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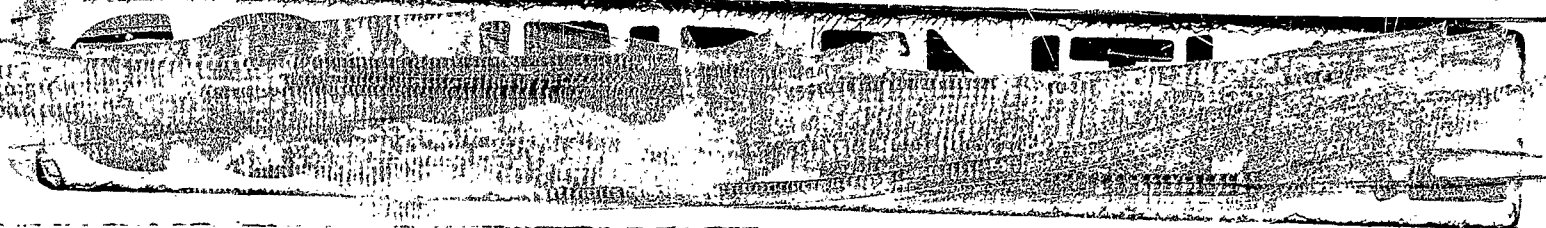
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FINAL REPORT
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Contract DAI-19-020-501-ORD-(P)-53
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205283

NN-F-6

DETERMINATION OF FREE-AIR BLAST OF
ONE-POUND HIGH EXPLOSIVE CYLINDERS

Contract DAI-19-020-501-ORD-(P)-53

FINAL REPORT

May 1955

Submitted by:

V. Philipchuk

Approved by:

C. M. Sauer, Jr.
Assistant Manager

Approved by:

S. J. Porter
Manager

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2.

TEST AUTHORITY

Test requirements for free-air blast determinations on 210 one-pound explosive charges, supplied by Picatinny Arsenal, were outlined in Picatinny Arsenal letter ORDBB-TJ2; S. M. Adelman/mtb/5259, dated 1 December 1954. Testing was conducted under Contract DAI-19-020-501-ORD-(P)-53.

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1.0 CHARGE DATA

1.1 The 210 charges submitted by Picatinny Arsenal consisted of groups of 30 each for 7 different explosives. Each group of 30 was comprised of 10 bare, 10 steel-cased, and 10 aluminum-cased charges.

1.2 Data on the test items were submitted by Picatinny Arsenal on Experimental Ammunition Data Cards or computed by National Northern as follows:

HE	HE wt.		HE Density		HE Volume (cc.)	HE Diameter (in.)	HE Height (in.)
	lbs.	grams	*N	**P. A.			
MOX-2B	1.02	463	2.03	2.10	228	1 7/8	5 1/16
SSB/K5	1.03	467	1.73	1.79	269	1 7/8	5 15/16
PBX	1.01	458	1.60	1.61	285	1 7/8	6 5/16
TNT	1.06	482	1.60	--	299	1 7/8	6 10/16
Torpex-2	1.08	491	1.79	--	273	1 7/8	6 1/16
HBX-1	1.03	467	1.70	--	273	1 7/8	6 1/16
HBX-6	1.05	476	1.75	--	272	1 7/8	6 1/32

* computed from volume in cylinders by National Northern

** pellet density reported by Picatinny Arsenal

1.3 The steel and aluminum cylinders all had a 1 7/8" I.D., a 2.0" O.D., and were closed at the base with a 1" thick plug pressed into the cylinder. Steel plugs were used for the steel-cased charges and aluminum plugs for the aluminum-cased charges. The "equivalent" (i.e., neglecting the base plug in these cases) charge-to-weight ratios of the test items were computed as follows:

Cylinder I. D. = 1.875 in.

Cylinder O. D. = 2.00 in.

Density of steel = 7.83

Density of aluminum = 2.71

<u>HE</u>	<u>HE Density</u>	<u>"Equivalent" Charge - to - Weight Ratios</u>		
		<u>Bare</u>	<u>Al</u>	<u>Steel</u>
MOX-2B	2.03	1.0	.84	.65
SSB/K-5	1.73	1.0	.82	.61
PBX	1.60	1.0	.81	.60
TNT	1.60	1.0	.81	.60
Torpex-2	1.79	1.0	.83	.62
HBX-1	1.70	1.0	.82	.61
HBX-6	1.75	1.0	.82	.62

2.0 STATIC TEST EQUIPMENT

Static tests of the subject charges were conducted at National's Halifax Range at the Free-Air Blast Site. This site consists of a quadinstrument arrangement for detecting blast from a single charge. Details of this site and the Semi-Confined Blast Site (used to evaluate HE blast having partial confinement) are the subject of a separate report which will be released by National to contracting agencies in the near future. The details and instrumentation on the Free-Air Blast Site are briefly as follows:

2.1 Charge. The charge is placed 9 ft. above ground level with its axis at a 45° angle.

2.2 Gauges. Four detectors are located, each in different quadrants, around the charge and at various distances from it. Each instrument is so placed

as to receive the free-air blast (incident) wave, i. e., no reinforcement from reflected or Mach waves. These four detectors are as follows:

- 2.2.1 **Pendulum Gauge.** Designed by National to record an integration of pressure-time, 290 lbs. in weight, 2 ft. square, and 3 ft. from the charge's center.
- 2.2.2 **Catenary Diaphragm.** Developed for use in high-explosive blast determinations to record pressure-time, side-on to the blast wave, and 6' 8" from the charge's center.
- 2.2.3 **Foilmeter.** National's modification of the Bikini Gauge used to record peak pressures, face-on to the blast front at 5 feet from the charge's center. Foil of .0025 in. S aluminum.
- 2.2.4 **5" N-T-C.** Designed by National as a possible means for correlating with aircraft damage beyond an over-kill area. This gauge is 5" in diameter, facing the charge, and has steel tubular compartments (T-C) 6" in length with .0025 in. S aluminum foil between compartments. Face of No. 1 compartment 6' from the charge's center.

2.3 **Booster.** All charges in this test were initiated by 25 gram tetryl pellets and No. 8 electric blasting caps placed at the open ends of the cylinders.

3.0 TEST RESULTS

3.1 Detailed recordings of the individual charges are listed in the enclosed Tables I - IV, incl., and are summarized as follows:

FREE-AIR BLAST10 Round Averages, 1# HE Charges

<u>HE</u>	<u>Pendulum (Degrees)</u>		<u>Al</u>	<u>Bare</u>	<u>Foillmeter</u>		<u>Al</u>
	<u>Bare</u>	<u>Steel</u>			<u>Steel</u>		
Torpex-2	16.4	19.6	17.7	8.8	8.7		8.9
HBX-6	17.9	19.4	18.8	8.1	8.8		8.2
SSB/K-5	17.0	18.3	17.7	7.9	9.1		8.8
HBX-1	17.3	18.1	17.8	8.2	7.9		8.5
PBX	13.6	14.5	14.3	8.1	7.8		8.0
TNT	13.8	14.9	14.9	7.6	6.8		7.7
MOX-2B	11.5	14.7	12.8	4.3	5.7		4.7

<u>HE</u>	<u>*Category, Δ psi</u>			<u>Bare</u>	<u>5" N T-C</u>		<u>Al</u>
	<u>Bare</u>	<u>Steel</u>	<u>Al</u>		<u>Steel</u>		
Torpex-2	25.0	24.7	24.8	6.6	3.7		4.5
HBX-6	24.4	24.2	25.3	6.3	3.6		5.2
SSB/K-5	24.7	24.2	24.5	6.0	3.6		5.2
HBX-1	23.7	23.6	24.4	5.7	3.7		4.7
PBX	23.2	22.4	23.2	4.7	3.3		3.6
TNT	22.3	21.3	21.9	4.7	2.7		3.1
MOX-2B	16.1	17.3	16.3	2.9	2.4		2.6

* 13 of 210 readings were not recorded because of instrument failure.

4.0 CONCLUSIONS

Only general conclusions may be drawn from the free-air blast test results since many variables entered into the program: explosive volume (HE weight held at 1.0 lb. nominal), confinement (c/w ratio), and the measurement of various blast parameters (impulse, peak, and compartment damage).

4.1 Torpex-2, HBX-6, SSB/KS, and HBX-1 were the highest free-air blast producers on all four blast recorders, with PBX, TNT, and MOX-2B following in that order.

4.2 The steel-cased charges produced the highest pendulum readings, with aluminum-cased and bare charges following in that order.

4.3 Only small differences in peak pressures were noted among bare, steel-, and aluminum-cased charges at the distances recorded: 5' for the foll-meter and 6' 8" for the catenary.

4.4 Since the four explosives previously mentioned, Torpex-2, HBX-6, SSB/KS, and HBX-1, were essentially alike in blast performance, the selection of the best filler to be used in this item would be determined probably by the fragmentation characteristics, i.e., fragment velocity and mass distributions.

5.0 DETAILED TEST DATA

5.1 Table 1. Free-Air Pendulum

Nominal HE wt.: 1.0 lb.

Range: Halifax

<u>HE</u>	<u>Case</u>	<u>Pendulum Readings (Degrees)</u>	<u>Average</u>
Torpex-2	Bare	14, 17, 17, 18, 18 1/2, 13, 15, 19, 16 1/2, 17 1/2	16.4
"	Steel	18 1/2, 19 1/2, 20, 19, 18 1/2, 17 1/2, 20, 22, 21, 20	19.6
"	Al	16 1/2, 19 1/2, 17, 20, 16 1/2, 16, 21, 15, 17 1/2, 19	17.7

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<u>HE</u>	<u>Case</u>	<u>Pendulum Readings (Degrees)</u>	<u>Average</u>
HBX-6	Bare	22, 15 1/2, 14 1/2, 20 1/2, 19, 19, 19, 15 1/2, 15, 19	17.9
"	Steel	16 1/2, 16, 17, 18, 19, 19, 19 1/2, 21, 20, 22	19.4
"	Al	15, 17, 17, 20 1/2, 15, 21, 21, 21, 16 1/2, 24	18.8
SSB/K5	Bare	21, 18 1/2, 13 1/2, 13, 16, 14, 19, 19 1/2, 17 1/2, 17 1/2	17.0
"	Steel	19, 18, 15, 19, 18, 15 1/2, 20, 17, 20, 21	18.3
"	Al	17 1/2, 15 1/2, 15 1/2, 19, 19, 14, 16, 16 1/2, 21, 22 1/2	17.7
HBX-1	Bare	15, 16 1/2, 21, 17, 16 1/2, 17 1/2, 14 1/2, 19, 19, 17	17.3
"	Steel	16, 16 1/2, 16, 19, 17 1/2, 20, 17 1/2, 18 1/2, 18, 21 1/2	18.1
"	Al	17, 15 1/2, 15 1/2, 20, 15 1/2, 19, 19, 17 1/2, 18 1/2, 20 1/2	17.8
PBX	Bare	16 1/2, 12, 12, 14 1/2, 12 1/2, 12 1/2, 12 1/2, 14 1/2, 15, 14	13.6
"	Steel	12 1/2, 12 1/2, 14 1/2, 15 1/2, 13, 13, 14, 16 1/2, 17 1/2, 17	14.5
"	Al	13, 12, 14, 15, 13, 13, 13 1/2, 19, 16 1/2, 14	14.3
TNT	Bare	12, 13 1/2, 13, 14, 14, 13, 14, 16, 13, 15	13.8
"	Steel	14, 13, 14, 14, 14, 13, 14 1/2, 19 1/2, 19, 20	14.9
"	Al	17, 12, 14, 18, 11, 11, 18, 17 1/2, 12, 18 1/2	14.9
MOX-2B	Bare	10, 10 1/2, 10 1/2, 10 1/2, 13 1/2, 11, 12 1/2, 11 1/2, 12 1/2, 12	11.5
"	Steel	13 1/2, 14, 13 1/2, 16, 14, 14, 14 1/2, 15, 16 1/2, 16	14.7
"	Al	12, 13 1/2, 12 1/2, 11, 12, 13, 14 1/2, 14 1/2, 14, 12	12.8

5.2 Table II. Free-Air Foilmeter

Nominal HE wt.: 1.0 lb.

Range: Halifax

<u>HE</u>	<u>Case</u>	<u>Foilmeter Readings</u>	<u>Average</u>
Torpex-2	Bare	8, 9, 9, 9, 9, 9, 10, 8, 9, 9	8.8
"	Steel	8, 8, 8, 9, 9, 10, 9, 9, 9, 8	8.7
"	Al	8, 9, 9, 9, 9, 8, 9, 10, 9, 9	8.9
HBX-6	Bare	6, 8, 8, 8, 9, 9, 8, 8, 9	8.1
"	Steel	8, 9, 9, 8, 9, 9, 9, 9, 9	8.8

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<u>HE</u>	<u>Case</u>	<u>Foilmeter Readings</u>	<u>Average</u>
HBX-6	Al	8, 9, 7, 9, 9, 8, 7, 9, 7, 9	8.2
SSB/K5	Bare	7, 7, 7, 7, 8, 7, 8, 9, 9, 10	7.9
"	Steel	8, 10, 8, 9, 10, 8, 9, 9, 10, 10	9.1
"	Al	9, 9, 8, 8, 9, 9, 9, 9, 9, 9	8.8
HBX-1	Bare	8, 8, 4, 8, 9, 9, 9, 9, 9, 9	8.2
"	Steel	8, 8, 4, 8, 8, 8, 9, 9, 9, 8	7.9
"	Al	9, 7, 7, 9, 9, 8, 9, 10, 8, 9	8.5
PBX	Bare	6, 8, 9, 8, 7, 8, 9, 8, 9, 9	8.1
"	Steel	7, 6, 8, 8, 8, 8, 8, 8, 8, 9	7.8
"	Al	8, 7, 8, 7, 8, 7, 9, 9, 9, 8	8.0
TNT	Bare	7, 7, 8, 8, 7, 8, 8, 8, 7, 8	7.6
"	Steel	7, 6, 6, 6, 7, 6, 8, 8, 7, 7	6.8
"	Al	6, 7, 8, 7, 8, 8, 8, 8, 9, 8	7.7
MOX-2B	Bare	3, 1, 4, 3, 4, 4, 4, 6, 6, 8	4.3
"	Steel	6, 2, 5, 7, 4, 6, 7, 7, 5, 8	5.7
"	Al	5, 3, 5, 3, 4, 4, 4, 7, 5, 7	4.7

5.3 Table III. Free-Air Catenary

Nominal	HE wt.: 1.0 lb.	Range: Halifax	
<u>HE</u>	<u>Case</u>	<u>Catenary Readings (Δ PSI)</u>	<u>Average</u>
Torpex-2	Bare	22 1/2, 22 1/2, 25, 25, 27 1/2, 27 1/2, 25, --, 26, 24	25.0
"	Steel	22 1/2, 25, 22 1/2, 24, 27 1/2, 27 1/2, 25, --, 24, 24	24.7
"	Al	24, --, 24, 24, 27 1/2, 27 1/2, 25, --, 22 1/2, 24	24.8
HBX-6	Bare	22 1/2, 25, 25, 25, 25, 25, 25, 26, 22 1/2, 22 1/2	24.4
"	Steel	22 1/2, 25, 25, 25, 22 1/2, 25, 25, 25, 24, 22 1/2	24.2
"	Al	22 1/2, 25, 27 1/2, 25, 27 1/2, 25, 26, 25, 25, 24	25.3
SSB/K5	Bare	24, 22 1/2, 25, 24, 27 1/2, 25, 25, --, 25, 24	24.7
"	Steel	22 1/2, 22 1/2, 25, 25, 24, 25, 25, 24, 26, 22 1/2	24.2
"	Al	25, 22 1/2, 25, 25, 27 1/2, 25, 20, 25, 25, 25	24.5
HBX-1	Bare	--, --, 22 1/2, 24, 25, 24, 25, 22 1/2, 24, 22 1/2	23.7
"	Steel	22 1/2, --, 21, 25, 22 1/2, 25, 24, 25, --, --	23.6

<u>HE</u>	<u>Case</u>	<u>Catenary Readings (ΔPSI)</u>	<u>Average</u>
HBX-1	Al	22 1/2, --, 25, 22 1/2, 25, 25, 25, 25, 24, 24	24.4
FRX	Bare	22 1/2, 24, 20, 22 1/2, 22 1/2, 25, 25, 25, 22 1/2, 22 1/2	23.2
"	Steel	22 1/2, 22 1/2, 20, 20, 22 1/2, 25, 24, 24, 21, --	22.4
"	Al	--, 24, 20, 25, 25, 20, 25, 24, 23, 22 1/2	23.2
TNT	Bare	21, 21, 21, 22 1/2, 25, 22 1/2, 25, 20, 22 1/2, 22 1/2	22.9
"	Steel	21, 20, 22 1/2, 22 1/2, 20, 20 1/2, 24, 20, 20, 22 1/2	21.3
"	Al	22 1/2, 20, 21, 21, 24, 22 1/2, 22 1/2, 20, 24, 21	21.9
MOX-2B	Bare	16, 15, 15, --, 17 1/2, 17 1/2, 15, 15, 17, 17	16.1
"	Steel	16, 16, 16, 21, 15, 17 1/2, 17 1/2, 19, 17 1/2, 17 1/2	17.3
"	Al	15, 16, 16, 17 1/2, 12 1/2, 17 1/2, 17 1/2, 17 1/2, 16, 17 1/2	16.3

5.4 Table IV: Free-Air 5" NT-C

Nominal HE wt.: 1.0 lb.

Range: Halifax

<u>HE</u>	<u>Case</u>	<u>5" N T-C Readings</u>	<u>Average</u>
Torpex-2	Bare	7, 5, 5, 6, 6, 7, 9, 7, 7, 7	6.6
"	Steel	3, 2, 4, 3, 4, 4, 4, 4, 4, 5	3.7
"	Al	5, 3, 4, 5, 4, 5, 5, 3, 4, 7	4.5
HBX-6	Bare	6, 7, 5, 7, 7, 5, 6, 6, 8, 6	6.3
"	Steel	3, 3, 3, 3, 4, 4, 4, 4, 4, 4	3.6
"	Al	4, 5, 5, 6, 5, 4, 6, 5, 6, 6	5.2
SSB/K3	Bare	8, 6, 5, 5, 5, 5, 7, 6, 6, 7	6.0
"	Steel	3, 3, 4, 4, 4, 4, 4, 3, 3, 4	3.6
"	Al	6, 4, 5, 6, 6, 5, 5, 5, 6, 4	5.2
HBX-1	Bare	6, 5, 4, 5, 5, 7, 8, 5, 6, 6	5.7
"	Steel	3, 3, 3, 3, 3, 5, 4, 3, 4, 6	3.7
"	Al	3, 4, 5, 4, 4, 5, 5, 4, 7, 6	4.7
FRX	Bare	5, 4, 5, 5, 4, 4, 4, 6, 5, 5	4.7
"	Steel	4, 2, 3, 3, 3, 3, 3, 3, 5, 4	3.3
"	Al	3, 3, 4, 4, 3, 3, 4, 3, 4, 5	3.6
TNT	Bare	5, 4, 3, 5, 4, 4, 5, 6, 6, 5	4.7
"	Steel	2, 2, 3, 4, 2, 2, 3, 2, 3, 4	2.7
"	Al	2, 2, 6, 3, 2, 2, 4, 2, 4, 4	3.1
MOX-2B	Bare	3, 2, 2, 3, 4, 3, 3, 3, 3, 3	2.9
"	Steel	2, 2, 2, 2, 2, 2, 2, 3, 3, 4	2.4
"	Al	3, 2, 2, 2, 2, 3, 3, 3, 3, 3	2.6

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