

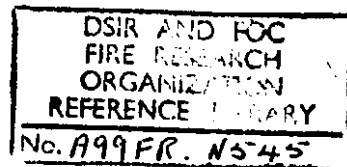
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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

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FIRE OFFICES' COMMITTEE

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THE DEVELOPMENT OF A DRY POWDER EXTINGUISHING
AGENT FOR METAL FIRES

by

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SUMMARY

A dry powder based on boron trioxide has been developed, and will extinguish metal fires without production of toxic fumes. The use of a larger particle size and range than is usual with dry powder extinguishing agents is advocated.

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Introduction

In recent years there has been a notable increase in the industrial use of many metals, formerly of only limited interest. Such metals as sodium, potassium and magnesium had a restricted use in industrial processes, while metals such as titanium, lithium and uranium were rarely encountered.

The needs of the atomic energy and aircraft industries have now led to the quantity production and use of many such metals. Since, however, they can present a fire hazard under various circumstances, methods for extinguishing them have become important.

Fire characteristics

Most of these metals are highly reactive, and burn at high temperatures, e.g. magnesium gives a flame temperature of about 1300°C. These factors make the use of most conventional fire fighting agents not only ineffective but dangerous. Water applied to sodium, even when the metal is cold, is dissociated into hydrogen and oxygen with an explosive reaction. Carbon dioxide applied to burning magnesium is dissociated into carbon and oxygen, again with a violent reaction. A consequence of the latter reaction is that ordinary dry powder extinguishing agents, based on bicarbonates, are ineffective on certain metal fires due to the release of carbon dioxide.

Earlier dry powder extinguishing agents

At an early stage in the development of dry powder fire fighting materials for metal fires, it was appreciated that the material used should seal off the surface of the burning metal to exclude gases and to reduce the rate of reaction until combustion ceased. Exclusion of gases is an important factor in the extinction of metal fires as some metals will continue burning in gases other than oxygen; for example, magnesium and titanium will burn in nitrogen and chlorine. A crude interpretation of the idea of gas exclusion was the wartime use of dry sand to smother incendiary bombs. Further development of this idea led to the use of materials such as borax which melted and formed a layer over the burning metal surface. At the same time, efforts were made to reduce the rate of reaction of the burning metal by adding a flammable constituent such as sawdust or powdered graphite, which burned on the surface of the metal and combined preferentially with the available oxygen, leaving a less intense fire to be extinguished.

More recently, a powder has been developed at the J.F.R.O.⁽¹⁾ and consists of a mixture of equal parts of borax and powdered polyvinyl chloride. This material has proved effective against some metal fires, but the chlorine compounds given off by the burning P.V.C. constitute a toxic hazard.

Development of a non-toxic powder

(1) Modification of existing powder. An investigation has been made to endeavour to eliminate the toxic fumes of the P.V.C./borax powder by selecting other suitable constituents. In the P.V.C./borax powder, the role of the P.V.C. was considered to be that of a "glueing" agent to stick the particles of borax on to the burning surface until they could fuse and form a sealing layer. It seemed possible that the substitution for the P.V.C. of a plastic material with no halogen content might eliminate the toxic hazard without reducing the efficiency of the powder. One such plastic is polyvinyl alcohol and a mixture of equal weights of borax and polyvinyl alcohol was tried on a small scale. In these small scale tests, 50 gram quantities of magnesium/aluminium alloy were melted and ignited by blow torch. The test powder was then sprinkled over the burning metal from a scoop until a complete layer of unchanged powder was visible. If no visible external change in the powder layer was observed after 1 minute, the powder layer was pierced to determine whether combustion had ceased. The polyvinyl alcohol did not appear to act as a "glueing" agent, but burnt readily, helping to create a bigger fire. There were indications that the powder cloud itself was igniting, and this, on a larger scale, might lead to a dangerous condition. Since most simple plastics containing no halogen content are flammable, it was concluded that replacement of the P.V.C. in P.V.C./borax powder was not practicable.

(2) New materials. A series of materials which might fuse to form glassy layers were tested on a small scale as before. Among these materials were borax, fly ash and ground glass, either as simple powders or as mixtures with each other and with polyvinyl alcohol. Some of these powders gave moderate control of the test fires but none extinguished the fires completely. A mixture of the raw components of glass i.e. sand, sodium carbonate and lime, was ground and tested as before. The test fire was extinguished but no continuous crust appeared to have formed.

Boric Oxide Powder

Powdered boric oxide with a particle size range of 20-250 microns was mixed with 1 per cent magnesium stearate as a flow improver and water-proofing agent. The resultant powder was tested on a small scale as before. All the test fires were extinguished easily without the liberation of any noxious fumes and with the formation of a hard crust over the molten metal. The quantity of powder required to extinguish the fires was found to be much less than the quantity of P.V.C./borax powder required to extinguish a similar fire. Small sodium fires involving 25 gram quantities of molten sodium were also extinguished without release of fumes and again with the formation of a hard crust over the metal.

The powder was now tested on a larger scale against magnesium/aluminium alloy and sodium fires. In the first test 17 lbs of magnesium/aluminium alloy was ignited and allowed to burn until about one third was molten and burning. The powder was applied from a conventional 20 lb extinguisher using a pourer type applicator. One minute after the burning material had been covered with a layer of powder, the crust formed was pierced and combustion was found to have ceased. The quantity of powder applied was 14 lbs. In the second test, 1 lb of sodium was melted and ignited. Powder was applied as in the previous test and the fire was extinguished in about 1½ minutes. In both tests the powder had reacted with the burning metal, liberating boron.

Particle size and caking tendency

The particle size range of the boron trioxide powder was between 20 and 250 microns. It seemed that provided the powder can be expelled from the extinguisher, the particle size and range are not of primary importance.

The caking tendency of the powder was assessed using the method given in Ministry of Works Specification MW/CS/368/1 Appendix B⁽²⁾. In this test the pellet crushing strength obtained was 124 grs, well within the limit set by this specification. The powder was found to be free-flowing from the extinguisher.

Conclusion

It was concluded that boric oxide (boron trioxide) was an effective dry powder fire fighting agent for use against magnesium/aluminium alloy and sodium fires, and was likely to be effective against a wide range of metal fires.

Acknowledgements

Mr. B. K. Chandisingh and Mr. M. Clements assisted with the experimental work.

References

- (1) U.K. Patent Application No. 22080/61 RM Forward and D. Hird
- (2) Ministry of Works Specification No. MW/CS/368/1 Appendix B.