AD NUMBER
AD025068
CLASSIFICATION CHANGES
TO: **unclassified**
FROM: **confidential**
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to DoD only; Administrative/Operational Use; NOV 1953. Other requests shall be referred to U.S. Naval Proving Ground, Dahlgren, VA.**
AUTHORITY
19641130 - DoDD 5200.10.

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1150

DEVELOPMENT OF A COOL PROPELLANT FOR THE 5"/54 CALIBER GUN

8th Partial Report

- -

BALLISTIC TEST OF COOL PROPELLANTS EX-7016 - EX-7021 INCLUSIVE, EX-7038, AND EX-7048 - EX-7050 INCLUSIVE

FINAL Report

Task Assignment NPG-Re2d-61-1-53

Copy No. 11

Classification CONFIDENTIAL SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

- -

PART A

SYNOPSIS

1. This is the eighth partial report on Task Assignment NPG-Re2d-61-1-53, the "Development of a Cool Propellant for the 5"/54 Caliber Gun", and the final report on "Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive".

2. From the results of the subject tests, it is concluded that:

a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 tsi pressure range within the limitation of 3".5 PPD (Production Packing Depth).

b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge or 20.75 lb. of EX-7020, an increase of 1".5 in PPD was obtained by graphiting the powder.

c. EX-7038 was unsatisfactory as a replacement for EX-6883.

d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

e. No appreciable differences in ballistics were obtained between the EX-23-1 and Mk 41-0 (60 lb.) projectiles.

Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.

f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

- -

TABLE OF CONTENTS

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

- -

PART B

INTRODUCTION

1. AUTHORITY:

The tests reported herein were authorized by references (b), (c), and (d) and conducted under Task Assignment NPG-Re2d-61-1-53 as established by reference (a).

2. REFERENCES:

a. BUORD Conf ltr Re2d-CNB:aph Ser 42692 of 29 July 1952
b. BUORD Conf ltr Re2d-CNB:aph Ser 44705 of 12 Sept 1952
c. BUORD Conf ltr NP9 Re2d-ERD:jd Ser 47824 of 18 Nov 1952
d. BUORD Conf ltr NP9 Re2d-ERD:dad Ser 48931 of 10 Dec 1952
e. BUORD Conf ltr Re2d-ERD:aph Ser 47419 of 7 Nov 1952 to E. I. duPont Company
f. NPG Conf Report No. 984 of 18 Aug 1952
g. Description Sheets of Manufacture and Closed Bomb Data
h. USNPF Conf Report No. 40 (NAVORD Report No. 3011) of 15 May 1952
i. NPG Conf Report No. 873 of 17 Dec 1951

3. BACKGROUND:

Reference (a) established the general task for the development of cool powders for the 5"/54 caliber gun. Reference (b) requested that EX-7016 through EX-7021 be fired for ballistic assessment in the 5"/54 caliber gun with the 60 lb. projectile in the 22-24 ton pressure range at a velocity of 3000 to 3100 f/s. Reference (b) described these propellants as cool picrite powders with a nominal flame temperature around 2350°K, prepared by duPont to determine the effect of variation in nitrate nitrogen content on ignition and gun ballistics. Reference (c) requested that EX-7038 be fired for charge determination in the 5"/54 caliber gun and described it as a 2350°K (nominal) picrite propellant for possible use as a replacement for EX-6883 in the continuation of the rapid fire-wear program as reported in reference (f). Reference (d) requested EX-7048, 7049 and 7050 (mono-perforated) be fired for ballistic assessment in the 5"/54 caliber gun. Reference (d) described these propellants as cool picrite powders prepared in accordance with reference (e). Reference (h) described the development of a method for the determination of the ignitability of propellants.

4. OBJECT OF TEST:

a. To determine whether EX-7016 to EX-7019 are ballistically suitable for the 5"/54 caliber gun using the 60 lb. projectile at a pressure of 22-24 tsi and velocity between 3000 and 3100 f/s.

b. To determine the effect of increased nitrate nitrogen content on ignition and ballistics.

c. To determine whether EX-7038 is a satisfactory replacement for EX-6883.

d. To determine whether mono-perforated propellants (EX-7048-7049-7050) are suitable ballistically for the 5"/54 caliber gun.

e. To determine if the subject propellants are ballistically satisfactory within a PPD (Production Packing Depth) of 3.5. (This value allows for manufacturing tolerances between different powder lots and is essential in the assembly of 5"/54 cone-crimped ammunition).

5. PERIOD OF TEST:

a. Dates of Project Letters: 29 July 1952
12 Sep 1952
7 Nov 1952
18 Nov 1952
10 Dec 1952

b. Dates Material Received:

EX-7016 to 7019 inclusive	7 Aug 1952
EX-7038	14 Oct 1952
EX-7048-7049-7050	10 Dec 1952

c. Date Commenced Test: 13 Dec 1952

d. Date Test Completed: 2 Feb 1953

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

- -

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

Reference (g) gave in detail the powder description and closed bomb data. A summary of the data follows:

Actual Composition	EX-7016	EX-7017	EX-7018
Nitrocellulose (13.20%N)	20.42%	20.33%	20.58%
Nitroglycerin #1	19.48	19.18	19.37
Picrite	50.51	51.12	50.49
Centralite	1.71	1.54	1.55
Dibutylphthalate	7.88	7.83	8.02
Lead Carbonate (added)	0.93	0.84	0.94

Actual Composition	EX-7019	EX-7020	EX-7021	EX-6883
Nitrocellulose (13.20%N)	31.12	31.00	30.48	19.98
Nitroglycerin #1	18.85	19.28	19.43	14.61
Picrite	39.41	39.64	39.58	58.40
Centralite	2.00	1.56	2.01	1.47
Dibutylphthalate	8.62	8.52	8.50	5.54
Lead Carbonate (added)	0.98	0.92	1.00	1.01

Actual Composition	EX-7038	EX-7048	EX-7049	EX-7050
Nitrocellulose (13.20%N)	19.16	19.90	19.20	19.08
Nitroglycerin #3	15.29(*)	15.36	14.69	14.42
Picrite	59.16	58.12	58.04	58.61
Centralite	1.81	2.02	1.97	1.88
Dibutylphthalate	4.58	4.60	4.94	4.76
Lead Carbonate (added)	0.96	0.95	0.96	0.99

* Nitroglycerin #1 with EX-7038

Reference (g) also gave the following information:

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

Sample	Calc. Flame Temp. (°K)	Grain Dimensions				RQ (%)	RF (%)	Nitrate Nitrogen (%)	Relative Ignitability (e) (%)
		Length (in.)	Diam. (in.)	Av. Web (in.)	No. of Perfs.				
EX-7016	2334	0.5460	0.2377	0.0422	7	95.7(a)	97.8(a)	6.42	180
						103.9(b)	110.3(b)		
EX-7017	2348	0.7150	0.2952	0.0512	7	82.8(a)	98.9(a)		190
						89.9(b)	111.6(b)		
EX-7018	2356	0.7400	0.3304	0.0596	7	72.1(a)	98.0(a)		181
						78.2(b)	111.0(b)		
EX-7019	2381	0.5490	0.2323	0.0415	7	103.5(a)	99.3(a)	7.66	277
						112.5(b)	112.7(b)		
EX-7020	2387	0.6613	0.3029	0.0510	7	86.0(a)	98.2(a)		287
						93.5(b)	111.5(b)		
EX-7021	2332	0.7490	0.3238	0.0569	7	72.9(a)	97.3(a)		273
						79.2(b)	110.4(b)		
EX-7038	2435	0.7220	0.2873	0.0504	7	88.5(a)	98.2(a)		
						97.8(b)	112.8(b)		
EX-7048	2436	0.3709	0.1428	0.0626	1	90.8(c)	95.9(c)		
						96.8(b)	113.2(b)		
EX-7049	2387	0.4270	0.1578	0.0705	1	91.4(c)	97.0(c)		
						102.9(d)	100.7(d)		
EX-7050	2393	0.4605	0.1778	0.0773	1	79.5(b)	111.1(b)		
EX-6883	2378	0.5750	0.2498	0.0457	7	75.0(c)	95.3(c)		
						84.4(d)	98.8(d)		
						75.6(b)	110.8(b)		
						71.5(c)	95.0(c)		
						80.4(d)	98.6(d)	5.03	150
						108.2(b)	114.1(b)		

(a) Based on EX-6833 as 100% at 90°F.
(b) Based on EX-6586 as 100% at 90°F.
(c) Based on EX-6882 as 100% at 90°F.
(d) Based on EX-7038 as 100% at 90°F.
(e) Based on Cordite N powder as 100%. (reference (h)).

7. PROCEDURE:

a. The subject propellants were fired in either the Mk 16-0 or Mk 18-0 5"/54 caliber guns. Comparative firings were conducted with related powders listed in references (f) and (i). All tests were conducted with the 60 lb. projectile for 3000-3100 f/s velocity and 22-24 tsi pressure.

Muzzle velocities, maximum pressures (copper crusher), ejection times, and visual observations of flash and smoke were obtained. Pressure-time records were obtained on representative powders.

b. Tests were conducted to determine powder packing depth differences with graphited and non-graphited powder.

8. RESULTS AND DISCUSSION:

The results of the subject tests are given in detail in the Appendices and are summarized below:

a. Uniformity:

Date	Gun No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. of Rds.
12-18-52	16076	EX-6883	4.6	20.15	2971±2	20.0±0.1	0.021±0.001	5
"	"	EX-7016	6.0	18.50	2850±0	21.5±0.3	0.018±0.001	2
"	"	EX-7017	5.1	18.50	2689±4	14.3±0.2	0.019±0.000	2
"	"	"	1.4	21.10	2954±1	18.4±0.2	0.019±0.001	3
"	"	EX-7018	3.1	20.00	2657±8	12.9±0.3	0.022±0.001	2
"	"	EX-7019	5.9	18.50	2930±3	26.6±0.4	0.017±0.001	2
"	"	EX-7020	4.9	18.50	2757±4	15.8±0.2	0.020±0.002	2
"	"	"	1.4	20.90	3004±6	20.2±0.1	0.017±0.001	2
"	"	EX-7021	4.6	19.00	2579±9	12.4±0.1	0.019±0.000	2
"	"	"	1.4	21.20	2809±4	15.2±0.1	0.021±0.001	2
"	"	EX-7038	7.2	18.00	2659±2	14.2±0.1	0.021±0.001	3
"	"	"	1.4	22.20	3070±4	20.7±0.3	0.018±0.001	3
12-19-52	14763	EX-6883	4.6	20.15	2990±7	20.9±0.5	0.019±0.000	5
"	"	EX-7020	4.9	18.50	2771±5	16.4±0.2	0.018±0.001	3
"	"	"	1.6	20.75	3001±3	21.0±0.2	0.017±0.001	5
"	"	EX-7038	7.2	18.00	2674±1	14.4±0.1	0.021±0.001	3
"	"	"	1.4	22.20	3059±5	20.9±0.3	0.018±0.001	5
"	"	Blend (a)	2.0	20.50	3007±7	21.8±0.3	0.016±0.000	5
"	"	"	5.7	18.00	2759±2	16.8±0.1	0.018±0.001	3
"	"	EX-7020(b)	3.1	20.75	2979±5	21.2±0.1	0.017±0.001	3

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

Date	Gun No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. of Rds.
12-19-52	14758	EX-6883	4.6	20.15	2940±0	18.6±0.2	0.020±0.001	3
"	"	EX-7020	1.6	20.75	2958±2	19.6±0.2	0.018±0.001	3
"	"	EX-7038	2.3	21.50	2960±7	18.6±0.2	0.017±0.000	3
"	"	Blend (a)	2.0	20.50	2975±4	21.6±0.3	0.017±0.001	3
"	"	EX-7050	7.8	18.65	2644±1	21.4±0.3	0.017±0.001	3
"	"	EX-7020(b)	3.1	20.75	2959±3	21.3±0.7	0.017±0.000	3
1-2-53	16077	EX-7038	6.7	18.50	2725±2	15.1±0.0	0.019±0.001	2
"	"	"	3.0	21.00	2966±4	18.5±0.3	0.018±0.001	4
"	"	" (c)	3.0	21.00	2960±10	17.8±0.4	0.020±0.002	5
"	"	EX-6822	7.3	18.50	2822±4	17.5±0.4	0.022±0.002	3
"	"	"	3.5	21.30	3076±5	22.0±0.2	0.019±0.001	5
"	"	" (c)	3.5	21.30	3076±7	21.8±0.3	0.019±0.002	5
"	"	EX-6883	6.9	18.50	2826±6	17.2±0.2	0.020±0.000	3
"	"	"	3.0	21.30	3099±3	21.7±0.5	0.019±0.001	5
"	"	" (c)	3.0	21.30	3102±2	21.9±0.3	0.019±0.001	5
1-22-53	14763	EX-7019(d)	8.1	17.00	2782±3	24.1±0.2	0.019±0.001	2
"	"	" (e)	8.1	17.00	2782±2	22.8±0.5	0.019±0.001	2
"	"	" (f)	8.1	17.00	2766±1	20.5±0.1	0.019±0.001	2
"	"	EX-7017(d)	1.4	21.10	2948±3	19.0±0.1	0.019±0.001	2
"	"	" (e)	1.4	21.10	2928±1	17.8±0.0	0.019±0.001	2
"	"	" (f)	1.4	21.10	2915±1	17.1±0.1	0.019±0.000	2
"	"	EX-6883(d)	4.4	20.15	2957±4	20.0±0.3	0.021±0.001	5
"	"	" (e)	4.4	20.15	2949±2	19.9±0.2	0.023±0.001	2
"	"	" (f)	4.4	20.15	2958±19	20.6±1.2		2
1-27-53	14763	EX-6822	3.0	21.56	3070±15	21.5±0.8(g) 22.3±0.2(h) 22.2±0.2(i)	0.020±0.002	2
"	"	EX-7019	7.7	17.00	2766±4	21.0±0.5(g) 20.8±0.4(h) 20.6±0.1(i)	0.019±0.002	3
1-28-53	14763	EX-6883	2.6	21.28	3063±8	21.6±0.7(g) 21.7±0.4(h) 22.5±0.5(i)	0.020±0.002(j)	5
2-2-53	16078	EX-6883	3.0(k)	21.31	3084±5	22.9±0.4	0.019±0.002	5
"	"	EX-6822	3.2(k)	21.56	3093±5	23.5±0.5	0.018±0.002	5

(a) 78/22 blend of EX-7020 and EX-7019
(b) Graphited
(c) Ex-23-1 projectile
(d) 800 grams of black powder in primer
(e) 600 " " " " " "
(f) 400 " " " " " "
(g) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges.
(h) MI-2 - Dynamic calibration pressure for 1/6 sq. in area gauges
(i) MI-3 - Dynamic calibration pressure for 1/30 sq. in area gauges
(j) Based on 3 rounds
(k) Cone crimp assembly

b. Charge Determination:

(1) 5"/54 caliber guns (as indicated) Firing conditions were the same as the Uniformity Firings.

Date	Powder	PPD (in.) (d)	Gun No.	Gun Mk-Mod		Velocity (f/s)	Charge (lbs.)	Pressure (t.s.i.)	Remarks
12-13-52	EX-7016	4.2	16076	18	0	3000	20.11	26.3	Too fast
"	"	2.6	"	"	"	3100	21.18	29.5(a)	Too fast
"	EX-7017	1.2	"	"	"	3000	21.55	19.4	Too slow
"	"	-0.3(e)	"	"	"	3100	22.53	21.6	Too slow
"	EX-7018	-2.0(e)	"	"	"	3000	23.89	18.4	Too slow
"	"	-3.6(e)	"	"	"	3100	24.96	19.9	Too slow
"	EX-7019	5.5	"	"	"	3000	19.16	29.2(a)	Too fast
"	"	4.1	"	"	"	3100	20.10	32.3(a)	Too fast
"	EX-7020	2.0	"	"	"	3000	20.86	20.1	Too slow
"	"	0.5	"	"	"	3100	21.83	21.9	Too slow
"	EX-7021	-0.6(e)	"	"	"	3000	23.03	17.5	Too slow
"	"	-2.3(e)	"	"	"	3100	23.98	18.7	Too slow
"	Blend (b)	3.5	"	"	"	3000	20.47	21.2	Too slow
"	"	2.2	"	"	"	3100	21.40	23.6	(f)
"	EX-7038	2.9	"	"	"	3000	21.49	19.6	Too slow
"	"	1.4	"	"	"	3100	22.51	21.2	Too slow
"	EX-7048	6.7	"	"	"	3000	19.35	(c)	Too fast
"	"	5.3	"	"	"	3100	20.26	(c)	Too fast
"	EX-7049	4.9	"	"	"	3000	21.06	(c)	Too fast
"	"	3.7	"	"	"	3100	21.98	(c)	Too fast
"	EX-7050	3.8	"	"	"	3000	22.15	(c)	Too fast
"	"	2.5	"	"	"	3100	23.12	(c)	Too fast
12-19-52	EX-7020	2.1	14763	16	0	3000	20.74	21.0	Too slow
"	"	0.7	"	"	"	3100	21.72	23.0	(f)
"	EX-7038	2.8	"	"	"	3000	21.56	19.9	Too slow
"	"	1.3	"	"	"	3100	22.65	21.6	Too slow
"	Blend (b)	3.6	"	"	"	3000	20.43	21.6	Too slow
"	"	2.3	"	"	"	3100	21.44	25.7	Too fast
1-2-53	EX-7038	3.1	16077	18	0	3000	21.35	19.0	Too slow
"	"	1.7	"	"	"	3100	22.39	20.4	Too slow
"	EX-6822	5.1	"	"	"	3000	20.46	20.5	(h)
"	"	3.7	"	"	"	3100	21.56	22.4	(h)
"	EX-6883	4.9	"	"	"	3000	20.28	20.1	(g)
"	"	3.5	"	"	"	3100	21.31	21.7	(g)

(a) Extrapolated value
(b) Blend of 78% EX-7020 and 22% EX-7019
(c) Over 30 t.s.i. by extrapolation
(d) PPD without gages
(e) Charge too large for cartridge case
(f) Satisfactory ballistically at 3100 f/s but unsatisfactory within PPD limits
(g) Evaluated separately in ref. (f)
(h) Evaluated separately in ref. (i)

(2) None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) at 3000-3100 f/s velocity and 22-24 tsi pressure were satisfactory within 3"5 PPD limitation.

(3) Soft surfaces and to a greater or lesser degree inherent "fish-scale" surface structures were observed on propellants EX-7016 through EX-7021. Because of the above conditions, optimum powder packing conditions were somewhat difficult to establish and maintain. One of the powders (EX-7020) was coated with a layer of graphite. The PPD for a charge of 20.75 lb. of this powder ungraphited was 1"6 while the same charge with a coating of graphite was 3"1, thereby allowing for 1"5 more free space remaining in the cartridge case.

(4) EX-7038 was too slow for the 5"/54 caliber gun and was found unsatisfactory as a replacement for EX-6883.

(5) EX-7048 through EX-7050, the first mono-perforated propellants fired in the 5"/54 caliber gun, were all too fast at either 3000 or 3100 f/s velocity.

It is evident that mono-perforated propellants are readily ignitable and have possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

(6) Comparative firings between the Ex-23-1 and Mk 41-0 (60 lb. projectiles) showed no appreciable difference in ballistics.

(7) One powder from each group was fired with different amounts of ignition in the primer. The data are as follows:

Powder Index	Charge (lbs.)	Relative Ignitability	Per Cent Nitrate Nitrogen	Ignition (grains)	Velocity (f/s)	Pressure (t.s.i.)	No. of Rds.
EX-7019	17.00	277	7.56	800	2782±3	24.1±0.2	2
"	"	"	"	600	2782±2	22.8±0.5	2
"	"	"	"	400	2766±1	20.5±0.1	2
EX-7017	21.10	190	6.42	800	2948±3	19.0±0.1	2
"	"	"	"	600	2928±1	17.8±0.0	2
"	"	"	"	400	2915±1	17.1±0.1	2
EX-6883	20.15	150	5.03	800	2957±4	20.0±0.3	2
"	"	"	"	600	2949±2	19.9±0.2	2
"	"	"	"	400(a)	2958±19	20.6±1.2	2

(a) 5 second hangfires

From the above results it can be seen that a propellant with a higher relative ignitability and higher percent nitrate nitrogen content is more sensitive to ignition changes.

Tests are currently being conducted on these propellants to determine ignition changes on pressure-time behavior and will be reported separately under "Case Gun Ignition" Task Assignment NPG-Re2a-184-1-53.

c. Pressure-Time Records:

(1) The pressure-time records obtained in the subject tests are presented in Appendix (B).

(2) EX-6822 and EX-6883 gave smooth pressure-time curves.

(3) The pressure-time curves obtained with EX-7038 had only slight steps occurring in the pressure-rise portion of the curves.

(4) EX-7020 (ungraphited) gave fairly pronounced steps in the pressure-rise region and were generally better than those obtained with EX-7020 after graphiting.

(5) Very large steps and rough peaks were obtained with EX-7019 and EX-7050.

(6) In general, none of the subject powders tested in the 5"/54 caliber gun gave as smooth pressure-time curves as either EX-6822 or EX-6883.

PART D

CONCLUSIONS

9. From the results of the subject tests, it is concluded that:

a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 t.s.i. pressure range within the limitation of 3".5 PPD (Production Packing Depth).

b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge of 20.75 lb. of EX-7020, an increase of 1".5 in PPD was obtained by graphiting the powder.

c. EX-7038 was unsatisfactory as a replacement for EX-6883.

d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

e. No appreciable differences in ballistics were obtained between the Ex-23-1 and Mk 41-0 (60 lb.) projectiles.

Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.

f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

- -

The tests upon which this report is based were conducted by:
J. A. KRYSTOFIK, Head of Test Branch
Interior Ballistics Division
Armament Department

This report was prepared by:
J. A. KRYSTOFIK, Head of Test Branch
Interior Ballistics Division
Armament Department

This report was reviewed by:
D. C. CAIN, Head of the Interior Ballistics Division
Armament Department
L. C. KLINGAMAN, Commander, USN
Armament Officer,
Armament Department
C. C. BRAMBLE, Director of Research, Ordnance Group

APPROVED: J. F. BYRNE
Captain, USN
Commander, Naval Proving Ground

E. A. RUCKNER
Captain, USN
Ordnance Officer
By direction

CONFIDENTIAL

NPG REPORT NO. 1150

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

8th Partial Report

on

Development of a Cool Propellant

for the 5"/54 Caliber Gun

- -

Final Report

on

Ballistic Test of Cool Propellants

EX-7016 - EX-7021 inclusive, EX-7038, and

EX-7048 - EX-7050 inclusive

Project No.: NPG-Re2d-61-1-53

Date:

Copy No.: 11

No. of Pages: 13

CONFIDENTIAL
SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

---

TABULATION OF FIRING DATA

Gun:	5"/54 Caliber, Mk 18-0 No. 16076 ESR = 42.4 D_o = 5.010 Mk 16-0 No. 14763 ESR = 180.5 D_o = 5.056 Mk 16-0 No. 14758 ESR = 296.8 D_o = 5.074 Mk 18-0 No. 16077 ESR = 54.2 D_o = 5.006 Mk 18-0 No. 16078 ESR = 271.7 D_o = 5.011
Projectile:	Mk 41-0 (60.00 lb.) Empty
Cartridge Case:	Mk 7
Primer:	Mk 45 (XC-M5B)
Lead Foil:	None
Powder:	As indicated
Plug:	Cork
Crimp:	Cone on 2/2/53 - None on rest
Wad and Spacer:	Cardboard, NGF Dwg. No. 132664 Pc. Nos. 18 and 15 (as required)
Powder Temp.:	90°F

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952

Gun: Mk 18-0, No. 16076
ESR = 42.4 D_o = 5.010

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)							
(a) 7	EX-6883	4.6	20.15	2977	20.4	0.022	Tr	150
8	"	"	"	2970	20.3	0.019	75	125
9	"	"	"	2970	20.0	0.022	0	150
10	"	"	"	2972	19.9	0.021	0	150
11	"	"	"	2976	20.0	0.019	75	125
12	"	"	"	2967	19.9	0.022	0	150
Mean of 5 rounds			20.15	2971±2	20.0±0.1	0.021±0.001		
13	EX-7016	8.1	17.00	2694	18.3	0.017	0	150
14	"	6.0	18.50	2850	21.2	0.018	0	150
15	"	"	"	2850	21.8	0.017	0	150
Mean of 2 rounds			18.50	2850±0	21.5±0.3	0.018±0.001		
16	EX-7016	3.8	20.00	2990	25.9	0.017	0	150
17	EX-7017	5.1	18.50	2693	14.4	0.019	75	125
18	"	"	"	2685	14.1	0.019	75	125
Mean of 2 rounds			18.50	2689±4	14.3±0.2	0.019±0.000		
19	EX-7017	2.2	20.50	2879	17.2	0.021	75	125
20	"	1.4	21.10	2953	18.3	0.017	75	125
21	"	"	"	2954	18.2	0.019	75	125
22	"	"	"	2956	18.7	0.020	75	125
Mean of 3 rounds			21.10	2954±1	18.4±0.2	0.019±0.001		
23	EX-7018	3.1	20.00	2645	13.1	0.022	75	125
24	"	"	"	2629	12.6	0.021	75	125
Mean of 2 rounds			20.00	2637±8	12.9±0.3	0.022±0.001		

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
25	EX-7018	1.4	21.20	2749	14.6	0.020	100	100
26	EX-7019	8.1	17.00	2777	20.7	0.020	75	125
27	"	5.9	18.50	2927	27.0	0.016	0	150
28	"	"	"	2932	26.2	0.017	75	125
Mean of 2 rounds			18.50	2930±3	26.6±0.4	0.017±0.001		
29	EX-7019	4.5	19.50	3036	-	0.016	75	125
30	EX-7020	6.4	17.50	2644	13.9	0.020	0	150
31	"	4.9	18.50	2753	15.6	0.021	100	100
32	"	"	"	2761	15.9	0.018	100	100
Mean of 2 rounds			18.50	2757±4	15.8±0.2	0.020±0.002		
33	EX-7020	1.4	20.90	2998	20.3	0.016	100	100
34	"	"	"	3009	20.1	0.017	100	100
Mean of 2 rounds			20.90	3004±6	20.2±0.1	0.017±0.001		
35	EX-7021	4.6	19.00	2588	12.5	0.019	100	100
36	"	"	"	2570	12.3	0.019	100	100
Mean of 2 rounds			19.00	2579±9	12.4±0.1	0.019±0.000		
37	EX-7021	1.4	21.20	2813	15.3	0.020	100	100
38	"	"	"	2805	15.1	0.021	100	100
Mean of 2 rounds			21.20	2809±4	15.2±0.1	0.021±0.001		

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
39	EX-7020	5.7	16.00	2730	15.7	0.020	100	100
	EX-7019		2.00					
40	"	4.2	16.00	2844	18.5	0.017	100	100
			3.00					
41	"	2.7	16.00	2945	19.6	0.019	100	100
			4.00					
42	"	1.4	16.00	3059	23.0	0.017	100	100
			5.00					
43	EX-7038	8.6	17.00	2555	12.6	0.019	100	100
44	"	7.2	18.00	2656	14.1	0.021	100	100
45	"	"	"	2661	14.3	0.019	100	100
46	"	"	"	2661	14.1	0.022	100	100
Mean of 3 rounds			18.00	2659±2	14.2±0.1	0.021±0.001		
47	EX-7038	4.4	20.00	2841	16.2	0.021	100	100
48	"	1.4	22.20	3065	20.9	0.019	100	100
49	"	"	"	3071	20.3	0.017	100	100
50	"	"	"	3075	20.9	0.017	100	100
Mean of 3 rounds			22.20	3070±4	20.7±0.3	0.018±0.001		
51	EX-7048	10.9	16.00	2644	-	0.016	0	150
52	"	9.5	17.00	2747	-	0.015	0	150
53	"	15.4	13.00	2324	17.3	0.018	0	150
54	"	13.7	14.00	2429	19.9	0.017	0	150
55	"	12.3	15.00	2549	-	0.020	0	150
56	EX-7049	12.7	15.00	2361	14.0	0.018	75	125
57	"	11.4	16.00	2474	17.5	0.021	75	125
58	"	10.0	17.00	2570	20.9	0.021	75	125
59	"	9.3	17.50	2624	22.9	0.018	75	125
60	EX-7050	11.3	16.00	2387	14.0	0.018	75	125
61	"	10.0	17.00	2494	16.8	0.018	0	150
62	"	8.6	18.00	2588	18.8	0.016	100	100
63	"	6.7	19.50	2736	23.2	0.016	100	100

(a) Conditioning round.

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

Gun: Mk 16-0, No. 14763
ESR = 180.5 D_o = 5".056

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)							
(a) 7	EX-6883	4.6	20.15	3007	21.4	0.019	0	150
8	"	"	"	2983	20.6	0.019	0	150
9	"	"	"	2994	21.7	-	0	150
10	"	"	"	2990	20.5	0.019	0	150
11	"	"	"	3004	21.5	0.018	0	150
12	"	"	"	2979	20.4	0.019	0	150
Mean of 5 rounds			20.15	2990±7	20.9±0.5	0.019±0.000		
13	EX-7020	4.9	18.50	2776	16.7	0.017	100	100
14	"	"	"	2774	16.4	0.018	0	150
15	"	"	"	2764	16.1	0.020	0	150
Mean of 3 rounds			18.50	2771±5	16.4±0.2	0.018±0.001		
16	EX-7020	1.6	20.75	3001	20.7	0.019	100	100
17	"	"	"	2993	20.7	0.016	100	100
18	"	"	"	3002	21.2	0.017	100	100
19	"	"	"	3005	21.1	0.017	100	100
20	"	"	"	3004	21.1	0.018	100	100
Mean of 5 rounds			20.75	3001±3	21.0±0.2	0.017±0.001		
21	EX-7020	1.4	20.90	3010	20.8	0.016	100	100
22	EX-7038	7.2	18.00	2674	14.2	0.022	0	150
23	"	"	"	2672	14.5	0.020	25	125
24	"	"	"	2675	14.4	0.021	0	150
Mean of 3 rounds			18.00	2674±1	14.4±0.1	0.021±0.001		
25	EX-7038	2.3	21.50	2977	19.3	0.020	100	100
26	"	1.4	22.20	3070	21.1	0.018	100	100
27	"	"	"	3049	20.7	0.019	100	100
28	"	"	"	3062	21.1	0.017	100	100
29	"	"	"	3059	21.1	0.017	100	100
30	"	"	"	3057	20.3	0.018	100	100
Mean of 5 rounds			22.20	3059±5	20.9±0.3	0.018±0.001		

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
31	EX-7020 EX-7019	2.0	16.00 4.50	2998	22.0	0.017	100	100
32	"	"	"	3012	22.1	0.016	100	100
33	"	"	"	2998	22.0	0.016	100	100
34	"	"	"	3011	21.0	0.016	100	100
35	"	"	"	3017	22.0	0.017	100	100
Mean of 5 rounds			16.00 4.50	3007±7	21.8±0.3	0.016±0.000		
36	EX-7020 EX-7019	1.4	16.39 4.61	3049	23.5	0.016	100	100
37	"	5.7	14.05 3.95	2759	16.6	0.018	0	150
38	"	"	"	2762	16.8	0.016	0	150
39	"	"	"	2757	17.0	0.020	0	150
Mean of 3 rounds			14.05 3.95	2759±2	16.8±0.1	0.018±0.001		
40	EX-7020 (b)	2.6	20.75	2978	22.5	0.019	100	100
41	"	2.0	21.50	3065	25.0	0.016	100	100
42	"	3.1	20.75	2983	21.0	0.016	100	100
43	"	"	"	2982	21.4	0.018	100	100
44	"	"	"	2972	21.2	0.016	100	100
Mean of 3 rounds			20.75	2979±5	21.2±0.1	0.017±0.001		

(a) Conditioning round
(b) Graphited

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

Gun: Mk 16-0, No. 14758
ESR = 296.8 D_o = 5.074

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a) 1	EX-6883	6.9	18.50	2730	16.4	--	0	175
2	"	4.6	20.15	2940	18.8	0.020	75	125
3	"	"	"	2941	18.5	0.018	Tr	150
4	"	"	"	2940	18.4	0.021	Tr	150
Mean of 3 rounds			20.15	2940±0	18.6±0.2	0.020±0.001		
5	EX-7020	1.6	20.75	2955	19.9	0.019	100	100
6	"	"	"	2958	19.6	0.016	100	100
7	"	"	"	2962	19.4	0.018	100	100
Mean of 3 rounds			20.75	2958±2	19.6±0.2	0.018±0.001		
8	EX-7038	2.3	21.50	2949	18.7	0.018	100	100
9	"	"	"	2968	18.3	0.017	100	100
10	"	"	"	2963	18.7	0.017	100	100
Mean of 3 rounds			21.50	2960±7	18.6±0.2	0.017±0.000		
11	EX-7020	2.0	16.00	2975	21.4	0.017	100	100
	EX-7019 (b)		4.50					
12	"	"	"	2981	22.0	0.016	100	100
13	"	"	"	2968	21.4	--	100	100
Mean of 3 rounds			16.00 4.50	2975±4	21.6±0.3	0.017±0.001		
14	EX-7050	7.8	18.65	2642	21.1	0.016	80	125
15	"	"	"	2645	21.8	0.019	80	125
16	"	"	"	2644	21.2	0.016	80	125
Mean of 3 rounds			18.65	2644±1	21.4±0.3	0.017±0.001		
17	EX-7020 (c)	3.1	20.75	2963	20.7	0.016	100	100
18	"	"	"	2957	20.8	0.017	100	100
19	"	"	"	2956	22.3	0.017	100	100
Mean of 3 rounds			20.75	2959±3	21.3±0.7	0.017±0.000		

(a) Conditioning round (b) 78/22 blend (c) Graphited

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953

Gun: Mk 18-0, No. 16077
ESR = 54.2 D_o = 5".006

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
1 - 6	(Reported separately)							
(a) 7	EX-7038	6.7	18.50	2732	15.4	0.011	50	100
8	"	"	"	2727	15.1	0.018	50	100
9	"	"	"	2723	15.1	0.019	0	150
Mean of 2 rounds			18.50	2725±2	15.1±0.0	0.019±0.001		
10	EX-7038	3.0	21.00	2971	18.3	0.018	100	100
11	"	"	"	2960	18.7	0.020	100	100
12	"	"	"	2968	18.8	0.018	100	100
13	"	"	"	2965	18.2	0.017	100	100
Mean of 4 rounds			21.00	2966±4	18.5±0.3	0.018±0.001		
14	EX-7038 (b)	3.0	21.00	2971	18.8	0.018	100	100
15	"	"	"	2949	17.4	0.018	0	150
16	"	"	"	2967	17.7	0.021	0	150
17	"	"	"	2967	17.9	0.019	100	100
18	"	"	"	2947	18.0	0.022	100	100
Mean of 5 rounds			21.00	2960±10	17.8±0.4	0.020±0.002		
19	EX-6822	7.3	18.50	2829	18.0	0.019	0	150
20	"	"	"	2817	17.5	0.022	25	100
21	"	"	"	2821	16.9	0.025	25	100
Mean of 3 rounds			18.50	2822±4	17.5±0.4	0.022±0.002		
22	EX-6822	5.0	20.20	2981	19.8	0.018	0	150
23	"	3.9	21.00	3056	21.9	0.017	0	150
24	"	3.5	21.30	3082	22.3	0.021	Tr	150
25	"	"	"	3080	21.6	0.018	Tr	150
26	"	"	"	3071	21.7	0.018	Tr	150
27	"	"	"	3069	22.2	0.017	Tr	150
28	"	"	"	3079	22.0	0.019	Tr	150
Mean of 5 rounds			21.30	3076±5	22.0±0.2	0.019±0.001		

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
29	EX-6822 (b)	3.5	21.30	3084	22.5	0.020	Tr	150
30	"	"	"	3064	21.7	0.021	Tr	150
31	"	"	"	3071	21.6	0.018	Tr	150
32	"	"	"	3081	21.6	0.021	100	100
33	"	"	"	3080	21.4	0.017	100	100
Mean of 5 rounds			21.30	3076±7	21.8±0.3	0.019±0.002		
34	EX-6822	3.2	21.50	3099	23.6	0.018	Tr	150
35	EX-6883	6.9	18.50	2833	17.3	0.020	0	150
36	"	"	"	2818	16.9	0.019	50	100
37	"	"	"	2828	17.5	0.020	0	150
Mean of 3 rounds			18.50	2826±6	17.2±0.2	0.020±0.000		
38	EX-6883	4.7	20.15	2982	20.2	0.019	100	100
39	"	3.4	21.00	3062	21.1	0.021	100	100
40	"	3.0	21.30	3101	21.3	0.021	Tr	150
41	"	"	"	3096	21.1	0.018	100	100
42	"	"	"	3105	21.9	0.018	Tr	150
43	"	"	"	3094	22.6	0.021	Tr	150
44	"	"	"	3099	21.4	0.018	100	100
Mean of 5 rounds			21.30	3099±3	21.7±0.5	0.019±0.001		
45	EX-6883 (b)	3.0	21.30	3102	22.1	0.021	Tr	150
46	"	"	"	3104	21.7	0.018	100	100
47	"	"	"	3101	21.8	0.018	Tr	150
48	"	"	"	3098	22.5	0.019	100	100
49	"	"	"	3103	21.3	0.018	100	100
Mean of 5 rounds			21.30	3102±0.3	21.9±0.3	0.019±0.001		
50	EX-6883	6.9	18.50	2830	17.2	0.019	100	100

(a) Conditioning round
(b) Ex-23-1 projectile

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953

Gun: Mk 16-0, No. 14763
ESR = 180.5 D_o = 5".056

	Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a)	1	EX-7019 (d)	8.1	17.00	2705	21.0	0.017	0	200
	2	"	"	"	2779	23.9	0.018	0	150
	3	"	"	"	2784	24.2	0.019	0	150
	Mean of 2 rounds			17.00	2782±3	24.1±0.2	0.019±0.001		
	4	EX-7019 (e)	8.1	17.00	2780	22.3	0.019	0	150
	5	"	"	"	2783	23.2	0.018	0	150
	Mean of 2 rounds			17.00	2782±2	22.8±0.5	0.019±0.001		
	6	EX-7019 (f)	8.1	17.00	2765	20.5	0.018	0	150
	7	"	"	"	2767	20.4	0.021	0	150
	Mean of 2 rounds			17.00	2766±1	20.5±0.1	0.020±0.002		
	8	EX-7017 (d)	1.4	21.10	2945	18.9	0.019	100	100
	9	"	"	"	2951	19.1	0.018	100	100
	Mean of 2 rounds			21.10	2948±3	19.0±0.1	0.019±0.001		
	10	EX-7017 (e)	1.4	21.10	2929	17.8	0.018	100	100
	11	"	"	"	2927	17.8	0.019	100	100
	Mean of 2 rounds			21.10	2928±1	17.8±0.0	0.019±0.001		
	12	EX-7017 (f)	1.4	21.10	2915	17.0	0.019	100	100
	13	"	"	"	2914	17.2	0.019	100	100
	Mean of 2 rounds			21.10	2915±1	17.1±0.1	0.019±0.000		

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
14	EX-6883 (d)	4.4	20.15	2965	19.3 (b) 19.7 (c)	0.023	100	100
15	"	"	"	2959	-- 20.1 (c)	0.021	100	100
16	"	"	"	2953	19.3 (b) 19.6 (c)	0.021	100	100
17	"	"	"	2950	19.2 (b) 20.0 (c)	0.021	100	100
18	"	"	"	2957	19.1 (b) 20.8 (c)	0.020	100	100
Mean of 5 rounds			20.15	2957±4	19.2±0.1 (b) 20.0±0.3 (c)	0.021±0.001		
19	EX-6883 (e)	4.4	20.15	2947	19.7	0.022	100	100
20	"	"	"	2951	20.0	0.023	0	150
Mean of 2 rounds			20.15	2949±2	19.9±0.2	0.023±0.001		
21	EX-6883 (f)	4.4	20.15	2939	19.4	--	100	100
22	"	"	"	2976	21.8	--	100	100
Mean of 2 rounds			20.15	2958±19	20.6±1.2			
23	EX-7017	5.1	18.50	2664	13.7	0.019	100	100

(a) Conditioning round
(b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges
(c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges
(d) 800 grams of black powder in primer
(e) 600 " " " " " "
(f) 400 " " " " " "

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 27 January 1953 Gun: Mk 16-0, No. 14763
ESR = 180.5 D_o = 5.056

	Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)(b)	Pressure (t.s.i.)(c)	Pressure (t.s.i.)(d)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a)	1	EX-7019	7.7	17.00	2761	19.5	19.4	20.0	0.020	0	100
	2	EX-6822	3.0	21.56	3084	22.3	22.4	22.4	0.018		
	3	"	"	"	3055	20.7	22.1	22.0	0.022		
	Mean of 2 rounds			21.56	3070±15	21.5±0.8	22.3±0.2	22.2±0.2	0.020±0.002		
	4	EX-7019	7.7	17.00	2763	20.9	21.0	20.6	0.019		
	5	"	"	"	2773	21.7	21.3	20.5	0.016		
	6	"	"	"	2763	20.4	20.2	20.7	0.022		
	Mean of 3 rounds			17.00	2766±4	21.0±0.5	20.8±0.4	20.6±0.1	0.019±0.002		

(a) Conditioning round
(b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges
(c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges
(d) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 28 January 1953 Gun: Mk 16-0, No. 14763
ESR = 180.5 D_o = 5.056

	Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)(b)	Pressure (t.s.i.)(c)	Pressure (t.s.i.)(d)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a)	1	EX-7019	7.7	17.00	2769	20.6	21.2	20.6	-	-	-
	2	EX-6883	2.6	21.28	3052	20.5	21.2	21.5	-	-	-
	3	"	"	"	3055	21.1	21.9	22.2	-	-	-
	4	"	"	"	3071	21.6	21.2	22.7	0.021	-	-
	5	"	"	"	3068	22.2	22.3	21.7	0.017	-	-
	6	"	"	"	3070	22.7	22.0	23.0	0.021	-	-
	Mean of 5 rounds				3063±8	21.6±0.7	21.7±0.4	22.2±0.5	0.020±0.002(e)		

(a) Conditioning round
(b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges
(c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges
(d) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges
(e) Based on 3 rounds

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 February 1953

Gun: Mk 18-0, No. 16078
ESR = 271.7 D_o = 5.011

Rd. No.	Powder	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	Flash (%)	Smoke (%)
(a) 1	EX-6883	3.0	21.31	3045	23.2	0.019	0	150
2	"	"	"	3084	23.2	0.017	100	100
3	"	"	"	3072	23.0	0.020	100	100
4	"	"	"	3088	22.0	0.021	Tr	150
5	"	"	"	3086	22.7	0.021	100	100
6	"	"	"	3091	23.6	0.017	75	125
Mean of 5 rounds			21.31	3084±5	22.9±0.4	0.019±0.002		
7	EX-6822	3.2	21.56	3085	23.7	0.018	100	100
8	"	"	"	3094	23.8	0.020	100	100
9	"	"	"	3096	23.9	0.016	100	100
10	"	"	"	3100	22.4	0.016	100	100
11	"	"	"	3089	23.8	0.021	100	100
Mean of 5 rounds			21.56	3093±5	23.5±0.5	0.018±0.002		

Note: Cone crimp assembly on all rounds.

(a) Conditioning round.

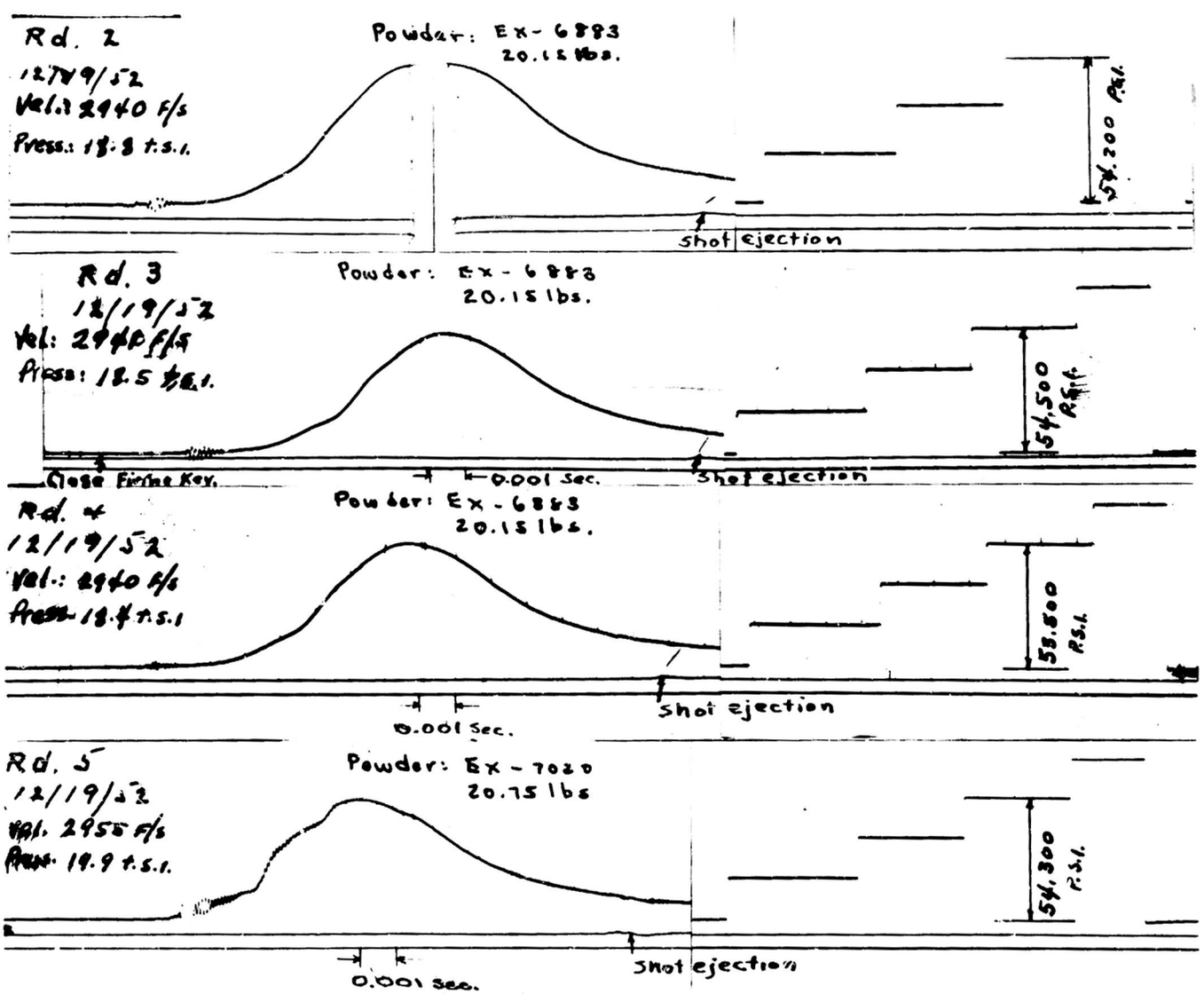
Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

PRESSURE TIME-CURVES

Gun:	5"/54 caliber Mk 16-0, No's. 14758 and 14763
Projectile:	Mk 41-0 (60.00 lb.) Empty
Cartridge Case:	Mk 7
Primer:	Mk 45
Lead Foil:	None
Powder:	As indicated
Plug:	Cork
Was and Spacer:	Cardboard, NGF Dwg. 132664 Pc. Nos. 18 and 15 (as required)
Powder Temp.:	90°F

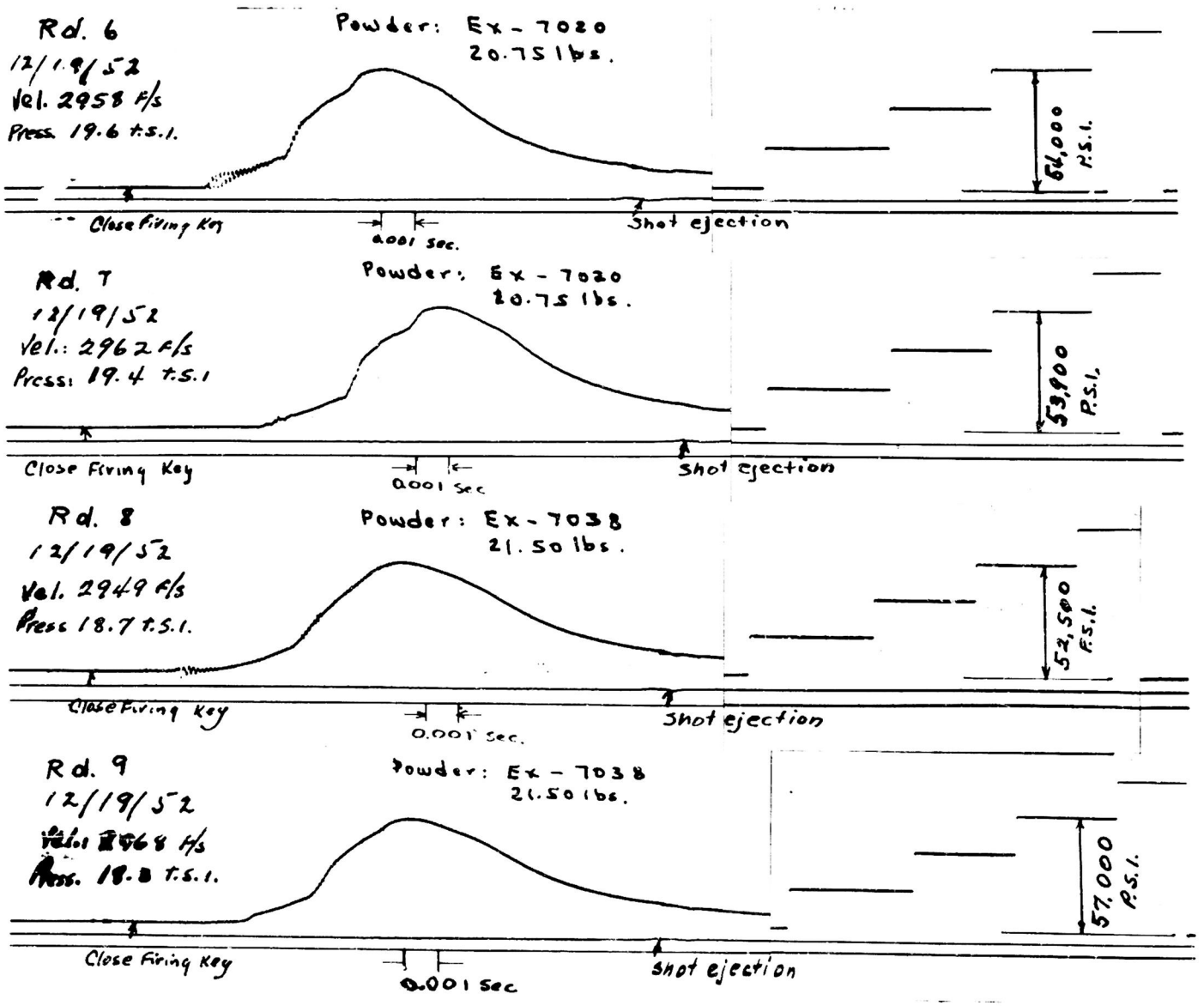
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



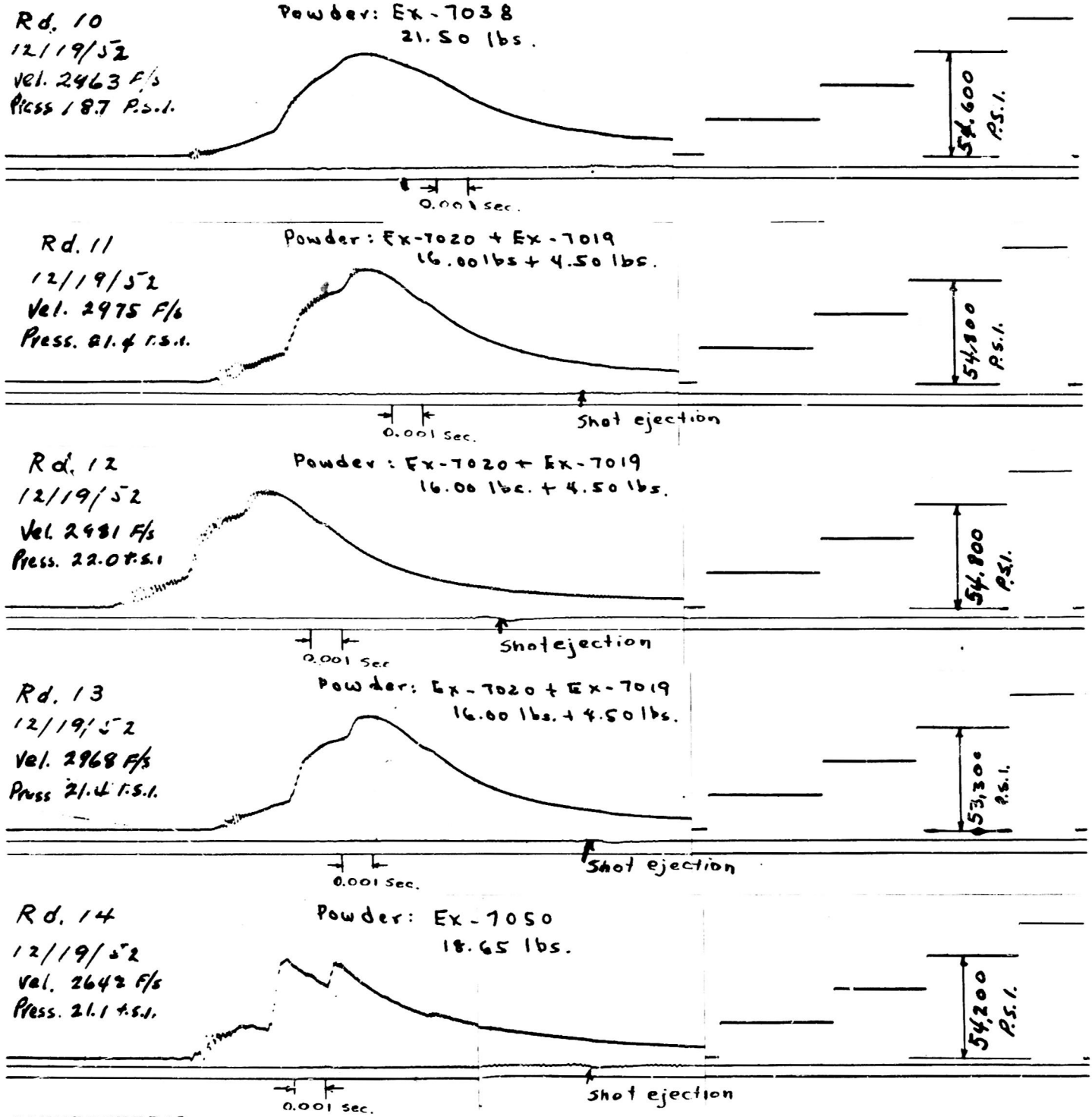
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



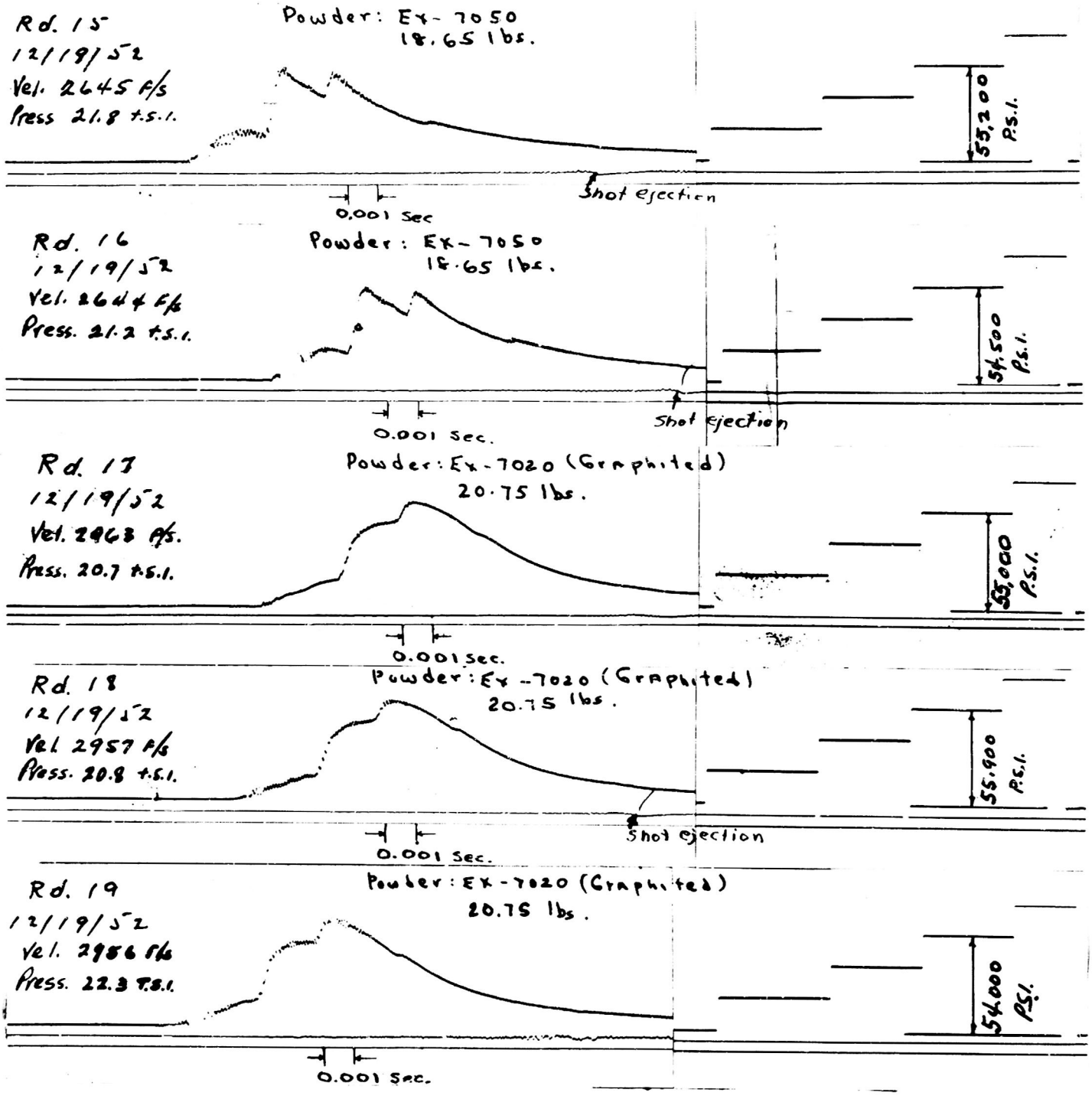
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



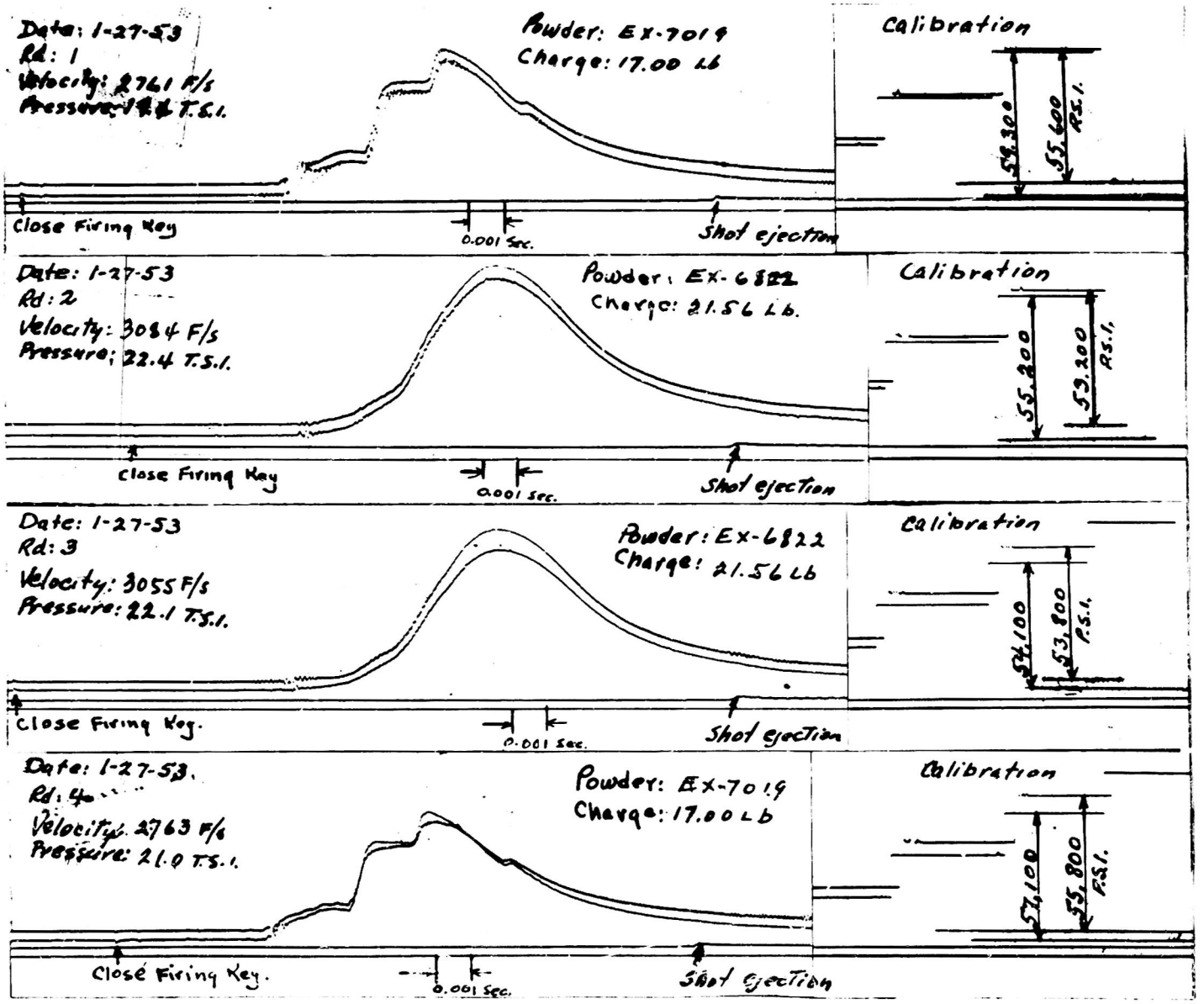
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



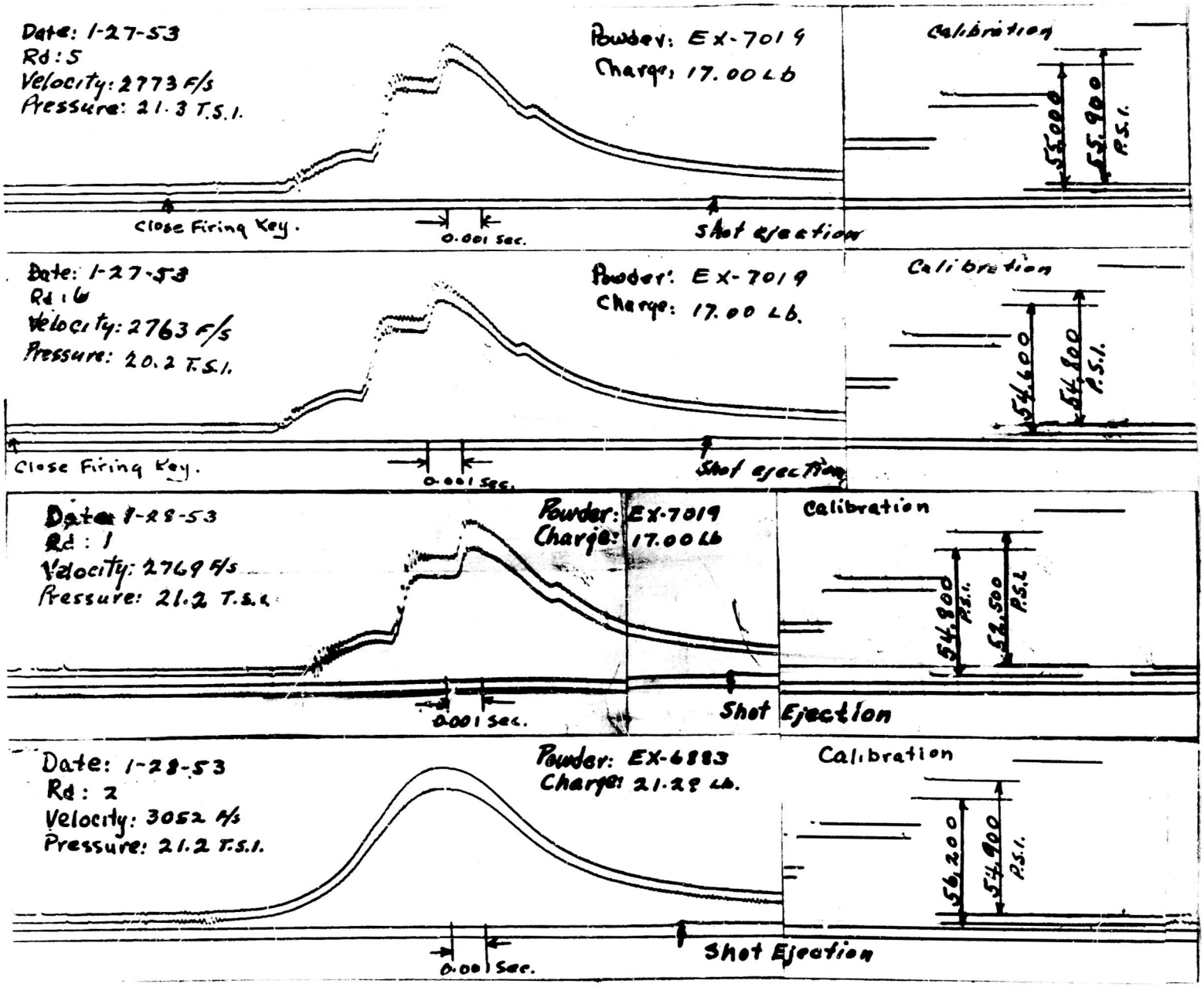
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



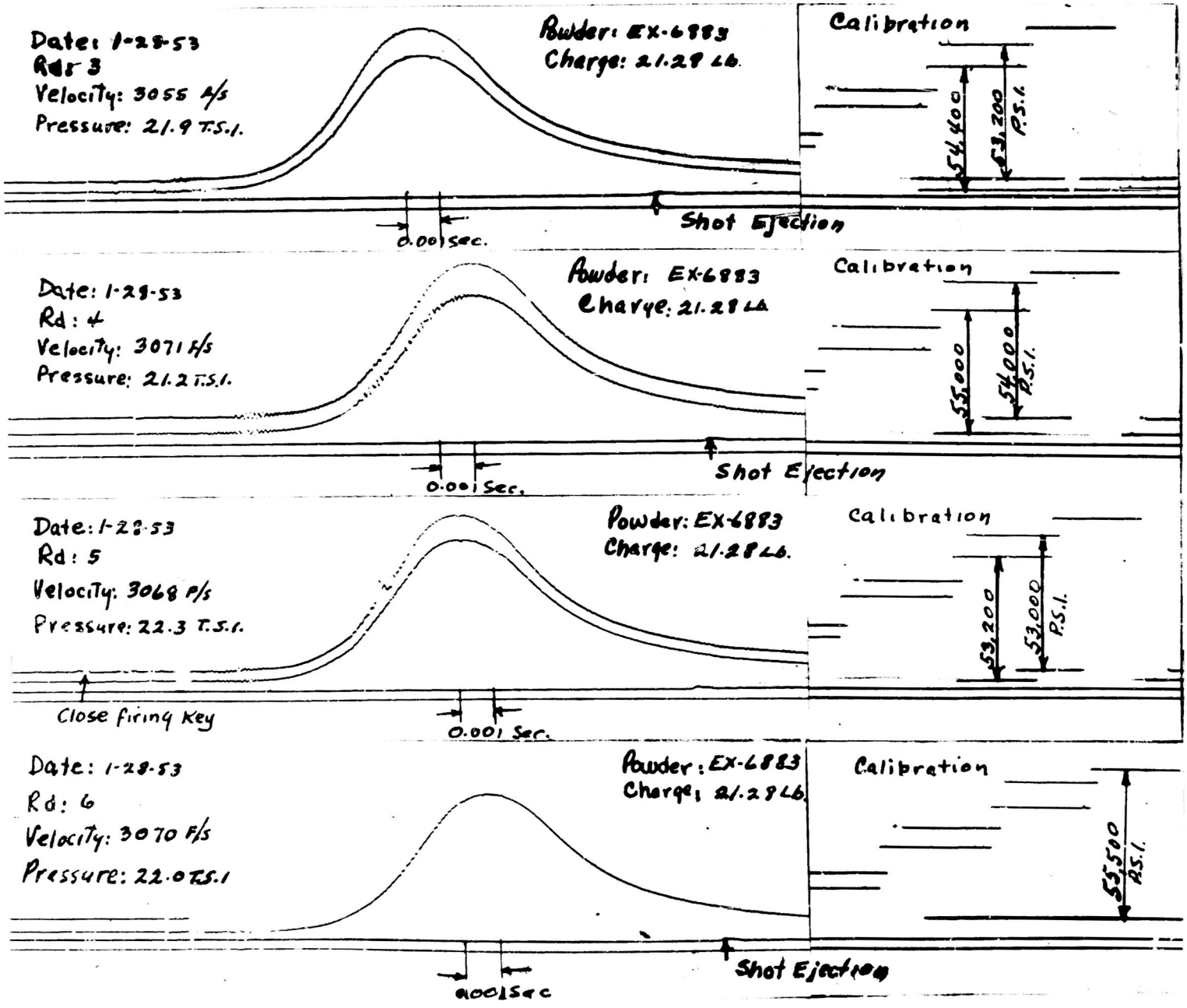
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

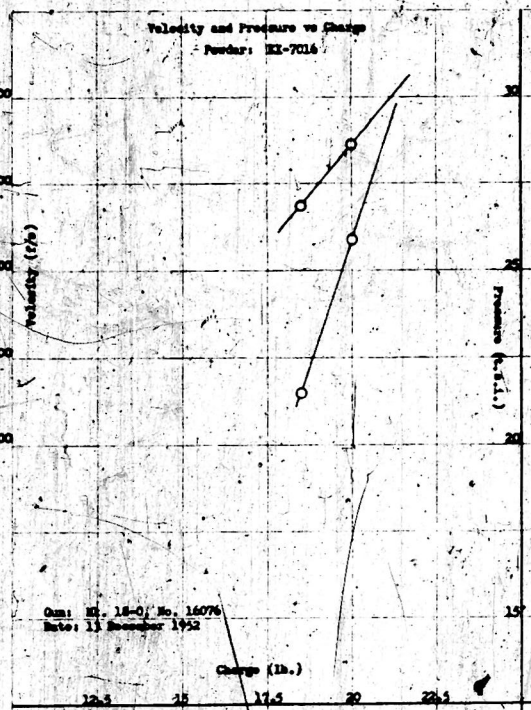
PRESSURE-TIME CURVES

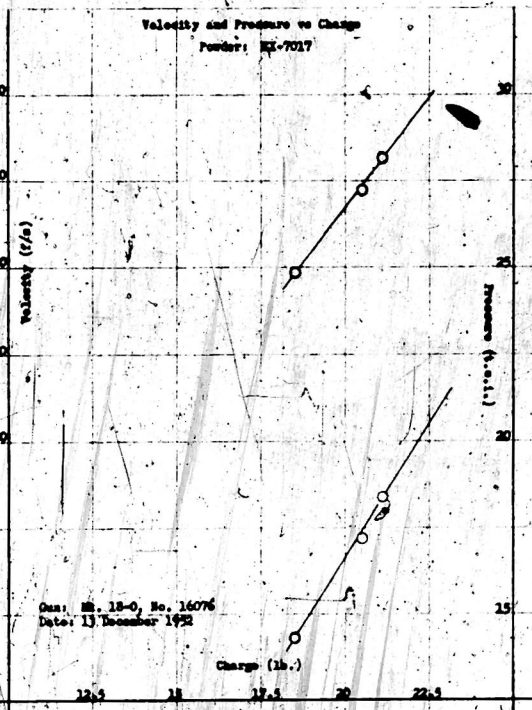


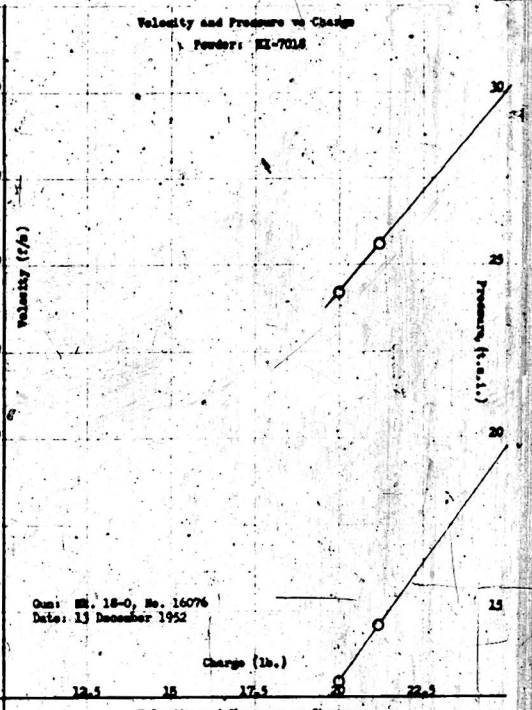
Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive, EX-7038, and EX-7048-EX-7050 Inclusive

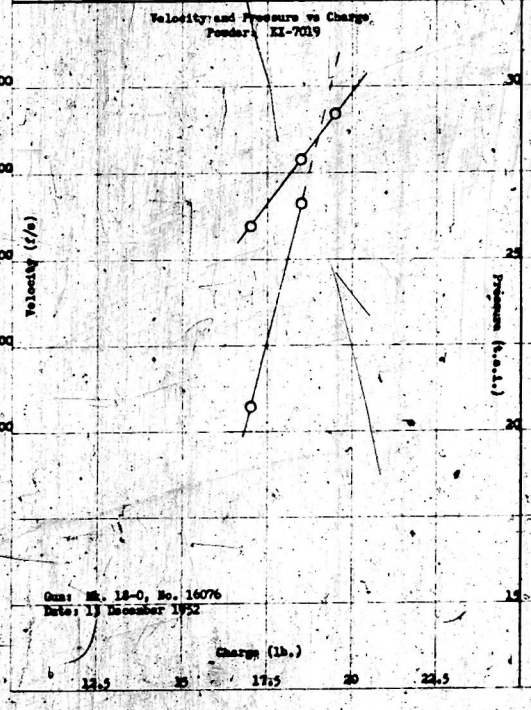
PRESSURE-TIME CURVES

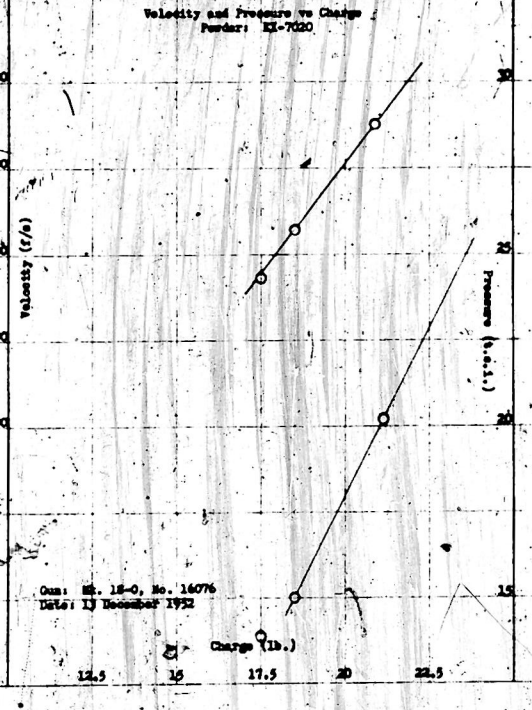


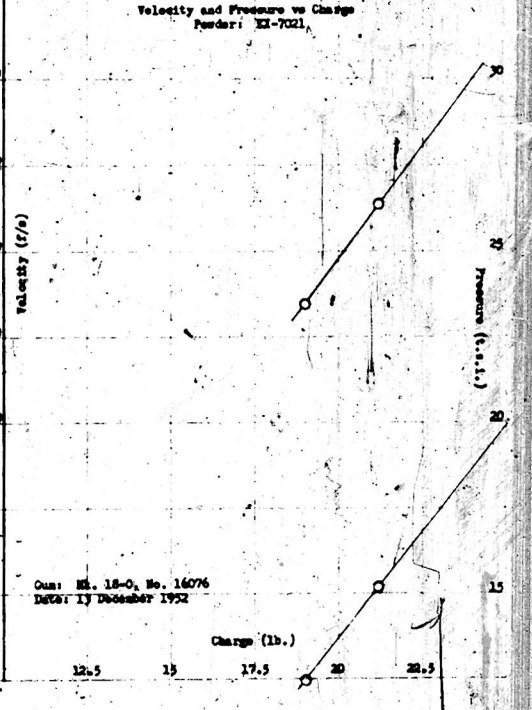

Velocity and Pressure vs Charge
Powder: XI-7016
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952


Velocity and Pressure vs Charge
Powder: XI-7017
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

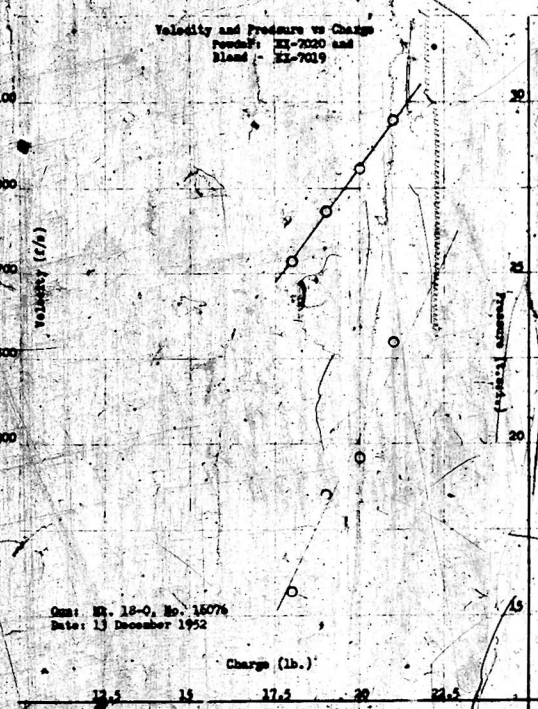

Velocity and Pressure vs Charge
Powder: XI-7018
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952


Velocity and Pressure vs Charge
Powder: XI-7019
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952


Velocity and Pressure vs Charge
Powder: XI-7020
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

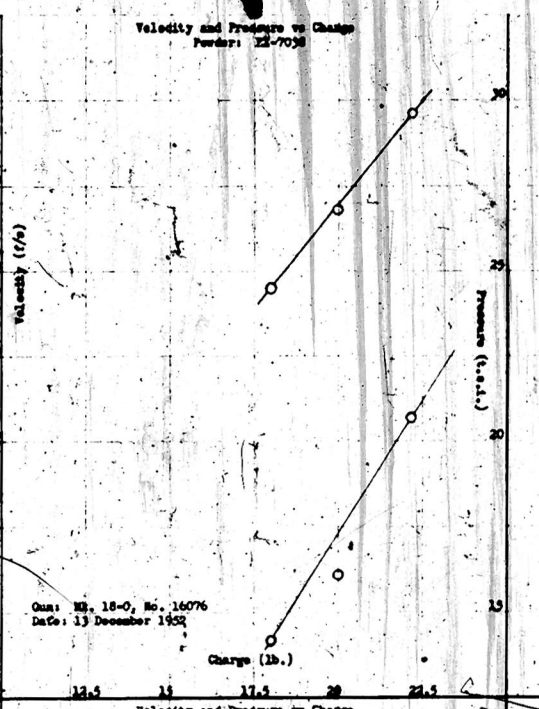

Velocity and Pressure vs Charge
Powder: XI-7021
Velocity (f/s)
Pressure (t.s.i.)
Charge (lb.)
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020 and
Blend :- EX-7019



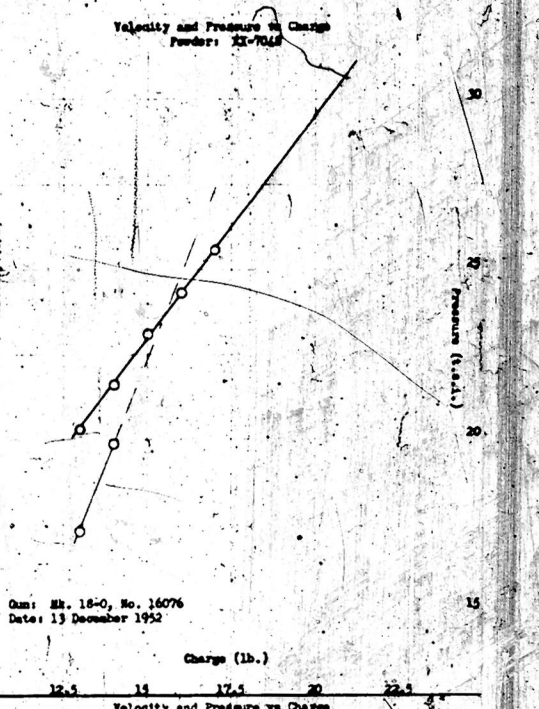
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7050



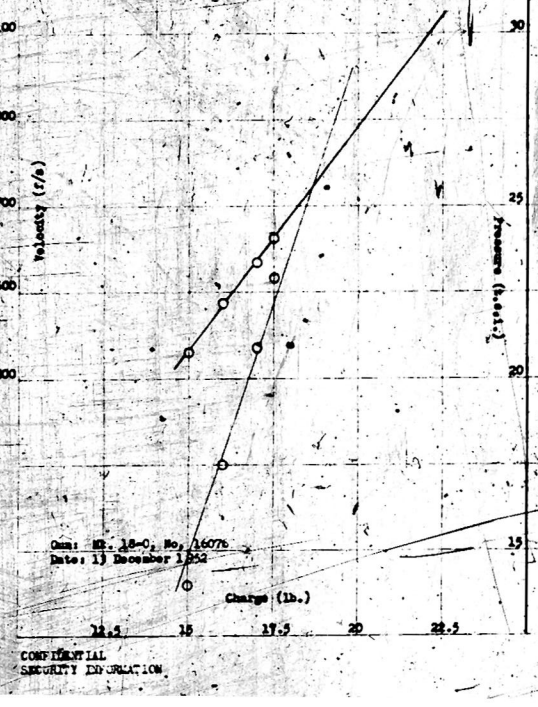
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7049



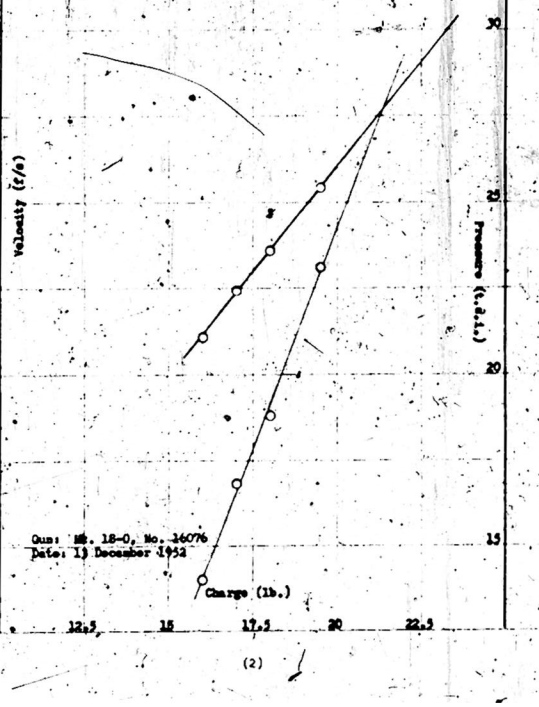
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7049



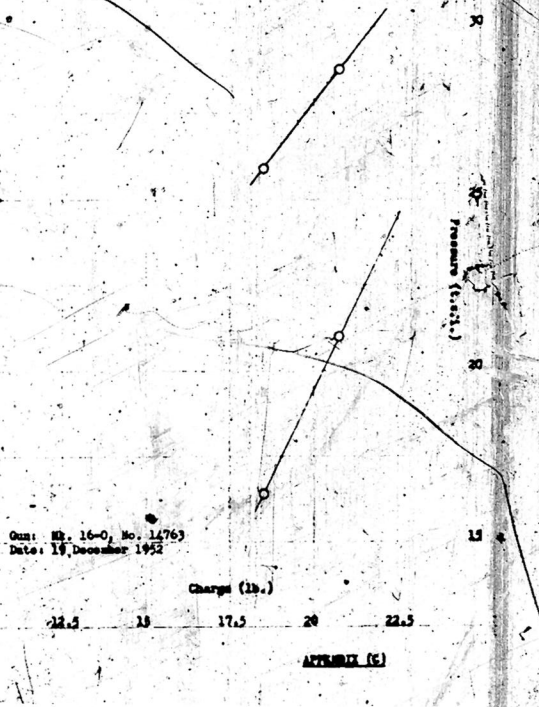
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7050



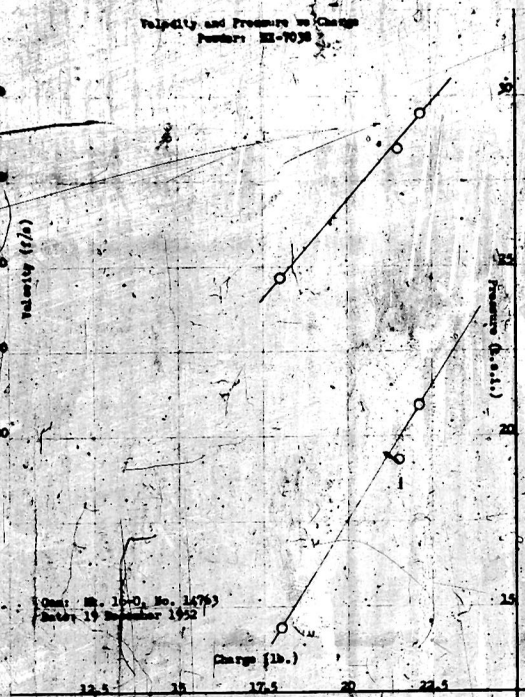
Gun: Mk. 18-0, No. 16076
Date: 13 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020



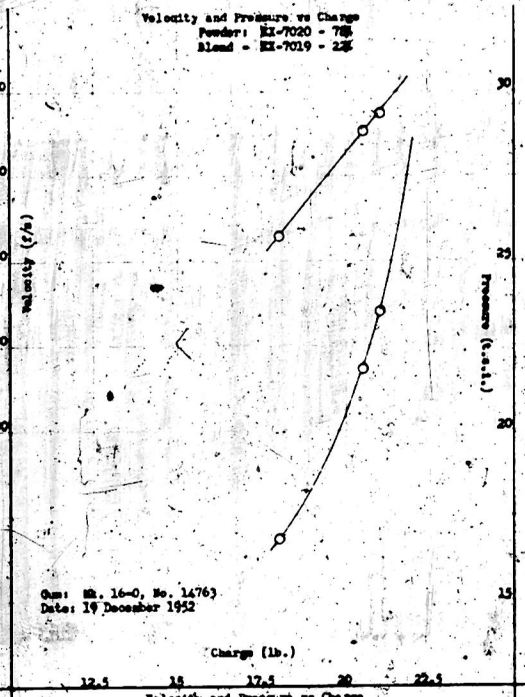
Gun: Mk. 16-0, No. 14763
Date: 19 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020



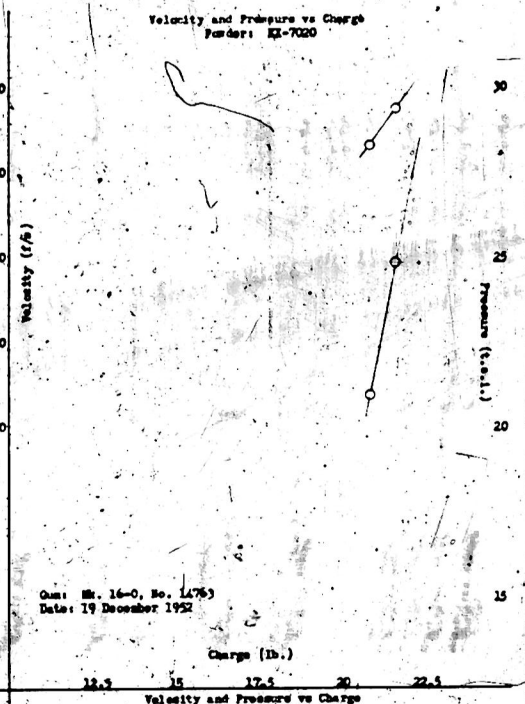
Gun: Mk. 16-0, No. 14763
Date: 19 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020 - 78%
Blend - EX-7019 - 22%



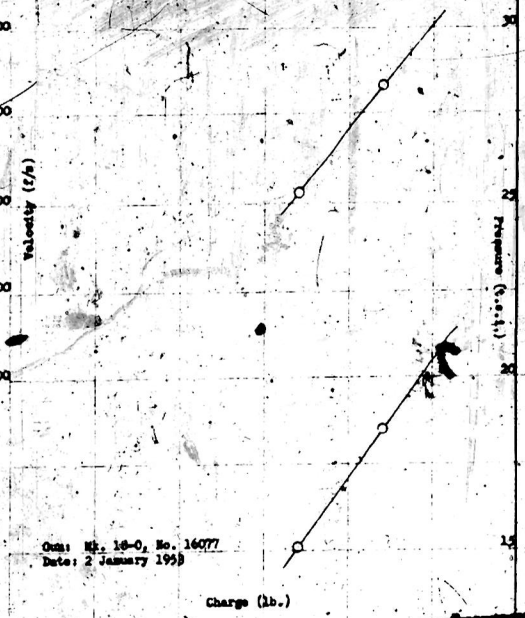
Gun: Mk. 16-0, No. 14763
Date: 19 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020



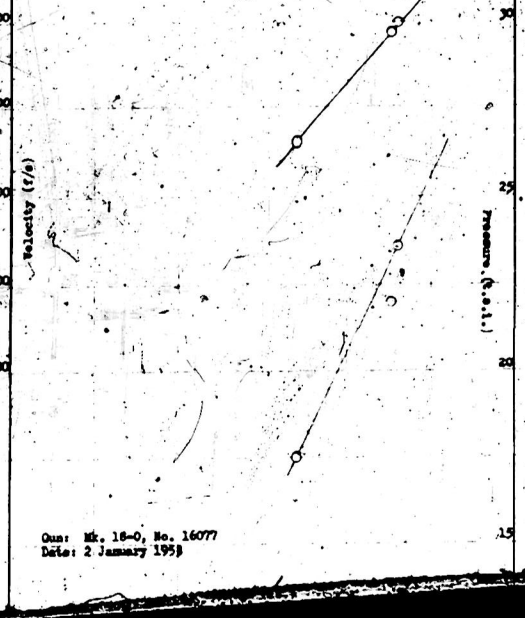
Gun: Mk. 16-0, No. 14763
Date: 19 December 1952

Velocity and Pressure vs Charge
Powder: EX-7020



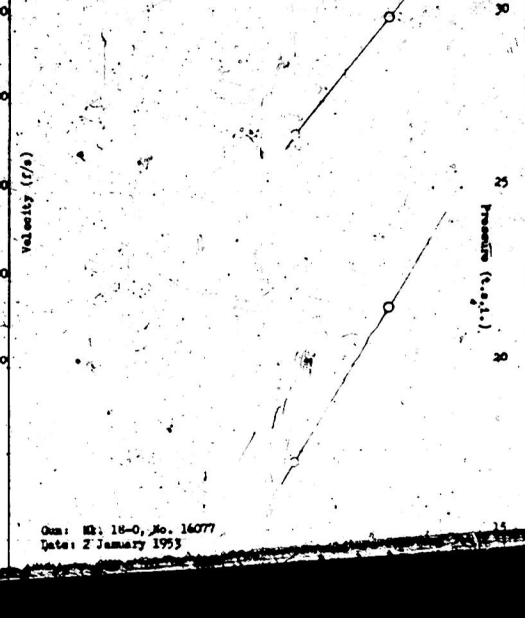
Gun: Mk. 16-0, No. 16077
Date: 2 January 1953

Velocity and Pressure vs Charge
Powder: EX-6822



Gun: Mk. 16-0, No. 16077
Date: 2 January 1953

Velocity and Pressure vs Charge
Powder: EX-6883



Gun: Mk. 16-0, No. 16077
Date: 2 January 1953