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TECHNICAL REPORT 4587

THE SENSITIVITY, PERFORMANCE AND MATERIAL PROPERTIES OF SOME HIGH EXPLOSIVE FORMULATIONS

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SEPTEMBER 1973

PICATINNY ARSENAL
DOVER, NEW JERSEY

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Technical Report 4587

The Sensitivity, Performance, and Material Properties of Some High Explosive Formulations

by

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Sept 1973

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ABSTRACT

The work reported represents part of a continuing effort to determine the important characteristics of some explosives as they pertain to performance in ammunition.

Tests were conducted to determine the fragment velocity, blast pressure, detonation velocity, sensitivity to impact and friction, thermal stability, mechanical strength, and thermal expansion of each explosive. Tests were applied to TNT and TNT-based compositions including Composition B, Composition B-3, 75/25 Cyclotol, 70/30 Octol, 75/25 Octol, 80/20 Tritonal, H-6, HBX-3, HTA-3, and HTA-4; and plastic- or wax-bonded compositions including LX-04-1, PBX 9010, PBX Types A and B, PBX 9404, Comp A-3, PBXN-1, PBXN-3, 95/5 HMX/Kel F-800, Composition C-4, and 86/14 RDX/Wax.

INTRODUCTION

The object of the effort described in this report is the provision of a common basis for comparison of existing explosives and explosive formulations with respect to the properties of major interest for military application.

The particular studies reported here were initiated in September 1962 and terminated in 1967. Variations of experimental parameters negate direct comparison of much reported data; therefore, during the investigation, the utmost consideration was given to conducting tests on each explosive in an identical manner. Close control was exercised over every phase from selection of raw materials to close scrutiny of each test.

EXPERIMENTAL PROCEDURES

Tests conducted on explosive compositions except for fragment velocity, blast, and detonation velocity tests followed standard testing procedures. The modifications to the three aforementioned tests are outlined below.

Fragment Velocity

The fragment velocity test specimens consisted of an explosive charge machined to a barrel-shaped configuration (Figure 1) covered by a single layer of Permacel 32 plastic adhesive tape. A layer of 32-grain cubical steel fragments was bonded to the explosive charge with epoxy cement using additional epoxy cement to fill the interstices between fragments. Wooden caps were placed at each end of the test charge with the bottom end-cap serving to hold the charge erect in firing position while the top end-cap positioned the detonating fuze leading to the centrally located 1.75 gram tetryl booster (Figure 2). *

The charges were positioned four feet above ground level (Figure 3). Three equally spaced, curved wooden frames held 4 x 8 foot sheets of aluminum horizontal in arcs twenty feet from the test charge (Figure 4). The center of each panel was placed at the same

* 40-gram tetryl booster charges were used for complete detonation of TNT and 80/20 Tritonal.

height as the charge. Fifty feet behind each aluminum panel, a Fastex camera operating at 13 to 14 thousand frames per second recorded the detonation flash through a 2-inch diameter hole in the center of the panel. From the second flash of light caused by the impacting fragments on the aluminum panels, the average fragment velocity for 70 fragments could be calculated over the first twenty feet. Data was accumulated and analyzed in accordance with Reference 7.

Blast Test

Bare, barrel shaped test charges identical to those described in the fragment velocity test were used in the blast test. The values recorded for blast pressure and impulse are an average of five test firings. Twenty charges of Composition B were test fired to provide a standard for comparison. The procedure outlined in Reference 5 was developed during this investigation (see Figures 6 and 7).

Detonation Velocity

TNT-based explosives were prepared by cutting 1/2, 1, and 1 1/2 inch squares 6 inches long from deaerated castings. Two exceptions were TNT which was cast from a non-deaerated melt into molds 1, 1 1/2, and 2 inches in diameter and Tritional which was cut into 1, 1 1/2, and 2 inch squares from a non-deaerated melt.

Plastic bonded explosives were compressed into specimens 1/2 x 1/2 x 6 inches. Composition C-4 was frozen and machined to 1 x 1 x 6 and 1 1/2 x 1 1/2 x 6 inch configurations. Extreme care

was used in handling and measuring the thawed C-4 charges to prevent deformation. The exact length of each specimen was determined to the nearest ten thousandth of an inch and this length utilized in calculating the rate of detonation.

Ionization switches made of strips of one mil silver foil, separated by a sixteenth inch gap, were laid flat at each end of the specimen. A 2-inch booster segment of the same cross section as the 6-inch specimen was butted tightly against one end of the specimen. [Booster segments for castable compositions were cut from the same cast melt.] A 1 E 15 electric detonator was used to initiate the booster segment which in turn detonated the 6-inch specimen. A tetryl pellet 1 inch diameter x 1 inch high weighing 20.5 grams was placed between the detonator and booster segments for the TNT and Tritional tests. A 2.59 gram Tetryl pellet 1/2 inch diameter x 1/2 inch high was used for HBX-3.

An oscilloscope (Model 101 Raster System manufactured by the Denver Research Institute) having a trace electronically graduated at .05 microseconds displayed the time interval between pulses generated by the ionization switches. A photographic record of the oscilloscope trace was examined in a Vanguard Motion Analyzer and the location of the current pips mechanically interpolated to give readings to 0.001 microseconds.

P.A. Impact - Reference 1.

Vacuum Stability - Reference 1.

Explosion Temperature - Reference 1.

Friction Pendulum - Reference 2.

Autoignition Temperature - Reference 4.

Setback Pressure Sensitivity - Reference 3.

Tensile, Compression, Shear, and Torsional Shear Tests

The procedures utilized to determine the mechanical strength of the explosive samples were the same as those outlined in the ASTM Std. for plastic materials. The configuration of the test charges was altered to fit the test apparatus.

a. Tensile Test - A dumbbell-shaped specimen having a minor diameter of 0.5 inches was used for this test. The cross head speed of the Tinius Olsen Universal Test Apparatus was set at 0.5 in./sec.

b. Compression Test - A cylindrical specimen 2 inches high with a diameter of 1 inch was formed for this test. The cross head speed of the Baldwin Universal Tester was set at 0.5 in./min.

c. Torsional Shear - The specimen was stressed at a rate of 36°/min on the Tinius Olsen Torsion Tester.

Thermal Expansion Test

The thermal expansion of the explosive specimens was determined utilizing ASTM procedures for plastic materials (Figure 8).

MATERIALS

Comp A-3	WAB-13-411, WAB-1-158
Composition B	Lot HOL 7-1879, HOL 7-1928
Composition B-3	Lot HOL 11-92, HOL 37-3, HOL 37-7
Comp C-4	WAB-12-4
75/25 Cyclotol	Lot HOL 6-62
H-6	EEC Batch 2613
HBX-3	EEC Batch 2612
95/5 HMX/Kel F-800	EEC Batch 1-21
HTA-3	EEC Batch 1581
HTA-4	EEC Batch 2604
LX-04-1	HOL SR-396-62 Blend 491-4-2
70/30 Octol	Lot HOL SR-146-61, HOL SR-1-58
PBX, Type A	HOL SR-10-56 Batch 86-67-5
PBX, Type B	HOL SR-46-57 Batch 59-8
PBXN-1	HOL SR-338-59
PBXN-3	HOL SR 45-63 Batch 86-611-1A
PBX 9404	HOL SR-139-59, HOL SR-511-61, HOL SR-135-61
PBX 9010	HOL SR-490-61 Blend 126, HOL SR-36-62 Blend 120
86/14 RDX/Wax	HOL 54-61 Batch 354-3
TNT	Lot KNK 12-638, Lot KNK 11-369

Composition A-3

Composition: RDX 91%, Wax 9%

Density: 1.64 to 1.65 g/cc Theoretical Max 1.669 g/cc

Sample Molding Temperature: 25°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	15
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	-	-	
Unaffected	100	5	

Explosion Temperature: 281°C Autoignition Temperature: 215°C

Vacuum Stability Test:

Temperature °C		100	120	130	140	150	160
ML. gas from 5 gm sample	40 hrs	0.34	0.44	0.59	0.75	5.99	11^{4}
	8 hrs	-	-	-	-	-	1.26

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	86800
50%	113800
99.9%	149200

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5363	5352	5358
Initial Velocity, ft/sec.:			5699

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.64	8486	8466	8473
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2750 gms

Distance from Charge:	10 ft	15 ft.	20 ft.
Overpressure, psi:	31	12.0	7.9
Impulse, psi - milliseconds:	22	12.6	9.1

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	4182	2935	537	145	85
Compression at Rupture, %:	0.30	0.81	0.26	0.21	0.16
Mod. of Elasticity, psi x 10^{-3}:	1358	1141	590	156	68
Work to Prod. Rupture, ft-lb/in^3:	.78	1.52	.072	.013	.006

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	291	321	164	50	26
Elongation at Rupture, %:	.018	.041	.041	.021	.014
Mod. of Elasticity, psi x 10^{-3}:	1996	1206	731	330	230
Work to Prod. Rupture, ft-lb/in^3:	.002	.006	.004	.0005	.0001

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	680	901	298	93	92

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.38	1.37	1.27	1.27	1.22
Izod. inch-pounds:	-	-	1.06	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	197
Mod. of Elasticity, psi:	95000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	6.72	7.17	7.99	8.49

Composition B

Composition: RDX 59.5%, TNT 39.5%, Wax 1%

Density: 1.71 to 1.72 g/cc Theoretical Max 1.728 g/cc

Sample Casting Temperature: 180°F

Impact Sensitivity:

B. M. Apparatus, in.	12
P. A. Apparatus, in.	20
Sample Weight, mgs.	

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	20	1	
Burned	-	-	
Unaffected	80	4	

Explosion Temperature: 272°C **Autoignition Temperature:** 194°C

Vacuum Stability Test:

Temperature °C		100	120	130	140
ML. gas from 5 gm sample	40 hrs	0.17	1.39	4.27	11+
	8 hrs	-	-	-	3.47

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	85000
50%	117000
99.9%	161000

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5360	5346	5353
Initial Velocity, ft/sec.:	-	-	5690

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.72	7905	7902	7903
1.0" x 1.0" x 6"	1.72	7945	7910	7930
1.5" x 1.5" x 6"	1.72	7942	7922	7929
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2862 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	34.1	12.9	6.8
Impulse, psi - milliseconds:	18.3	12.6	8.6

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	2190	1764	1759	1013	528
Compression at Rupture, %:	0.31	0.35	0.24	0.06	-
Mod. of Elasticity, psi x 10^{-3}:	734	673	1180	2580	-
Work to Prod. Rupture, ft-lb/in^3:	0.28	0.30	0.24	0.03	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	95	142	208	102	40
Elongation at Rupture, %:	.008	.011	.015	.007	.007
Mod. of Elasticity, psi x 10^{-3}:	1580	1540	1696	2408	1426
Work to Prod. Rupture, ft-lb/in^3:	.0004	.007	.001	.0004	.0002

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	745	527	637	543	414

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.43	1.50	1.57	1.48	1.47
Izod. inch-pounds:	-	-	1.01	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	177
Mod. of Elasticity, psi:	102000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	4.82	5.61	7.81	9.47

Composition B-3

Composition: RDX 59.5%, TNT 40.5%

Density: 1.73 g/cc Theoretical Max 1.743 g/cc

Sample Casting Temperature: 183°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	14
Sample Weight, mgs.	20

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	60	3	
Burned	-	-	
Unaffected	40	2	

Explosion Temperature: 271°C Autoignition Temperature: 199°C

Vacuum Stability Test:

Temperature °C		120	130	140
ML. gas from 5 gm sample	40 hrs	0.84	207	11^{+}
	8 hrs	-	-	1.66

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	55000
50%	104000
99.9%	197000

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5397	5467	5432
Initial Velocity, ft/sec.:	-	-	5778

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.72	7851	7813	7831
1.0" x 1.0" x 6"	1.72	7945	7881	7916
1.5" x 1.5" x 6"	1.72	7955	7923	7930
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2892 gms

Distance from Charge:	10 ft	15 ft.	20 ft.
Overpressure, psi:	32.6	12.3	8.0
Impulse, psi - milliseconds:	21.8	11.5	10.4

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	3005	3437	1670	1154	685
Compression at Rupture, %:	0.24	0.27	0.21	0.20	-
Mod. of Elasticity, psi x 10^{-3}:	1271	1379	1258	831	-
Work to Prod. Rupture, ft-lb/in^3:	0.31	0.43	0.19	0.12	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	55	145	109	82	56
Elongation at Rupture, %:	.018	.014	.007	.012	.015
Mod. of Elasticity, psi x 10^{-3}:	478	1458	2141	938	693
Work to Prod. Rupture, ft-lb/in^3:	.0006	.0008	.0004	.0005	.0004

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	1186	1249	902	673	460

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.61	1.68	1.52	1.45	1.62
Izod. inch-pounds:	-	-	1.00	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	153
Mod. of Elasticity, psi:	125000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	6.04	6.62	8.93	10.39

Composition C-4

Composition: RDX 91%, Di(2-ethylbenzl) sebacate 5.3%, polyisobutylene 2.1%, motor oil 1.6%

Density: 1.64 to 1.66 g/cc Theoretical Max 1.67 g/cc

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	17
Sample Weight, mgs.	24

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	40	2	
Unaffected	60	3	

Explosion Temperature: 263°C **Autoignition Temperature:** 215°C

Vacuum Stability Test:

Temperature °C		120	130	140	150	160
ML. gas from 5 gm sample	40 hrs	0.37	0.34	0.59	1.66	11+
	8 hrs	-	-	-	0.55	2.15

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	38400
50%	111200
99.9%	324500

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5467	5490	5479
Initial Velocity, ft/sec.:	-	-	5829

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	-	-	-	-
1.0" x 1.0" x 6"	1.64	8355	8338	8337
1.5" x 1.5" x 6"	1.66	8388	8330	8368
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2729 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	33.4	12.4	7.1
Impulse, psi - milliseconds:	21.5	11.6	7.9

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:
Stress at Rupture, psi:
Compression at Rupture, %:
Mod. of Elasticity, psi x 10^{-3}:
Work to Prod. Rupture, ft-lb/in^3:

Tensile Strength - Load Rate .05 in/min

Temperature °F:
Stress at Rupture, psi:
Elongation at Rupture, %:
Mod. of Elasticity, psi x 10^{-3}:
Work to Prod. Rupture, ft-lb/in^3:

Shear Strength -

Temperature °F
Stress at Rupture, psi:

Impact Strength -

Temperature °F
Charpy, inch-pounds:
Izod. inch-pounds:

Torsional Shear - Load Rate 36°/min

Temperature °F
Stress at Rupture, psi:
Mod. of Elasticity, psi:

Linear Coefficient of Thermal Expansion:

Temperature Range °C
Coefficient, in % x 10^{-3}/°C:

75/25 Cyclotol

Composition: RDX 75%, TNT 25%

Density: 1.74 to 1.76 g/cc Theoretical Max 1.768 g/cc

Sample Casting Temperature: 185°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	15
Sample Weight, mgs.	17

Friction Pendulum Test:

Steel Shoe	Crackled
Fiber Shoe	NA

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	60	3	
Burned	-	-	
Unaffected	40	2	

Explosion Temperature: 276°C Autoignition Temperature: 197°C

Vacuum Stability Test:

Temperature °C		120	130	140
ML. gas from 5 gm sample	40 hrs	1.12	3.02	11+
	8 hrs	-	-	1.97

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	80000
50%	122000
99.9%	186000

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5722	5686	5704
Initial Velocity, ft/sec.:	-	-	6067

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.76	8157	8127	8138
1.0" x 1.0" x 6"	1.76	8220	8196	8213
1.5" x 1.5" x 6"	1.74	8223	8173	8197
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2923 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	32.7	16.1	7.1
Impulse, psi - milliseconds:	19.0	14.5	9.6

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	1619	1994	1678	1164	584
Compression at Rupture, %:	.233	.224	.122	.135	-
Mod. of Elasticity, psi x 10^{-3}:	731	891	3039	1252	-
Work to Prod. Rupture, ft-lb/in^3:	.159	.185	.112	.085	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	98	119	225	159	60
Elongation at Rupture, %:	.011	.014	.114	.013	.013
Mod. of Elasticity, psi x 10^{-3}:	1021	1011	275	1466	846
Work to Prod. Rupture, ft-lb/in^3:	.0005	.0007	.012	.0013	.0004

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	519	721	628	550	383

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.50	1.47	1.59	1.55	1.42
Izod. inch-pounds:	-	-	.98	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	95
Mod. of Elasticity, psi:	56700

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	3.71	4.28	6.76	8.05

Composition: RDX 44%, TNT 29.5%, Aluminum 21%, D-2 Desensitizer 5%, Calcium Chloride .5%

Density: 1.75 to 1.76 g/cc Theoretical Max 1.791 g/cc

Sample Casting Temperature: 183°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	13
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	20	1	
Unaffected	80	4	

Explosion Temperature: 273°C Autoignition Temperature: 200°C

Vacuum Stability Test:

Temperature °C		120	130
ML. gas from 5 gm sample	40 hrs	2.66	11+
	8 hrs	-	2.40

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	87300
50%	105300
99.9%	127800

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5116	5116	5116
Initial Velocity, ft/sec.:	-	-	5442

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	-	-	-	-
1.0" x 1.0" x 6"	1.76	7267	7238	7249
1.5" x 1.5" x 6"	1.76	7370	7358	7364
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2939 gms			
Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	37.0	13.2	7.2
Impulse, psi - milliseconds:	24.1	13.4	9.1

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	4522	3687	3619	2198	860
Compression at Rupture, %:	0.65	0.61	0.37	0.31	-
Mod. of Elasticity, psi x 10^{-3}:	851	805	1580	1733	-
Work to Prod. Rupture, ft-lb/in^3:	1.37	1.11	0.70	0.42	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	196	358	382	372	149
Elongation at Rupture, %:	0.022	0.032	0.022	0.028	-
Mod. of Elasticity, psi x 10^{-3}:	943	1207	1786	1433	-
Work to Prod. Rupture, ft-lb/in^3:	.002	.005	.003	.005	-

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	906	1002	870	796	624

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.40	1.48	1.48	1.30	1.38
Izod, inch-pounds:	-	-	1.29	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F .	73
Stress at Rupture, psi:	170
Mod. of Elasticity, psi:	130000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	4.14	4.80	6.28	6.91

HBX-3

Composition: RDX 31%, TNT 28.5%, Aluminum 35%, Calcium Chloride .5%, D Desensitizer 5%

Density: 1.84 to 1.85 g/cc Theoretical Max 1.882 g/cc

Sample Casting Temperature: 183°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	12
Sample Weight, mgs.	21

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	-	-	
Unaffected	100	5	

Explosion Temperature: 243°C Autoignition Temperature: 200°C

Vacuum Stability Test:

Temperature °C		120	130	140
ML. gas from 5 gm sample	40 hrs	2.37	7.09	11+
	8 hrs	-	-	6.98

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	96200
50%	128000
99.9%	170200

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	4517	4476	4496
Initial Velocity, ft/sec.:	-	-	4772

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.83	6924	6847	6886
1.0" x 1.0" x 6"	1.84	7132	7109	7123
1.5" x 1.5" x 6"	1.84	7151	7145	7149
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3098 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	34.4	13.8	7.3
Impulse, psi - milliseconds:	20.4	15.5	10.9

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	4765	4291	4180	2694	1143
Compression at Rupture, %:	0.66	0.56	0.36	0.32	-
Mod. of Elasticity, psi x 10^{-3}:	1096	1226	2128	2017	-
Work to Prod. Rupture, ft-lb/in^3:	1.67	1.27	0.78	0.52	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	323	388	404	402	161
Elongation at Rupture, %:	0.025	0.029	0.019	0.026	0.024
Mod. of Elasticity, psi x 10^{-3}:	1329	1407	2105	1750	1048
Work to Prod. Rupture, ft-lb/in^3:	.004	.005	.003	.005	.002

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	911	1207	1116	1048	888

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.45	1.43	1.42	1.42	1.43
Izod, inch-pounds:	-	-	1.43	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	209
Mod. of Elasticity, psi:	145000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	4.03	4.57	6.46	8.19

95/5 HMX/Kel F-800

Composition: HMX Grade II, Class A 95%, Kel F-800 5%

Density: Molded Density 1.87 g/cc Theoretical Max 1.906 g/cc

Sample Molding Temperature: 110°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	9
Sample Weight, mgs.	18

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	100	5	5
Partials	-	-	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature:

Autoignition Temperature: 254°C

Vacuum Stability Test:

Temperature °C		100	120	130	140
ML. gas from 5 gm sample	40 hrs	0.32	0.47	0.65	1.27
	8 hrs	-	-	-	-

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	110400
50%	135600
99.9%	166500

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	6085	6080	6083
Initial Velocity, ft/sec.:	-	-	6469

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.88	8896	8893	8895
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3130 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	39.5	14.0	7.2
Impulse, psi - milliseconds:	19.2	12.7	9.1

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	5924	6051	4095	2219	1528
Compression at Rupture, %:	0.70	0.70	1.48	1.10	0.97
Mod. of Elasticity, psi x 10^{-3}:	947	1139	909	677	510
Work to Prod. Rupture, ft-lb/in^3:	1.84	2.06	3.80	1.36	0.769

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	355	434	613	472	300
Elongation at Rupture, %:	.037	.042	.065	.066	.060
Mod. of Elasticity, psi x 10^{-3}:	1295	1176	1126	950	715
Work to Prod. Rupture, ft-lb/in^3:	.008	.008	.018	.021	.010

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	1195	2087	1240	1709	946

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.50	1.73	1.62	1.58	1.60
Izod, inch-pounds:	-	-	1.42	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	426
Mod of Elasticity, psi:	280000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	3.34	2.83	4.60	6.12

HTA-3

Composition: HMX 49%, TNT 29%, Aluminum 22%

Density: 1.93 to 1.94 g/cc Theoretical Max 1.943 g/cc

Sample Casting Temperature: 185°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	17
Sample Weight, mgs.	21

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	40	2	
Burned	-	-	
Unaffected	60	3	

Explosion Temperature: 291°C Autoignition Temperature: 229°C

Vacuum Stability Test:

Temperature °C		120	130	140	150
ML. gas from 5 gm sample	40 hrs	0.47	0.87	2.03	11+
	8 hrs	-	-	-	1.34

Sensitivity of [illegible]ve to Set Back Pressure (psi) at 160°F:

Probability	Pressure
0	104800
50.	114100
99.9%	124800

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5539	5557	5548
Initial Velocity, ft/sec.:	-	-	5902

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.93	7743	7673	7720
1.0" x 1.0" x 6"	1.94	7922	7854	7893
1.5" x 1.5" x 6"	1.91	7808	7791	7799
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3211 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	39.2	14.7	7.9
Impulse, psi - milliseconds:	20.5	14.4	9.8

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	2251	2349	2293	1665	1180
Compression at Rupture, %:	0.33	0.32	0.15	0.34	1.20
Mod. of Elasticity, psi x 10^{-3}:	833	933	1796	999	1586
Work to Prod. Rupture, ft-lb/in^3:	0.36	0.37	0.31	0.32	0.68

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	126	168	269	201	121
Elongation at Rupture, %:	.009	.017	0.16	.023	.015
Mod. of Elasticity, psi x 10^{-3}:	1370	1188	1752	1013	1201
Work to Prod. Rupture, ft-lb/in^3:	.001	.001	.002	.002	.005

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	1008	796	1008	869	653

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.55	1.44	1.58	1.66	1.50
Izod. inch-pounds:	-	-	1.33	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	219
Mod. of Elasticity, psi:	226000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	2.61	3.60	5.48	5.48

HTA-4

Composition: HMX 38%, Aluminum 32%, TNT 30%

Density: 1.99 to 2.00 g/cc Theoretical Max 2.009 g/cc

Sample Casting Temperature: 185°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	13
Sample Weight, mgs.	22

Friction Pendulum Test:

Steel Shoe	N.A.
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	20	1	5
Partials	40	2	
Burned	-	-	
Unaffected	40	2	

Explosion Temperature: 302°C Autoignition Temperature: 228°C

Vacuum Stability Test:

Temperature °C		120	130	140	150
ML. gas from 5 gm sample	40 hrs	1.19	2.38	7.03	11+
	8 hrs	-	-	-	5.52

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	90200
50%	120100
99.9%	160300

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	4997	4979	4988
Initial Velocity, ft/sec.:	-	-	5307

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	2.00	7497	7490	7494
1.0" x 1.0" x 6"	2.00	7632	7659	7640
1.5" x 1.5" x 6"	2.00	7659	7607	7633
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3311 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	39.2	13.6	7.6
Impulse, psi - milliseconds:	21.3	13.3	9.9

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	2901	3214	3417	2415	1186
Compression at Rupture, %:	0.37	0.36	0.29	0.36	0.11
Mod. of Elasticity, psi x 10^{-3}:	1047	1240	1878	1197	1566
Work to Prod. Rupture, ft-lb/in^3:	0.51	0.58	0.54	0.49	0.07

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	158	177	318	253	69
Elongation at Rupture, %:	.019	.017	.017	.029	.027
Mod. of Elasticity, psi x 10^{-3}:	960	1088	1821	1289	634
Work to Prod. Rupture, ft-lb/in^3:	.0012	.0012	.0021	.0034	.0009

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	1135	1198	1142	1180	607

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.45	1.53	1.57	1.50	1.55
Izod. inch-pounds:	-	-	1.45	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	155
Mod. of Elasticity, psi:	161000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	2.94	3.74	7.20	8.37

LX-04-1

Composition: HMX 85%, Viton A 15%

Density: Molded Density 1.86 to 1.88 g/cc Theoretical Max 1.892 g/cc

Sample Molding Temperature: 120°C

Impact Sensitivity:

B. M. Apparatus, in.
P. A. Apparatus, in. 9
Sample Weight, mgs. 30

Friction Pendulum Test:

Steel Shoe NA
Fiber Shoe

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	100	5	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 337°C Autoignition Temperature: 255°C

Vacuum Stability Test:

Temperature °C		100	120	130	140	150	160	170
ML. gas from 5 gm sample	40 hrs	0.19	0.19	0.27	0.45	0.97	5.50	11+
	8 hrs	-	-	-	-	-	-	1.09

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	131000
50%	144200
99.9%	158900

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5699	5693	5696
Initial Velocity, ft/sec.:	-	-	6059

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.87	8551	8523	8537
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3133 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	34.2	12.9	6.7
Impulse, psi - milliseconds:	20.5	12.1	7.6

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	11399	7969	1044	717	565
Compression at Rupture, %:	2.41	2.37	0.92	1.01	1.10
Mod. of Elasticity, psi x 10^{-3}:	1672	1333	282	123	61.6
Work to Prod. Rupture, ft-lb/in^3:	18.2	13.0	0.48	0.31	0.25

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	1450	1274	436	288	227
Elongation at Rupture, %:	0.11	0.26	0.36	0.19	0.22
Mod. of Elasticity, psi x 10^{-3}:	1526	837	374	308	170
Work to Prod. Rupture, ft-lb/in^3:	.072	0.17	0.11	.025	.022

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	3542	2861	764	370	286

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	2.80	2.85	3.32	4.63	6.32
Izod, inch-pounds:	-	-	2.00	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	498
Mod. of Elasticity, psi:	55400

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	5.54	7.27	7.06	6.20

75/25 Octol

Composition: HMX 75%, TNT 25%

Density: 1.81 g/cc Theoretical Max 1.832 g/cc

Sample Casting Temperature: 185°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	15
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	60	3	
Burned	-	-	
Unaffected	40	2	

Explosion Temperature: 288°C Autoignition Temperature: 212°C

Vacuum Stability Test:

Temperature °C		120	130	140	150
ML. gas from 5 gm sample	40 hrs	0.65	1.13	2.66	11^{+}
	8 hrs	-	-	-	2.19

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	95000
50%	119000
99.9%	149000

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5766	5813	5790
Initial Velocity, ft/sec.:	-	-	6159

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.82	8355	8303	8328
1.0" x 1.0" x 6"	1.82	8399	8393	8396
1.5" x 1.5" x 6"	1.81	8390	8351	8364
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3022 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	37.4	13.1	7.1
Impulse, psi - milliseconds:	18.1	12.5	9.1

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	1182	1169	1509	1022	635
Compression at Rupture, %:	0.21	0.23	0.20	0.26	0.23
Mod. of Elasticity, psi x 10^{-3}:	720	492	1344	892	526
Work to Prod. Rupture, ft-lb/in^3:	0.11	0.14	0.14	0.16	0.15

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	88	81	146	113	120
Elongation at Rupture, %:	.019	.014	.010	.015	.018
Mod. of Elasticity, psi x 10^{-3}:	445	678	1565	1548	1102
Work to Prod. Rupture, ft-lb/in^3:	.0007	.0005	.0006	.0008	.001

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	599	529	769	640	498

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.80	1.88	1.81	1.76	1.81
Izod. inch-pounds:	-	-	1.27	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	113
Mod. of Elasticity, psi:	101000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	1.73	3.38	7.02	7.13

70/30 Octol

Composition: HMX 70%, TNT 30%

Density: 1.80 to 1.81 g/cc Theoretical Max 1.819 g/cc

Sample Casting Temperature: 180°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	19
Sample Weight, mgs.	20

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	100	5	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 289°C Autoignition Temperature: 227°C

Vacuum Stability Test:

Temperature °C		120	130	140	150	160
ML. gas from 5 gm sample	40 hrs	0.76	0.97	1.50	5.10	11+
	8 hrs	-	-	-	1.01	3.86

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	80000
50%	119000
99.9%	176000

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5761	5783	5772
Initial Velocity, ft/sec.:	-	-	6139

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.80	8252	8230	8241
1.0" x 1.0" x 6"	1.80	8338	8274	8305
1.5" x 1.5" x 6"	1.80	8319	8300	8310
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3022 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	37.9	14.6	6.7
Impulse, psi - milliseconds:	21.2	15.5	11.2

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:
Stress at Rupture, psi:
Compression at Rupture, %:
Mod. of Elasticity, psi x 10^{-3}:
Work to Prod. Rupture, ft-lb/in^3:

Tensile Strength - Load Rate .05 in/min

Temperature °F:
Stress at Rupture, psi:
Elongation at Rupture, %:
Mod. of Elasticity, psi x 10^{-3}:
Work to Prod. Rupture, ft-lb/in^3:

Shear Strength -

Temperature °F
Stress at Rupture, psi:

Impact Strength -

Temperature °F
Charpy, inch-pounds:
Izod. inch-pounds:

Torsional Shear - Load Rate 36°/min

Temperature °F
Stress at Rupture, psi:
Mod. of Elasticity, psi:

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	2.59	2.75	7.38	8.05

PBX, Type A

Composition: RDX 90%, Polystyrene 8.5%, Dioctylphthalate 1.5%

Density: Molded Density 1.67 to 1.68 g/cc Theoretical Max 1.687 g/cc

Sample Molding Temperature: 98°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	13
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	60	3	5
Partials	40	2	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 266°C

Autoignition Temperature: 209°C

Vacuum Stability Test:

Temperature °C		100	120	130	140	150	160
ML. gas from 5 gm sample	40 hrs	0.15	0.29	0.69	2.51	3.04	11+
	8 hrs	-	-	-	-	-	3.53

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	59800
50%	120700
99.9%	243300

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5372	5488	5430
Initial Velocity, ft/sec.:	-	-	5775

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.67	8225	8215	8220
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2807 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	33.2	12.9	6.3
Impulse, psi - milliseconds:	19.6	12.2	7.1

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	11291	10513	7301	2886	870
Compression at Rupture, %:	0.92	0.91	2.10	2.01	1.12
Mod. of Elasticity, psi x 10^{-3}:	1700	1839	1381	627	131
Work to Prod. Rupture, ft-lb/in^3:	5.34	5.22	10.4	3.80	0.48

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	779	770	627	700	304
Elongation at Rupture, %:	.007	.053	.035	0.14	0.22
Mod. of Elasticity, psi x 10^{-3}:	1852	2001	2065	743	266
Work to Prod. Rupture, ft-lb/in^3:	.030	.018	.009	.049	.028

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	2360	3305	2781	2196	1055

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.43	1.52	1.35	1.38	1.95
Izod. inch-pounds:	-	-	1.50	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	624
Mod. of Elasticity, psi:	215000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	5.90	6.59	7.71	8.56

PBX, Type B

Composition: RDX 89.9%, Gum Rosin 4.4%, Polystyrene and Dye 5.7%

Density: Molded Density 1.67 to 1.68 g/cc Theoretical Max 1.690 g/cc

Sample Molding Temperature: 100°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	16
Sample Weight, mgs.	21

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	100	5	5
Partials	-	-	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 269°C

Autoignition Temperature: 207°C

Vacuum Stability Test:

Temperature °C		100	120	130	140
ML. gas from 5 gm sample	40 hrs	0.26	0.59	1.29	11+
	8 hrs	-	-	-	2.39

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	78000
50%	115200
99.9%	170200

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5360	5357	5359
Initial Velocity, ft/sec.:	-	-	5700

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec) High	Low	Ave.
0.5" x 0.5" x 6"	1.68	8210	8200	8205
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2778 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	31.9	11.9	7.9
Impulse, psi - milliseconds:	19.8	12.2	9.5

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	11189	11546	10065	7903	4755
Compression at Rupture, %:	0.85	0.94	1.29	1.93	1.73
Mod. of Elasticity, psi x 10^{-3}:	1554	1655	1567	1457	883
Work to Prod. Rupture, ft-lb/in^3:	4.35	5.52	7.69	10.18	5.45

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	744	729	866	757	642
Elongation at Rupture, %:	.056	.047	.047	.045	.038
Mod. of Elasticity, psi x 10^{-3}:	1507	1941	2004	1842	1936
Work to Prod. Rupture, ft-lb/in^3:	.019	.016	.018	.013	.011

Shear Strength -

Temperature °F	-30	-40	73	125	160
Stress at Rupture, psi:	3224	3251	3268	2902	2604

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.50	1.46	1.45	1.42	1.44
Izod, inch-pounds:	-	-	1.27	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	604
Mod. of Elasticity, psi:	284000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C.	5.41	5.88	6.56	8.63

PBXN-1

Composition: RDX 69%, Aluminum 20%, Zytel 63 12%

Density: Molded Density 1.77 to 1.78 g/cc Theoretical Max 1.796 g/cc

Sample Molding Temperature: 120°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	16
Sample Weight, mgs.	31

Friction Pendulum Test:

Steel Shoe NA
Fiber Shoe

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	100	5	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 285°C Autoignition Temperature: 191°C

Vacuum Stability Test:

Temperature °C		100	120	130
ML. gas from 5 gm sample	40 hrs	0.71	7.82	11+
	8 hrs	-	-	11+

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	130800
50%	142100
99.9%	154500

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	4750	4756	4753
Initial Velocity, ft/sec.:	-	-	5056

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.78	7977	7962	7970
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2968 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	28.9	12.9	6.8
Impulse, psi - milliseconds:	21.8	12.2	8.2

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	15883	14826	12457	9195	6767
Compression at Rupture, %:	1.73	1.67	2.10	3.67	2.74
Mod. of Elasticity, psi x 10^{-3}:	1554	1541	1511	1130	934
Work to Prod. Rupture, ft-lb/in^3:	14.4	13.6	16.4	23.0	12.6

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	873	813	1230	1087	981
Elongation at Rupture, %:	.049	.047	.067	.084	.074
Mod. of Elasticity, psi x 10^{-3}:	1816	1523	1913	1371	1356
Work to Prod. Rupture, ft-lb/in^3:	.019	.014	.035	.048	.031

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	4397	4992	4373	3833	3245

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.88	2.28	2.10	2.13	2.62
Izod. inch-pounds:	-	-	2.42	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	1082
Mod. of Elasticity, psi:	282000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	5.05	5.95	7.16	8.16

PBXN-3

Composition: HMX 85%, Zytel 63 15%

Density: Molded Density 1.70-1.71 g/cc Theoretical Max 1.731 g/cc

Sample Molding Temperature: 120°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	17
Sample Weight, mgs.	31

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	40	2	5
Partials	40	2	
Burned	20	1	
Unaffected	-	-	

Explosion Temperature: 337°C Autoignition Temperature: 212°C

Vacuum Stability Test:

Temperature °C		100	120	130	140
ML. gas from 5 gm sample	40 hrs	0.30	2.97	6.91	11+
	8 hrs	—	—	—	5.90

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	92300
50%	147800
99.9%	236700

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5335	5435	5385
Initial Velocity, ft/sec.:	-	-	5728

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.71	8463	8438	8447
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2821 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	28.7	11.8	7.8
Impulse, psi - milliseconds:	22.0	13.2	8.6

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	11189	11546	10065	7903	4755
Compression at Rupture, %:	0.85	0.94	1.29	1.93	1.73
Mod. of Elasticity, psi x 10^{-3}:	1554	1655	1567	1457	883
Work to Prod. Rupture, ft-lb/in^3:	4.35	5.52	7.69	10.18	5.45

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	744	729	866	757	642
Elongation at Rupture, %:	.056	.047	.047	.045	.038
Mod. of Elasticity, psi x 10^{-3}:	1507	1941	2004	1842	1936
Work to Prod. Rupture, ft-lb/in^3:	.019	.016	.018	.013	.011

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	3224	3251	3268	2902	2604

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.50	1.46	1.45	1.42	1.44
Izod. inch-pounds:	-	-	1.27	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	604
Mod. of Elasticity, psi:	284000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	5.26	5.97	7.05	7.88

PBX 9404

Composition: HMX 94%, Tris Beta Chloroethyl phosphate 3%, Nitrocellulose 2.9%, Diphenylamine .1%

Density: Molded Density 1.83 to 1.85 g/cc Theoretical Max 1.870 g/cc

Sample Molding Temperature: 75°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	17
Sample Weight, mgs.	34

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	100	5	5
Partials	-	-	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 309°C

Autoignition Temperature: 230°C

Vacuum Stability Test:

Temperature °C		100	120	130
ML. gas from 5 gm sample	40 hrs	1.33	8.02	11^+
	8 hrs	-	-	11^+

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	102500
50%	143300
99.9%	200500

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	6020	6037	6031
Initial Velocity, ft/sec.:	-	-	6415

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.85	8825	8820	8823
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 3102 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	39.1	13.9	7.1
Impulse, psi - milliseconds:	19.1	12.2	8.9

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	8603	8466	2448	1480	1010
Compression at Rupture, %:	0.58	0.77	1.53	0.95	0.69
Mod. of Elasticity, psi x 10^{-3}:	1864	1781	760	325	340
Work to Prod. Rupture, ft-lb/in^3:	2.11	3.47	2.69	0.71	0.31

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	328	620	636	326	119
Elongation at Rupture, %:	.024	.036	.010	.012	.091
Mod. of Elasticity, psi x 10^{-3}:	2439	1960	942	478	506
Work to Prod. Rupture, ft-lb/in^3:	.005	.010	.032	.019	.008

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	2553	2410	1399	1028	795

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.54	1.59	1.60	1.52	1.56
Izod. inch-pounds:	-	-	1.31	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	533
Mod. of Elasticity, psi:	148000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	4.38	4.38	4.38	4.38

PBX 9010

Composition: RDX 90%, Kel F Elastomer 10%

Density: Molded Density 1.78 to 1.80 g/cc Theoretical Max 1.814 g/cc

Sample Molding Temperature: 120°C

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	9
Sample Weight, mgs.	31

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	60	3	5
Partials	40	2	
Burned	-	-	
Unaffected	-	-	

Explosion Temperature: 295°C Autoignition Temperature: 210°C

Vacuum Stability Test:

Temperature °C		100	120	130	140	150
ML. gas from 5 gm sample	40 hrs	0.28	0.92	2.09	4.65	11+
	8 hrs	-	-	-	-	1.66

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	94100
50%	128300
99.9%	174800

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5667	5688	5678
Initial Velocity, ft/sec.:	-	-	6039

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.79	8382	8365	8374
1.0" x 1.0" x 6"	-	-	-	-
1.5" x 1.5" x 6"	-	-	-	-
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2992 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	32.6	16.0	8.2
Impulse, psi - milliseconds:	19.6	14.9	10.3

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	9230	8374	1360	746	599
Compression at Rupture, %:	0.79	0.96	0.80	0.67	0.67
Mod. of Elasticity, psi x 10^{-3}:	1668	1490	505	444	433
Work to Prod. Rupture, ft-lb/in^3:	3.77	4.77	0.59	0.30	0.25

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	687	741	387	241	232
Elongation at Rupture, %:	.041	.057	0.158	.088	.093
Mod. of Elasticity, psi x 10^{-3}:	2080	1532	962	552	541
Work to Prod. Rupture, ft-lb/in^3:	.013	.019	.039	.012	.011

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	2182	2105	858	574	417

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.52	1.52	1.58	1.67	1.72
Izod. inch-pounds:	-	-	1.26	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	564
Mod. of Elasticity, psi:	117000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 75
Coefficient, in % x 10^{-3}/°C:	6.35	7.29	8.21	8.56

86/14 RDX/Wax

Composition: RDX 86%, Wax 14%

Density: 1.59 to 1.60 g/cc Theoretical Max 1.6 g/cc

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	16
Sample Weight, mgs.	18

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	-	-	
Unaffected	100	5	

Explosion Temperature: 271°C Autoignition Temperature: 209°C

Vacuum Stability Test:

Temperature °C		100	120	130	140	150
ML. gas from 5 gm sample	40 hrs	0.46	0.70	1.72	4.31	11+
	8 hrs	-	-	-	-	2.63

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	80700
50%	108400
99.9%	145500

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	5296	5244	5270
Initial Velocity, ft/sec.:	-	-	5615

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	1.59	8252	8233	8243
1.0" x 1.0" x 6"	1.60	8363	8292	8322
1.5" x 1.5" x 6"	1.60	8366	8341	8349
2.0" x 2.0" x 6"	-	-	-	-

Blast Test:

Weight of Charge: 2670 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	30.9	12.2	6.4
Impulse, psi - milliseconds:	18.0	11.2	7.5

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125
Stress at Rupture, psi:	1391	2066	588	118
Compression at Rupture, %:	0.21	0.30	0.59	0.27
Mod. of Elasticity, psi x 10^{-3}:	699	921	582	258
Work to Prod. Rupture, ft-lb/in^3:	0.12	0.32	0.25	.021

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125
Stress at Rupture, psi:	103	154	363	79
Elongation at Rupture, %:	.016	.018	.040	.063
Mod. of Elasticity, psi x 10^{-3}:	852	1087	1172	289
Work to Prod. Rupture, ft-lb/in^3:	.002	.001	.007	.040

Shear Strength -

Temperature °F	-80	-40	73	125
Stress at Rupture, psi:	596	643	418	115

Impact Strength -

Temperature °F	-80	-40	73	125
Charpy, inch-pounds:	1.34	1.33	1.23	1.35
Izod. inch-pounds:	-	-	1.38	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	257
Mod. of Elasticity, psi:	115000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	5.79	6.69	10.9	16.1

Trinitrotoluene (TNT)

Composition: TNT

Density: 1.60 to 1.61 g/cc Theoretical Max 1.654 g/cc

Sample Casting Temperature: 177°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	12
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	-	-	
Unaffected	100	5	

Explosion Temperature: 458°C Autoignition Temperature: 274°C

Vacuum Stability Test:

Temperature °C		120	140	150	160	170	180
ML. gas from 5 gm sample	40 hrs	0.33	0.37	0.46	0.58	1.28	11+
	8 hrs	-	-	-	-	-	0.41

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	66000
50%	120000
99.9%	219000

Fragment Velocity:	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	4346	4270	4308
Initial Velocity, ft/sec.:	-	-	4580

Rate of Detonation:

Configuration of Specimen *	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	-	-	-	-
1.0" x 1.0" x 6"	1.61	6602	6546	6579
1.5" x 1.5" x 6"	1.61	6785	6744	6766
2.0" x 2.0" x 6"	1.61	6868	6833	6850

* TNT was cast in cylindrical charges.

Blast Test:

Weight of Charge: 2695 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	19.6	7.0	4.4
Impulse, psi - milliseconds:	13.3	6.9	6.0

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	2312	2220	978	615	545
Compression at Rupture, %:	0.27	0.55	0.29	0.04	-
Mod. of Elasticity, psi x 10^{-3}:	861	627	545	1692	-
Work to Prod. Rupture, ft-lb/in^3:	0.25	0.63	0.15	0.01	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	67	153	120	64	61
Elongation at Rupture, %:	0.02	0.02	0.03	0.02	-
Mod. of Elasticity, psi x 10^{-3}:	452	966	600	446	-
Work to Prod. Rupture, ft-lb/in^3:	.0006	.002	.002	.0007	-

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	770	635	481	364	299

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.27	1.40	1.25	1.27	1.27
Izod, inch-pounds:	-	-	1.25	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	138
Mod. of Elasticity, psi:	53900

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	5.24	5.74	6.71	7.35

80/20 Tritonal

Composition: TNT 80%, Aluminum 20%

Density: 1.77 to 1.78 g/cc Theoretical Max 1.793 g/cc

Sample Casting Temperature: 186°F

Impact Sensitivity:

B. M. Apparatus, in.	
P. A. Apparatus, in.	12
Sample Weight, mgs.	19

Friction Pendulum Test:

Steel Shoe	NA
Fiber Shoe	

Rifle Bullet Impact Test:

	%	No.	Trials
Explosions	-	-	5
Partials	-	-	
Burned	-	-	
Unaffected	100	5	

Explosion Temperature: 432°C Autoignition Temperature: 270°C

Vacuum Stability Test:

Temperature °C		120	130	140	150	160	170	180+
ML. gas from 5 gm sample	40 hrs	0.26	0.27	0.34	0.44	0.56	1.48	11
	8 hrs	-	-	-	-	-	-	1.67

Sensitivity of Explosive to Set Back Pressure (psi) at 160°F:

Probability of Reaction	Pressure
0.1%	86300
50%	93500
99.9%	101300

Fragment Velocity:

	Trial 1	Trial 2	Ave.
Ave. Velocity @ 20 ft from sample, ft/sec:	4461	4413	4437
Initial Velocity, ft/sec.:	-	-	4719

Rate of Detonation:

Configuration of Specimen	Density (gm/cc)	Detonation Velocity (m/sec)		
		High	Low	Ave.
0.5" x 0.5" x 6"	-	-	-	-
1.0" x 1.0" x 6"	1.78	6223	5929	6056
1.5" x 1.5" x 6"	1.77	6527	6491	6506
2.0" x 2.0" x 6"	1.77	6587	6468	6522

Blast Test:

Weight of Charge: 2975 gms

Distance from Charge:	10 ft.	15 ft.	20 ft.
Overpressure, psi:	23.6	10.3	5.6
Impulse, psi - milliseconds:	15.1	9.5	6.9

Mechanical Properties -

Compressive Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	4534	3835	2129	1495	1002
Compression at Rupture, %:	0.53	0.56	0.32	0.18	-
Mod. of Elasticity, psi x 10^{-3}:	1253	1275	1146	1345	-
Work to Prod. Rupture, ft-lb/in^3:	1.42	1.17	0.29	0.14	-

Tensile Strength - Load Rate .05 in/min

Temperature °F:	-80	-40	73	125	160
Stress at Rupture, psi:	153	271	277	177	74
Elongation at Rupture, %:	0.01	0.02	0.03	0.045	-
Mod. of Elasticity, psi x 10^{-3}:	1769	1328	1540	756	-
Work to Prod. Rupture, ft-lb/in^3:	.001	.002	.004	.004	-

Shear Strength -

Temperature °F	-80	-40	73	125	160
Stress at Rupture, psi:	974	811	724	521	524

Impact Strength -

Temperature °F	-80	-40	73	125	160
Charpy, inch-pounds:	1.42	1.45	1.37	1.35	1.42
Izod. inch-pounds:	-	-	1.28	-	-

Torsional Shear - Load Rate 36°/min

Temperature °F	73
Stress at Rupture, psi:	236
Mod. of Elasticity, psi:	150000

Linear Coefficient of Thermal Expansion:

Temperature Range °C	-50 to -20	-20 to 20	20 to 50	50 to 65
Coefficient, in % x 10^{-3}/°C:	4.21	4.53	6.37	7.92

Table 1

Autoignition Temperature

Explosive	Temperature °C
PBXN-1	191
Comp B	194
75/25 Cyclotol	197
Comp B-3	199
HBX-3	200
H-6	200
PBX, Type B	207
PBX, Type A	209
86/14 RDX/Wax	209
PBX 9010	210
75/25 Octol	212
PBXN-3	212
Comp C-4	215
Comp A-3	215
70/30 Octol	227
HTA-4	228
HTA-3	229
PBX 9404	230
95/5 HMX/Kel F-800	254
LX-04-1	255
80/20 Tritional	270
TNT	274

Table 2

Blast Impulse as a Function of Distance

Explosive	Charge Weight (grams)	Impulse (psi-milliseconds) @ 10 ft.	15 ft.	20 ft.
TNT	2695	13.5	6.9	6.0
80/20 Tritonal	2975	15.1	9.5	6.9
86/14 RDX/Wax	2670	18.0	11.2	7.5
75/25 Octol	3022	18.1	12.5	9.1
Comp B	2862	18.3	12.6	8.6
75/25 Cyclotol	2923	19.0	14.5	9.6
PBX 9404	3102	19.1	12.2	8.9
95/5 HMX/Kel F-800	3130	19.2	12.7	9.1
PBX, Type A	2807	19.6	12.2	9.5
PBX 9010	2992	19.6	14.9	10.3
PBX, Type B	2778	19.8	12.2	9.5
HBX-3	3098	20.4	15.5	10.9
LX-04-1	3133	20.5	12.1	7.6
HTA-3	3211	20.5	14.4	9.8
70/30 Octol	3023	21.2	15.5	11.2
HTA-4	3311	21.3	13.3	9.9
Comp C-4	2729	21.5	11.6	7.9
Comp B-3	2892	21.8	11.5	10.4
PBXN-1	2968	21.8	12.2	8.2
PBXN-3	2821	22.0	13.2	8.6
Comp A-3	2750	22.9	12.6	9.1
H-6	2939	24.1	13.4	9.1

Table 3

Detonation Rates for Different Densities *

Explosive	Density (gms/cc)	Molding Pressure (psi) x 10^{-3}	Rate of Detonation (M/sec)
PBX 9404	1.831	10	8760
	1.846	14	8815
	1.849	18	8823
	1.854	26	8838
PBX 9010	1.782	10	8371
	1.785	14	8364
	1.789	18	8374
	1.793	26	8398
LX-04-1	1.862	10	8452
	1.869	18	8468
	1.872	22	8537
	1.872	26	8511
PBX, Type A	1.671	10	8210
	1.673	18	8220
	1.675	22	8230
	1.678	26	8248
PBX, Type B	1.665	10	8165
	1.670	14	8175
	1.676	18	8205
	1.678	26	8218
PBXN-3	1.704	26	8374
	1.708	26	8450
	1.717	26	8477
PBXN-1	1.773	10	7958
	1.781	14	7962
	1.779	18	7970
	1.782	22	7981
A-3	1.621	10	8340
	1.626	14	8344
	1.633	18	8398
	1.643	26	8473

* All values tabulated are for single firings of test samples 1/2" x 1/2" x 6".

Table 4

Rate of Detonation for Different Configurations (1)

Explosive	Density (gms/cc)	Detonation Velocity (meters/second) 1/2" x 1/2" x 6"	1" x 1" x 6"	1 1/2" x 1 1/2" x 6"	2" x 2" x 6"
80/20 Tritonal	1.77	--	6056	6506	6522
TNT (2)	1.61	--	6579	6766	6850
HBX-3	1.83	6886	7123	7149	--
H-6	1.76	7249	7364	7367	--
HTA-4	2.00	7494	7659	--	--
HTA-3	1.93	7720	7893	7799	--
Comp B-3	1.72	7831	7916	7930	--
Comp B	1.72	7903	7930	7929	--
PBXN-1 (3)	1.78	7970	--	--	--
75/25 Cyclotol	1.75	8138	8213	8197	--
PBX, Type B (3)	1.68	8205	--	--	--
PBX, Type A (3)	1.67	8220	--	--	--
70/30 Octol	1.80	8241	8305	8310	--
86/14 RDX/Wax	1.60	8243	8322	8349	--

Table 4 (cont'd)

Rate of Detonation for Different Configurations (1)

Explosive	Density (gms/cc)	Detonation Velocity (meters/second) 1/2" x 1/2" x 6"	1" x 1" x 6"	1 1/2" x 1 1/2" x 6"	2" x 2" x 6"
Comp C-4	1.65	--	8337	8568	--
75/25 Octol	1.81	8328	8396	8364	--
PBX 9010 (3)	1.79	8374	--	--	--
PBX N-3 (4)	1.71	8450	--	--	--
LX-04-1	1.87	8468	--	--	--
A-3 (3)	1.64	8473	--	--	--
PBX 9404 (3)	1.85	8823	--	--	--
95/5 HMX/ Kel F-800 (5)	1.88	8895	--	--	--

(1) All values given are an average of at least three trials.
(2) TNT was cast in cylindrical shapes 1", 1 1/2", and 2" dia.
(3) The density of the explosive reached a plateau at 18,000 psi molding pressure.
(4) The density of the explosive reached a plateau at 26,000 psi molding pressure.
(5) 95/5 HMX/Kel F-800 was molded at 20,000 psi.

Table 5

Explosion Temperature *

Explosive	Temperature °C (5 seconds)
HBX-3	243
Comp C-4	263
PBX, Type A	266
PBX, Type B	269
Comp B-3	271
86/14 RDX/Wax	271
Comp B	272
H-6	273
75/25 Cyclotol	276
Comp A-3	281
PBXN-1	285
75/25 Octol	288
70/30 Octol	289
HTA-3	291
PBX-9010	295
HTA-4	302
PBX 9404	309
PBXN-3	337
LX-04-1	337
80/20 Tritonal	432
TNT	458

* Smoke was the indication of decomposition in all cases.

Table 6

Fragment Velocity

Explosive	Ave. Fragment Velocity for 20 ft (ft/sec)	Initial Fragment Velocity (Ft/sec)
TNT	4308	4580
80/20 Tritonal	4437	4719
HBX-3	4496	4772
PBXN-1	4753	5056
HTA-4	4988	5307
H-6	5116	5442
86/14 RDX/Wax	5270	5615
Comp B	5353	5691
Comp A-3	5358	5699
PBX, Type B	5359	5700
PBXN-3	5385	5728
PBX, Type A	5430	5775
Comp B-3	5432	5778
Comp C-4	5479	5829
HTA-3	5548	5902
PBX 9010	5678	6039
LX-04-1	5696	6059
75/25 Cyclotol	5704	6067
70/30 Octol	5772	6139
75/25 Octol	5790	6159
PBX 9404	6031	6415
95/5 HMX/Kel F-800	6083	6469

Table 7

Friction Pendulum Test

Explosive	Steel Shoe	Fiber Shoe
Comp A-3	NA	--
Comp B	NA	--
Comp B-3	NA	--
Comp C-4	NA	--
75/25 Cyclotol	Crackled in one trial	NA
H-6	NA	--
HBX-3	NA	--
95/5 HMX/Kel F-800	NA	--
HTA-3	NA	--
HTA-4	NA	--
LX-04-1	NA	--
75/25 Octol	Crackled in 4 trials *	--
70/30 Octol	NA	--
PBX, Type A	NA	--
PBX, Type B	NA	--
PBXN-1	NA	--
PBXN-3	NA	--
PBX 9404	NA	--
PBX 9010	NA	--
86/14 RDX/Wax	NA	--
TNT	NA	--
80/20 Tritonal	NA	--

* Repeat test: No action in 10 trials

Table 8

Peak Overpressures as a Function of Distance

Explosive	Charge Weight (grams)	Peak Overpressures (psi) @ 10 ft.	15 ft.	20 ft.
TNT	2695	19.6	7.0	4.4
80/20 Tritonal	2975	23.6	10.3	5.6
PBXN-3	2821	28.7	11.8	7.8
PBXN-1	2968	28.9	12.9	6.8
86/14 RDX/Wax	2670	30.9	12.2	6.4
Comp A-3	2750	31.0	12.0	7.9
PBX, Type B	2778	31.9	11.9	7.9
Comp B-3	2892	32.6	12.3	8.0
PBX 9010	2992	32.6	16.0	8.2
75/25 Cyclotol	2923	32.7	16.1	7.1
PBX, Type A	2807	33.2	12.9	6.3
Comp C-4	2729	33.4	12.4	7.1
Comp B	2862	34.1	12.9	6.8
LX-04-1	3133	34.2	12.9	6.7
HBX-3	3098	34.4	13.8	7.3
H-6	2939	37.0	13.2	7.2
75/25 Octol	3022	37.4	13.1	7.1
70/30 Octol	3023	37.9	14.6	6.7
PBX 9404	3102	39.1	13.9	7.1
HTA-4	3311	39.2	13.6	7.6
HTA-3	3211	39.2	14.7	7.9
95/5 HMX/Kel F-800	3130	39.5	14.0	7.2

Table 9

P.A. Impact Sensitivity *

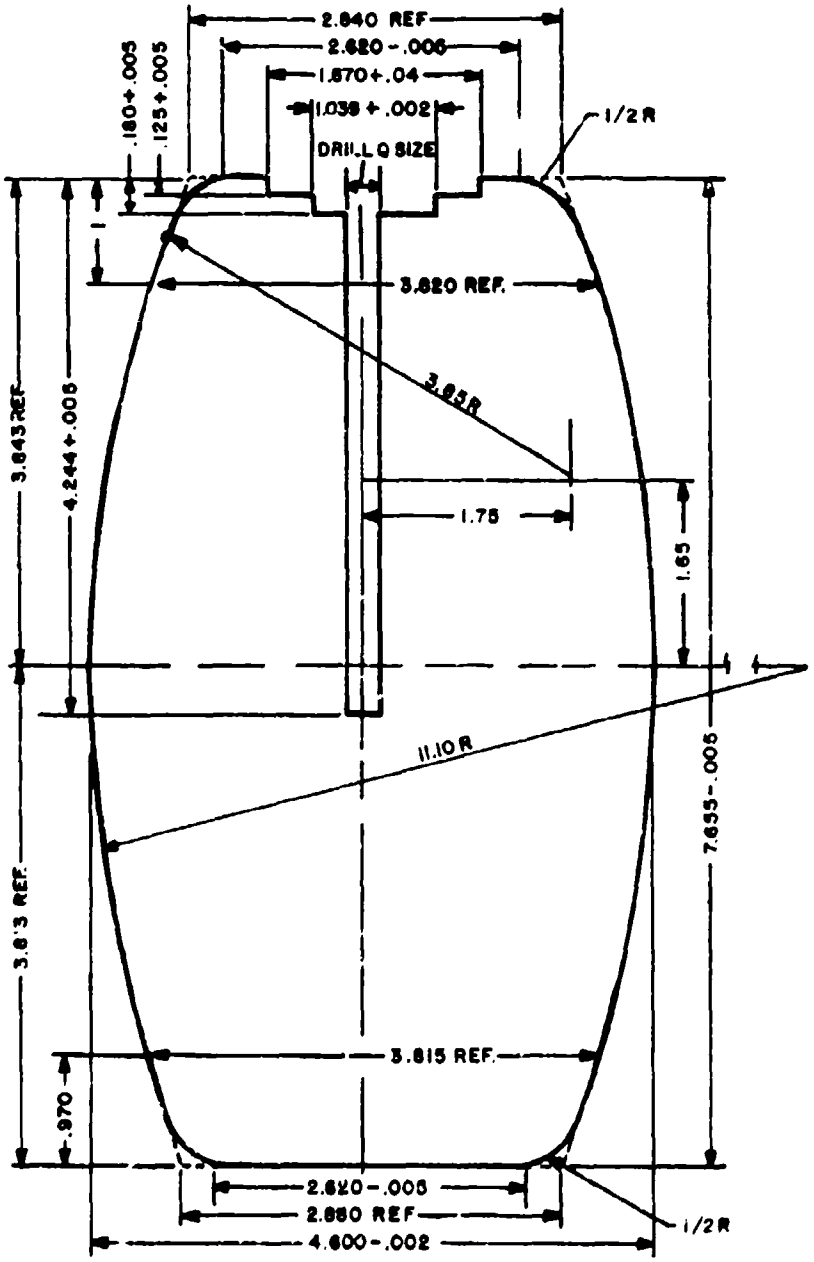
Explosive	P.A. Impact (inches)	Sample Weight (mgs)
95/5 HMX/Kel F-800	9	18
LX-04-1	9	30
PBX 9010	9	31
HBX-3	12	21
80/20 Tritonal	12	19
Comp B	12	20
TNT	12	19
H-6	13	19
HTA-4	13	22
PBX, Type A	13	19
Comp B-3	14	20
75/25 Cyclotol	15	17
75/25 Octol	15	19
Comp A-3	15	19
86/14 RDX/Wax	16	18
PBXN-1	16	31
PBX, Type B	16	21
PBXN-3	17	31
Comp C-4	17	24
PBX 9404	17	34
HTA-3	17	21
70/30 Octol	19	20

* Values tabulated are for the 10 percent point.

Table 10

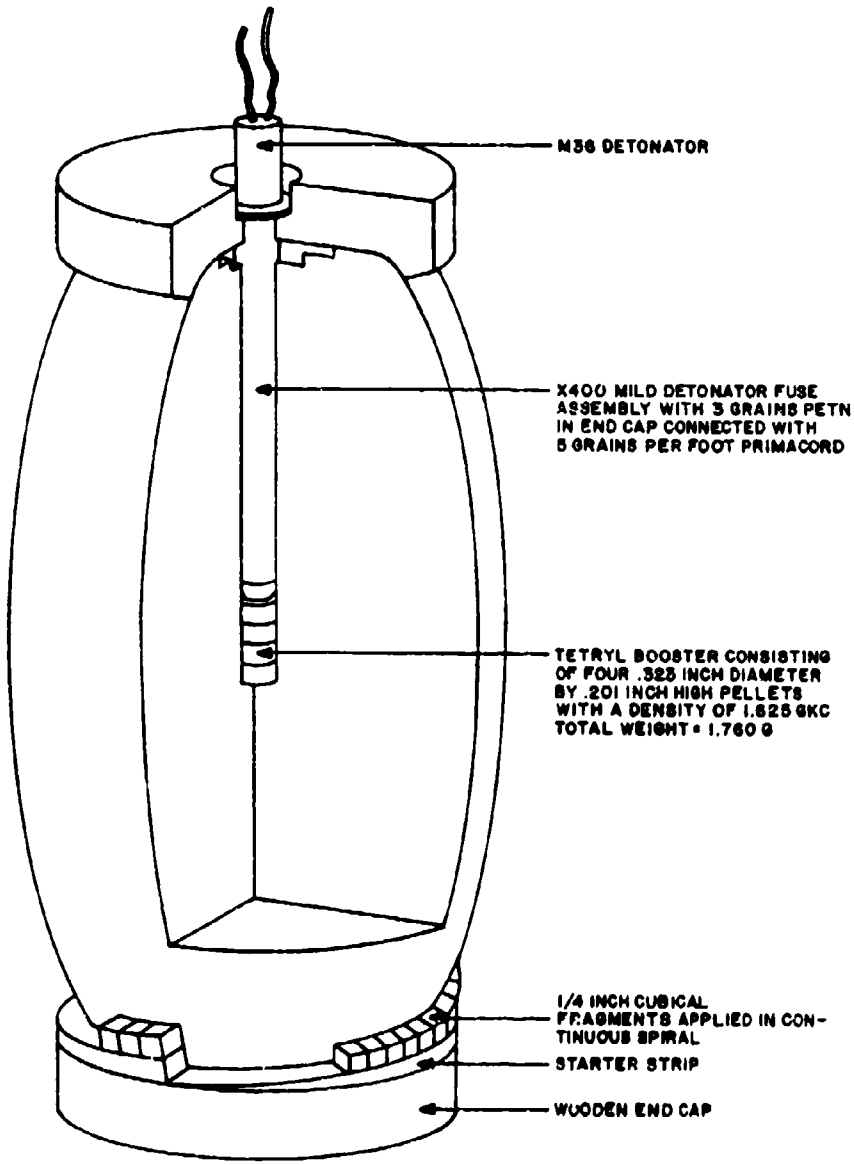
Sensitivity of Explosive to Setback Pressure @ 160°F

Explosive	Pressure (psi) x 10^{-3} for Firing at Three Probability Levels 50.%	0.1%	99.9%
80/20 Tritonal	93.5	86.3	101.3
Comp B-3	104.0	55.0	197.0
H-6	105.3	87.3	127.8
86/14 RDX/Wax	108.4	80.7	145.5
Comp C-4	111.2	38.4	324.5
Comp A-3	113.8	86.8	149.2
HTA-3	114.1	104.8	124.8
PBX, Type B	115.2	78.0	170.2
Comp B	117.0	85.0	161.0
70/30 Octol	119.0	80.0	176.0
75/25 Octol	119.0	95.0	149.0
TNT	120.0	66.0	219.0
HTA-4	120.1	90.2	160.3
PBX, Type A	120.7	59.8	243.3
75/25 Cyclotol	122.0	80.0	186.0
HBX-3	128.0	96.2	170.2
PBX 9010	128.3	94.1	174.8
95/5 HMX/Kel F-800	135.6	110.4	166.5
PBXN-1	142.1	130.8	154.5
PBX 9404	143.3	102.5	200.5
LX-04-1	144.2	131.0	158.7
PBXN-3	147.8	92.3	236.7



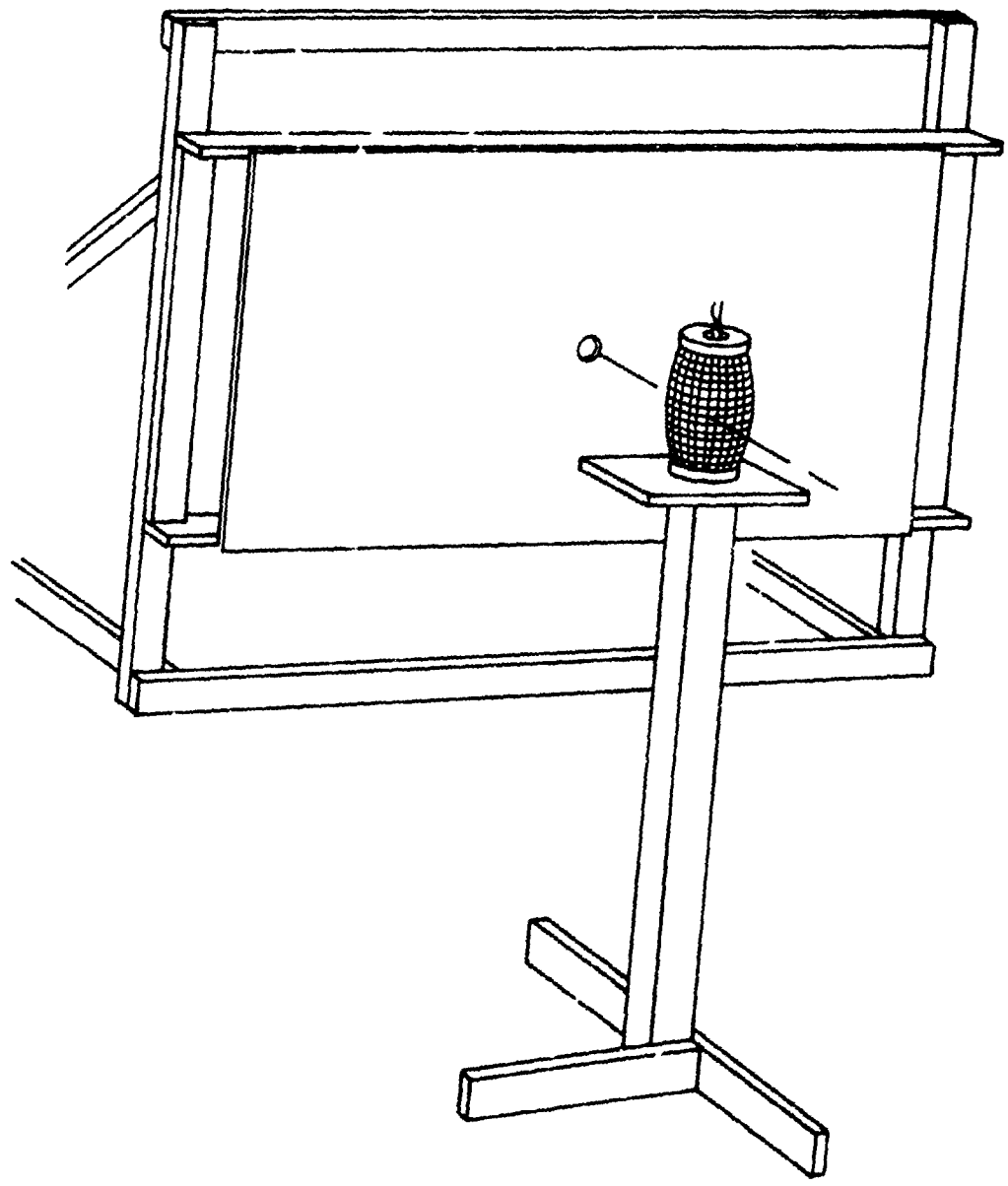
BLAST & FRAGMENT TEST CHARGE

Figure 1



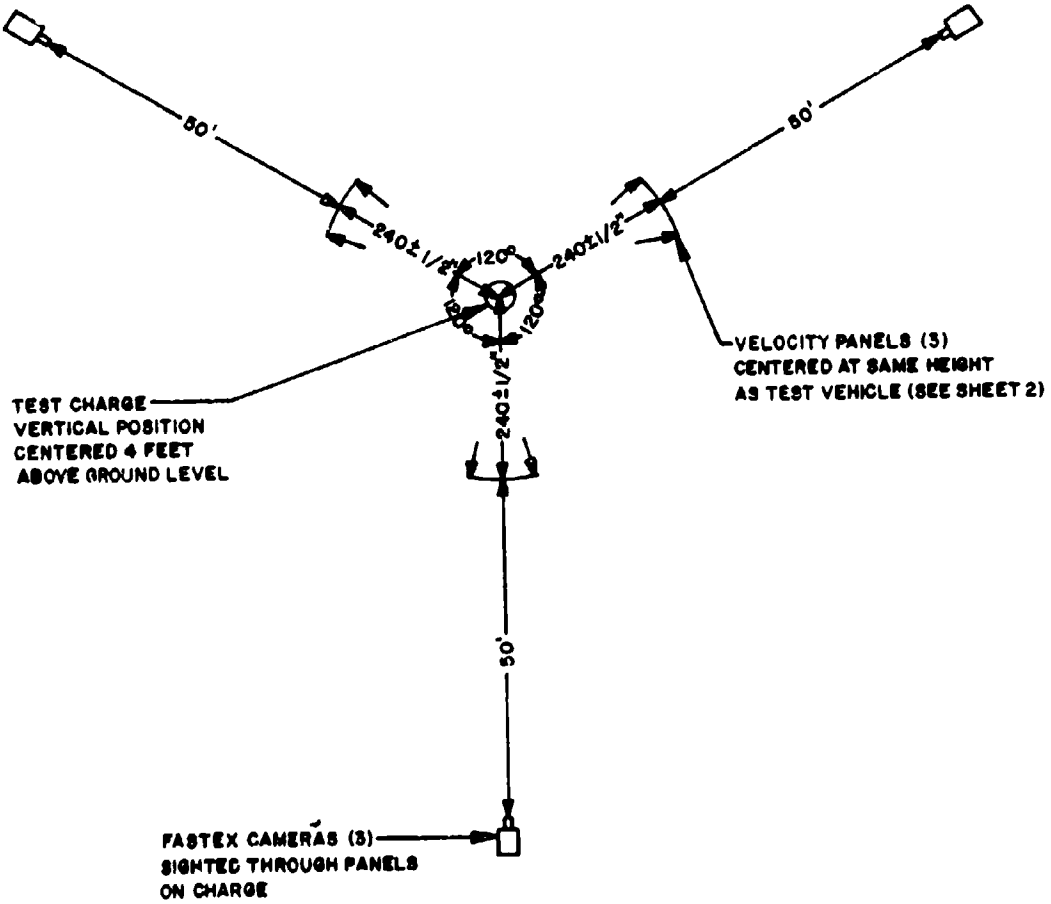
FRAGMENT VELOCITY TEST CHARGES

Figure 2



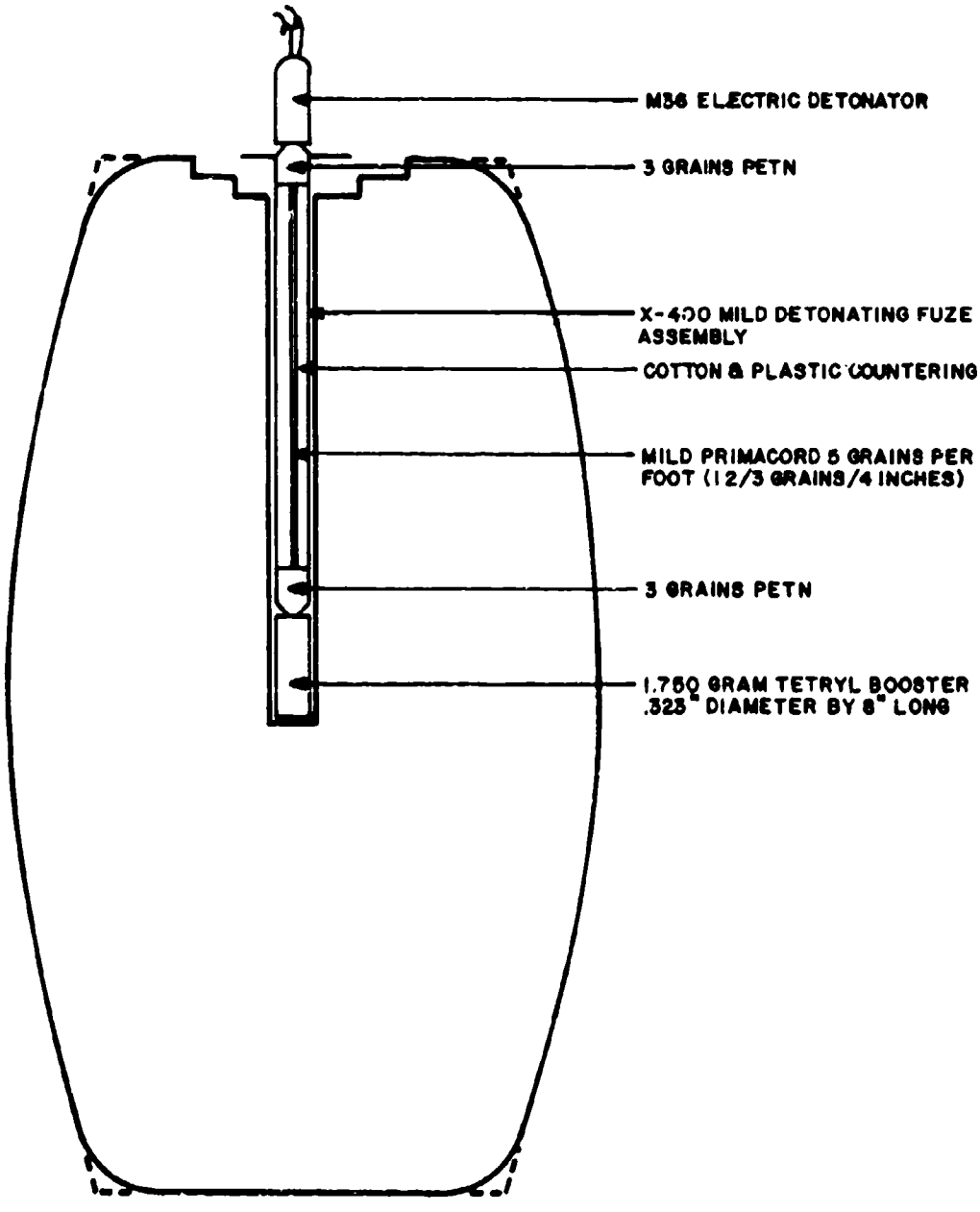
THE TEST WARHEAD IN PLACE READY FOR FIRING

Figure 3



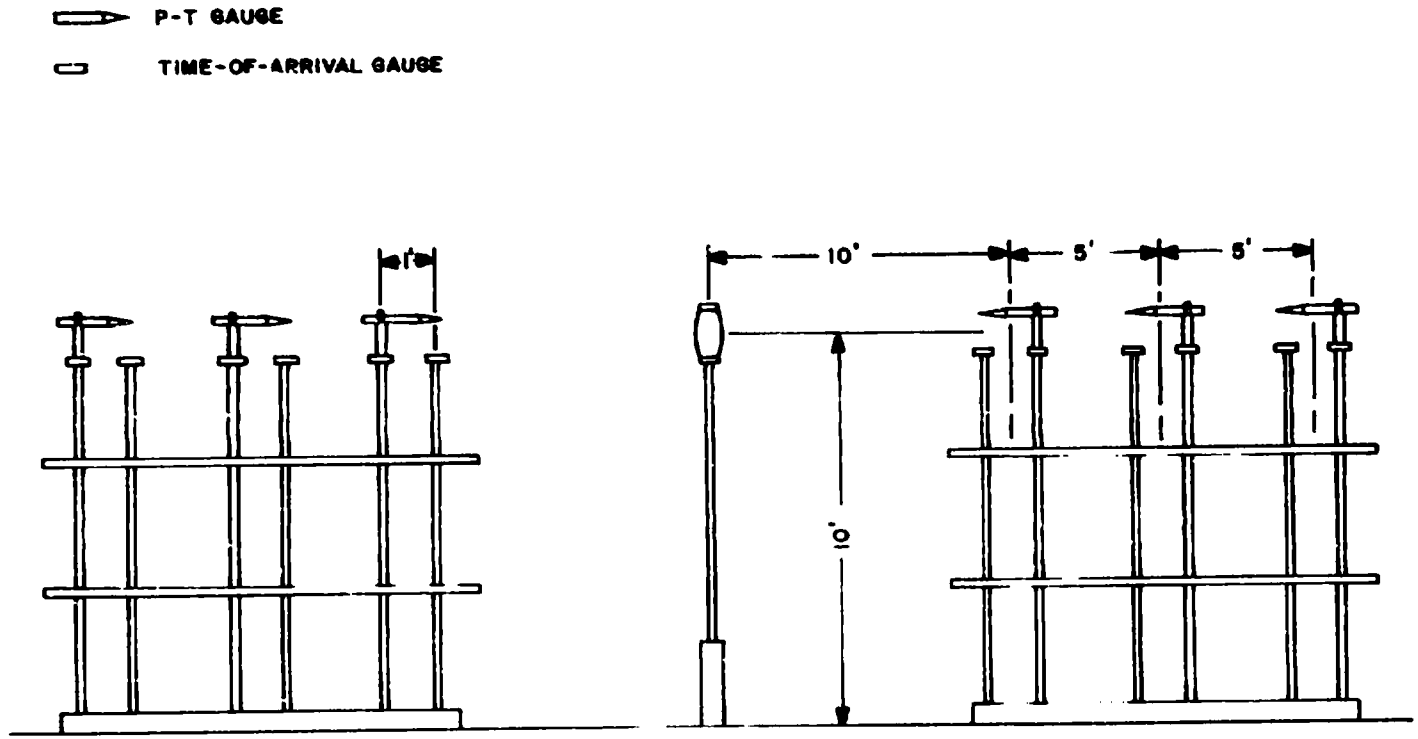
FRAGMENT VELOCITY TEST

Figure 4



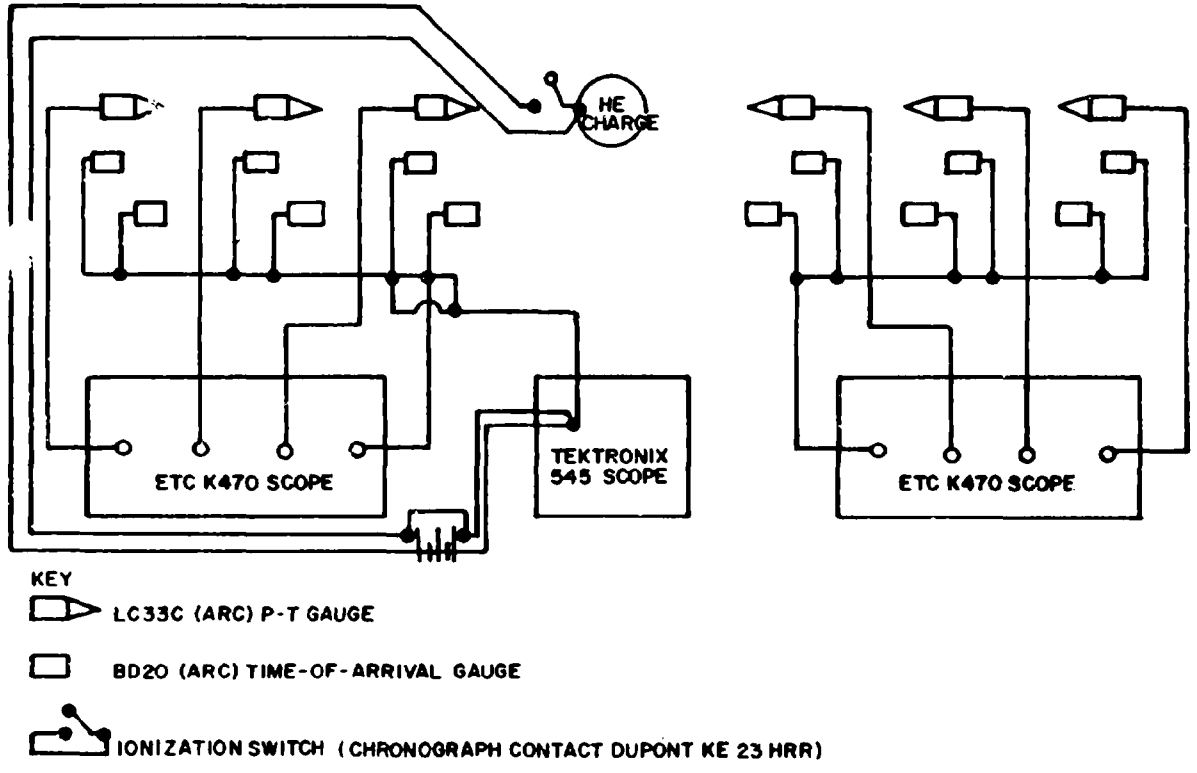
INITIATION TRAIN

Figure 5



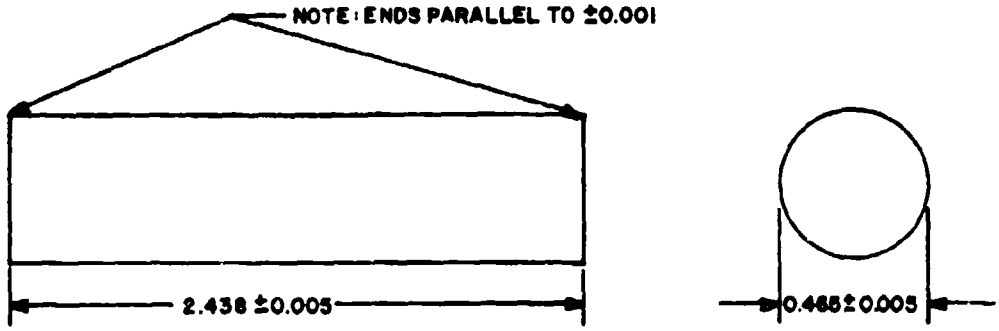
BLAST PARAMETER MEASUREMENT TRANSDUCER ARRAYS,
SHOWING RELATIVE POSITION OF HE CHARGE

Figure 6

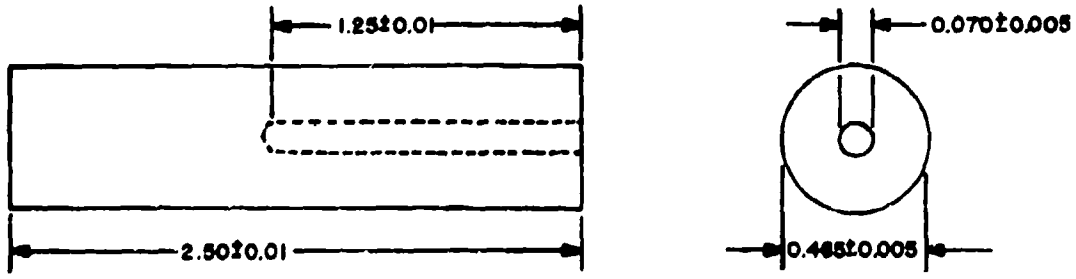


BLAST INSTRUMENT SCHEMATIC

Figure 7



THERMAL EXPANSION TEST SPECIMEN



THERMOCOUPLE RECEPTACLE

Figure 8

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13. ABSTRACT

The work reported represents part of a continuing effort to determine the important characteristics of some explosives as they pertain to performance in ammunition.

Tests were conducted to determine the fragment velocity, blast pressure, detonation velocity, sensitivity to impact and friction, thermal stability, mechanical strength, and thermal expansion of each explosive. Tests were applied to TNT and TNT-based compositions including Composition B, Composition B-3, 75/25 Cyclotol, 70/30 Octol, 75/25 Octol, 80/20 Tritonal, H-6, HBX-3, HTA-3, and HTA-4; and plastic- or wax-bonded compositions including LX-04-1, PBX 9010, PBX Types A and B, PBX 9404, Comp A-3, PBXN-1, PBXN-3, 95/5 HMX/Kel F-800, Composition C-4, and 86/14 RDX/Wax.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Composition A-3						
Composition B						
Composition B-3						
Composition C-4						
75/25 Cyclotol						
H-6						
HBX-3						
95/5 HMX/Kel F-800						
HTA-3						
HTA-4						
LX-04-1						
75/25 Octol						
70/30 Octol						
PBX, Type A						
PBX, Type B						
PBXN-1						
PBXN-3						
PBX 9404						
PBX 9010						
86/14 RDX/Wax						
TNT						
80/20 Tritonal						
Explosive Properties						
Fragment Velocity						
Blast Test or Blast Pressure						
Detonation Velocity or Rate of Detonation						
Impact Sensitivity						
Friction Sensitivity						
Thermal Stability						
Mechanical Properties						
Thermal Expansion						