A Library of Prompt Detonation Reaction Zone Data

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Abstract

Tables are given listing literature data that allows calculation of sonic reaction zones at or near steady-state for promptly-detonating explosive cylinders. The data covers homogeneous, heterogeneous, composite, inorganic and binary explosives and allows comparison across the entire explosive field. Table 1 lists detonation front curvatures. Table 2 lists Size Effect data, ie the change of detonation velocity with cylinder radius. Table 3 lists failure radii and detonation velocities. Table 4 lists explosive compositions. A total of 51 references dating back into the 1950's are given. Calculated reaction zones, radii of curvature and growth rate coefficients are listed.

Table of Contents

I Description of the Tables

Table 1 Detonation Front Curvature	I-3
Table 2 Size Effect	I-4
Table 3 Failure Radius	I-4
Table 4 Compositions of Explosives	I-5
Table References	I-5

II Comparing the Data

II-1

Tables

Table 1 Detonation Front Curvature	T-1
Table 2A Size Effect Homogeneous and Heterogeneous	T-5
Table 2B Size Effect Composite and Inorganic	T-12
Table 3 Failure Radius	T-18
Table 4 Compositions of Explosives	T-21

I. Description of the Tables

The intent is to collect steady state, prompt detonation data that pertains to calculation of the average sonic reaction zone length, ie the distance behind the detonation front that furnishes chemical energy to push the front. We here present results on the detonation front curvature in cylinders and the Size Effect, ie the change of detonation velocity with cylinder radius. The data is listed plus the calculated parameters that constitute the input to Larry Fried's upcoming LLNL code KINETIC CHEETAH.

Table 1: Detonation Front Curvature

A collection of cylinder detonation front curvature data, as obtained from streak camera measurements, follows, necessarily compressed from the original data files. The data is divided into sections with attempts to create families. The 92.5-97.5 wt% TATB family is the only one where explosives from different sources are collected, because of the general agreement between samples. The ANFO and PBXW-111 families are separated not only as to where they came from but also whether they are confined or unconfined. In each family, the data is ordered from small to large radii.

The sections may be seen to fall into larger groups. Most of the table is made up of "quadratic" curvatures, ie those where the radius-squared makes up half or more of the lag and where the curves are smooth across the

entire diameter. The top sections are homogeneous and heterogeneous explosives, the bottom sections are composites. Near the bottom comes the small set of "non-quadratic" curves, which have steep edge lags and ragged centers. These occur only for explosives with short reaction zones. We next have the extreme non-quadratic curves where defects of the order of 1/10th the cylinder radius have severely broken up the front but steep edge effects are still clearly visible. Finally, we have three quadratic slabs with a square cross section.

The columns contain the following

- 1) the explosive name
- 2) initial density, ρ_0
- 3) initial outer radius of the explosive, R_0 , and inner radius of a metal sleeve if present, for a cylinder. For the slabs, R_0 is the half-width
- 4) measured edge lag, L_0 , where the data was taken all the way out to the edge
- 5) calculated reaction zone lengths, $\langle x_c \rangle$ in mm using the theory from P. C. Souers and R. Garza, "Kinetic Information from Detonation Front Curvature," *Eleventh International Detonation Symposium*, submitted
- 6) measured detonation velocity, U_s , for the radius R_0
- 7) infinite-radius/infinite containment detonation velocity, D , obtained by the extrapolation of the inverse radius to zero

- 8) lag-fit coefficient of the radius-squared, A, which describes the sideways energy flow across the entire cylinder
- 9) lag-fit coefficient of the radius to the sixth power, B, which describes the effects of the edge. Note: A quadratic curve is fit by the lag equation $L = AR^2 + BR^6$, a non-quadratic curve is fit by BR^6
- 10) measured edge angle, where the error is generally $\pm 5^\circ$ to $\pm 10^\circ$
- 11) calculated edge angle, obtained from the derivative of the lag fit equation
- 12) growth rate coefficient, G, in the $GP^2(1-F)$ overall explosive reaction rate
- 13) radius of curvature on the cylinder axis, R_{cur} , as obtained directly from the curvature fit coefficient A
- 14) wall confinement material, if any
- 15) wall confinement thickness in mm
- 16) energy conductivity, K (in MW/mm^2), as calculated from the quadratic coefficient, A, and which seeks to describe transverse energy flow across the cylinder
- 17) length of cylinder in mm
- 18) reference

The material of confinement is listed where known, even though its effect might have been negligible. The abbreviations are

- Br brass, 8.56 g/cc
- Cb cardboard, 0.5 g/cc
- Cu copper, 8.93 g/cc
- PVC plastic, 1.5 g/cc
- Py pyrex glass, 2.2 g/cc
- SS stainless steel, 7.8 g/cc

Some explosive families have been studied in different places. The abbreviations for these are

1) PBXN-111 N = U.S. Navy, A = Australia

1) ANFO NM = New Mexico, SW = Sweden

Table 2. Size Effect

The Size Effect is the change of detonation velocity with cylinder radius. The data listed is

- 1) name, density, pre-pressed explosive particle size and reference
 - 2) radius, R_0 , in mm
 - 3) measured detonation velocity in mm/ μs
- The first entry opposite $R_0 = \infty$ is the extrapolated infinite radius detonation velocity
- 4) calculated reaction zone length, $\langle x_e \rangle$ in mm
 - 5) the first number is the C-J pressure as calculated by CHEETAH. It is used to calculate the growth rate coefficient, G, listed below it
 - 6) radius of curvature, R_{cur} , on the cylinder axis as calculated from the detonation velocities

Table 3. Failure Radius

The failure radii of page 1 are mostly the subset of the Size Effect. Listed are the following

- 1) density in g/cc

2) failure radius, R_f (mm) We use only data sets where it mentions that failure was observed. The failure radius is the average of the smallest radius for which detonation was observed and the largest at which it was not. The definition of failure is set by the researcher. Campbell required propagation beyond four 50 mm-long rate sticks for PBX-9502,²⁶ which is undoubtedly far stricter than the average definition. All samples are unconfined unless noted.

3) approximate detonation velocity at failure, U_{sf} (mm/ μ s). This is usually the last measured value lowered to the nearest 0.1 mm/ μ s.

4) infinite-radius/infinite containment detonation velocity, D , obtained by inverse-square extrapolation of the radius to zero.

5) extrapolated sonic reaction zone length at failure, $\langle x_e \rangle_f$ (mm).

6) calculated growth coefficient G .

7) calculated radius of curvature on the axis, R_{cur} (mm).

8) reference.

Page 2 has the void volume fraction, f_v , and the inert material fraction f_f and their sum.

Table 4. Compositions of Explosives

All compositions are in wt %

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II. Comparing the Data

We now consider some simple comparisons of the data. Figure 1 shows a detonation velocity, U_s , -inverse radius plot, where the widest possible spread of data has been taken. Infinite radius is at the left, moving to the right causes shrinking of the cylinder. Ultimately, the lines die out because of failure, i.e. the cylinder no longer propagates the detonation because too much energy is lost out the sides. Large size cylinders lie to the left, tiny ones to the right.

Fig. 1 Detonation velocity vs inverse radius for the widest possible spread of explosive data

The most obvious thing about Fig. 1 is the huge spread over orders of magnitude. It would be nice to reduce to normalized coordinates. The most obvious choice for detonation velocity is U_s/D or $1 - U_s/D$, where D is the infinite radius detonation velocity. It is not possible, however, to select a standard radius because there is no overlap in many cases. The only apparent fixed

radius is that for failure, R_f , but this is a function of confinement.

From Fig. 1, we see varying changes of slope. XTX-8003 barely changes its detonation velocity before it fails, whereas the composite explosives can detonate at extremely reduced velocities.

The same broad spread appears in Figure 2 when we plot the calculated reaction zone lengths versus cylinder radius. The short zones of XTX-8003 lie at the lower left and the long zones of HANFO at the upper right.

Figure 2 The broad spread of calculated reaction zone lengths. The smallest belongs to XTX-8003 and the longest to HANFO.

Figure 3 shows a family of TNT samples, taken at various densities. We see that adding void volume increases both the reaction zone length and the failure radius. Also, the reaction

zone length at a given density increases with radius with a power between 0.5 and 1.0

Figure 3 Reaction zone-radius for a family of TNT samples of different densities. All work was done by the same researchers. The densities are listed.

Many other effects appear. Figure 4 shows two high-HMX explosives: PBX-9501 (95%) and PBX-9404 (94%). The two curves overlap each other but the different binders produce different failure radii. The binders are PBX-9404-NC and CEF and PBX-9501-estane and BDNPA-F.

Figure 4 Inverse radius plot for two high-HMX explosives showing that binder affects the failure radius.

Figure 5 shows an inverse radius plot for PBXN-111, the only explosive with comparable confined and unconfined data. The failure radius is shorter for the unconfined data. The reaction zone lengths are about the same. The infinite radius detonation velocities are the same.

Figure 5 Inverse radius plot of confined (solid symbols) and unconfined (open) PBXN-111. Data is from the U.S. Navy and Australia. Confinement also decreases the failure radius.

Figure 6 shows a dramatic reaction zone effect in 70% RDX-urethane, where particle sizes were carefully set and the explosive was pressed near full density, so there would be almost no hot spots. This last feature makes this an unusual explosive in the ranks of those listed in this report. The data is also different in that no radius effect is seen. The measurements were unfortunately not extended to failure. With radius not a factor, the reaction zone lengths are roughly given by

$$\langle x_c \rangle \sim 0.5 + 0.006d(\mu\text{m}) \quad (1)$$

where d is the RDX particle size NM and liquid TNT show a weak dependence on radius, so that hot spots may be the cause of the radius effect

Figure 6 The reaction zone length varies dramatically in these 70%RDX-urethane samples with well-sieved sizes and almost no hot spots

Table 1 Detonation front curvature data.

Section	Explosive	Den-	Rad-	Edge	calc. $\langle x_e \rangle$ (mm)	Det Velocity		Curvature		Meas.	Calc.	G (μs^{-1} *GPa $^{-2}$)	Rcur 1/2A (mm)	Wall		K (MW/ mm 2)	Len- gth (mm)
		sity ρ_0 (g/cc)	ius R_0 (mm)	Lag, L_0 (mm)		U_s (mm/ μs)	D (mm/ μs)	fit parameters A (mm $^{-1}$)	B (mm $^{-5}$)	Edge	Edge						
		Angle (deg)	Angle (deg)	mat		(mm)											
Quadratic TATB Family	PBX-9502	1.890	6.0	0.78	1.4	7.495	7.78	1.28E-02	5.69E-06	46	23	0.021	39			85	
	PBX-9502	1.890	5.0	0.74	1.2	7.455	7.78	1.68E-02	1.91E-05	40	28	0.026	30			74	
	PBX-9502	1.890	9.0	1.03	2.0	7.553	7.78	7.51E-03	6.58E-07	37	20	0.016	67			117	
	PBX-9502	1.890	5.0	0.77	1.1	7.458	7.78	1.64E-02	2.17E-05	40	30	0.027	31			75	
	T2	1.855	25	1.92	0.9	7.620	7.65	2.25E-03	2.08E-09	8	13	0.037	222			46	
	LX-17	1.907	25.4	2.07	2.6	7.630	7.72	2.42E-03	1.91E-09	15	14	0.012	207	Cu	2.7	136	305
	T2	1.855	50	2.92	1.1	7.633	7.65	9.23E-04	4.38E-11	6	10	0.029	542			56	
	PBX-9502	1.890	25.0	2.08	3.3	7.677	7.78	2.03E-03	2.77E-09	42	15	0.009	246			199	
	PBX-9502	1.890	25.0	2.18	3.4	7.672	7.78	2.21E-03	2.48E-09	31	14	0.009	227			192	
	EDC-35	1.904	5.0		0.8	7.440	7.73	2.56E-02	1.57E-05		29	0.036	20			43	60
	EDC-35	1.904	5.0		0.7	7.440	7.73	2.30E-02	3.59E-05		42	0.042	22			48	60
	EDC-35	1.904	5.0		0.8	7.440	7.73	2.27E-02	2.98E-05		38	0.039	22			49	60
	EDC-35	1.904	25.4		2.0	7.670	7.73	2.43E-03	1.24E-09		11	0.016	206			98	762
	EDC-35	1.904	25.4		1.9	7.670	7.73	2.51E-03	1.52E-09		13	0.017	199			95	762
	EDC-35	1.904	25.4		2.0	7.670	7.73	2.60E-03	6.76E-10		10	0.016	192			91	762
Quadratic NM Families	NM	1.118	6.35	0.21	0.2	6.199	6.21	4.36E-03	6.66E-07	4	6	0.57	115	Br	2.0	7	
	NM	1.118	25.4	0.54	0.7	6.205	6.21	6.76E-04	5.52E-10	1	4	0.21	740	Py	2.0	21	
	NM	1.124	18.42	0.85	0.3	6.230	6.24	9.50E-04	1.16E-08	12	10	0.40	526	Py	1.0	18	
	NM	1.124	13.78	0.80	0.2	6.229	6.24	1.79E-03	6.61E-08	16	14	0.62	279	Py	1.0	11	
	NM	1.124	9.57	0.86	0.4	6.208	6.24	6.32E-03	3.52E-07	14	16	0.37	79	Py	1.0	13	
	NM-silica	1.171	18.59	1.13	1.8	6.140	6.55	9.62E-04	1.74E-08	27	15	0.0077	520	Py	1.0	1099	
	NM-silica	1.171	9.57	0.99	4.9	6.128	6.55	5.96E-03	5.69E-07	19	21	0.028	84	Py	1.0	182	
	NM-silica	1.171	6.80	0.95	2.7	6.090	6.55	1.47E-02	2.86E-06	21	24	0.051	34	Py	1.0	80	
	NM-silica	1.171	5.26	0.98	2.5	5.800	6.55	2.99E-02	7.33E-06	21	26	0.051	17	Py	1.0	61	
Quadratic RDX- urethane	6 μm , mono	1.45	15	0.60	1.1	7.420	7.45	2.51E-03	3.15E-09	4	5	0.035	199			42	200
	127 μm , b1 6	1.45	15	1.40	1.8	7.330	7.45	6.21E-03	8.48E-09	10	13	0.021	81			67	200
	307 μm , b1 6	1.45	15	2.00	4.5	7.030	7.45	8.92E-03	6.87E-09	15	17	0.008	56			156	200
	428 μm , mono	1.45	15	5.00		6.870	7.45	2.57E-02	NA	35	38		19				200

Table 1, page 2																		
Section	Explosive	ρ_0	R_0	L_0	xe	U_s	D	A	B	Angle	Calc.	G	Rcur	mat	(mm)	K(A)	L	ref
Misc.	PBX-9404	1.840	12.7	0.46	1.9	8.750	8.80	1.01E-03	5.68E-08	16	8	0.012	495			254		3
Quadratic	LX-04	1.854	12.7	0.53	1.0	8.455	8.49	1.58E-03	6.22E-08	9	9	0.025	316	Cu	3.2	105	305	1
Homo- and	LX-04	1.853	12.7	0.54	2.1	8.420	8.49	2.18E-03	3.32E-08	14	7	0.013	229	Cu	3.2	151	305	1
Hetero-	LX-04	1.863	12.7	0.58	0.4	8.476	8.49	1.31E-03	7.65E-08	16	10	0.063	382	Cu	3.2	51	305	1
geneous	LX-04	1.863	12.7	0.59	0.3	8.480	8.49	2.19E-03	4.84E-08	12	9	0.099	228	Cu	3.2	22	305	1
	PBXN-110	1.680	24.95	2.35		8.390		2.04E-03	4.22E-09	24	19		245				178	16
	IRX-1	1.430	25	2.38	4.8	7.491	7.67	2.42E-03	3.74E-09	21	19	0.0080	207			73		17
	PBXW-131	1.740	25.4	0.96		8.644		1.02E-03	6.46E-10	26	5		490	Cu	5.1		508	1
	PBXW-131	1.740	25.4	1.01		8.652		2.07E-04	2.57E-09	38	10		2413	Cu	5.1		508	1
	TNT pressed	1.621	12.7	0.49		6.915		1.82E-03	4.12E-08	16	7		274	Cu	3.2		289	1
	Ult. TATB	1.808	12.7	1.02		7.503		3.76E-03	7.97E-08	18	14		133	Cu	3.2		305	1
	NQ	1.66	12.7	1.43		8.032		7.24E-03	5.91E-08	23	10		69	Cu	3.1		298	
	Comp B	1.670	25.43	1.74	0.3	7.860	7.87	2.40E-03	1.43E-09	9	12	0.108	208			19		14
	Comp B	1.670	25.43	1.85	0.3	7.860	7.87	2.48E-03	8.00E-10	12	10	0.104	202	SS	12.7	18		14
	Octol	1.809	12.7	0.61	1.7	8.415	8.49	2.24E-03	6.97E-08	11	11	0.015	223	Cu	2.6	166	305	1
	RX-08-HD	1.718	12.7	1.15		8.147		7.21E-03	not used	12	10		69	Cu	3.2		305	1
	RX-52-AD	1.770	25.4	1.69		7.546		1.91E-03	1.54E-09	13	11		262	Cu	2.7		305	1
	RX-52-AE	1.780	25.4	1.73		7.570		1.73E-03	2.31E-09	13	13		289	Cu	2.7		305	1
	Pentolite	1.560	25.4	5.70		7.190		8.88E-03	not used	22	24		56					16
	AP, 15 μ m	0.927	26.04	4.14		3.390		6.47E-03	not used	17	19		77	Cu	4.0		1067	1
	AP, 9 μ m	1.020	25.0	4.72	6	3.600	3.80	6.65E-03	7.25E-10	33	21	0.173	75				229	19
	AP, 26 μ m	1.435	25.4	5.93		2.400		1.03E-02	5.30E-09	51	41		49				114	19
Quad-	PBXN-111-N	1.790	24.22	2.85	7	5.611	5.90	4.63E-03	9.86E-10	16	15	0.0056	108	Br	17.1	59	305	8,15
ratric	PBXN-111-N	1.790	33.96	4.00	5	5.757	5.90	2.90E-03	3.52E-10	15	16	0.0077	172	Br	7.3	48	305	8
PBXN-	PBXN-111-A	1.79	12.60	1.60	10	5.130	5.96	9.75E-03	1.98E-08	19	16	0.0037	51	Br	5.1	73	177	9
111	PBXN-111-A	1.79	18.94	2.10	12	5.406	5.96	4.86E-03	7.81E-09	19	17	0.0033	103	Br	5.0	102	217	9
Families	PBXN-111-A	1.79	23.49	2.50	12	5.513	5.96	3.68E-03	3.45E-09	20	18	0.0033	136	Br	5.1	111	253	9
	PBXN-111-A	1.79	50.00		20	5.747	5.96	1.06E-03	4.27E-11	9	11	0.0021	471	Br	5.0		378	9
	PBXN-111-N	1.790	34.12	5.74	7	5.572	5.81	3.57E-03	1.00E-09	25	28	0.0061	140			64	305	8,14
	PBXN-111-N	1.790	24.01	4.75	8	5.309	5.81	8.21E-03	2.66E-09	25	28	0.0051	61			56	305	8,14
	PBXN-111-N	1.790	20.52	4.29	9	5.158	5.81	8.49E-03	1.15E-08	22	31	0.0044	59			68	305	8,14
	PBXN-111-N	1.790	24.06	4.87	8	5.311	5.81	6.46E-03	6.16E-09	27	31	0.0047	77			71	305	8,14

Table 1, Page 3

Section	Explosive	p ₀	R ₀	L ₀	x _e	U _s	D	A	B	Angle	Calc.	G	R _c	mat	(mm)	K(A)	L	ref
	PBXN-111-N	1 790	20 45	4.81	8	5 154	5.81	9.58E-03	1.24E-08	29	33	0.0047	52			61	305	8,14
	PBXN-111-A	1 79	49.95	6.60	17	5.688	6.04	1.58E-03	1 78E-10	31	26	0.0024	317			208	378	9
	PBXN-111-A	1 79	34.13	5.60	14	5.527	6.04	3.38E-03	1.13E-09	29	29	0.0029	148			138	306	9
	PBXN-111-A	1 79	24.06	5.00	11	5.313	6.04	6.50E-03	6.24E-09	33	32	0.0034	77			98	367	9
	PBXN-111-A	1 79	24.01	5.30	11	5.312	6.04	7.19E-03	6.39E-09	40	33	0.0037	70			89	329	9
	PBXN-111-A	1 79	20.45	4.90	10	5 186	6.04	9.62E-03	1.27E-08	32	34	0.0039	52			76	326	9
Quad- ratic ANFO Families	ANFO-SW	1 16	6.8		10	3 740	5.88	2.47E-02	1 73E-06		26	0.0061	20			130	700	10,11
	ANFO-SW	1 16	8.5		9	4.350	5.88	2.01E-02	6.76E-07		28	0.0082	25			132	700	10,11
	ANFO-SW	1 16	10.6		9	4.530	5.88	1.58E-02	3.53E-07		32	0.0081	32			155	700	10,11
	ANFO-SW	1 16	10.85		10	4.530	5.88	1.63E-02	8.85E-08		23	0.0073	31			150	700	10,11
	ANFO-SW	1 16	16.8	2.80	7	5.370	5.88	8.35E-03	1.89E-08	22	23	0.013	60			131	700	10,11
	ANFO-SW	1 16	19.0		7	5.350	5.88	8.19E-03	9.63E-09		24	0.012	61			138	520	10,11
	ANFO-SW	1 16	28.3		10	5 450	5.88	4.65E-03	1.39E-09		23	0.0087	108			201	600	10,11
	ANFO-SW	1 16	39.3		9	5.640	5.88	2.74E-03	4.18E-10		24	0.0107	182			197	600	10,11
	ANFO-NM	1.248	20 45	4.05	20	4.870	6.46	8.19E-03	8.28E-09	21	27	0.0040	61	PVC	3 7	373	762	12
	ANFO-NM	1.248	38.95	7 15	23	5.580	6.46	3.84E-03	3 78E-10	20	27	0.0040	130	PVC	5.5	505	915	12
	ANFO-NM	1.248	51 15	8.67	23	5.840	6.46	2.66E-03	8.77E-11	19	25	0.0042	188	PVC	6.0	537	1220	12
	HANFO	1.061	60.05	13.00	65	2.900	4 42	3.08E-03	1.21E-10	24	43	0.0010	162	Cb	1 0	711	1000	9
	HANFO	1.061	76.35	17.30	68	3.280	4 42	2.52E-03	1 77E-11	26	33	0 0011	198	Cb	1.0	738	1000	9
	HANFO	1.069	126.8	29.80	12	4.300	4 42	1.58E-03	8.88E-13	32	30	0.0079	316	Cb	1.0	162	1000	9
	HANFO	1 070	40.2	12.20		2.386	4 42							Cb	1 0		1000	9
Quad- ratic Misc. Comp- osite	IRX-3A	1.580	25	1.87	3	7 787	7 87	2.82E-03	3.36E-10	19	9	0.024	177			44		17
	QM100R	1.509	50.8	2.91	13	7 429	7.59	9.91E-04	3.11E-11	9	9	0.0045	505	Cu	10 6	477	1016	1
	QM100R	1.509	50.8	3.29	12	7 420	7.59	1.26E-03	8.23E-12	14	8	0.0048	397	Cu	10 6	396	1016	1
	PBXW-126	1.800	50.8	3.00		6.470		8.80E-04	4.24E-11	8	10		568	Cu	10 6		1016	1
	IRX-4	1.500	25	3 76	16	5.620	6.42	3.83E-03	6.47E-09	30	30	0.0023	131			274	178	16
	PBXW-123	1.920	38.5	6.55		5.560		3.69E-03	6.26E-10	21	31		136	Br	6 4		152	18
Non- Quadratic	PETN	1 743	12.7	0 10		8.201		NA	2.36E-08	3	3			Cu	3.2		305	1
	LX-14	1.825	12.7	0 16		8.778		NA	4.11E-08	4	5			Cu	3.2		305	1
	HMX	1 739	12.7	0 19		8.550		NA	3 72E-08	7	4			Cu			305	1
	LX-10	1.87	25 4	0.26		8.820		NA	8.93E-10	6	3			Cu	6.1		305	1
	LX-04	1.87	25 4	0.39		8.470		NA	1.51E-09	7	5			Cu	6.1		305	1

Table 1, Page 4

Section	Explosive	ρ_0	R_0	L_0	x_c	U_s	D	A	B	Angle	Calc.	G	R_{cur}	mat	(mm)	K(A)	L	ref
Non-Quad. Perturbed	LX-19	1.939	12.7	0.13		9.181		NA	NA	9				Cu	3.2		305	1
	RX-54-AJ	1.82	12.8	0.55		7.650		NA	1.16E-07	13				Cu	2.5		305	1
	RX-08-HD	1.67	12.7	0.62		8.035		NA	1.24E-07	16				Cu	2.6		305	1
Slabs	EDC-35	1.904	5.0			7.56	7.73	1.65E-02	1.62E-05								60	5
	EDC-35 -40°C	1.904	5.0			7.54	7.73	2.09E-02	2.31E-05								60	5
	EDC-35	1.904	10.0			7.62	7.73	6.68E-03	3.70E-07								120	5

D values in italics are thermochemical calculations, not inverse-radius extrapolations.

Table 2a Size Effect Data for Pure and Heterogeneous Explosives

page 1

HOMOGENEOUS EXPLOSIVES- TNT

	Radius Ro (mm)	Us (mm/ μs)	calc <xe> (mm)	G (μs-1* GPa-2)	Rcur (mm)		Radius Ro (mm)	Us (mm/ μs)	calc <xe> (mm)	G (μs-1* GPa-2)	Rcur (mm)
Liq TNT	∞	6 57		19 4		TNT	∞	6 84		17 0	
1 44 g/cc,	75 6	6 55	4 1	0 014	1068	pressed	39 09	6 83	1 0	0 08	817
100oC	47 5	6 53	3 5	0 016	572	unconf	39 09	6 82	1 6	0 05	634
unconf	35 0	6 52	3 1	0 018	381	1 56	19 53	6 83	0 5	0 16	408
ref 21	32 5	6 52	3 1	0 018	344	g/cc	13 02	6 81	0 7	0 11	180
TNT	∞	4 75		5 7		ref 20	9 76	6 80	0 7	0 11	122
pressed	39 08	4 71	3 4	0 14	434	TNT	∞	6 84		18 0	
conf 0 90	19 53	4 66	3 0	0 16	164	pressed	39 07	6 83	1 0	0 07	817
g/cc	13 02	4 63	2 4	0 19	98	conf	19 53	6 83	0 4	0 17	449
ref 20	9 80	4 59	2 3	0 20	66	1 60	13 02	6 83	0 5	0 14	220
TNT	∞	5 22		7 5		ref 20	9 76	6 82	0 5	0 14	141
pressed	39 08	5 18	3 3	0 09	442	TNT	∞	6 91		18 0	
conf	19 53	5 13	2 8	0 11	169	pressed	39 09	6 907	0 5	0 14	1134
1 05	13 02	5 10	2 3	0 13	102	unconf	39 09	6 910			414
ref 20	9 80	5 05	2 2	0 13	68	1 61	19 53	6 903	0 4	0 16	427
TNT	∞	5 69		9 6		g/cc	13 02	6 907	0 2	0 42	378
pressed	39 08	5 66	2 5	0 08	502	ref 20	9 76	6 902	0 2	0 29	204
conf	19 53	5 62	2 2	0 09	189	TNT	∞	6 95		18 9	
1 20	13 02	5 60	1 8	0 11	113	pressed	39 12	6 930	1 7	0 036	605
ref 20	9 80	5 57	1 7	0 12	78	unconf	39 09	6 942	0 9	0 066	820
TNT	∞	6 01		11 3		1 63	39 09	6 941	1 0	0 061	791
pressed	39 08	5 98	2 4	0 063	514	g/cc	36 30	6 928	1 7	0 036	544
conf	39 08	5 99	1 9	0 078	573	ref 20	19 55	6 927	1 0	0 065	288
1 30	19 54	5 96	1 9	0 079	205		19 55	6 944	0 4	0 16	451
g/cc	19 54	5 95	1 9	0 077	201		13 03	6 941	0 3	0 18	263
ref 20	13 03	5 93	1 7	0 089	118		13 02	6 929	0 6	0 10	198
	13 03	5 93	1 6	0 090	120		12 70	6 926	0 6	0 10	185
	9 53	5 90	1 5	0 10	79		9 76	6 933	0 4	0 16	159
TNT	∞	6 47		14 3			9 76	6 937	0 3	0 19	175
pressed	39 12	6 45	1 9	0 05	570		7 62	6 924	0 4	0 15	108
unconf	19 53	6 42	1 6	0 06	223		5 45	6 922	0 3	0 20	75
1 44	9 76	6 37	1 3	0 08	87		4 23	6 905	0 3	0 19	50
ref 20							3 47	6 906	0 3	0 24	41
TNT	∞	6 49		14 3		TNT	∞	6 94		19 0	
pressed	39 12	6 469	1 9	0 05	582	pressed	39 12	6 941			414
conf	39 08	6 466	2 1	0 05	556	conf	19 55	6 938	0 19	0 33	651
1 45	19 54	6 442	1 6	0 06	221	1 64	13 02	6 935	0 23	0 27	319
g/cc	19 53	6 443	1 6	0 06	223	ref 20	9 76	6 933	0 22	0 28	213
ref 20	13 02	6 418	1 4	0 07	129						
	13 02	6 425	1 3	0 08	133	TNT	∞	5 04		4 7	
	9 76	6 401	1 2	0 08	90	pressed	15 0	4 17	10 2	0 06	60
	9 76	6 398	1 3	0 08	88	0 80	12 5	3 98	9 7	0 06	47
TNT	∞	6 70		16 0		g/cc	10 0	3 84	8 5	0 07	35
pressed	39 09	6 68	1 7	0 05	605	unconf	7 0	3 39	7 3	0 07	22
unconf	39 09	6 68	1 5	0 05	643	<385 μm	5 0	2 82	6 4	0 06	15
1 51	19 53	6 66	1 4	0 06	240	ref 37	4 5	2 20	6 8	0 05	12
g/cc	13 02	6 64	1 2	0 07	140		4 0	1 87	6 5	0 04	10
ref 20	9 76	6 63	1 1	0 08	96		3 5	failed			
TNT	∞	6 75		16 0							
pressed	39 07	6 74	0 8	0 11	895						
conf	19 53	6 74	0 5	0 18	407						
1 53	13 02	6 72	0 7	0 11	178						
ref 20	9 76	6 73	0 4	0 21	158						

Table 2a, page 2

TNT						OTHER HOMOGENEOUS EXPLOSIVES					
	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
TNT	∞	5 23		7 0		TNT	∞	7 09		19 4	
pressed	15 00	4 71	7 1	0 04	71	cast	29 0	7 00	3 5	0 02	274
1 00	10 00	4 53	5 8	0 05	43	unconf	20 0	6 98	2 8	0 02	176
g/cc	7 50	4 18	5 7	0 05	28	77 K	17 5	7 00	2 1	0 03	165
unconf	5 00	3 94	4 3	0 06	17	ref 42	16 0	6 99	2 1	0 03	144
<385 μm	4 50	3 44	4 8	0 05	14		15 0	6 97	2 1	0 03	131
ref 37	4 00	failed					12 5	6 96	1 9	0 03	103
							10 0	6 92	1 8	0 03	76
TNT	∞	6 70		14 5			9 0	6 88	1 9	0 03	64
pressed	20 0	6 55	3 5	0 03	156		8 0	6 86	1 8	0 03	55
1 46	15 9	6 50	3 4	0 03	113		7 0	6 82	1 7	0 03	46
g/cc	10 0	6 53	1 9	0 05	75		6 0	6 78	1 6	0 04	37
unconf	7 45	6 45	1 8	0 05	49		5 0	6 74	1 5	0 04	30
<385 μm	5 10	6 39	1 4	0 07	31		4 0	6 75	1 2	0 05	24
ref 37	4 09	6 33	1 3	0 07	24						
	3 08	6 12	1 3	0 07	15	TNT	∞	7 08		19 4	
	2 58	5 96	1 3	0 07	12	cast	28 0	6 98	3 6	0 02	252
	2 34	5 77	1 4	0 06	10	unconf	20 0	6 99	2 3	0 03	192
	2 08	failed				20 K	16 0	6 99	2 0	0 03	149
TNT	∞	6 93		16 6		ref 42	15 0	6 95	2 2	0 03	126
pressed	10 00	6 85	1 1	0 07	97		12 5	6 97	1 7	0 04	111
1 55	7 50	6 79	1 2	0 06	61		10 0	6 94	1 6	0 04	82
g/cc	5 00	6 74	1 0	0 08	37		9 0	6 90	1 7	0 03	68
unconf	4 12	6 72	0 9	0 09	29		8 0	6 89	1 6	0 04	60
<385 μm	2 58	6 60	0 7	0 10	16		7 0	6 84	1 6	0 04	47
ref 37	1 94	6 50	0 7	0 11	11		6 0	6 76	1 7	0 03	37
	1 58	6 34	0 7	0 11	8						
TNT	∞	7 08		20 5							
pressed	15 00	7 00	1 7	0 03	147						
1 62	10 35	7 00	1 1	0 05	101						
g/cc	7 55	6 98	1 0	0 05	69						
unconf	5 10	6 98	0 7	0 08	46						
<385 μm	4 12	6 94	0 7	0 08	34						
ref 37	3 10	6 86	0 7	0 08	22						
	2 08	6 75	0 6	0 09	13						
	1 59	6 63	0 6	0 09	9						
	1 03	failed									
TNT	∞	7 13		20 5							
cast	25 0	6 95	4 7	0 011	187						
1 62	20 0	6 95	3 8	0 014	150						
g/cc	15 0	6 92	3 1	0 017	107						
unconf	10 0	6 82	2 7	0 019	63						
ref 37	7 5	6 61	2 9	0 017	40						
	7 0	failed									
TNT	∞	6 96		19 4							
cast	28 0	6 91	2 3	0 03	323						
unconf	20 0	6 90	1 9	0 03	208						
291 K	17 5	6 87	2 1	0 03	165						
1 615	15 0	6 86	2 0	0 03	135						
g/cc	12 5	6 85	1 7	0 03	110						
ref 42	10 0	6 82	1 7	0 03	80						
	9 0	6 80	1 6	0 04	70						
	8 0	6 68	2 1	0 03	51						

Table 2a, page 3

HOMOGENEOUS EXPLOSIVES

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
PETN	∞	5 277		7 8		RDX	1 41	5 09	0 8	0 31	6
conf	8 25	5 14	1 6	0 17	61						
0 95	7 00	5 06	1 8	0 15	45	Tetryl	∞	5 86		7 7	
g/cc	7 00	5 11	1 5	0 18	49	unconf	37 70	5 77	5	0 06	342
65 μm	5 70	5 01	1 7	0 16	34	0 94	21 95	5 28	10	0 03	105
ref 28	5 70	5 02	1 7	0 16	34	±0 02	15 90	4 86	11	0 02	64
	3 81	4 88	1 5	0 17	20	g/cc	12 70	5 25	6	0 05	60
	3 81	4 86	1 5	0 17	20	600-	12 70	5 27	6	0 05	61
	2 03	4 56	1 2	0 21	9	840 μm	12 70	4 97	8	0 03	53
	2 03	4 58	1 2	0 21	9	ref 38	12 70	5 02	8	0 04	53
	2 03	4 60	1 1	0 22	9		11 11	5 16	6	0 05	50
	2 03	4 58	1 2	0 21	9		11 11	5 07	6	0 04	48
PETN	∞	5 53		8 6			11 11	4 93	7	0 04	46
unconf	11 10	5 57			157		11 11	4 97	7	0 04	46
1 00	9 50	5 50	0 7	0 34	113		9 53	5 34	4	0 07	47
±0 01	9 50	5 47	1 1	0 23	94		9 53	5 02	6	0 05	40
g/cc	7 95	5 42	1 3	0 18	65		9 53	4 84	7	0 04	37
corr Us	6 35	5 40	1 1	0 21	49		7 95	4 52	7	0 04	29
150-	4 77	5 40	0 9	0 27	37		6 35	4 28	6	0 04	21
210 μm	4 77	5 37	1 0	0 23	34		6 35	4 34	6	0 04	22
ref 38	3 18	5 29	0 9	0 26	20		4 67	1 52	8	0 01	11
	3 18	5 18	1 1	0 20	17		4 67	1 99	8	0 01	12
	1 59	5 10	0 6	0 35	8		4 67	2 01	8	0 01	12
	1 59	4 94	0 8	0 27	7		3 18	failed			
PETN	∞	5 53		7 9		Tetryl	∞	5 85		8 3	
unconf	12 70	5 23	4 0	0 07	74	unconf	37 70	5 61	10	0 03	241
0 96	9 50	5 20	3 2	0 08	53	0 98	37 70	5 44	14	0 02	202
+0 01	7 95	5 41	1 3	0 21	64	±0 03	31 50	5 60	9	0 03	199
g/cc	6 35	5 27	1 8	0 15	39	g/cc	31 50	5 66	7	0 04	216
corr Us	6 35	5 35	1 4	0 19	44	300-	25 20	5 76	3	0 08	225
300-	4 77	5 29	1 3	0 21	30	400 μm	25 20	5 59	7	0 04	156
420 μm	4 77	5 31	1 2	0 22	30	ref 38	21 95	5 67	5	0 06	156
ref 38	3 18	5 17	1 1	0 24	17		21 95	5 73	4	0 07	174
	3 18	5 13	1 2	0 22	17		15 90	5 33	7	0 04	78
RDX	∞	6 69		14 5			12 70	5 33	6	0 04	62
unconf	12 70	6 24	4 6	0 02	69		12 70	5 10	7	0 03	56
1 19	11 10	6 38	3 1	0 03	68		12 70	5 20	6	0 04	58
±0 04	11 10	6 42	2 9	0 03	71		11 11	4 95	7	0 03	46
g/cc	9 50	6 43	2 4	0 04	61		11 11	4 97	7	0 03	46
150-210	9 50	6 41	2 5	0 04	61		11 11	5 19	6	0 04	51
μm	7 95	6 70			58		11 11	5 12	6	0 04	49
ref 38	7 95	6 44	2 0	0 05	53		9 53	5 42	4	0 07	51
	6 35	6 83			47		9 53	5 07	5	0 04	41
	6 35	6 83			47		9 53	5 15	5	0 05	43
	4 77	6 60	0 6	0 18	45		7 95	5 36	3	0 07	40
	4 77	6 49	1 0	0 10	34		7 95	5 45	3	0 09	43
	3 18	6 44	0 8	0 13	21		6 35	5 38	3	0 10	33
	3 18	6 47	0 7	0 14	22		6 35	5 27	3	0 08	30
	1 58	5 88	0 8	0 11	7		4 67	5 19	2	0 10	21
	1 58	5 71	1 0	0 09	7		4 67	5 23	2	0 11	22
RDX	∞	5 83		8 2			4 67	4 82	3	0 07	18
unconf	3 45	5 50	1 1	0 24	20		4 67	5 04	3	0 09	20
0 90 g/cc	2 83	5 50	0 9	0 28	16		3 18	4 88	2	0 11	13
ref 49	2 28	5 33	1 0	0 26	11		1 59	failed			
	1 78	5 20	0 9	0 28	8						
	1 76	5 05	1 0	0 24	8						

Table 2a, page 4

HOMOGENEOUS EXPLOSIVES

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
ADNBF	∞	8 23		25 3		NM	∞	6 210		11 9	
1 71	2 98	7 81	0 9	0 04	18	conf	47 63	6 210			
g/cc	2 03	7 72	0 7	0 06	11	1 033	12 70	6 201	0 4	0 39	247
unconf	1 01	7 09	0 6	0 06	4	g/cc	12 69	6 200	0 4	0 37	238
ref 43						33oC	6 395	6 188	0 3	0 43	92
ADNBF	∞	8 26		26 7		ref 22	6 350	6 190	0 3	0 46	94
1 75	2 03	7 81	0 6	0 06	12		3 165	6 169	0 2	0 57	37
g/cc	1 01	7 31	0 5	0 06	5		3 215	6 166	0 3	0 53	37
unconf	1 01	7 43	0 5	0 07	5		1 525	6 125	0 2	0 72	14
ref 43							1 500	6 128	0 2	0 75	14
DNBF	∞	7 55		22 1			1 21	failed			
1 58	6 38	7 42	0 9	0 05	55	NM	∞	6 236		11 9	
g/cc	2 98	7 41	0 4	0 11	25	unconf	18 42	6 233	0 2	0 57	517
unconf	2 03	7 45	0 3	0 19	19	1 130	18 42	6 227	0 5	0 27	360
ref 43	2 03	7 31	0 4	0 11	14	g/cc	15 46	6 233	0 2	0 67	434
	1 01	7 09	0 3	0 14	6	ref 4	13 78	6 228	0 4	0 39	279
DNBF	∞	7 80		24 6			13 70	6 229	0 3	0 43	291
1 66	6 38	7 62	1 2	0 03	49		11 06	6 226	0 3	0 42	208
g/cc	2 98	7 54	0 7	0 06	20		9 67	6 220	0 4	0 35	156
unconf	2 98	7 58	0 6	0 07	21		9 58	6 221	0 4	0 37	157
ref 43	2 03	7 46	0 6	0 07	13		9 57	6 196	0 7	0 19	113
	1 01	6 79	0 6	0 06	4		8 63	6 212	0 5	0 30	120
DNBF	∞	7 65		25 5			8 33	6 199	0 6	0 23	101
1 69	2 03	7 52	0 3	0 13	18		8 32	6 220	0 3	0 41	134
g/cc	1 01	7 48	0 2	0 21	8	EDNA	∞	6 2		9 4	
unconf	0 76	7 33	0 2	0 18	5	unconf	99 45	6 13			980
ref 43						1 00	99 45	6 16			1173
2,4-	∞	4 33		4 8		±0 03	99 45	6 08	16	0 014	810
DNT	10 00	3 89	5	0 11	47	g/cc	99 45	6 13			971
unconf	8 00	3 78	4	0 12	36	150-	99 45	5 70			512
0 95	6 25	3 59	4	0 12	25	210 μm	99 45	5 75			532
g/cc	5 00	3 27	4	0 11	17	ref 38	37 70	6 38			277
ref	3 13	2 88	3	0 12	10		37 70	6 30			277
3 6	2 50	2 45	3	0 11	7		12 70	5 43	7	0 03	56
DINGU	∞	4 5		4 8			12 70	5 52	6	0 03	58
unconf	30	4 0	15	0 04	138		11 10	5 32	7	0 03	47
0 80 g/cc	10	3 0	11	0 04	32		11 10	5 38	6	0 03	48
ref 39							9 50	5 16	6	0 03	38
DINGU	∞	5 9		8 2			9 50	5 37	5	0 04	41
1 05 g/cc	30	5 2	16	0 016	135		7 95	5 37	5	0 04	34
ref 39	10	3 8	11	0 016	31		7 95	5 45	4	0 05	35
DINGU	∞	6 46		13			6 35	5 34	4	0 05	27
unconf	30	6 1	10	0 013	174		6 35	5 47	3	0 06	29
1 30 g/cc	20	6 0	8	0 016	107		4 77	4 99	4	0 05	18
ref 39	10	5 45	6	0 017	41		4 77	5 21	3	0 06	20
DINGU	∞	7 26		16			3 18	4 14	3	0 04	10
unconf	20	6 8	7	0 012	110		3 18	3 56	4	0 03	9
1 45 g/cc	10	6 45	5	0 016	46	EDNA	∞	6 1		9 5	
ref 39	6	5 8	5	0 016	23	unconf	12 70	5 49	6	0 03	60
DINGU	∞	7 5		20		0 99	12 70	5 44	6	0 03	58
unconf	20	7 25	5	0 012	136	± 0 02	12 70	5 61	5	0 04	65
1 60 g/cc	10	7 05	3	0 016	56	g/cc	12 70	5 68	5	0 04	69
ref 39	6	6 7	3	0 018	28	370-	11 10	5 14	7	0 03	46
						420 μm	11 10	5 39	6	0 03	50
						ref 38	11 10	5 56	5	0 04	54
							11 10	5 64	4	0 05	58

Table 2a, page 5

HOMOGENEOUS EXPLOSIVES

	Ro	Us	<xe>	G	Rcur	Ro	Us	<xe>	G	Rcur
EDNA	9 50	5 39	5	0 04	43					
unconf	9 50	5 32	5	0 04	42					
0 99	9 50	5 56	4	0 05	46					
g/cc	9 50	5 58	4	0 05	47					
unconf	7 95	5 00	6	0 03	31					
370-	7 95	5 22	5	0 04	34					
420 μ m	7 95	5 47	4	0 05	37					
ref 38	7 95	5 34	4	0 04	35					
	6 35	5 21	4	0 05	27					
	6 35	4 77	5	0 03	24					
	6 35	5 20	4	0 05	26					
	6 35	5 24	4	0 05	26					
	4 77	4 09	5	0 03	15					
	4 77	4 86	4	0 05	18					
	4 77	4 86	4	0 05	18					
	4 77	4 98	3	0 05	19					
	3 18	3 46	4	0 03	9					
	3 18	3 49	4	0 03	9					
NTO	∞	7 78		25						
1 75	20	7 72	1 7	0 02	222					
g/cc	14	7 74	0 9	0 04	177					
unconf	10	7 65	1 5	0 03	85					
450 μ m	9	7 69	1 0	0 04	87					
ref 25	7	failed								
NTO	∞	8 42		28 6						
1 84	14	8 19	3	0 011	102					
g/cc	10	8 04	3	0 011	62					
unconf	9	7 97	3	0 011	52					
ref 25	7	7 93	2	0 013	40					
NTO	∞	8 23		28 6						
1 85	20	8 09	3	0 011	172					
g/cc	14	8 12	2	0 018	129					
unconf	10	8 02	2	0 017	75					
450 μ m	9	7 97	2	0 016	63					
ref 25	8	failed								
NTO	∞	8 25		28 6						
1 87	18 00	8 18	2	0 019	192					
g/cc	16 26	8 16	2	0 019	163					
unconf	14 46	8 17	1	0 022	150					
250 μ m	12 88	8 14	2	0 021	121					
LANL	12 68	8 14	2	0 021	121					
ref 24	12 70	failed								
picric	∞	5 25		6 2						
acid	8 57	4 92	3	0 14	47					
0 90 g/cc	4 35	4 58	2	0 16	19					
unconf	3 90	4 42	3	0 15	16					
ref 49	3 06	4 32	2	0 17	12					
	2 48	4 06	2	0 17	9					
	2 08	4 08	2	0 20	7					
	2 03	3 69	2	0 16	7					
	1 52	2 48	2	0 10	4					
	1 36	2 23	2	0 09	4					

Table 2a, page 6

HETEROGENEOUS-<20% BINDER

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
XTX-	∞	7 307		18		NM	4 77	4 916	4	0 03	18
8003	1 02	7 248	0 09	0 8	11 2	silica	last one failing				
1 53	0 45	7 244	0 04	1 7	4 8	X-0219	∞	7 684		26 3	
g/cc	0 26	7 167	0 04	1 7	2 1	unconf	25 40	7 555	4	0 010	220
unconf	0 19	7 087	0 04	1 7	1 4	1 91	20 60	7 531	3	0 010	168
ref 22						g/cc	12 70	7 462	3	0 013	92
Comp	∞	8 300		27		ref 22	12 70	7 457	3	0 013	90
A	12 69	8 262	0 8	0 05	167		12 70	7 453	3	0 013	90
1 69	6 35	8 254	0 4	0 08	79		9 00	7 397	2	0 015	60
g/cc	4 23	8 236	0 4	0 10	47		7 95	7 380	2	0 017	52
ref 22	3 18	8 213	0 3	0 11	32		7 00	failed			
	2 54	8 172	0 3	0 10	22	EDC-35	∞	7 72		27 5	
	2 12	8 143	0 3	0 11	18	1 90	63 50	7 690	3 5	0 009	886
PBX-	∞	8 805		34 5		g/cc	25 40	7 67	2 7	0 012	300
9404	73 00	8 800	1 1	0 02	1941	ref 5,	25 40	7 639	2 7	0 012	255
unconf	73 00	8 803	0 6	0 04	2631	29	12 70	7 586	1 9	0 017	108
1 83	19 05	8 789	0 6	0 04	342		6 35	7 485	1 4	0 023	45
g/cc	12 70	8 774	0 6	0 04	184		5 00	7 44	1 2	0 03	33
ref 22	12 70	8 775	0 6	0 04	185	EDC-35	∞	7 92		27 5	
	11 45	8 793	0 3	0 08	226	-40oC	63 50	7 813	8	0 004	585
	8 16	8 789	0 3	0 09	147	ref 29	25 40	7 648	6	0 005	172
	6 35	8 776	0 3	0 08	94		12 70	7 586	3	0 009	80
	3 19	8 731	0 3	0 08	34		6 35	7 423	2	0 014	35
	1 44	8 651	0 2	0 11	12	PBX-	∞	7.78		27 5	
	1 40	8 668	0 2	0 12	12	9502	54 00	7 729	4 2	0 008	637
	1 00	8 525	0 2	0 10	7	unconf	25 00	7 664	3 3	0 010	221
	0 75	8 355	0 2	0 10	4	1 890	25 00	7 667	3 3	0 010	225
	0 64	7 874	0 3	0 07	3	±0 003	15 75	7 624	2 6	0 013	128
	0 61	7 279	0 4	0 05	2	g/cc	11 65	7 586	2 2	0 015	87
	0 58	failed				24°C	9 00	7 557	1 9	0 017	65
PBX-	∞	8 82		35 1		ref 26	9 00	7 552	1 9	0 017	64
9501	12 70	8 79	0 6	0 04	185		6 00	7 503	1 4	0 022	40
unconf	12 70	8 791	0 6	0 04	187		5 00	7 475	1 3	0 025	33
1 83	12 70	8 792	0 6	0 04	191		4 50	7 456	1 2	0 03	28
g/cc	2 51	8 728	0 3	0 09	25		4 25	7 42	1 2	0 03	26
ref 22	1 42	8 612	0 3	0 09	11		4 00	7 421	1 1	0 03	24
	1 01	8 487	0 2	0 09	7		3 75	failed			
	0 79	8 259	0 3	0 08	4	PBX-	∞	7 723		27 5	
NM-	∞	6 550		11		9502	25 00	7 648	2 5	0 013	257
silica-	18 60	6 143	6	0 03	104	75oC	16 50	7 614	2 1	0 015	150
guar	18 45	6 14	2 5	0 06	162	unconf	9 00	7 548	1 6	0 020	70
unconf	9 57	6 128	1 4	0 12	82	1 892	6 00	7 501	1 2	0 026	43
1 17	8 95	6 113	1 4	0 11	73	±0 002	5 00	7 477	1 1	0 03	34
g/cc	6 80	6 086	1 2	0 13	52	ref 26	4 00	7 439	1 0	0 03	26
ref 4	6 74	6 093	1 2	0 13	52		3 00	7 377	0 8	0 04	19
	6 63	6 071	1 3	0 12	49		failed				
	5 81	5 978	1 5	0 10	37	PBX-	∞	7 691		27 5	
	5 78	5 973	1 5	0 10	37	9502	25 00	7 67	1 1	0 030	392
	5 50	5 777	2 1	0 07	29	-55oC	25 00	7 665	1 2	0 026	367
	5 43	5 818	2 0	0 08	29	unconf	16 50	7 616	1 7	0 019	170
	5 43	5 893	1 7	0 09	31	1 891	9 00	7 546	1 4	0 023	75
	5 43	5 854	1 9	0 08	30	±0 002	7 15	7 485	1 4	0 022	53
	5 31	5 872	1 8	0 09	30	ref 26	6 00	7 465	1 3	0 025	43
	5 27	5 772	2 1	0 07	28		5 50	7 424	1 3	0 024	37
	5 26	5 869	1 8	0 09	30		5 25	7 398	1 3	0 024	34
	5 07	5 399	2 9	0 05	22						

Table 2a, page 7

HETEROGENEOUS-<20% BINDER

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
EDC-35	∞	7 76		27 5		70%	∞	7 45		15	
SLAB	10 0	7 62	2 4	0 014	67	RDX-	25 0	7 44	0 67	0 16	497
unconf	5 0	7 56	1 5	0 021	30	urethane	15 0	7 42	0 84	0 13	207
LX-17	∞	7 713		26 8		1 45 g/cc	10 0	7 41	0 67	0 16	126
conf	25 4	7 621	2 9	0 012	244	6 μm	7 5	7 38	0 73	0 14	78
ref 1	12 7	7 528	2 3	0 014	97	ref 6, 7	5 0	7 37	0 54	0 20	50
T2	∞	7 646		27		70%	∞	7 45		15	
unconf	5 0	7 633	1 6	0 02	921	RDX-	24 0	7 37	2 61	0 04	238
ref 13	25	7 62	1 2	0 03	364	urethane	14 8	7 33	2 13	0 05	128
RDX	∞	8 50		22 8		1 45 g/cc	9 9	7 22	2 18	0 05	70
94 6/	6 38	7 59	3 2	0 015	30	127 μm	7 5	7 12	2 08	0 05	46
pew	6 38	7 57	3 2	0 014	30	70%	∞	7 45		15	
unconf	2 96	6 10	2 8	0 013	10	RDX-	25 0	7 39	2 21	0 05	275
1 56 g/cc	2 00	fail				urethane	15 0	7 22	3 25	0 03	105
ref 43						1 45 g/cc	10 0	6 84	4 15	0 02	51
RDX	∞	8 50		24 0		134 μm					
97 8/	6 38	7 96	2 2	0 020	35	70%	∞	7 45		15	
pcw	2 96	7 38	1 7	0 024	13	RDX-	24 2	7 32	3 52	0 03	210
unconf	2 00	6 48	1 7	0 021	7	urethane	15 0	7 03	4 90	0 02	85
1 56 g/cc	1 54	5 44	1 7	0 018	5	1 45 g/cc					
ref 43	1 01	fail				307 μm					
RDX	∞	8 49		26 9		70%	∞	7 45		15	
97 8/	6 35	8 30	1 1	0 03	50	RDX-	24 2	7 27	4 37	0 02	187
pew	6 35	8 25	1 3	0 03	46	urethane	14 9	6 87	6 00	0 02	77
unconf	2 96	8 04	0 9	0 04	17	1 45 g/cc					
1 64 g/cc	2 00	7 97	0 7	0 05	11	428 μm					
ref 43	1 54	7 89	0 6	0 06	8	72%	∞	8 17		15 5	
	1 01	7 21	0 6	0 05	4	RDX-	10 0	7 88	2 40	0 04	67
RDX	∞	8 58		29 7		urethane	9 0	7 84	2 35	0 04	58
97 8/	2 96	8 47	0 37	0 08	27	no 3	9 0	7 79	2 57	0 04	55
pew	2 96	8 48	0 33	0 09	29	ref 40	9 0	7 94	1 84	0 06	65
unconf	2 00	8 46	0 26	0 12	18		7 5	7 84	1 96	0 05	48
1 71 g/cc	1 01	8 29	0 23	0 13	7		7 5	7 87	1 83	0 06	50
ref 43							5 0	7 61	1 83	0 06	27
						72%	∞	7 73		15 5	
						RDX-	15 0	7 39	4 12	0 02	93
						urethane	15 0	7 46	3 56	0 03	101
						no 5	10 0	7 44	2 44	0 04	66
						ref 40	10 0	7 51	2 04	0 05	72
							9 0	7 51	1 86	0 05	65
							7 5	7 35	2 22	0 04	45
							7 5	7 42	1 93	0 05	48
							5 0	7 01	2 25	0 04	25

Table 2b Size Effect Data for Binary and Composite Explosives

page 1

BINARY EXLOSIVES											
	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
Comp B	∞	7 92		26 8		Octol	∞	8 472		32 2	
Type I	12 75	7 868	1 0	0 04	149	unconf	25 40	8 452	1 0	0 03	418
<400 μm	12 75	7 887	0 7	0 05	175	1 82	19 06	8 45	0 8	0 03	305
RDX	12 40	7 869	0 9	0 04	146	g/cc	11 45	8 415	0 9	0 03	134
1 71	12 40	7 864	1 0	0 03	143	ref 22	11 45	8 427	0 8	0 03	144
g/cc	12 40	7 847	1 2	0 03	130		8 15	8 402	0 7	0 04	89
ref 23	6 35	7 816	0 8	0 04	59		8 15	8 4	0 7	0 03	88
	6 35	7 819	0 8	0 05	59		6 36	8 357	0 8	0 03	59
	5 00	7 787	0 7	0 05	43		3 17	8 161	0 8	0 03	21
	5 00	7 792	0 7	0 05	44	X-0341	∞	7 82		28 1	
	5 00	7 755	0 8	0 04	40	1 90 g/cc	25 0	7 75	2 4	0 01	265
	4 24	7 738	0 8	0 05	33	unconf	9 0	7 64	1 6	0 019	69
	4 24	7 742	0 7	0 05	33	ref 41	4 5	7 48	1 2	0 025	28
	3 98	7 738	0 7	0 05	31	HMX	4 0	7 41	1 2	0 024	23
	3 98	7 725	0 7	0 05	30	15 μm					
	3 98	7 746	0 7	0 05	32	TATB					
	3 18	7 648	0 7	0 05	22	60 μm					
	3 18	7 650	0 7	0 05	22	X-0342	∞	7 87		28 5	
	2 81	7 572	0 8	0 04	18	1 90 g/cc	25 0	7 82	1 9	0 02	296
	2 81	7 561	0 8	0 04	18	unconf	9 0	7 72	1 4	0 02	73
	2 55	7 476	0 8	0 04	15	ref 41	4 5	7 59	1 1	0 03	30
	2 54	7 476	0 8	0 04	14		4 0	7 56	1 0	0 03	26
	2 32	7 326	0 9	0 04	12		3 5	7 50	1 0	0 03	21
	2 30	7 308	0 9	0 04	12	X-0343	∞	7 91		29 0	
	2 23	7 092	1 1	0 03	10	1 90 g/cc	25 0	7 88	1 3	0 02	360
	2 22	7 066	1 1	0 03	10	unconf	9 0	7 79	1 2	0 02	81
	2 14	6 709	1 3	0 02	9	ref 41	4 5	7 70	0 9	0 03	33
	2 14	failed					3 5	7 64	0 8	0 04	23
							3 0	7 59	0 8	0 04	19
Comp B	∞	7 92		26 8		X-0344	∞	8 05		29 5	
Type II	12 45	7 743	2 2	0 02	97	1 89 g/cc	25 0	8 03	1 1	0 03	389
400-800 μm	12 42	7 789	1 8	0 02	107	unconf	9 0	7 96	1 0	0 03	89
	12 45	7 787	1 8	0 02	108	ref 41	4 5	7 87	0 8	0 04	35
RDX	6 37	7 631	1 5	0 02	42	HMX	4 0	7 85	0 8	0 04	30
1 71	6 37	7 643	1 5	0 02	43	15 μm	3 5	7 83	0 7	0 04	26
g/cc	6 37	7 664	1 4	0 02	44	TATB	3 0	7 80	0 6	0 04	21
ref 23	4 24	7 503	1 3	0 03	25	60 μm	2 0	7 67	0 6	0 05	12
	4 24	7 516	1 3	0 03	25	PBXW-7	∞	7 56		17 3	
	4 20	7 485	1 3	0 02	24	Type II	6 38	7 32	1 4	0 06	44
	3 91	7 394	1 4	0 02	21	1 51 g/cc	2 96	6 79	1 4	0 05	14
	3 91	7 481	1 2	0 03	23	ref 43	1 54	6 33	1 0	0 07	6
	3 75	7 372	1 4	0 02	20	PBXW-7	∞	7 92		23 0	
	3 75	7 458	1 2	0 03	21	Type II	6 38	7 78	0 9	0 05	54
	3 58	7 233	1 5	0 02	18	1 70 g/cc	6 38	7 69	1 3	0 04	46
	3 60	7 268	1 5	0 02	19	unconf	6 38	7 89	0 3	0 15	94
	3 56	7 369	1 3	0 02	19	ref 43	2 96	7 49	0 9	0 05	17
	3 56	7 273	1 5	0 02	18		2 96	7 40	1 1	0 04	16
							2 96	7 60	0 8	0 06	19
Cyclotol	∞	8 208		29 4			2 01	7 40	0 7	0 06	11
unconf	50 80	8 217					2 01	7 44	0 7	0 07	11
1 74	25 40	8 204					1 54	7 28	0 6	0 07	8
g/cc	12 70	8 160	0 9	0 03	155		1 01	fail			
ref 22	8 45	8 107	1 0	0 03	80	BX-4	∞	7 90		24 8	
probably	6 35	8 116	0 7	0 04	63	1 75 g/cc	12 70	7 80	1 6	0 026	118
77-23	4 25	8 012	0 8	0 04	32	unconf	10 00	7 78	1 3	0 030	89
	3 65	7 859	1 0	0 03	23	ref 43	6 35	7 70	1 2	0 033	47
	3 20	7 664	1 2	0 02	17						
	2 80	failed									

Table 2b, page 2 COMPOSITES - ANFO											
	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
QM-100	∞	6 53		10		ANFO	∞	4 74		4 6	
unconf	152 40	6 29	37	0 006	1008	0 80 g/cc	146 0	4 56	36	0 019	944
1 26	76 20	6 05	29	0 007	407	unconf,	146 0	4 55	38	0 018	933
g/cc	50 80	5 81	26	0 008	233	ref 32	51 0	3 89	36	0 016	200
ref 1,	38 10	5 58	23	0 008	159		25 5	3 25	26	0 019	81
35	30 48	5 38	21	0 009	120	HANFO	∞	5 350		6 2	
	25 40	5 10	20	0 009	92	1 069	126 8	4 302	94	0 004	487
						5					
	19 05	4 62	18	0 009	62	g/cc	92 40	3 732	92	0 003	302
ANFO	∞	5 88		9 2		ref 9	92 40	3 512	100	0 003	285
SW	44 00	5 62	12	0 017	272		76 35	3 277	89	0 003	228
unconf	44 00	5 61	12	0 017	269		60 05	2 904	78	0 003	174
1 16	39 30	5 64	10	0 021	251		50 40	2 581	71	0 003	139
g/cc	28 30	5 45	11	0 019	151		50 40	2 657	70	0 003	141
ref 10,	24 00	5 38	10	0 020	120		44 85	2 364	67	0 003	123
11	19 00	5 35	8	0 024	93		40 15	2 386	60	0 003	110
	17 00	5 21	9	0 022	76		35 10	2 288	53	0 004	91
	17 00	5 07	10	0 019	74		35 10	2 164	55	0 003	90
	16 80	5 37	7	0 028	84		30 30	1 917	50	0 003	77
	10 85	4 53	9	0 019	39		29 00	1 932	47	0 003	74
	10 60	4 53	9	0 020	38		23 00	failed			
	10 25	4 65	8	0 022	37	QM-100R	∞	7 20		13 9	
	10 25	4 74	8	0 024	39	80-20/6	37 5	4 98	38	0 002	123
	8 50	4 32	8	0 021	29	1 41 g/cc	31 5	4 23	38	0 002	94
	8 50	4 38	8	0 022	30	fresh	25 0	fail			
	6 80	3 74	8	0 019	21	unconf	19 0	fail			
	6 50	3 67	7	0 019	20	ref 34					
	6 00	failure				QM-100R	∞	7 20		14 6	
ANFO	∞	4 50		6 4		80-20/8	37 5	5 19	35	0 002	128
0 95	49 21	4 43	7	0 053	439	1 45 g/cc	31 5	4 70	34	0 002	97
g/cc	42 79	4 39	8	0 044	325	fresh	25 0	fail			
ref 33	44 24	4 27	13	0 025	262	unconf	19 0	fail			
	39 37	4 27	12	0 028	230	ref 34					
	36 79	4 30	10	0 033	227	QM-100R	∞	6 27		15 4	
	35 15	4 16	14	0 023	184	70-30/6	37 5	6 05	9	0 009	251
	31 25	4 06	15	0 022	151	1 44 g/cc	31 5	5 91	10	0 008	179
	30 05	4 13	12	0 026	153	fresh	25 0	5 91	8	0 010	142
	26 60	4 08	12	0 026	127	unconf	19 0	5 77	8	0 010	98
	24 01	3 97	13	0 024	108	ref 34	16 0	fail			
	21 17	3 84	13	0 023	90		12 5	fail			
	19 11	3 76	13	0 023	77	QM-100R	∞	7 60		16 5	
	16 40	3 71	11	0 026	64	60-40/8	75 0	7 26	21	0 004	463
	14 47	3 47	12	0 023	52	1 46 g/cc	62 5	7 22	19	0 005	374
	13 21	3 406	11	0 023	46	fresh	50 0	7 06	19	0 004	265
	12 15	3 241	11	0 022	42	unconf	37 5	7 06	14	0 006	200
ANFO	∞	6 464		9 5		ref 34	31 5	6 68	17	0 005	139
NM	101 35	6 156	29	0 007	619		25 0	6 35	17	0 005	100
1 248	51 15	5 835	24	0 009	247		19 0	6 20	14	0 005	75
g/cc	38 95	5 575	23	0 009	169		16 0	6 05	12	0 006	60
unconf	26 25	5 275	19	0 010	102		12 5	5 52	12	0 006	43
ref 12	20 45	4 862	18	0 010	71		9 5	fail			
	15 95	4 044	18	0 008	49						
RX-HD	∞	5 5		12 5							
1 34	84 38	5 2	27	0 004	486						
g/cc	84 38	4	78	0 001	285						
31	62 50	4 4	47	0 002	238						
ref 1, 31	50 80	failure									

Table 2b, page 3

COMPOSITES - ANFO

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
QM-100R	∞	7 74		16 5		HMX 20,	∞	7 59		15 5	
60-40/8	62 5	7 15	25	0 003	328	emulsion	27 45	5 45	26	0 0028	95
1 48 g/cc	50 0	7 06	22	0 004	244	un&conf	11 12	2 41	19	0 0017	28
60 days	37 5	7 06	16	0 005	183	1 47 g/cc	10 24	1 86	19	0 0013	25
old	31 5	6 87	16	0 005	145	ref 48	9 49	1 42	18	0 0010	22
unconf	25 0	6 87	13	0 006	115		8 90	0 71	18	0 0005	20
ref 34	19 0	6 51	12	0 006	78		8 33	failed			
	16 0	6 20	12	0 006	61	HMX 30,	∞	7 42		17 3	
	12 5	5 29	13	0 005	40	emulsion	28 04	6 96	10	0 0077	154
QM-100R	∞	7 86		17 2		un&conf	13 44	6 25	9	0 0077	55
60-40/6	37 5	7 06	18	0 004	177	1 51 g/cc	13 44	6 01	10	0 0066	51
1 47 g/cc	31 5	6 68	20	0 004	130	ref 48	10 93	6 32	7	0 0101	46
fresh	25 0	6 68	16	0 005	103		9 21	6 17	6	0 0106	37
unconf	19 0	5 91	17	0 004	66		8 22	5 85	6	0 0097	31
ref 34	16 0	5 91	14	0 005	56		7 09	5 02	7	0 0073	23
	12 5	fail					6 14	5 10	6	0 0088	20
QM-100R	∞	7 62		17 2			5 51	3 40	8	0 0045	15
60-40/6	37 5	7 06	14	0 005	200		4 96	2 53	8	0 0033	12
1 50 g/cc	31 5	6 68	17	0 004	139		5 00	failed			
60 days	25 0	6 51	15	0 005	105	HMX 40,	∞	7 51		19 6	
old	19 0	6 20	14	0 005	75	emulsion	13 44	7 08	4	0 013	76
unconf	16 0	6 05	12	0 005	60	un&conf	6 29	6 64	3	0 017	28
ref 34	12 5	fail				1 55 g/cc	6 32	6 52	4	0 015	27
QM-100R	∞	7 58		18 1		ref 48					
50-50/8	75 0	7 47	10	0 007	674	HMX 50,		8 74		21 7	
1 48 g/cc	62 5	7 47	8	0 009	562	emulsion	13 30	7 75	7	0 008	60
fresh	50 0	7 33	11	0 006	347	un&conf	6 26	7 47	4	0 013	27
unconf	37 5	7 27	10	0 007	240	1 60 g/cc	6 32	7 27	4	0 012	25
ref 34	31 5	7 06	12	0 006	170	ref 48	4 80	6 64	4	0 011	17
	25 0	7 06	9	0 007	135		3 66	5 85	4	0 010	12
	19 0	6 87	9	0 008	92		3 28	3 83	5	0 005	9
	16 0	6 68	9	0 008	72		3 13	failed			
	12 5	6 51	7	0 009	53						
	9 5	6 35	6	0 010	38						
QM-100R	∞	7 74		18 1							
50-50/8	62 5	7 62	9	0 009	549						
1 50 g/cc	50 0	7 47	12	0 006	335						
60 days	37 5	7 26	13	0 005	209						
old	31 5	7 06	14	0 005	154						
unconf	25 0	6 87	13	0 005	115						
ref 34	19 0	6 68	11	0 006	82						
	16 0	6 68	9	0 007	69						
	12 5	6 05	10	0 006	47						
	9 5	6 05	8	0 008	35						

Table 2b, page 4

COMPOSITES - NON-ALUMINIZED

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
Amatol	∞	6 71		18 4		Amatol	∞	5 22		7 8	
50/50	88 9	6 35	28	0 002	515	50	123	4 71	58	0 004	594
unconf	63 5	6 28	22	0 003	350	10 g/cc	80	4 31	55	0 004	310
1 53 g/cc	63 5	6 48	15	0 004	430	TNT 150-	63 6	4 18	48	0 005	243
type 1	63 5	6 30	22	0 003	353	300 μm	63 6	4 27	45	0 005	250
AN un-	63 5	6 26	23	0 003	343	AN 840-	63 6	4 30	44	0 005	250
sieved,	63 5	6 23	24	0 002	339	1200 μm	49 7	4 15	38	0 006	186
cast	50 8	6 46	12	0 005	336	packed,	49 7	4 03	41	0 005	179
ref 30	50 8	6 01	25	0 002	241	unconf	49 7	4 05	40	0 005	181
	50 8	6 43	14	0 004	321	ref 30	44 1	3 88	39	0 005	154
	50 8	6 54	10	0 006	381		44 1	3 91	39	0 005	154
	50 8	6 00	25	0 002	235		44 1	4 00	37	0 006	158
	50 8	6 22	19	0 003	272		37 7	3 75	36	0 006	127
	38 1	6 27	14	0 004	210		37 7	3 99	32	0 007	136
	38 1	6 12	17	0 003	187		37 7	3 97	32	0 007	132
	38 1	5 95	20	0 003	176		31 5	3 82	29	0 007	106
	38 1	5 81	22	0 003	165		31 5	3 75	30	0 007	106
	38 1	6 02	18	0 003	179		31 5	3 86	28	0 007	106
	25 2	5 54	17	0 003	99		25 2	3 72	24	0 008	82
	25 2	5 46	18	0 003	96		25 2	3 89	22	0 009	88
	25 2	5 41	19	0 003	96		25 2	3 75	24	0 008	85
	25 2	5 20	21	0 002	91		19 15	3 79	18	0 011	65
	25 2	5 22	20	0 002	90		19 15	3 58	19	0 010	62
	25 2	5 59	17	0 003	101		12 65	2 95	16	0 010	37
	25 2	5 09	21	0 002	88		12 65	3 05	15	0 010	37
	25 2	5 60	17	0 003	101		9 5	2 83	12	0 012	28
	19 05	4 89	18	0 003	65		9 5	3 27	11	0 016	29
	19 05	4 51	20	0 002	61		9 5	2 73	13	0 011	27
	17 5	failed					9 5	2 68	13	0 011	27
Amatol	∞	6 62		18 4			8	2 32	12	0 010	22
50/50	99 50	6 37	25	0 002	643		8	2 41	12	0 011	22
unconf	99 50	6 37	25	0 002	658		6 4	1 77	11	0 009	16
1 53 g/cc	88 9	6 32	25	0 002	543		6 4	1 87	10	0 009	16
type 2	79 0	6 28	24	0 002	467		6 4	1 83	11	0 009	16
AN 600-	79 0	6 32	22	0 003	488		6 4	1 82	11	0 009	16
840 μm,	63 5	6 30	18	0 003	388		6 25	failed			
cast	63 5	6 35	17	0 004	406	Amatex	∞	7 00		17 7	
ref 30	51 0	6 25	16	0 004	295	20	50 8	6 94	5	0 015	553
	51 0	6 24	17	0 004	289	unconf	25 4	6 84	4	0 016	198
	44 5	6 14	17	0 003	235	1 61 g/cc	12 7	6 53	5	0 015	69
	44 5	6 16	16	0 004	240	ref 22	8 5	6 03	5	0 012	37
	38 1	6 07	16	0 004	189	Comp B-	∞	7 75		22 8	
	38 1	6 09	16	0 004	196	AN	64	7 51	14	0 003	450
	31 5	5 847	17	0 003	142	79-21	64	7 53	13	0 003	461
	31 5	5 847	17	0 003	142	1 59 g/cc	50 5	7 54	10	0 005	369
	25 2	5 405	18	0 003	97	AN 840-	50 5	7 51	11	0 004	355
	25 2	5 19	20	0 002	94	1200 μm	37 8	7 43	10	0 005	239
	25 2	5 199	20	0 002	94	unconf	37 8	7 57	7	0 007	291
	25 2	5 207	20	0 002	94	ref 30	37 8	7 51	8	0 006	266
	25 2	5 195	20	0 002	94		25 4	7 55	5	0 009	188
	19 05	4 765	18	0 003	65		25 4	7 76			298
	19 05	failed					25 4	7 61	4	0 012	212
	17	failed					25 4	7 49	6	0 008	172
							25 4	7 53	5	0 009	183
							19 1	7 27	7	0 007	106
							19 1	7 36	6	0 008	112

Table 2, page 5

COMPOSITES: NON-ALUMINIZED & PBXN-111

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
Comp B-	19 1	7 28	7	0 007	106	PBXN-	∞	5 95		20 5	
AN	19 1	7 38	6	0 008	117	111	50 01	5 637	15	0 003	296
79-21	19 1	7 21	7	0 006	102	Navy	24 22	5 611	8	0 005	137
	12 4	7 05	5	0 008	61	conf,	33 96	5 757	8	0 006	233
	12 4	7 05	5	0 008	61	sizes (μm)	23 44	5 600	8	0 005	133
	12 4	7 00	6	0 007	60	RDX 60	18 94	5 499	7	0 006	99
	12 4	7 13	5	0 009	64	AP 200	12 66	5 123	7	0 005	54
	12 4	7 14	5	0 009	64	Al 5	12 47	5 098	8	0 005	53
	12 4	7 14	5	0 009	64	1 79	12 41	5 112	7	0 005	53
	8 55	6 87	4	0 010	39	g/cc	9 55	4 840	7	0 005	37
	8 55	6 78	5	0 009	38	ref 8	9 50	4 855	7	0 005	37
	8 55	6 77	5	0 009	38		7 94	failed			
	8 55	6 86	4	0 010	38	PBXN-	∞	5 95		20 5	
	8 55	6 86	4	0 010	38	111	49 95	5 632	16	0 003	289
	6 85	6 70	4	0 010	30	Navy	34 55	5 540	13	0 003	187
	6 85	6 70	4	0 010	30	unconf,	34 12	5 572	12	0 004	188
	6 85	failed				sizes (μm)	24 95	5 315	12	0 003	115
Prop-	∞	6 60				RDX 60	24 85	5 331	12	0 003	117
ellant	95 25	6 52	12			AP 200	24 80	5 365	12	0 004	120
B	95 25	6 55	9			Al 5	24 80	5 421	11	0 004	122
55-60 μm	95 25	6 44	17			1 79	24 78	5 365	12	0 004	119
AP	76 20	6 44	14			g/cc	24 06	5 311	12	0 003	110
unconf	76 20	6 44	14			ref 8	24 01	5 309	12	0 003	110
ref 46	76 20	6 44	14				23 45	5 383	11	0 004	112
	50 80	6 42	10				22 25	5 228	12	0 003	99
	50 80	6 39	11				20 55	5 19	11	0 003	90
	50 80	6 41	10				20 52	5 158	12	0 003	89
	31 75	6 27	9				20 45	5 154	12	0 003	89
	31 75	6 27	9				19 34	5 036	12	0 003	80
							17 75	failed			
Prop-	∞	6 70				PBXN-	∞	6 036		20 5	
ellant	76 20	6 66	5			111	49 95	5 688	16	0 003	283
C	50 80	6 47	12			Australia	34 13	5 527	14	0 003	171
55-60 μm	31 75	6 44	8			unconf	24 06	5 313	13	0 003	108
AP	25 40	6 37	8			ref 9	24 01	5 312	13	0 003	108
unconf	19 05	6 30	6				20 45	5 186	12	0 003	87
ref 46											
Prop-	∞	7 07				PBXN-	∞	6 036		20 5	
ellant	50 80	6 89	10			111	50 00	5 747	15	0 003	305
D	31 75	6 83	7			Australia	23 49	5 513	10	0 004	117
55-60 μm	31 75	6 80	8			conf	18 94	5 406	9	0 004	89
AP	25 40	6 82	6			ref 9	12 60	5 130	8	0 005	52
unconf	19 05	6 65	6			Prop-	∞	6 40			
ref 46	19 05	6 68	6			ellant	95 25	6 35	8		
	15 88	6 54	6			A-1	95 25	6 36	7		
	15 88	6 56	6			55-60 mm	76 20	6 31	10		
Prop-	∞	7 31				AP	76 20	6 28	12		
ellant	50 80	7 26	4			unconf	50 80	6 28	8		
E	31 75	7 15	5			ref 46	50 80	6 31	6		
55-60 μm	25 40	7 19	4				31 75	6 09	9		
AP	19 05	7 08	4				31 75	6 15	8		
unconf	15 88	7 10	3				31 75	6 17	8		
ref 46	12 70	7 03	3				25 40	6 07	8		
							25 40	6 05	8		
							25 40	6 07	8		
							19 05	6 07	6		
							19 05	6 05	6		

Table 2, page 6

COMPOSITES: ALUMINIZED ; INORGANIC

	Ro	Us	<xe>	G	Rcur		Ro	Us	<xe>	G	Rcur
Prop-ellant	19 05	6 07	6			AP	∞	4 95		5	
	15 88	5 97	6			1 26	38 1	4 17	24	0 02	156
A-1	15 88	5 93	6			g/cc	31 8	4 08	22	0 02	125
Prop-ellant	∞	6 55				10 μm	25 4	3 85	21	0 02	90
	31 75	6 33	7			ref 45	19 1	3 42	19	0 02	62
A-2	25 40	6 35	6				17 5	3 33	18	0 02	55
10-18 μm	19 05	6 34	4			AP	∞	4 64		4	
AP	15 88	6 20	5			1 24 g/cc	31 8	3 80	22	0 03	125
unconf	15 88	6 15	5			in steel	31 8	3 88	21	0 04	127
ref 46	12 70	6 11	5			55-60 μm	12 7	2 65	16	0 03	37
	12 70	6 09	5			ref 46	12 7	2 65	16	0 03	37
Prop-ellant	∞	5 96					12 7	2 65	16	0 03	37
	50 80	5 79	11			95% AP	∞	3 39		4	
F	31 75	5 67	9			5% Al	38 10	3 20	12	0 05	221
55-60 μm	31 75	5 74	8			0 81 g/cc	25 40	3 12	10	0 06	131
AP	25 40	5 63	8			unconf	17 35	2 98	9	0 06	78
unconf	25 40	5 65	8			ref, 47	12 70	2 83	8	0 07	51
ref 46	22 23	5 60	8				9 55	2 66	8	0 07	36
	22 23	5 55	8			AP-Al	∞	4 33		5	
Prop-ellant	∞	4 64				ref 47	38 10	4 01	15	0 03	200
	31 75	3 80	22			1 11 g/cc	25 40	3 92	12	0 04	122
A-1	31 75	3 88	21			unconf	17 35	3 71	10	0 05	73
55-60 mm	12 70	2 65	16			AP <10	12 70	3 55	9	0 05	50
AP	12 70	2 65	16			μm; Al	12 70	3 49	9	0 05	48
conf	12 70	2 65	16			<7 μm	9 55	3 15	9	0 05	33
ref 46						AP-Al	∞	5 00		6	
AN	∞	4 45		4		ref 47	38 10	4 52	18	0 02	182
1 0	230 0	2 82	259	0 0022	708	1 25 g/cc	25 40	4 34	14	0 03	110
g/cc	230 0	2 71	271	0 0020	688	unconf	17 35	4 01	13	0 03	67
unconf	202 0	2 42	263	0 0018	587		12 70	3 62	12	0 03	43
300-	202 0	2 30	274	0 0017	571	AP-Al	∞	5 20		6	
420 μm	178 5	2 15	253	0 0017	491	ref 47	38 10	4 67	18	0 02	179
ref 30	127 0	1 89	193	0 0020	331	1 33 g/cc	25 40	4 41	16	0 02	104
	127 0	1 60	208	0 0015	331	unconf	17 35	4 04	14	0 03	63
	127 0	1 61	207	0 0016	331	Baratol	∞	4 896		6	
	99 5	1 63	161	0 0020	259	76	50 80	4 767	10	0 04	376
	99 5	1 67	160	0 0021	259	2 6 g/cc	32 65	4 700	8	0 05	209
	99 5	1 36	172	0 0016	246	unconf	24 07	4 625	8	0 05	139
	87 0	1 55	144	0 0021	215	ref 22	19 04	failed			
	87 0	1 35	150	0 0018	215						
	80 0	1 46	135	0 0022	198						
	80 0	1 15	144	0 0016	189						
	63 6	failed									
AP	∞	2 39		2 5							
0 61 g/cc	25 4	2 04	16	0 07	106						
10 μm	12 7	1 69	12	0 07	42						
ref 45											
AP	∞	3 73		4							
1 0 g/cc	122 0	3 60	29	0 02	817						
13 μm	51 0	3 39	23	0 03	251						
ref 44	17 5	2 78	15	0 04	61						
AP	∞	3 74		4							
1 0 g/cc	38 1	3 43	16	0 04	189						
10 μm	25 4	3 28	14	0 05	112						
ref 45	17 5	3 05	12	0 05	68						
	12 7	2 82	11	0 05	45						

Table 3 Data for cylinders where failure was measured

	ρ_0 (g/cc)	R_f (mm)	detvel (mm/ μ s)		$\langle x_e \rangle_f$ (mm)	G (μ s ⁻¹ *GPa ⁻²)	R_{cur} (mm)	ref
Homogeneous								
TNT, pressed	0.80	3.75	1.8	5.04	6.5	0.040	2.3	37
TNT, pressed	1.00	4.25	3.4	5.23	4.5	0.049	4.3	37
TNT, pressed	1.46	2.21	5.7	6.70	1.4	0.062	3.5	37
TNT, pressed	1.62	1.31	6.6	7.08	0.6	0.084	2.9	37
TNT, cast	1.62	7.25	6.6	7.13	2.8	0.018	15.3	37
TNT, creamed	1.62	7.3		6.94				27
TNT, liquid	1.44	1.42		6.57	3			27
tetryl	0.94	3.92	2.0	5.86	8	0.013	2.4	38
tetryl	0.98	2.38	4.8	5.85	2	0.11	3.4	38
NM	1.03	1.36	6.12	6.21	0.2	0.81	5.3	22
NTO	1.75	8	7.6	7.78	1	0.039	26	25
NTO	1.85	8.5	7.9	8.23	2	0.015	23	25
NTO	1.87	12.7	8.1	8.25	2	0.016	46	24
Heterogeneous								
XTX-8003	1.53	0.19	7.05	7.307	0.04	1.7	0.54	22
PBX-9404	1.83	0.60	7.27	8.805	0.05	0.39	0.9	22
NM-silica-guar	1.17	4.77	4.92	6.550	4	0.033	6	4
X-0219	1.91	7.5	7.35	7.68	2	0.017	20	22
X-0290	1.90	4.5		7.71			1.3	27
PBX-9502	1.89	3.88	7.42	7.78	1.0	0.031	10	26
RDX 94 6/pew	1.56	2.5	6.0	8.50	2.8	0.013	3	43
RDX 97 8/pew	1.56	1.26	5.4	8.50	1.7	0.018	1.2	43
Comp B	1.71	2.14	6.7	7.92	1.3	0.023	3	23
Cyclotol 77-23	1.74	3.0	7.6	8.21	1	0.028	6	22
PBXW-7	1.70	1.28	7.25	7.92	0.6	0.073	3	43
Composites								
ANFO, SW	1.16	6.25	3.6	5.88	7	0.019	6	10,11
RX-HD	1.34	56	4	5.5	40	0.0020	65	31
HANFO	1.07	26	1.9	5.35	45	0.0035	16	9
QM-100R 80-20/6	1.41	28.8	4.2	7.20	38	0.0018	26	34
QM-100R 80-20/8	1.45	28.8	4.7	7.20	34	0.0021	29	34
QM-100R 70-30/6	1.44	17.5	5.7	6.27	8	0.0096	34	34
QM-100R 60-40/8	1.46	11	5.5	7.60	12	0.0054	13	34
QM-100R 60-40/6	1.47	14.2	5.9	7.86	12	0.0053	17	34
QM-100R 60-40/6	1.50	14.2	6.0	7.62	12	0.0054	19	34
HMX 20, emulsion	1.47	8.6	0.7	7.59	18	0.0005	3	48
HMX 30, emulsion	1.51	5.0	2.5	7.42	8	0.0033	3	48
HMX 50, emulsion	1.60	3.2	3.8	8.74	4	0.0065	2	48
Amatol 50/50	1.53	18.3	4.5	6.71	19	0.0022	19	30
Amatol 50/50	1.53	18.3	4.7	6.62	19	0.0023	21	30
Amatol 50/50	1.00	6.32	1.8	5.22	10	0.0095	4	30
Amatex 20	1.61	8.5		7.03	10		2	27
CompB-AN 79-21	1.59	6.85	6.7	7.75	4	0.010	11	30
PBXN-111, N, conf	1.79	8.7	4.8	5.95	7	0.0052	12	8
PBXN-111, N, unc	1.79	18.5	5.0	5.95	12	0.0032	28	8
Baratol	2.60	21.5	4.6	4.90	8	0.051	49	22
AN	1.00	72	1.1	4.45	130	0.002	37	30

Table 3, page 2

reference 50	ρ_0 (g/cc)	R_f (mm)	Radius at U_s	smallest U_s	f_v	f_f	f_v+f_f	explosive grain size 100 μm
90% RDX-talc	1 10	3 5	4 0	5 05	0 40	0 10	0 50	
80% RDX-talc	1 25	4 5	5 0	5 10	0 35	0 20	0 55	
75% RDX-talc	1 33	6 5	7 0	5 10	0 32	0 25	0 57	
70% RDX-talc	1 43	7 5	8 0	5 07	0 29	0 30	0 59	
60% RDX-talc	1 66	8 5	9 0	5 90	0 20	0 40	0 60	
55% RDX-talc	1 80	3 3	3 3		0 15	0 45	0 60	
50% RDX-talc	2 00	3 3	3 3		0 075	0 50	0 58	
95% RDX-wax	1 05	4 5	5 0	5 3	0 39	0 05	0 44	
90% RDX-wax	1 10	4 5	5 0	5 3	0 32	0 10	0 42	
80% RDX-wax	1 25	4 4	5 0	6 2	0 17	0 20	0 37	
76% RDX-wax	1 32	4 4	5 0	6 7	0 094	0 24	0 33	
72% RDX-wax	1 39	4 4	5 0	7 3	0 012	0 28	0 29	
70% HMX-talc	1 43	7 5	8 0	5 09	0 31	0 30	0 61	
58% HMX-talc	1 72	6 5	7 0	6 17	0 20	0 42	0 62	
50% HMX-talc	2 05		3 8	6 30	0 038	0 50	0 54	
90% HMX-wax	1 10	6 5	7 0	5 20	0 36	0 10	0 46	
58% HMX-wax	1 28	7 5	8 0	5 85	0 21	0 42	0 63	
50% HMX-wax	1 42	8 5	9 0	6 80	0 00	0 50	0 50	
90% TNT-talc	1 10	7 5	8 0	4 10	0 40	0 10	0 50	
75% TNT-talc	1 33	8 5	9 0	4 10	0 28	0 25	0 53	
70% TNT-talc	1 43	8 5	9 0	4 00	0 24	0 30	0 54	
65% TNT-talc	1 54	9 5	10 0	4 45	0 20	0 35	0 55	
60% TNT-talc	1 66	6 5	7 0	4 55	0 15	0 40	0 55	
55% TNT-talc	1 80	6 5	7 0	4 97	0 10	0 45	0 55	
90% TNT-Al	1 10	7 5	8 0	4 10	0 40	0 10	0 50	
65% TNT-Al	1 54	9 5	10 0	4 60	0 20	0 35	0 55	
60% TNT-Al	1 66	6 5	7 0		0 15	0 40	0 55	
55% TNT-Al	1 80	6 5	7 0	5 39	0 10	0 45	0 55	
95% TNT- lucite pwd	1 05	11	12 0	4 07	0 36	0 05	0 41	
85% TNT- lucite pwd	1 16	16 5	18 0	4 88	0 26	0 15	0 41	
80% TNT- lucite pwd	1 25	11	12 0	4 80	0 19	0 20	0 39	
78% TNT- lucite pwd	1 28	9 5	10 0		0 17	0 22	0 39	
75% TNT- lucite pwd	1 33	8 5	9 0	4 88	0 12	0 25	0 37	
70% TNT- lucite pwd	1 43	7 5	8 0	5 80	0 034	0 30	0 33	

Table 3, page 3

reference 51	ρ_0	R_r	containment
Liquid TNT, 85oC	1.46	3.8	13 mm steel
		60	glass
		90	cellophane
Liquid TNT, 95oC	1.45	3.6	13 mm steel
		48	glass
		72	cellophane
92% NM, acetone	1.10	3.5	13 mm steel
		27	glass
		42	cellophane
90% NM, acetone	1.09	4.6	2-12 mm steel
		33	glass
		54	cellophane
81.3% NM, acetone	1.05	1.7	3-12 mm steel
		136	glass
		220	cellophane
AN	1.06	<3	5 mm steel
		>80	glass
		>100	cellophane

Table 4 Compositions of explosives used in this report

Explosive	Composition of Mixtures (wt%)
ABNBF	7-amino-4,6-dinitrobenzofuroxan
Amatex 20	AN 80, TNT 20
Amatol 50/50	AN 50, TNT 50
AN	ammonium nitrate
ANFO-generic	AN 94, fuel oil 6
ANFO-NM	AN 77, water 16, mineral oil 6, emulsifier 1
ANFO-SW	AN 77, water 14 7, oil 3 9, sorbitol monooleate 0 7, ?
AP	ammonium perchlorate
BX-4	TATB 60, RDX 30, HMX, 5, Viton A 5
C-4	RDX 91, pib 9
Comp A	RDX 91, wax 9
Comp B	RDX 63, TNT 36, Wax 1
Cyclotol	RDX 75, TNT 25
Cyclotol 77-23	RDX 77, TNT 23
DINGU	dinitroglycoluril
DNBF	4,6-dinitrobenzofuroxan
DNT	2,4-dinitrotoluene
EDC-35	TATB 95, kel-F 5 (moist-aminated TATB)
EDNA	ethylenediamine nitramine
HANFO	AN 72 4, fuel oil 4 6, AN/water/emulsion 23
HMX 20-emulsion	AN 57 2, HMX 20, SN 8 0, water 9 6, fuel oil 5 2
HMX 30-emulsion	AN 50 1, HMX 30, SN 7 0, water 8 4, fuel oil 4 6
HMX 40-emulsion	AN 42 9, HMX 40, SN 6 0, water 7 2, fuel oil 3 9
HMX 50-emulsion	HMX 50, AN 35 8, SN 5 0, water 6 0, fuel oil 3 3
IRX-1	HMX 70, htpb 30
IRX-3A	HMX 70, htpb 20, Al 10
IRX-4	HMX 30, htpb 30, AP 24, Al 16
LX-04	HMX 85, Viton-A 15
LX-10	HMX 90, Viton-A 10
LX-17-1	TATB 92 5, kel-F 7 5 (wet-aminated TATB)
NM	NM 94, nitroethane 4, nitropropane 1
NM-silica	NM 93, silica 6, guar gum 1 (gel)
NTO	5-nitro-1,2,4-triazol-2-one
Octol	HMX 75, TNT 25
PBX-9404	HMX 94, nitrocellulose-11 3, c e phosphate 3
PBX-9501	HMX 95, estane 2 5, bdnpa 1 25, bdnpf 1 25
PBX-9502	TATB 95, kel-F 5 (dry-aminated TATB)
PBXN-110	HMX 88, htpb 12
PBXN-111	RDX 20, AP 43, Al 25, htpb 12
PBXW-7 type II	TATB 60, RDX 35, Viton A 5
PBXW-123	AP 44 8, Al 30 2, TMETN 18 8, pcl 4 2, ndpa 1, ipdi 1
PBXW-126	Al 26, NTO 22, AP 20, RDX 20, polyurethane 12
Pentolite	PETN 50, TNT 50
Picric Acid	2,4,6-trinitrophenol
Propellant A	plastisol-NC 55, AP 30, Al 15
Propellant B	plastisol-NC 64 7, AP 35 3

Table 3, page 2

Explosive	Composition of Mixtures (wt%)
Propellant C	plastisol-NC 64 7, AP 29 4, RDX 5 9
Propellant D	plastisol-NC 64 7, AP20 3, RDX 15
Propellant E	plastisol-NC 64 7, RDX 35 3
Propellant F	plastisol-NC 54 7, KCl 30 4, Al 14 9
QM-100	AN 75, water 18, oil 5, glass microballoons 2
QM-100R, 80-20/6	AN 60 4, RDX 20, water 15 1, fuel oil 4 5
QM-100R, 80-20/8	AN 59 3, RDX 20, water 14 8, fuel oil 5 9
QM-100R, 70-30/6	AN 52 8, RDX 30, water 13 2, fuel oil 4 0
QM-100R, 60-40/6	AN 45 3, RDX 40, water 11 3, fuel oil 3 4
QM-100R, 60-40/8	AN 44 4, RDX 40, water 11 1, fuel oil 4 4
QM-100R, 50-50/8	AN 37 0, RDX 50, water 9 3, fuel oil 3 7
RDX-pew	RDX variable, polyethylene wax variable
70% RDX-urethane	RDX 70, polyurethane 29 65, graphite 0 35
72 RDX-urethane#3	RDX 72, binder 28 C 33%,H 60, O 5 4, 0 97 g/cc
72 RDX-urethane#5	RDX 72, binder 28 C 14%,H 29, O 29, Si 29, I 02 g/cc
RX-08-HD	HMX 74, TMETN 20, Tone 260 5 2
RX-52-AD	TATB 65, FEFO 31, pcl 1 6, pvf 1 4, n-100 1 1
RX-52-AE	TATB 65, FEFO, 32, pcl, 1 6, pvf, 1 4
RX-54-AJ	HMX 47, Al 28, TMETN 16, NC 8
RX-HD	AN 78 7, fuel oil 6 4, calcium nitrate 5 5, water 9 4
T2	TATB 97, unknown binder 3
Tetryl	trinitro-2,4,6-phenylmethylnitramine
Ult TATB	ultrafine-grain (6 μ m) TATB
X-0219	TATB 90, Kel-F 10
X-0290	TATB 95, Kel-F 5, became PBX-9502
X-0341	TATB 90 25, HMX 4 75, kel-F 5
X-0342	TATB 85 5, HMX 9 5, kel-F 5
X-0343	TATB 80 75, HMX 14 25, kel-F 5
X-0344	TATB 71 25, HMX 23 75, kel-F 5
XTX-8003	PETN 80, silicone rubber (sylgard) 20
Binder	Composition
htpb	hydroxy-terminated polybutadiene
idpi	isophorone diisocyanate
n-100	commerical isoceprate
ndpa	nitrodiphenylamine
pcl	polycaprolactone
pew	polyethylene wax
pib	polyisobutylene
plastisol-NC	nitrocellulose with about 10% nitroglycerin
pvf	polyvinylchloride
Abbreviations	
ANFO-NM	from New Mexico (Lee)
ANFO-SW	from Sweden (Swedish Rock)
PBXN-111-N	from U S Navy (Forbes)
PBXN-111-A	from Australia (Kennedy)