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"Wooden" Explosives for Woodcock

J. Kury

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MEMO

TO: A. Biehl

FROM: J. Kury - Chemistry Division

SUBJECT: "Wooden" Explosives for Woodcock

For the past month the explosives group of the Chemistry Division has spent considerable time on the high explosives portion of the Woodcock program. The preliminary results obtained in the course of this investigation as well as data accumulated at other laboratories throughout the country are presented in this memorandum. Part I is concerned with the preparation and properties of the most promising "wooden" (shock insensitive and high-temperature stable) explosives. Part II deals with several substitute explosives which could be used immediately in a hydrodynamic program. Part III presents a tentative schedule and indicates the role various groups at UCRL have agreed to play in the Woodcock explosives program for the next few weeks.

PART I

In Table I are listed the properties of the most promising "wooden" explosives. Two of these materials, HMX-Exon and HMX-Epoxy, are almost immediately available on a large scale. Picatinny Arsenal has completed a thorough evaluation of the HMX-Exon system and most of the data presented in Table I were determined by J. D. Hooper of the Arsenal.[1-2] The HMX-Epoxy system (which is castable) has been developed by Paul Archibald[3] at UCRL and under contract from UCRL by Poulter Laboratories of Stanford Research Institute.

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[1] Private communication, Mr. L. H. Eriksen to Dr. John S. Foster, July 17, 1958.

[2] "A Progress Report on an Investigation of Fluorocarbon Polymers as Binders for HMX," presented by J. D. Hooper at the Livermore High-Explosives Symposium, Feb. 19 and 20, 1958.

[3] A detailed description of the HMX-Epoxy system will be presented in a forthcoming UCRL report.

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(Insert appropriate classification level or indicate Unclassified)

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The third system contains diamminotrinitrobenzene (DATB), one of the most shock insensitive and thermally stable explosives known,[4-5] and as such, is an excellent candidate for the explosive in Woodcock. No suitable binder, however, has yet been found for DATB. From a general consideration of plastic-bonded explosives and based on work now in progress at NOL, NOTS and UCRL, it seems extremely likely that a 95% DATB-5% binder system will be available in the near future. The properties of this material were extrapolated from data on known DATB-binder systems.[6]

The fourth explosive is a homogeneous solution of organic liquids. This solution is in itself not "wooden" (shock insensitive or high-temperature stable), but because of its ability to be easily stored separately from the other vital bomb components, its proper use could produce a truly "wooden" weapon. The liquid system does however also present problems; two of which are the high change of density, and therefore detonation velocity, with temperature, and the inherent difficulty in defining the sensitivity of a liquid. Some of the more important properties of this liquid explosive are presented in Table I.[7]

Of the above four systems, the DATB explosive seems to have the most advantages and, as such, has been tentatively picked as the explosive to be used in Woodcock.

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[4] NAVORD-6016, "Heat Resistant Explosives II. 1,3-Diamino-2,4,6-trinitrobenzene, DATB," March 31, 1958.

[5] PATR-2524, "Preparation of Thermally Stable Explosives: 2,4,6-trinitrobenzene Derivatives," June, 1958.

[6] NOL and UCRL work on DATB-Epoxy systems.

[7] A more detailed report of the physical and explosive properties of this liquid explosive will be presented in a forthcoming UCRL report.

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TABLE I

	DATB-Binder	HMX Exon	HMX Epoxy	Liquid Explosive
Composition (wt. %)	95% DATB 5% Binder	70% HMX 30% Exon 461	70% HMX 15% Epon 510 15% Hexahydrophthlic-anhydride	51.7% nitromethane 33.2% tetranitromethane 15.1% 1-nitropropane
Density (g/cc)	1.74	1.83	1.65	1.340 at -50°C 1.236 at 25°C 1.174 at 70°C
Theoretical Maximum Density (g/cc)	1.78	1.835	~1.65	---
E_o (a)	102% of TNT	108% of TNT	106% of TNT	138% of TNT
D	~7.4 mm/µsec.	7.87 mm/µsec.	~7.6 mm/µsec. (d)	6.35 mm/µsec. (e) at 25°C
SENSITIVITY				
Drop Hammer (b)	> 200 cm No explosions at drop heights twice as great as the TNT 50% point.	100 cm Like TNT.	70 cm Slightly more sensitive than TNT. Like Comp. A.	33 cm Data not too significant because of method of test.
Wedge Test (c)	High shock initiation build-up time like Comp. B.	No data	High shock initiation build-up time considerably slower than Comp. B; like 75/25 cyclotol.	No data
Vacuum Stability at 200°C	0.2 cc gas/g.hr.	5 cc gas/g.hr.	Acceptable at 100°C but degased rapidly at 150°C.	No data
Compressive Strength	Can be as high as 10,000 psi.	10,700 psi	10,000 psi	---

TABLE I -- Continued

	DATB-Binder	HMX Exon	HMX Epoxy	Liquid Explosive
Temperature Cycling	No data	Diameter grew 0.001" in 2.000" over one 24-hr. cycle from 80°F to -65°F to 165°F to 80°F. No cracking observed.	Diameter grew less than 0.001" in 2.000" in a cycle from 80°F to 165°F to -55°F to 165°F to 75°F. No cracking observed.	---
Processing	Will probably be a slurry type process followed by isostatic pressing.	Slurry type process followed by isostatic pressing at 100°C and 20,000 psi with a few minute dwell time. Easily machinable.	Vacuum mixed and cast at room temp. Requires at least 24-hr. curing in mold. Easily machinable.	Mix and pour.

[a] Relative energy per gram of explosive determined by UCRL small-scale plate-push test.

[b] Drop hammer 50% heights based on UCRL scale with 5 kg. weight. The HMX-Epoxy and the liquid explosive numbers were obtained at NOL and have been scaled to allow comparison with the other numbers in this memorandum.

[c] NAVORD-5710 describes the wedge technique.

[d] Preliminary number obtained optically from a 1/2" diameter, 3" long stick of explosive.

[e] Determined optically on a column of explosive 3/8" x 3/8" x 6".

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PART II

In order to use DATB immediately, it was necessary to find a binder system which would produce a machinable explosive at a high fraction of theoretical density. This material must also be comparable in density and explosive properties to the final 95% DATB-5% binder system. Because of the DATB particle size problem, it was found necessary to add 15% of a mobile binder to reproducibly meet the above criteria. The composition of this substitute system ($DEPT_s$) as well as some of its properties are presented in Table II.

To cover the possibility that Holston and Picatinny Arsenal will not be able to supply sufficient DATB for even the $DEPT_s$ formulation, there are available two possible substitutes which should mock-up the explosive properties of the final DATB system. These are TERD-1.74 and 70% HMX-30% Epon at 95% of theoretical density. The composition and the properties of these materials are also presented in Table II.

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TABLE II

	DEPT	TERD-1.74	HMX-Exon
Composition (wt. %)	85% DATB 2% Exon 461 3% Polystyrene 10% TNT	29.2% TNT 18.0% Exon 461 43.8% RDX 9.0% p-Dibromo-benzene	70% HMX 30% Exon 461
Density (g/cc)	1.75	1.74	1.74
Theoretical Maximum Density (g/cc)	1.77	1.77	1.83
E_o (a)	~100% of TNT	100% of TNT	102% of TNT
D	~7.5 mm/μsec. (d)	~7.2 mm/μsec. (d)	7.5 mm/μsec. (c)
SENSITIVITY			
Drop Hammer (b)	No explosion at 200 cm.	50 cm Less sensitive than Comp. B.	100 cm Like TNT.
Wedge Test	High shock initiation build-up time exactly like DATB.	No data	No data
Vacuum Stability at 125°C	0.2 cc gas/g.48 hrs.	0.9 cc gas/g.48 hrs.	~0.15 cc gas/g.48 hrs.
Compressive Strength	6,500 psi	6,000 psi	~10,000 psi
Processing	Dry-ball milling of ingredients followed by isostatic pressing at 85°C and 20,000 psi. The material must be cooled carefully to avoid cracking. Machines very well.	Dry-ball milling of ingredients followed by isostatic pressing at about 70°C and 20,000 psi. This material must be slowly cooled to avoid cracking. Should machine well.	Slurry process followed by isostatic pressing at 55°C and 15,000 psi.

[a] Relative energy per gram of explosive determined by UCRL small-scale plate-push test.

[b] Drop hammer 50% heights based on UCRL scale with 5 kg. weight.

[c] Calculated from the measured value at a density of 1.83 g/cc.

[d] Preliminary numbers obtained optically from 1/2" diameter, 3" long sticks of explosive.

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PART III

B-Division has scheduled a one-half scale hydrodynamic shot of Woodcock for early August. UCRL Site 300 personnel have undertaken the problem of blending, pressing, and machining the explosive for this test. In order to gain experience in handling DATB and its possible substitute explosives, Site 300 has agreed to furnish 6" x 6" x 0.72" slabs of DEPT$_S$, TERD-1.74 and HMX-Exon as soon as possible for "one dimensional" hydrodynamic shots. The results of these tests, combined with the latest information on DATB production, should enable one to make a decision on which explosive formulation to use in the one-half scale hydrodynamic shot.

Chemistry Division personnel, especially W. Voreck of the Chemical Engineering Group and Milton Finger and John Kury of the Physical, Inorganic and Analytical Group, will be available for advice and assistance during the above mentioned Site 300 operations. Chemistry Division will also for the time being carry out the composition analyses of the various blends before and after pressing.

John W. Kury

John W. Kury
Chemistry Division

JWK:jf

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