LIBRARY REFERENCE ONLY

THE LIBRARY
FIRE RESEARCH STATION
BOREHAM WOOD
HERTS.
No. A99FR.N200

F.R. Note No. 200/1955
Research Programme Objective C4/1

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

This report has not been published and should be regarded as confidential advance information. No reference should be made to it in any publication without the written consent of the Director of Fire Research. (Telephone: ELStree 1341 and 1797).

REVIEW OF THE USE OF FINE POWDERS FOR FIRE EXTINCTION

by

D. Hird

Summary

Present practice in the use of dry powder is reviewed, as well as the use of fine powders for suppressing dust explosions and the ignition of methane-air mixtures. The outstanding problems are discussed.

September, 1955.

Fire Research Station,
Boreham Wood,
Herts.

© BRE Trust (UK) Permission is granted for personal noncommercial research use. Citation of the work is allowed and encouraged.

REVIEW OF THE USE OF FINE POWDERS FOR FIRE EXTINCTION

by

D. Hird

Both sodium bicarbonate and common salt have been used for a long time for "damping down" domestic fires, and one of the first dry chemical extinguishers consisted of a container from which the chemical (sodium bicarbonate) was either thrown or sprinkled on the fire. About forty years ago a gas pressurized unit which expelled dry chemical at a high velocity was developed in Germany. The chemical used was sodium bicarbonate containing about 15 per cent borax, which, it was hoped, would make the powder effective against solid combustible materials. A metallic stearate was added as a waterproofer.

Although interest has been aroused and dry chemical has been much more widely used since 1945, there has been little change in the type of chemicals used. It has been found that smaller particle sizes give better results but the majority, if not all the dry chemical used at present contains about 98 per cent sodium bicarbonate, and metallic stearates are widely used as additives.

The present commercial dry chemical is undoubtedly more efficient than carbon dioxide or chemical foam for extinguishing small spill fires and the 20 lb. dry chemical extinguisher, of similar size to the 2 gallon foam extinguisher, is rated by the Factory Mutual Laboratory as capable of extinguishing a 12½ square foot petrol fire. The comparable figure for a 20 lb. carbon dioxide extinguisher is 7 square feet. In trained hands the 20 lb. dry powder extinguisher is capable of extinguishing a much larger area of burning petrol than 12½ square feet.

Because of the possibility of a rapid extinction or reduction in intensity of a petrol fire by dry chemicals, the main development of large-scale equipment has been directed to aircraft crash fires. The present opinion in this country is that relatively small amounts of dry chemical (400 lb.) should be used in conjunction with foam for aircraft crash fire-fighting. The Royal Canadian Air Force, however, and some overseas commands of the Royal Air Force have equipped themselves with large mobile trucks carrying 4,000 lb. of chemical. No reports of actual service experience of this equipment have been received, but the Canadian Air Force claim to have carried out successful tests on large simulated crash fires.

One of the obvious disadvantages of this type of medium is that it does not give any protection against reignition of the petrol, and because of this its use in conjunction with foam would be more satisfactory. Experience both here and in America (1) has shown that many commercial powders can cause the rapid breakdown of foam, not only if the powder is applied on the foam, but also when the foam is applied to petrol which has been extinguished by dry chemicals. The effect is thought to be mainly due to the high surface activity of the metallic stearates, which indeed are used as commercial antifoaming agents. The decomposition of the sodium bicarbonate under fire conditions can lead to a change in pH value of the foam solution leading to a more rapid breakdown, but this is likely to be a secondary effect.

Special powders have also been developed for the extinction of metal fires such as sodium and lithium. The mechanism in this case is simpler and in most of these powders one constituent is a fusible material, (bitumen and "hoof and horn" have been used) which will melt on the burning metal and exclude the oxygen. The products of decomposition of the carrier powder must not react with the metal.

The mechanism of extinction by fine powders

The only investigations published to date of the extinction of liquid fuel fires by fine powders were carried out at the National Bureau of Standards (2), who concluded from subjective tests on a 16 square foot petrol fire that particle size and dispersibility were important and that materials other than sodium bicarbonate were effective. The dispersion of the powder is of course as much a function of the equipment as of the powder.

Incombustible powders have been used for a long time for the inhibition of dust explosions, and large quantities of limestone dust are used annually for this purpose in our coalmines. Incombustible powders are also included in or around the charge whilst firing is in progress in the mines to suppress the possible ignition of methane-air mixtures.

The mechanism of both these processes may be similar in many ways to that of dry chemical on liquid fuel fires, and they have been investigated in some detail by a number of workers.

(a) The suppression of dust explosions by incombustible powders

Many measurements have been made of the proportion of added dust required to make a combustible dust non-inflammable at any concentration in air (2, 4, 5, 6). The majority of this work has been done with coal dust but Bowes *et alia* (7) investigated the effect of a number of incombustible dusts on flour and cork dust. They also investigated the effect of fineness of the incombustible dust and found an increase in flame suppressing efficiency with the finer powders. They noted that the addition of a small amount of waterproofing agent to aid dispersion of the dusts had no effect on their flame-suppressing capabilities.

The general conclusions of all the workers on dusts are that alkali metal salts are more effective suppressors than are insoluble mineral salts, and that the alkali halides are particularly effective, potassium being superior to sodium and the order of increasing efficiency of the halides being chloride, bromide, iodide and fluoride. The flame-suppressing efficiency of mineral dusts appears to be roughly related to their heat capacities, but the efficiency of the alkali salts is greater than thermal considerations would suggest.

The suppression of methane-air ignitions by fine powders

The first detailed study of this phenomenon was undertaken by Jorissen (4) who had earlier investigated the effect of vapours on the explosion of gases. He found that at a certain dust concentration the mixture of methane and air was no longer explosive, and he expressed the efficiency of different powders in terms of the concentration by weight necessary to extinguish a methane-air flame propagated in a glass tube. Dijsksman (8) extended this work using a different technique and gave as good extinguishers of methane-air explosions, potassium chloride, sodium chloride and sodium bicarbonate; he also established an approximately linear relationship between specific surface and extinction efficiency. Later Jorissen (9) using Dijsksman's method and working near the lower flammability limits, found the alkali halides particularly effective.

Dufraisse (11) in 1938 investigated the effects of various powders on town gas, methane and carbon monoxide flames. He found potassium bicarbonate more effective than sodium bicarbonate and showed that the flames could be extinguished by promotors of combustion such as sodium or potassium nitrate. He suggested that the extinction by these powders was at least partly due to an anti-oxidising catalytic effect. He later (12) gave the most efficient extinguisher as potassium oxalate but showed that the addition of certain materials such as silica to the oxalate improved the efficiency. Mixtures of potassium oxalate (30 per cent) and sodium bicarbonate (70 per cent) were also shown to be more effective than either salt.

Sperckaert (12) investigated the effect of various salts on explosive mixtures by igniting the mixture of explosive and salt and measuring the duration, temperature and length of the resultant flame in different gases. He found some relation between the specific heat, latent heats of fusion and vaporization, and the efficiency of the salts, and gave again the alkali metal halides as particularly effective, placing them in the following order of efficiency.

Li, Na, K

and Fl, Cl, Br, I.

Recently Dolan and Dempster (13) have investigated more fully the relationship between physical and thermal properties of powders and efficiency in suppressing ignition of methane-air mixtures. They have shown that the efficiency of a particular material is dependent on its specific surface and can be expressed in cm^2/litre of gas mixture. They found that salts which decompose below 200°C are generally effective, but that the efficiency of some salts, particularly the alkali metal halides could not be explained on purely thermal grounds. They suggest that since partial vaporization takes place there is some ion interference in the methane/air reaction.

The alkali metals and the halides are placed in different orders of efficiency by workers using different techniques, but they still emerge as amongst the most efficient suppressors of methane-air ignition.

Discussion

Although the mechanism of extinction of petrol fires by fine powders may be similar to that of mixtures of methane and air, it is unlikely to be identical. Firstly, with a diffusion flame near to burning petrol the combustible gases will be near the upper flammability limit, and powders or their products of dissociation may interfere with the diffusion of air to the flame. The application of powder at high velocities with the entrainment of appreciable amounts of air would therefore seem to be inefficient. It has been suggested (2) that fine powders absorb much of the radiation from the flames and thus reduce the heat transfer from flames to fuel and reduce the rate of burning.

The degree to which the efficiency of extinction of petrol fires is due to purely thermal and physical effects might be clarified by the use of a material whose extinguishing action on methane-air mixtures has been shown to be accountable on purely thermal grounds for example ferric oxide (13).

Conclusions

The outstanding problems in the use of dry powders for extinguishing liquid fuel fires are:-

(1) To determine the best type of powder and particle size.

(2) To determine the best methods of applying the powder to different types of fire.

These problems involve such considerations as methods of production and storage and cost of the powders but it is first necessary to make a quantitative assessment of their firefighting capabilities.

References

1. N.R.L. Reports 3250-103/49 amm. and 3250-72/49 amm.
2. Lee, T. G. and Shaub, H. Extinguishment efficiency of some powders on gasoline fires. N.B.S. Report No. 2310.
3. Greenwald, H. D. U.S. Bur. Mines, 1939, Rept. Invest. 3462.
4. Jorissen, W. P. et alia. Rec. Trav. Chim. 1933 52 403.
5. van der Dussen, A. A. ibid, 1935, 54 873.
6. Matla, W. P. M. ibid, 1936, 55 73.
7. Bowes, P. C., Burgoyne, J. H. and Rasbash, D. J. J. Soc. Chem. Ind. 1948, 67 125.
8. Dijksman, A. J. Chem. Werkbl., 1934, 12.1, 718.
9. Jorissen, W. G., Snijders, H. G. and Vink, H. J. Rec. Trav. Chim. 1940, 59 957.
10. Dufraisse, C., and German, M. C.R. Acad. Sci., Paris, 1935. 207, 1221.
11. Dufraisse, C. ibid, 1953, 236, 164.
12. Sperckaert, P. "Explosifs", 1952, 2, 65.
13. Dolan, J. F. and Dempster, P. B. The suppression of methane/air ignitions by fine powders - "to be published".

PC.