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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
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CAKING AND FLOW PROPERTIES OF DRY POWDERS - I

by

R. M. Forward

SUMMARY

A method is described for measuring the discharge characteristics of dry powder extinguishing agents before and after accelerated storage tests, as a measure of the caking tendency of the powder.

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Introduction

Since dry powder extinguishers may stand for a number of years before being used on a fire, it is essential that the powder should remain free-flowing and easily dispersible for long periods. This note describes a method for measuring the discharge characteristics of dry powders before and after accelerated storage tests. This direct measure of the caking tendency can be used to help evaluate laboratory methods, or, alternatively, if no satisfactory parameter can be found linking small scale with large scale experiments, it may be used, itself, as a basis of a test for dry powders.

Method

The method at present used to evaluate the caking tendency of dry chemical powder consists of making up a standard pellet of known volume and packed density, placing it, in turn, in atmospheres of 92 per cent relative humidity and 0 per cent relative humidity for six and twenty-four hours respectively, and then determining the force needed to crush the pellet. An arbitrary limit of 400 gm/cm^2 was set on the crushing strength, any powder having a value higher than this being considered unsatisfactory.

The accelerated storage tests were devised in order to estimate the value of this crushing strength test and on the limit imposed for satisfactory performance, as well as any other property of the powders that may be studied in the laboratory. The storage tests consist of subjecting charged extinguishers to extremes of temperature and humidity. For this purpose a chamber measuring 3 feet by 3 feet 6 inches by 3 feet deep was constructed of $\frac{1}{2}$ inch asbestos wood in which up to twelve 25 lb standard extinguishers can be stored. The temperature within the cabinet, which is controlled thermostatically is maintained by six 180 watt tubular heaters arranged in the base and along the sides. Trays of water, which can be removed when not required, are arranged in the base of the cabinet and provide the source of humidity. At elevated temperatures, about 120°F, the relative humidity was found to fall off to about 30 per cent but this has since been increased to 60 per cent by coating the outside of the chamber with a suitable paint which has the effect of reducing the permeability of the walls to water vapour.

If the maximum temperature reached in the cabinet is 120°F, the moisture content of the air can be varied, in a cyclic manner, from zero to 4.8 per cent (saturation at room temperature ≡ 1.14 per cent moisture).

The valve of the nozzle of the extinguisher, which is never completely air-tight, is maintained slightly open during storage to facilitate the passage of air into and out of the extinguisher when the temperature changes. This treatment will show up any tendency for the powder to cake and form lumps by absorbing moisture and then drying out afterwards.

The most positive way of assessing the performance of a dry powder after storage is to discharge the powder and measure both the rate of expulsion and the weight of the residue remaining in the body of the extinguisher. A value of the average rate of discharge may be obtained easily by noting the total discharge time and the loss in weight of the extinguisher. However, a continuous value over the whole of the period of discharge seemed to be more valuable as a measure of the characteristics of the powder, and the apparatus shown in Fig. (1) and Plate (1) was developed for this purpose.

The collecting vessel, which has a lead-in to centrifuge the powder to the walls, has a brush filter clamped on top of the main body which prevents all but the very fine powder escaping through the air outlet at the top. The whole assembly is suspended from a 4 feet long, 1 inch square, steel cantilever with strain gauges mounted 1 inch from the fixed end. The change in resistance of the gauges due to the increasing load is measured by means of a Wheatstone Bridge circuit, and the out-of-balance current is amplified and measured on a continuous recorder. The resistance changes linearly with load over the range used, and the weight can be estimated to ± 2 oz. Fig. (2) shows some typical results obtained for commercial powders, the 25 lb extinguisher having been pressurised with air to 130 pounds per square inch. Total discharge time for powder 'A' was 21 seconds while that for powder 'B' was 28 seconds. A residue of 1 lb of powder 'B' remained in the extinguisher. No sputtering was observed in either case. Thus, for the same conditions of pressure, etc., powder 'A' is evidently more easily dispersed than powder 'B'. Storage tests on two standard powders, lasting up to two months, showed that no caking had taken place during this period, the discharge characteristics and the residue remaining in the extinguisher being the same before and after storage.

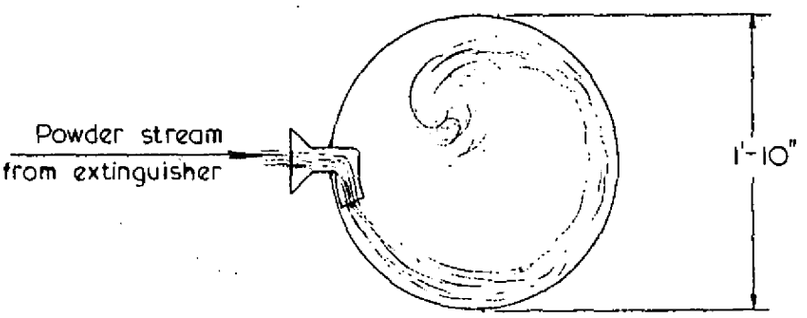
Experiments carried out initially, in which weighed quantities of powder were discharged into the collector, indicated that 1 per cent or less of the powder passed through the filtering device. Although this loss is small and will have little effect on the measurement of the discharge, the reduction in specific surface area as a result of the loss of these fines will evidently be quite appreciable. Measurements on three different samples, using the Lea and Nurse air permeability apparatus, showed that, after discharging the powder into the collector, the specific surface area had fallen by 4 - 5 per cent. This loss in fines will almost certainly have an effect on the caking properties of the powder, and therefore, the accelerated storage tests should be carried out on a freshly prepared sample.

Conclusion

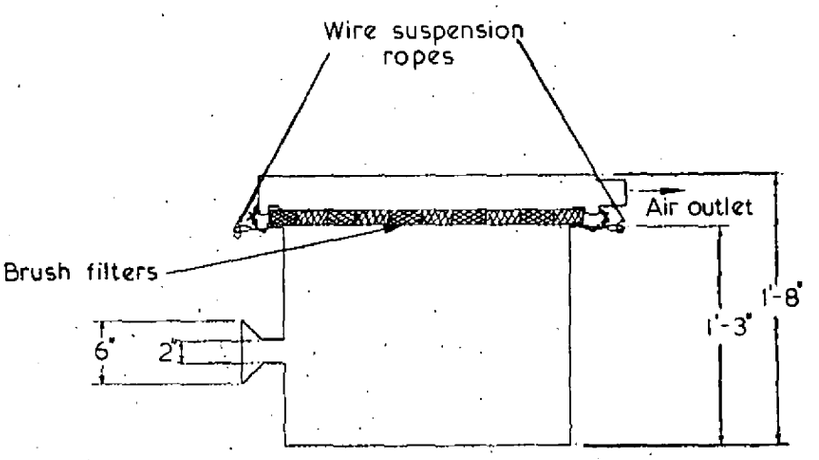
The test method gives an accurate record of the discharge rate of powders from 25 lb extinguishers, and can show up sputtering or discontinuity of discharge. It would be useful to prepare a series of powders of different base compositions, with various amounts of Mg. stearate and other additives, that would give a range of dispersing and caking properties. Sufficient powder should be made up both to charge the extinguishers for discharge and storage tests, and also to carry out investigations of its properties in the laboratory in order to correlate one with the other.

Reference

1. LEA, F. M. and NURSE, R. W. Specific Surface of Fine Powders. J. Soc. Chem. Inds, London. 1939, 58 277-83.



SECTION THROUGH COLLECTING VESSEL



SECTION SHOWING FILTER ARRANGEMENT

FIG.1. POWDER COLLECTION VESSEL

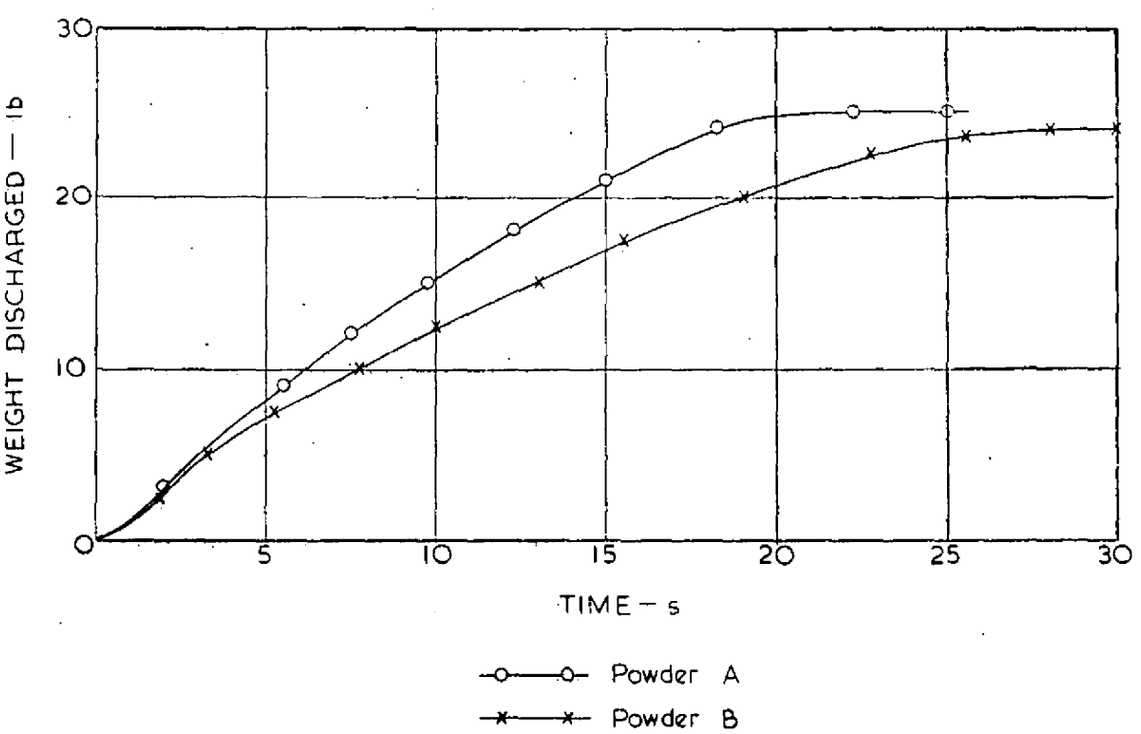
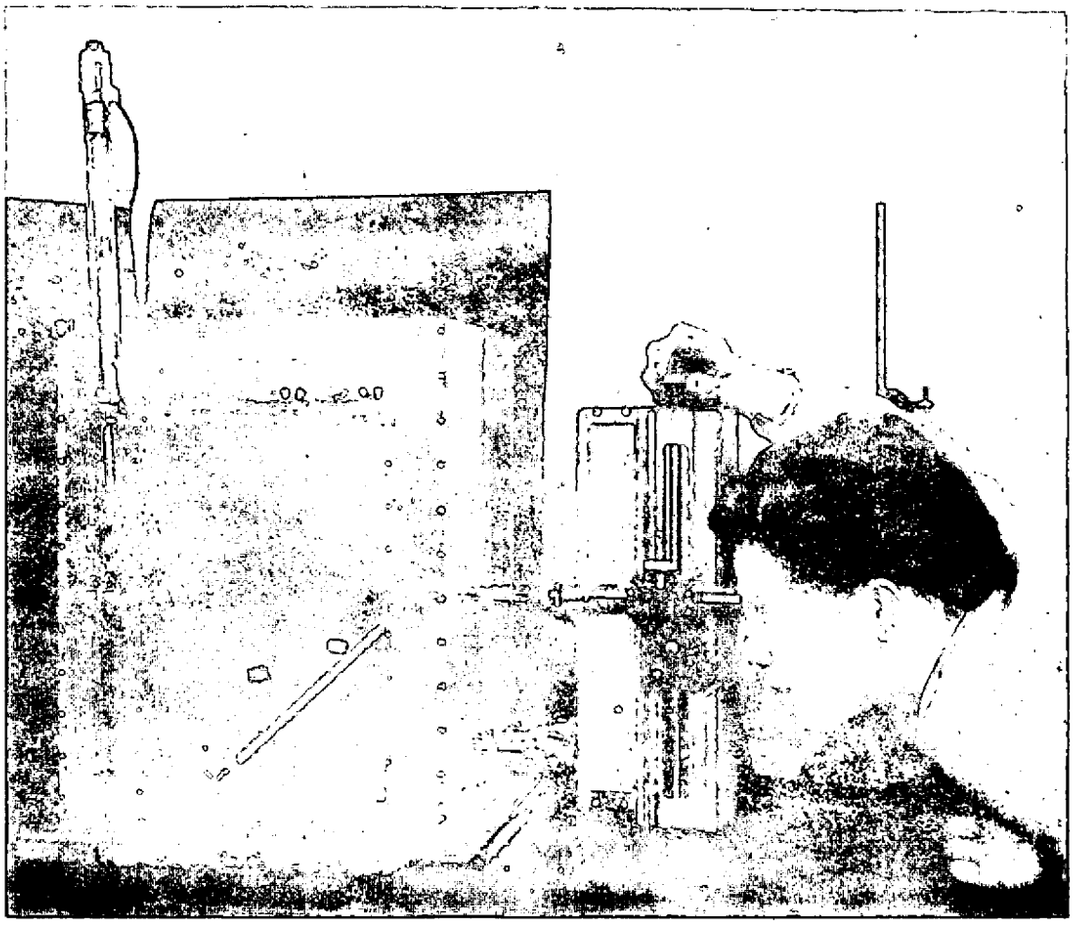


FIG.2. RATE OF DISCHARGE OF DRY POWDER FROM 25 LB EXTINGUISHER



APPARATUS FOR DETERMINATION OF MOISTURE
ABSORPTION OF DRY POWDERS

PLATE 1