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THE EFFECT OF [illegible] AGENTS ON [illegible]

OF SMALL PROPELLANT FIRES

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for

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE EFFECT OF WETTING AGENTS ON WATER QUENCHING OF SOLID PROPELLANT FIRES

ABSTRACT

A brief study was made of the effects of water, both with and without a wetting agent, on the burning rate of solid propellant rocket fuel.

INTRODUCTION

It appears that under some conditions the premature burning of solid propellants in damaged or misfired missiles may be brought under control by the early application of large quantities of water to the surface of the propellant. Some measurements were made to determine whether or not wetting agents might be expected to increase the effectiveness of this method of control.

MATERIALS AND TEST METHODS

The propellant furnished by the Navy was MK33-Mod 0 guided missile rocket propellant cast in cylindrical rods ½ inch in diameter and about one foot in length. These rods were cut into specimens of two sizes: (a) right cylinders ½ inch in diameter and 1½ inches in length and (b) such cylinders quartered longitudinally to produce specimens of quarter-circular cross section and 1½ inches in length.

Tap water did not wet the surface of the propellant at room temperature. After one minute of immersion and 15 sec of draining, only a few globules, about 1 or 2 millimeters in diameter, adhered to the surface.

Burning propellant samples of both sizes described were readily extinguished by immersion in water. It appeared that the water wet the hot parts of the sample. This might be expected in view of the usual variation of surface tension with temperature.

Several different wetting agents were used in recommended concentrations and in each case a thin film

of treated water adhered to all surfaces immersed at room temperature. The following wetting agents were used:

Triton X 100	1 percent
Aerosol OT	0.2 percent
Nino 2021A	2 percent
U Nox	1 percent

RESULTS AND DISCUSSION

The effect of wetting on the rate of flame spread was measured in the following way. The propellant specimen was immersed to a depth of 1¼ inch for 15 sec. This left a dry length of ¼ inch for the initiation of flame spread. The specimen was drained 15 sec before testing. A small steel pin inserted in the base of the specimen supported it with a minimum of surface contact during the draining and subsequent burning. The specimen was oriented with the longitudinal axis vertical and with the dry segment at the top. The specimen was ignited on the top surface and the time required for the flame to spread to the bottom of the specimen was recorded. Such tests were run on at least five each of the untreated specimens, specimens immersed in water, and those immersed in the various wetting solutions. The differences between the effects of the various wetting agents was not considered significant in view of the probable error of the method. Since in every case the upper part of the specimen was untreated, the time required to burn that part, i.e. one-sixth of the time to burn an untreated specimen, was subtracted from the total time to obtain the time required for the flame to spread downward across the treated surface. The rates of flame spread are tabulated below:

Treatment	Rate of Flame Spread			
	Circular cylinders		Quartered cylinders	
	$s/v = 8.00\ in.^{-1}$		$s/v = 18.4\ in.^{-1}$	
	in./sec	percent	in./sec	percent
No treatment	0.056	100	0.16	100
Water	.049	88	.085	53
Wetting solution (average of all)	.040	71	.050	31

The notable differences in the results for the two different specimen shapes may be attributed to the difference in the ratio of lateral area to volume. The ratios are given in the table.

Since no significant differences were found between the effect of the various wetting agents in reducing the flame spread rate, no refined measurements of the differences in wetting were made. Contact angle measurements would reveal such differences, if any. No measurements were made of the viscosity of the wetting solutions although it may be an important property in determining the effectiveness in actual fire-fighting. The more viscous solutions might form a thicker layer on the propellant surface with a greater cooling effect. On the other hand, increased viscosity might retard the flow and effectively delay the application of extinguishing agent during the incipient stage when any delay might have disastrous consequences. The increase in burning rate accompanying increased pressure might be avoided by sufficient venting of the space containing the propellant.

It may be concluded that:

1. Burning solid propellant of the type and size tested may be extinguished by immersion in water.

2. The presence of water on the surface of the propellant retards flame spread noticeably.

3. The use of any of the wetting agents tested with the water will materially increase its effectiveness in retarding flame spread.

4. The effectiveness of water or wetting solutions inretarding flame spread increases with increase in the ratio of area to volume of the propellant grain.