research Station,
Boreham Wood,
Herts.

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Introduction

Considerable research into the use of fine powdered chemicals for the suppression of methane/air ignition, and of dust explosions, has been undertaken during the last thirty years. As long ago as 1934, Dijskman [1] established an approximately linear relationship between the specific surface of some fine powders and their efficiency as flame suppressors. More recently, Dolan and Dempster [2] have confirmed this result in their work on the suppression of methane/air ignition, and they expressed extinction limits in terms of square centimetres of powder surface per litre of gas.

In view of this work it was thought that particle size might have a similar effect on the efficiency of extinction of flammable liquid fires by dry chemicals and this was investigated as likely to be of immediate importance.

Since the majority of commercial dry chemicals at present in use consist almost entirely of sodium bicarbonate, most of the investigations to be described were made with this material. Further work is in progress, however, in which other materials are being examined.

Experimental

A measure of the efficiency of any extinguishing agent is given by the minimum rate of application and the minimum amount of agent required to extinguish a fire of a given size. These were measured by applying dry chemicals to a fire at various rates of application, and recording the extinction time for each rate.

The chemicals used in the tests were "Powder A", a commercial dry chemical having a specific surface of about 4000 cm^2/gm; "Powder B", another commercial chemical having a specific surface of about 1500 cm^2/gm; "Powder C", sodium bicarbonate, not specifically sold as an extinguishing agent, but including a flow additive, and having a specific surface of about 1250 cm^2/gm; and "Powder D", sodium chloride with a flow additive having a specific surface of about 2300 cm^2/gm. The specific surfaces of the chemicals were measured by the method of Lea and Nurse [3], each value being the mean of from 5-10 determinations.

The chemicals were expelled from a commercial extinguisher at a maintained pressure of 75 lb/sq.in., by using an external source of carbon dioxide and a reducing valve, instead of the normal carbon dioxide cartridge. Ten feet of $\frac{3}{4}$ in. bore hose connected the extinguisher with a spring-loaded shut-off valve into the end of which was screwed the discharge nozzle. A flat spray nozzle, shown in tests to be described elsewhere to be most suitable for fires similar to the test fire, was used throughout the investigation.

The mass rate of discharge was varied (a) by using flat spray nozzles of different slit widths, and (b) by incorporating fibre washers between the extinguisher body and the delivery hose to restrict the flow of dry chemical.

The test fire consisted of $1\frac{1}{2}$ in. of burning petrol contained in a tray 3 ft. square and 4 in. deep. A preburn of one minute was allowed in each test, and the tests were conducted in a large steel shed to minimize the effect of wind.

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Experimental procedure

The extinguisher was filled with dry chemical, weighed together with the delivery hose and nozzle, and connected to the cylinder of carbon dioxide. Carbon dioxide was admitted to the extinguisher until the operating pressure of 75 lb/sq.in. was reached. The fire was lighted, and at the end of the preburn period, dry chemical was discharged onto the fire, and the extinction time was recorded. The extinguisher was then weighed again after expelling the residual carbon dioxide, to determine the amount of dry chemical used.

Tests were made at various rates of application until the "critical rate" for each of the four chemicals described above had been established. "Critical rate of application" is here defined as that rate below which extinction is unlikely. The fire was always of the same type and the same, experienced operator was employed in every test.

Results and discussion

Figures 1 and 2 show how the extinction time and the mass of dry chemical used depend on the mass rate of application of each of the three grades of sodium bicarbonate. Figure 3 shows extinction time as a function of rate of application in terms of surface area of all the chemicals tested.

It is seen that for a given mass rate of application both extinction time and mass of chemical required increase as specific surface decreases - that is, with increasing particle size. This is particularly marked at low rates of application. Figure 1 shows, further, that the critical mass rate of application increases with decreasing specific surface. On the other hand, when rate of application is expressed in terms of surface area of chemical, as in Figure 3, all three grades of sodium bicarbonate approximate more nearly to a single curve, and the limiting factor is the surface area of chemical exposed to the fire.

In considering the possible mechanism by which dry chemicals extinguish flames, the concentration of powder in the flames is clearly of importance. There is unlikely to be a simple relation between the rate of discharge from the nozzle and the concentration in the flame, which is likely to be affected by many factors, such as the velocity of the powder, which will be dependent on the mass rate of flow, and the dispersion, which may vary with particle size. No attempt was made in these experiments to determine this concentration and for this reason it is considered unwise to draw any firm conclusions from the results, as to the mechanism of extinction. It is interesting to note that sodium chloride has a similar efficiency to sodium bicarbonate but it is too early yet to advance any explanations for this.

Conclusions

It has been shown that the extinction efficiency on flammable liquid fires of the dry chemicals examined depends to a large extent on the surface area of the chemical presented to the flames. To extinguish a given fire, the higher the specific surface of the chemical the lower the rate of application, and the smaller the quantity required. Dry chemical extinguishing agents should therefore be ground as finely as possible consistent with maintaining good flow characteristics.

References

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(2) DOLAN, J. E. and DEMPSTER. P. G. The suppression of Methane-Air Ignitions by Fine Powders. J. App. Chem. 1955, 5. 510-17.

(3) LEA, F. M. and NURSE, R. W. An Air Permeability Method for Determining the Specific Surface of Fine Powders. J. Soc. Chem. Ind. 1939, 58. 277.T.

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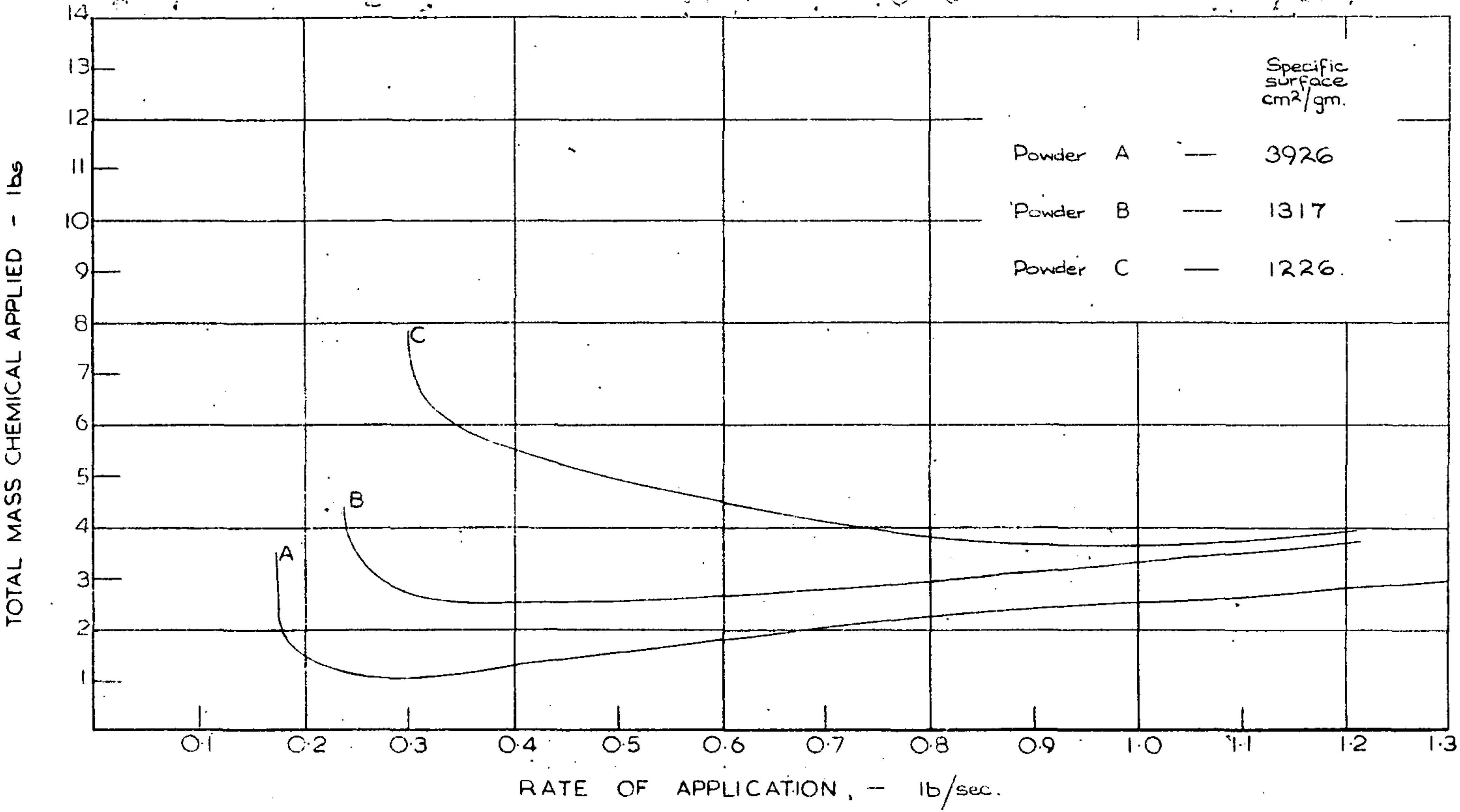

FIG. 2. THE TOTAL MASS OF POWDER REQUIRED FOR EXTINCTION AT DIFFERENT MASS RATES OF APPLICATION.

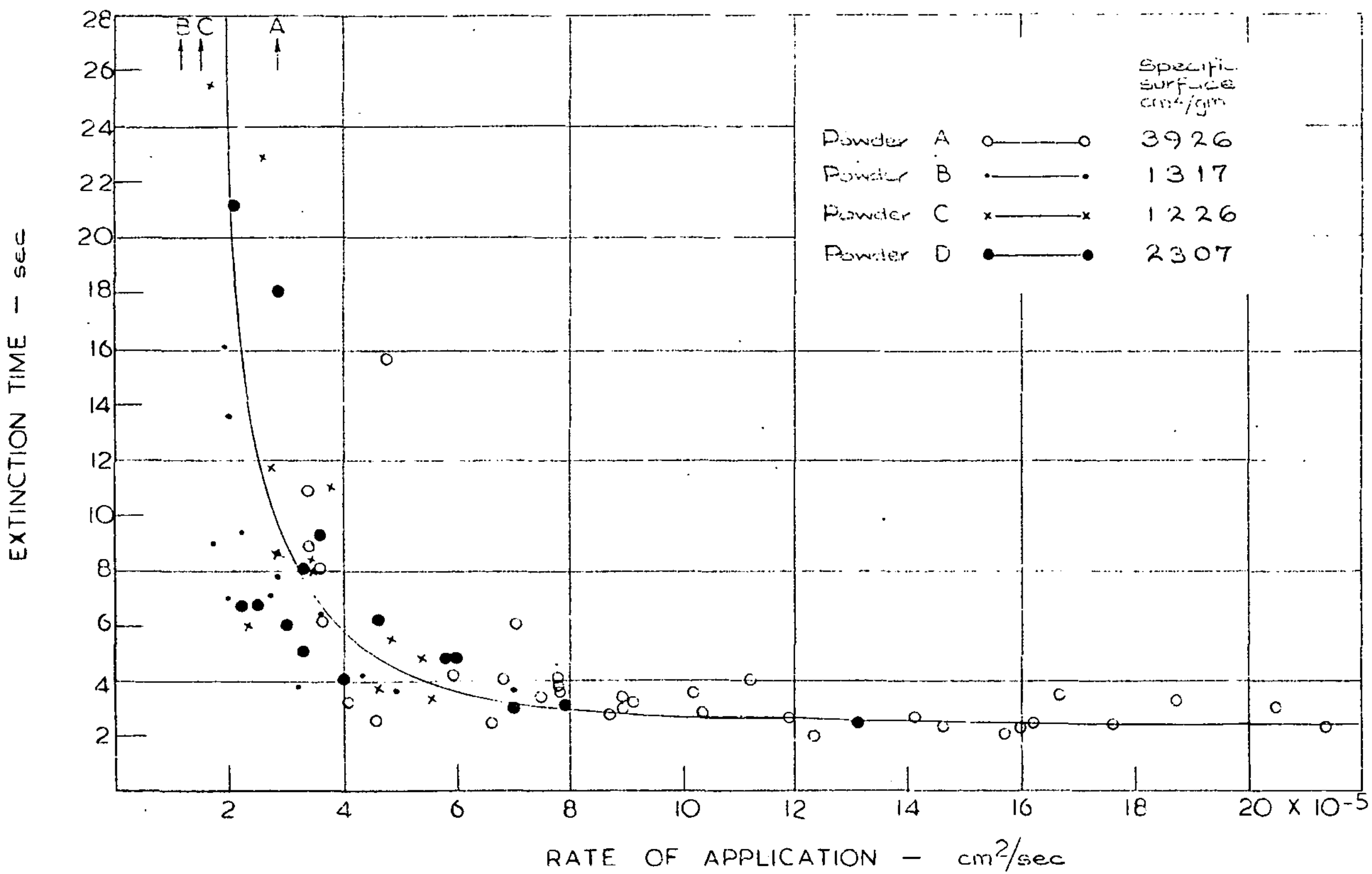

FIG. 3. EXTINCTION TIME AS A FUNCTION OF RATE OF APPLICATION IN TERMS OF SURFACE AREA OF POWDER.