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AD NUMBER (To be inserted by DDC)

ORIGINATING AGENCY: Naval Ordnance Lab, White Oak

REPORT SERIES AND NUMBER: NOLM-10203

ENCLOSURE (Report title): A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters by

REPORT DATE: 15 June 19

COG. NAVAIR CODE

CONTRACT/PROJECT/AIRTASK NUMBER

TO
Administrator
Defense Documentation Center for Scientific and Technical Information (DDC)
Bldg #5, Cameron Station
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NAVAL ORDNANCE LABORATORY MEMORANDUM 10,303

15 Jun[redacted]49

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From: L. C. Smith
S. R. Walton

To: Chief, Explosives Division

Subj: A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters. ~~(Task NOL-37-Re2e-19-1-b)~~.

Abstract: This memorandum describes the results of experiments which were conducted to determine the feasibility of replacing Tetryl as a booster material with an RDX/Wax mixture. On the basis of the experiments performed thus far in the Explosives Division of the Naval Ordnance Laboratory, this substitution appears to be not only feasible but desirable. Some work by other groups is necessary before this can be considered to have been conclusively demonstrated.

Foreword: The factual data presented herein is believed to be correct, and the opinions expressed are the well-considered ones of the authors. The Naval Ordnance Laboratory is not committed to endorse either.

Refs: (a) Allied and Enemy Explosives, Aberdeen Proving Ground, Aberdeen, Md.
(b) Cook-off Test in 3"/50 Cal. Gun with Automatic Loaders, U.S. Naval Proving Ground, Dahlgren, Virginia.
(c) OSRD 5625, Preparation and Properties of RDX Composition A.
(d) OSRD 5744, Physical Testing of Explosives, Part II.
(e) NOLM 10,003, Studies of the ERL Type 12 Drop-Weight Impact Machine at NOL.
(f) NOLM 10,336, Sensitivity of Explosives to Pure Shocks.

[redacted]

[redacted]

(g) OSRD 5746, Physical Testing of Explosives, Part III.

Encls: (A) Tables I, II.
(B) Plate 1

I. Introduction

1. The idea of using RDX or RDX/Wax mixtures as booster explosives is an obvious one and is a thought which has been advanced by many people independently. Indeed during the past war both RDX and a 95/5 RDX/Wax mixture were frequently used for this purpose by the Germans, Italians, and Japanese (reference a). In this country, because of the general satisfaction with Tetryl, there was no incentive to carry the RDX/Wax proposal beyond the suggestion stage.

2. More recently, however, "cook-off" tests conducted with the 3"/50 rapid fire gun at the NPG, Dahlgren, demonstrated that a mis-fired round remaining in the gun for thirty minutes could reach a temperature considerably above the melting point of the Tetryl booster (reference b). This once again brought up the question of RDX/Wax mixtures as booster explosives, and the experiments described in the following paragraphs were undertaken.

II. Preparation of RDX/Wax Mixtures

3. It was decided to include in this investigation RDX/Wax mixtures having the compositions 94/6, 96/4, and 98/2. These were all readily prepared by the water-slurry method (reference c) from RDX (Wabash) and Stanolind wax 1/0/175, to which two percent by weight of Alox 600 had been added.

III. Pressing Properties

4. All the RDX/Wax mixtures could be pressed without difficulty to give good pellets at 10,000 psi. Pressure-density curves for the various compositions were determined on the basis of one inch diameter, 10 gram pellets. Two pellets were pressed for each composition at each pressure, and the average measured densities are reported in Table I.

A sample of production Composition A-3 was included for reference purposes. The data of Table I have been plotted in Fig. 1.

IV. Sensitivity Tests

A. Impact Sensitivity

5. Drop-weight impact sensitivities of the RDX/Wax mixtures were determined in a group-test using the ERL Type 12 tools (references d and e). The following results were obtained:

Composition	50% Height (cm.)
98/2	27.4
96/4	40.8
94/6	54.2
91/9	89.3

The 50% heights for RDX and Tetryl under these conditions are about 20 cm. and 30 cm. respectively.

B. Booster Sensitivity

6. This test, the details of which will be reported in NOLM 10,336, reference (f), is designed to measure the relative ease with which an explosive may be initiated by a pure shock. The number reported for an explosive is roughly the thickness of wax through which the test explosive can be initiated by a standard Tetryl booster under specified conditions. Thus, the larger this "50% gap", the more sensitive the explosive. The data obtained for the materials in question are as follows:

Composition	Dens. (g/cc)	50% Gap
100/0	1.54	2.33
98/2	1.53	1.95
96/4	1.56	1.87
94/6	1.57	1.83
91/9	1.58	1.73

On this scale the 50% gaps observed for Tetryl and pressed TNT are 2.01" and 1.63" respectively.

C. Sensitivity to Initiation by Blasting Caps

7. Experiments were conducted to determine the sensitivities of the various compositions to initiation by electric blasting caps. The caps which were available and used included the DuPont No. 6 seismographic, the DuPont No. 8, and the Atlas Engineers Special. The test charges in these experiments were 1 5/8" dia. x 1" high pellets pressed at 10,000 psi. Two conditions were investigated, as follows:

(a) detonator inserted in 9/32" dia. x 1/2" deep well,

(b) detonator taped horizontally across the flat face of the pellet.

8. The results, summarized in Table II, indicate that the 94/6, 96/4 and 98/2 compositions can be reliably detonated by the No. 6 cap under either conditions (a) or (b). The Composition A-3 could be initiated with the No. 6 cap only under condition (a). The Engineers Special cap was required to initiate Composition A under condition (b).

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V. Output Characteristics

9. Boostering experiments suggest (reference f) that the effectiveness of a booster from the output standpoint is best expressed by its relative brisance as measured by the plate-denting test (reference g). In the table below are reported the relative brisance values (cast TNT = 100) for the several compositions pressed at 10,000 psi, together with values for pressed Tetryl and pressed TNT.

Composition	Dens. (g/cc)	Relative Brisance
100/0	1.54	121
98/2	1.53	121
96/4	1.56	121
94/6	1.57	119
91/9	1.58	121
Tetryl	1.55	112
TNT (pressed)	1.56	96

It is seen that when the several RDX/Wax compositions are pressed at the same pressure, the relative brisance is independent of the composition up to 9% wax. All the RDX/Wax compositions are seen to be superior to Tetryl, and greatly superior to pressed TNT.

VI. Resistance to High Temperatures

10. In order to determine the effect of high temperature on the RDX/Wax materials, 1 5/8" dia. x 1" high pellets of each composition were pressed at 10,000 psi. One pellet of each composition was suspended from a rack, by means of wire supports, over a glass dish. This assembly was then placed in a forced draft oven for four hours at 165° C (329°F). At the end of this time the assembly was removed and the pellets were examined.

11. No exudate was found in the glass dishes. All the pellets had become brown in color (inside as well as out) except a straight RDX pellet which had been included as a control. This showed only slight discoloration. The Composition A pellet had broken in two, but the others were weighed and the following weight losses determined:

Composition	Loss (gm.)	Loss (% of Wax)
98/2	0.41	39
96/4	0.44	21
94/6	0.37	12

12. The pellets were then broken up and sieved, and their sensitivities were determined in the impact machine. In the following table we have recorded the 50% points determined before and after heating, and $m_B - m_A$, which is the logarithm of the ratio of the 50% points.

	50% Point (cm)		
Composition	Before	After	$m_B - m_A$
RDX	20.8	18.5	0.0500
98/2	28.8	26.2	0.0415
96/4	38.8	34.6	0.0493
94/6	48.3	43.1	0.0500

All eight samples were run in the same group test. Although in no single case do the data reveal a significant increase in sensitivity, the constancy of the quantity $m_B - m_A$ suggests that if the data were considered collectively the change would be found to be significant. It can, in fact, be shown that for the three RDX/Wax mixtures the change in sensitivity on heating corresponds very closely to the change which would be expected from the weight loss, assuming all the material lost to be wax. It is not known why the RDX pellet showed a similar sensitivity change. This may have been a statistical accident, or the sensitivity change may be due to some factor other than loss of wax. The change is, in any event, small.

13. Vacuum stability tests were run on the heated materials and failed to reveal any delotorious effects resulting from the heating.

VII. Summary

14. We have now investigated the following properties of these RDX/Wax mixtures:

(a) ease of preparation

(b) pressing properties

(c) impact sensitivity

(d) booster sensitivity

(e) ease of initiation by detonators

(f) relative brisance

(g) resistance to high temperatures

On the basis of the results of these tests, the following conclusions appear justified:

(a) All the mixtures may be prepared readily by the usual Composition A-3 method.

(b) All the mixtures press well to give good pellets.

(c) The impact sensitivity varies with composition in the expected way and is equal to that of Tetryl for mixtures containing 2-3% wax.

(d) The booster sensitivity decreases with increasing wax content and is equivalent to that of Tetryl at 2% (or slightly less) wax.

(e) Mixtures containing up to 6% wax appear to be reliably initiated by a No. 6 blasting cap. It remains, of course, to be determined that they will be reliably initiated by service type leads and detonators under more realistic conditions.

(f) The relative output of all the compositions, as measured by the plate-denting test, is greater than that of Tetryl.

(g) The RDX/Wax mixtures are not seriously affected by brief (four hour) exposure to a temperature of 165°C. Under the conditions of this test the wax does not exude, though some of it is apparently volatilized with a resultant increase in sensitivity. The effect is, in any event, small. Although the pellets are discolored by this treatment, the materials appeared unchanged in the vacuum stability test.

15. The replacement of Tetryl as a booster explosive by an RDX/Wax composition would appear to offer some advantages. A composition containing 3-5% wax is tentatively suggested for this purpose.

L. C. Smith

S. R. Walton

ENCLOSURE A

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Table I

Pressure-Density Data for Various HDX/Wax Mixtures

Pressure lb/in.^{2}	Density, g/cc			
	98/2	96/4	94/6	91/9
1000	1.29	1.29	1.29	1.37
2000	1.33	1.36	1.38	1.44
4000	1.43	1.45	1.47	1.50
8000	1.53	1.55	1.55	1.57
10,000	1.55	1.57	1.58	1.58
14,000	1.60	1.61	1.60	1.61

Table II

Results of Initiation Tests on Various HDX/Wax Mixtures

Composition	No. 6 DuPont Seismo. in 9/32" x 1/2" well	Detonator Horiz. DuPont No. 6	DuPont No. 8	Atlas Eoc Spec
91/9	3/3[1]	0/3	0/2	2/2
94/6	1/1	3/3		
96/4	1/1	1/1		
98/2	[illegible]	1/1		

[1] Indicate number of explosions / number of trials

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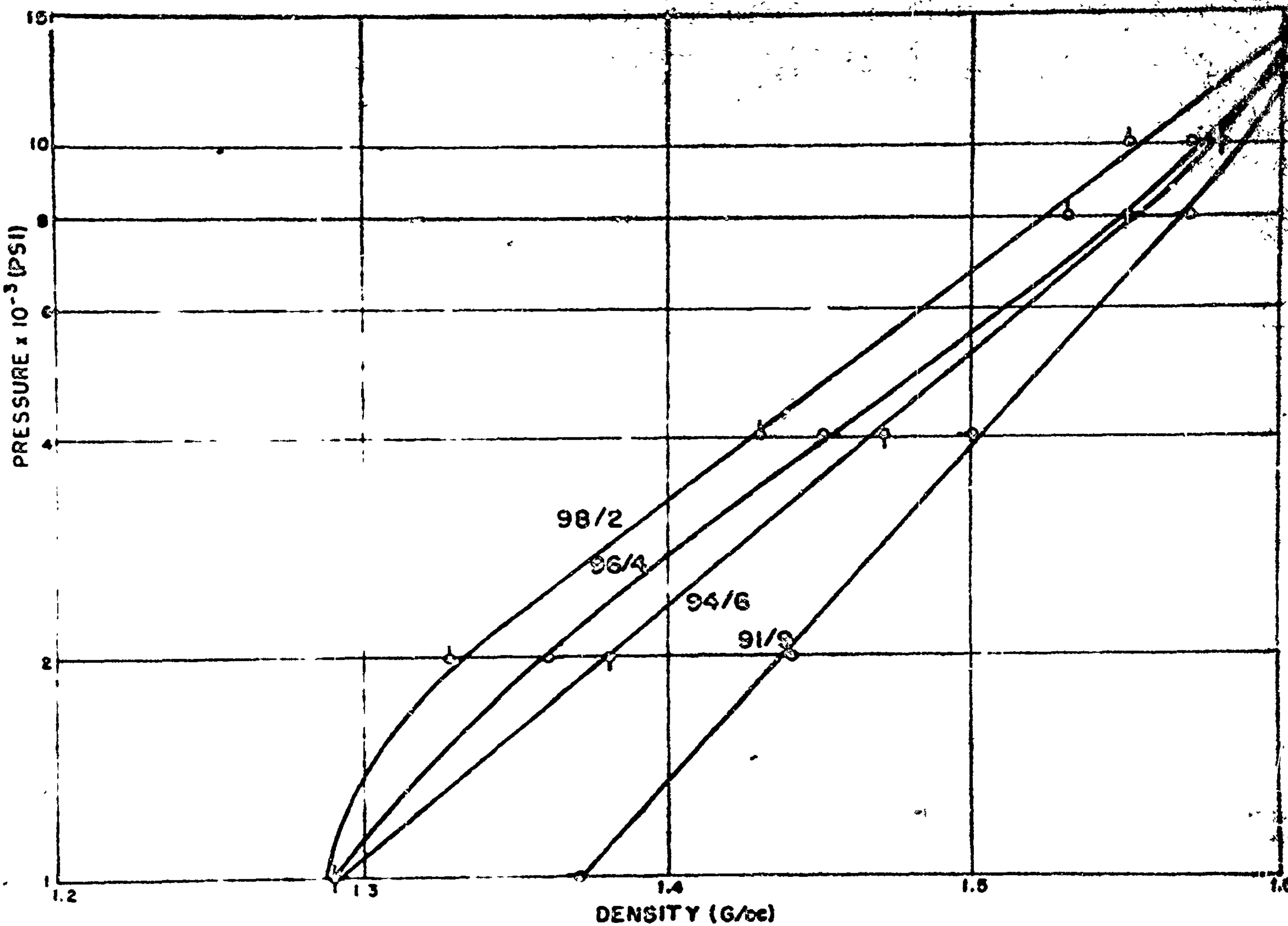
PRESSURE x 10^-3 (PSI)
15
10
8
6
4
2
1
1.2
1.3
1.4
1.5
1.6
DENSITY (G/cc)
98/2
96/4
94/6
91/9