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THE DEVELOPMENT OF AN IMPROVED DRY POWDER - FIELD TRIALS

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SUMMARY

The results of Class A and B fire tests using an experimental powder based on mono-ammonium phosphate of tailored particle size distribution are described.

The experimental powder was found to be comparable with commercially available general purpose powders on Class A fires and more effective than sodium bicarbonate powders on Class B fires.

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

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INTRODUCTION

A review[1] of the inhibition of flame by powdered materials indicated that it was unlikely that materials other than those currently used as Dry Powder extinguishing agents could form the basis of an improved agent unless a new chemical substance were devised. It appeared therefore that any improvement in D.P. agents would result from modifications to the particle size distribution.

Consequently laboratory experiments were made to investigate the effect of particle size on the flame extinguishing affectiveness of currently used chemicals and other chemicals, which although not contenders from practical considerations, are of interest for comparison. The main results of that investigation have been reported[2].

The laboratory investigation suggested that mono-ammonium phosphate, of a tailored particle size distribution substantially in the range 10 - 30 μm could form the basis of an improved dry powder which might be expected to be twice as effective as a standard sodium bicarbonate based powder. This report describes fire tests which have been carried out on an experimental powder based on mon-ammonium phosphate.

FIELD TRIALS

Class A fires

The test fire used was one of those specified in a draft European Standard. The particular fire, designated 21A, consisted of wood cribs 2.1 m long, 500 mm wide 560 mm high made from sticks of 'Pinus Silvestris' (moisture content 10-15 per cent) of 20 mm x 20 mm in cross section, spaced 20 mm apart. The crib was ignited by burning 5.5 l of AVGAS in a tray beneath the crib. This ignition source burnt for approx.2 min, after which time the tray was removed and the fire allowed to develop for a further six minutes before extinction was attempted. The fire was situated in a ventilated enclosure with a ceiling height of 7.5 m. One experienced operator was used throughout the series of tests.

In each experiment, 7 kg (15 lb) powder was contained in a standard 11 kg (25 lb) dry powder extinguisher under a stored pressure of 10 bar (150 lb/in^2). The operator wore a thick towelling hood with a transparent viewing window and a boiler suit as protective clothing. The hood was necessary to minimise the inhalation of powder in the indoor situation. When extinguishing the fire, the operator moved around the crib and in all tests, except test 2, was allowed to operate the extinguisher intermittently at his discretion.

A successful extinction was achieved if, after extinction of flaming combustion, no reappearance of flaming occurred within three minutes.

Class B fires

In this series of tests the standard circular CENTRI fires were used, burning AVGAS without a water base. Fire sizes 13B(0.41 m^2) to 233B(73 m^2) were used. Two series of tests were made; in the first series, the graded experimental powder was used against 13B, 21B and 34B fires, and in the second series the milled experimental powder was used against 55B to 23B fires. Neither protective clothing nor gloves was worn by the operator, who was experienced in extinguishing this type of fire. A standard 11 kg (25 lb) stored pressure extinguisher pressurised to 10 bar (150 lb/in^2) was used.

Powders used

Two forms of the experimental powder were used. The first was prepared by the Warren Springs Laboratory by air classification of a standard mono-ammonium phosphate raw material. Siliconised silica flow additive at 0.5% was substantially incorporated in a high speed mixer. This will be referred to as the graded experimental powder. The second was prepared by a manufacturer of general purpose (ABC) dry powder using a combination of grinding and air classification techniques. A surface silicone treatment was incorporated in the process. This will be referred to as the milled experimental powder.

A commercially available ABC powder was also used in the Class A fire tests, for comparison.

The size distributions of the three powders as determined by dry sieving down to 12.8 μm using an Allen Bradley Sonic Sifter and micromesh seives are summarised in Fig.1.

RESULTS AND DISCUSSION

Class A fires

The results of thr fire tests are summarised in Table 1. The average discharge rate from the extinguisher was about 0.37 kg s^{-1} in all the tests. A further test was made in which the discharge was throttled to 0.15 kg s^{-1} by an orifice. The fire could not be controlled at this rate which would seem to be below the critical rate for this fire.

Test 2 was unique in that continuous rather than intermittent discharge was used. The fire was controlled but not extinguished because there were areas where insufficient powder had been applied - the discharge time (18 s) was too short for powder to be applied evenly over all the crib, especially in the conditions of reduced visibility occurring during a test. It was also noted that powder would not penetrate the full thickness of the crib is applied from one side only.

No reignition of the crib occurred in any of the tests, apart from test 1, in which extinction was not achieved. However, very small patches of flaming did sometimes appear, mainly at the corners of the crib and in sheltered areas where two sticks overlapped. These occurrences were disregarded as being insignificant since experience showed that this flaming would not spread and invariably died out. It was commonly observed that once flaming was extinguished, residual smouldering would quickly go out and within a few seconds the crib was cool enough to be touched by hand.

Table 1 indicates that better resulrs were obtained using the commercial ABC powder but when the average weights of each powder used were compared using 'Student's t-Test', the differences were not found to be significant. The results therefore show that there were no substantial differences in the efficiency of the two powders in extinguishing the 21A test fire.

Class B fires

The results are plotted as extinction time versus application rate, and quantity required to extinguish versus application rate in Fig 2(a) and (b). Also shown on Fig 2 are curves for some typical sodium bicarbonate based powders[3] and for a commercially available synthetic powder based on potassium bibarbonate and urea[4]. Although the conditions in the fire tests for each set of data differ in detail, there is sufficient similarity for a comparison to be made. The critical and optimum rates and the minimum quantity of powder to extinguish (at the optimum rate) taken from Fig 2 are shown in Table 2.

It can be seen from fig 2 that the results for the graded experimental powder are for rather higher application rates than those for the milled experimental powder.

However the two sets of results appear to be correlated well by a single critical rate curve in fig 2(a)

It can be seen from Fig 2(a) that, as expected, at high application rates the critical rate curves for the experimental powders, the sodium bicarbonate powders and the potassium bicarbonate urea powder tend to merge. Overall, the experimental powders show a distinct advantage over the fine sodium bicarbonate (which at a specific surface or 400 m^2/kg is exceptionally fine, the surface mean diameter being 7 μm). Their performance is not as good as the commercial potassium bicarbonate/urea powder.

Fig 2(b) also shows the same general relativity of the powders. The difference between the experimental powders and the fine sodium bicarbonate in terms of the quantity to extinguish at the optimum rate is not so marked - see Table 2. The commercial potassium bicarbonate/urea powder is about twice as effective as the experimental powders in this respect.

CONCLUSIONS

An experimental dry powder of narrow particle size distribution, based on mono-ammonium phosphate incorporating suitable flow additives, has been found to be more effective on Class B test fires than an exceptionally fine standard sodium bicarbonate powder in terms of critical rate, optimum rate and minimum quantity to extinguish. The experimental powder is comparable to a typical commercially available general purpose (ABC) powder for the extinction of Class A test fires.

REFERENCES

1) THORNE P F Inhibition of the combustion of liquid and gaseous fuels by finely divided inorganic salts: a literature review. Fire Research Note 604 (1965).
2) THORNE P F New methods for testing the effectiveness of dry powder Fire October 1968. Also 'Fire Research 1967' page 53-56 HMSO 1968.
3) HIRD D and GREGSTEN M J. The extinction of flammable liquid fires by dry chemical extinguishing agents 1. The effect of particle size. Fire Research Note 239 (1956).
4) 'Monnex' a new fire fighting agent. Technical Service Note 7S/C/2283 I C I Ltd Mond Division 1969.

Table 1

Summary of results of Class A fire tests

Test No	Powder used	Weight of powder used to extinguish the fire (kg)
1	E	6.7
2	E	6.6
3	C	6.0
4	E	5.2
5	C	4.2
6	C	4.35
7	E	5.0
8	C	3.75
9	C	4.9
10	E	4.55
11	C	5.55
12	C	5.45

The extinguisher was charged with 6.8 kg of powder in each test

E = Milled experimental powder

C = Commercial ABC powder

Table 2

Comparison of critical (R_c) and optimum (R_{opt}) rates and minimum quantity (Q_{min}) to extinguish Class B test fires

Powder	R_c Kg/m^2 sec	R_{opt} Kg/m^2 sec	Q_{min} Kg/m^2
Sodium Bicarbonate S.S. 130 m^2/kg	0.125	0.22	1.35
Sodium Bicarbonate S.S. 400 m^2/kg	0.10	0.19	0.7
Experimental mono-ammonium phosphate powders	0.037	0.1	0.5
Commercial potassium bicarbonate/urea powder	0.015	0.09	0.25

S.S.= specific surface

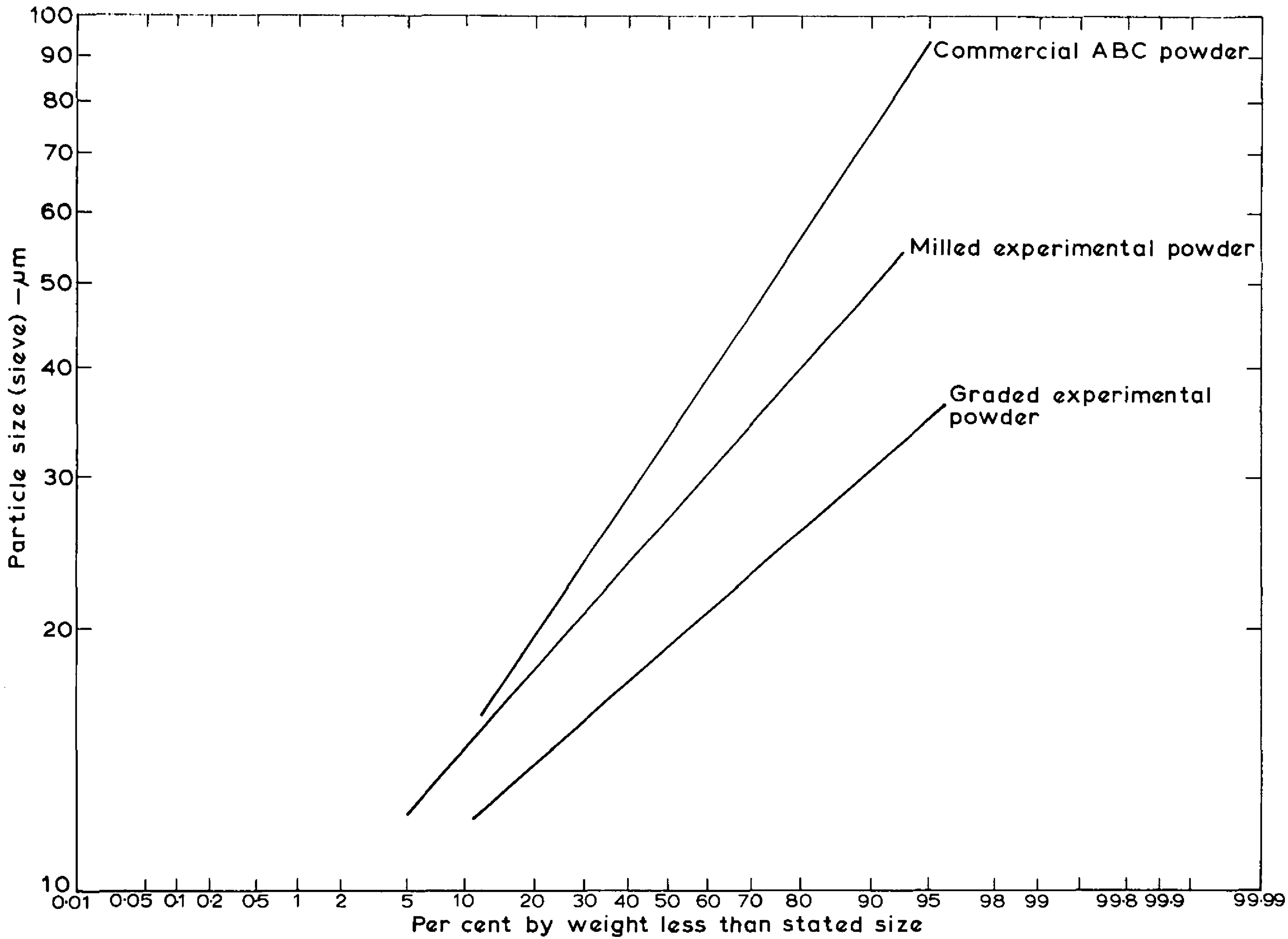
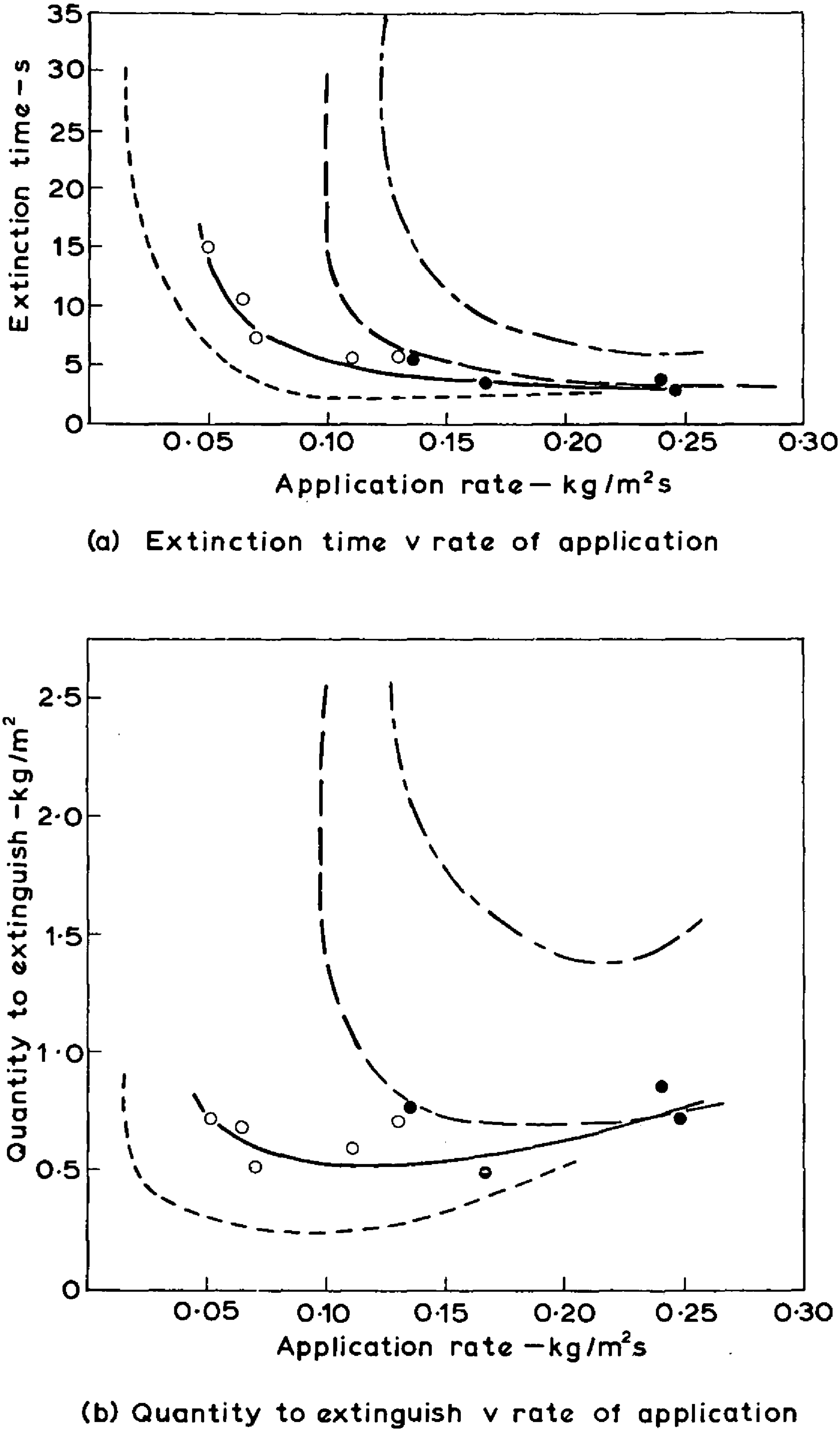


Figure 1 Summary of size distribution of powders



(a) Extinction time v rate of application

(b) Quantity to extinguish v rate of application

— - - — Sodium bicarbonate specific surface $130 m^2/kg$

— — — Sodium bicarbonate specific surface $400 m^2/kg$

- - - - - - Commercial potassium bicarbonate–urea powder

● Graded experimental powder

○ Milled experimental powder

Figure 2 Results of class B test fires