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U.S. NAVAL PROVING GROUND, DAHLGREN, VA. (NPG REPORT NO. 770)

TENTH PARTIAL REPORT ON DEVELOPMENT OF A COOL PROPELLANT FOR THE 3"/50 CALIBER GUN - SIXTEENTH PARTIAL REPORT ON DEVELOPMENT OF A COOL PROPELLANT FOR THE 3"/70 CALIBER GUN - THIRD PARTIAL REPORT ON DEVELOPMENT OF IGNITION SYSTEMS FOR "COOL" PROPELLANT CHARGES - FINAL REPORT ON BALLISTIC TEST OF COOL PROPELLANTS EX-6735, EX-6721, AND IMPS-S-83C - AND APPENDIXES A-K

SCHAEFER, WILLIAM E. (SUBMITTER) 9 JUNE '51 90PP PHOTOS, TABLE, GRAPHS, DRWGS

POWDER, PROPELLANT - BALLISTICS
PROPELLANTS - GUNFIRE TEST
PROPELLANTS, COOL

ORDNANCE AND ARMAMENT (22)
EXPLOSIVES (6)

CONFIDENTIAL

U S NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 770

DEVELOPMENT OF A COOL PROPELLANT
FOR THE 3"/50 CALIBER GUN

10th Partial Report

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DEVELOPMENT OF A COOL PROPELLANT
FOR THE 3"/70 CALIBER GUN

16th Partial Report

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DEVELOPMENT OF IGNITION SYSTEMS
FOR "COOL" PROPELLANT CHARGES

3rd Partial Report

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BALLISTIC TEST OF COOL PROPELLANTS
EX-6735, EX-6721, AND IMBP-S-83C

FINAL Report

Task Assignment NPG-15-Re2d [illegible]
NPG-[illegible]-Re2d-62-1
NPG-13-Re2a-184-3

Copy No: 29

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Ballistic Test of Cool Propellants

PART A

SYNOPSIS

1. This is the tenth partial report on Task Assignment NPG-15-Re2d-64-1, the "Development of a Cool Propellant for the 3"/50 Caliber Gun", the sixteenth partial report on Task Assignment NPG-14-Re2d-62-1, the "Development of a Cool Propellant for the 3"/70 Caliber Gun", the third partial report on Task Assignment NPG-13-Re2a-184-3, the "Development of Ignition Systems for "Cool" Propellant Charges", and the final report on "Ballistic Test of Cool Propellants Ex-6735, Ex-6721, and IHPB-S-83C.

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

a. Ex-6721 was too fast for the 3"/70 large chamber gun and too slow for use in the 3"/50 caliber gun.

b. Ex-6735 was ballistically suitable for use in the 3"/50 caliber gun with the XC-D22/250 primer. The pressure-time records obtained with the Mk 42 primer plus 2 empty pyralin containers were fairly smooth while those obtained with all other ignition systems had slight steps in the pressure-rise section of the curves.

c. IHPB-S-83C with the XC-D22/250 primer was too slow for use in the 3"/50 caliber gun but was ballistically satisfactory with the Mk 42 primer. The pressure-time curve obtained with IHPB-S-83C and the XC-D22/250 primer had a slight step in the pressure-rise section but was much better than the ones obtained with IHPB-S-83C using the Mk 42 primer and with NFFB-223 using the XC-D22/250 primer. No carbon deposits were obtained with IHPB-S-83C.

d. Ex-6735 with the XC-D22/250 primer gave as much or more black smoke than the other non-picrite powders at service charge with the exception of Ex-6721 which produced slightly denser smoke.

e. The smoke was similar in appearance (i.e. black) for both single and double-base cool non-picrite (DBP) propellants on flashless rounds, with the exception of IX-29 (single-base) and IX-31 and IX-32 (double-base) which gave dark grey smoke. Flashing rounds in general produced brownish smoke although low intensity flashes were frequently accompanied by brown and black or brown and grey smoke.

f. A relationship exists between the amount of black smoke produced and the ignition systems used with cool non-picrite (DBP) powders and is dependent on the occurrence or non-occurrence of flash. Carbon deposition was only slightly affected by changes in ignition.

g. There is no apparent correlation between the appearance of black smoke and carbon deposits produced with non-picrite propellants and ballistic regularity or the smoothness of the pressure-time curves.

h. The extent of carbon deposition, while not serious enough to cause mechanical difficulties in a few rounds of slow gun firings, is greatly aggravated during extended rapid fire conditions. It is evident that the carbon deposits causing gun operating failure are not due to a few unusual rounds but to a cumulative effect.

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PART B

INTRODUCTION

1. AUTHORITY:

References (a) through (h).

2. REFERENCES:

a. Task Assignment NPG-15-Re2d-64-1 of 14 June 1949.
b. Task Assignment NPG-14-Re2d-62-1 of 14 June 1949.
c. Task Assignment NPG-13-Re2a-184-3 of 10 December 1948.
d. BUORD ltr NP9 Re2d-CNB:ltm Ser 12612 of 6 October 1950.
e. BUORD ltr S-78-1(3") Re2d-CNB:aph Ser 13763 of 8 November 1950.
f. BUORD ltr NP9 Re2d-CNB:ltm Ser 10288 of 25 July 1950.
g. BUORD ltr NP9 Re2d-CNB:aph Ser 16707 of 2 February 1951.
h. BUORD ltr NP9 (Re2a-184-3) WES:blm of 10 December 1948.
i. NPG Report No. 602 of 7 August 1950.
j. NPG Report No. 636 of 31 August 1950.
k. NPG Report No. 640 of 18 September 1950.
l. Description Sheets of Manufacture and Closed Bomb Data.

3. BACKGROUND:

References (a), (b), and (c) set up the general tasks for the development of cool powders for the 3"/50 and 3"/70 caliber guns and the development of ignition systems for cool propellant charges respectively. Reference (d) requested that Ex-6735 be fired for ballistic assessment in the 3"/50 caliber gun and described it as a cool, single-base non-picrite propellant, with a calculated flame temperature of 1883°K. Reference (e) requested that the Naval Proving Ground investigate the occurrence of carbon deposits and black smoke, which was observed during rapid fire erosion studies of Ex-6735 in the 3"/50 caliber gun, and compare the amount and frequency of the carbon deposits and black smoke to that obtained with other non-picrite (single and double-base) powders. Reference (f) requested that Ex-6721 be fired for assessment in the 3"/70 caliber gun and described it as a single-base non-picrite propellant containing 1% lead carbonate with a calculated flame temperature of 1876°K. Reference (g) requested that IHBP sample 83C be fired for ballistic assessment and observance of carbon deposit in 3" guns and described it as a cool single-base powder, without dinitrotoluene or dibutylphthalate,

with a calculated flame temperature of 2123°K. Reference (h) requested that the Proving Ground conduct ignition and ballistic research on cool propellants as necessary to develop optimum ignition systems for various guns. References (i), (j) and (k) are reports on previous tests conducted with cool non-picrite powders.

4. OBJECT OF TEST:

a. To determine whether Ex-6735 is ballistically suitable for use in the 3"/50 caliber gun.

b. To investigate the carbon deposits resulting from firing of cool, non-picrite propellants in 3" guns.

c. To determine whether Ex-6721 is ballistically suitable for use in the 3"/70 caliber gun.

d. To determine whether IHPB-S-83C is ballistically suitable for use in the 3"/70 or 3"/50 caliber guns and to note the extent and nature of any carbon deposits.

e. To establish a suitable ignition system for various cool powders.

5. PERIOD OF TEST:

a. Dates Project Letters:	14 June 1949 25 July 1950 6 October 1950 8 November 1950 2 February 1951
b. Date Material Received:	
Ex-6721	7 July 1950
Ex-6735	4 October 1950
IHBP-S-83C	2 February 1951
c. Date Commenced Test:	26 July 1950
d. Test Completed	6 March 1951

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

Reference (1) gave in detail the powder description and closed bomb data. A summary of the data follows:

Actual Composition	Ex-6721	Ex-6735	IHPB-S-83C
Nitrocellulose (*)	75.07%	74.72%	88.52%
Dinitrotoluene	12.80	13.01	--
Dibutylphthalate	11.08	11.27	--
Diphenylamine	1.05	1.00	--
Lead Carbonate (added)	0.76	--	--
Ethyl Centralite	--	--	7.00
Total Volatiles	0.76	0.42	4.48

* Ex-6721 and Ex-6735 = (13.20%N)
IHPB-S-83C = (12.61%N)

Reference (1) also gave the following information:

Sample	Flame Temp. °K	Grain Dimensions Length (in.)	Diam. (in.)	Av. Web (in.)	No. of Perfs.	RQ (%)	RF (%)
Ex-6721	1876	0.486	0.1852	0.0327	7	117.1(a)	98.1(a)
Ex-6735	1883	0.4300	0.1595	0.0275	7	105.5(b)	101.3(b)
IHBP-S-83C	2123	0.476	0.186	0.029	7	76.2(c)	89.8(c)

(a) Based on Ex-6688 as 100% at 90°F
(b) Based on Ex-6722 as 100% at 90°F
(c) Based on NPFB-223 as 100% at 90°F

References (i), (j) and (k) gave similar information regarding other non-picrite powders used in the subject tests.

7. PROCEDURE:

a. Ex-6721 and IHPB-S-83C were fired in the 3"/70 and 3"/50 caliber guns. Ex-6735 was fired in the 3"/50 caliber gun. Muzzle velocities, maximum pressures (copper crusher) ejection-times, visual observations and photographs of smoke, flash and carbon deposits were obtained. Pressure-time records were obtained at 90°F with various ignition systems. All charges were assembled at PPD (Production Packing Depth).

b. Rapid fire tests were conducted with Ex-6735 in a 3"/50 caliber Mk 22-4 gun by firing up to 175 rounds per program in 25-round bursts with a 20 second delay between each burst. These tests were conducted under a task relative to gun life determinations. Results of gun wear will be covered by separate reports.

c. Tests were conducted to determine whether VT fuze performance would be satisfactory with the ignition system and charge assembly selected for the rapid fire wear trials.

d. In order to insure against obtaining hangfires or misfires during the scheduled rapid fire wear trials with Ex-6735, tests were conducted with Ex-6722, the pilot lot for Ex-6735, to determine the maximum black powder content of the XC-D22/ primer which would still give relatively smooth pressure-time curves.

8. RESULTS AND DISCUSSION:

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

a. Uniformity:

(1)

Gun:	3"/50 Caliber, Mk 21-0
No.:	8917, 7403, 7396 (New)
No.:	7575, 7643, 12811, 16519 (Worn)
Projectile:	Mk 33-1(13.00 lbs.) Epsom Salt loaded
Cartridge Case:	Mk 7, Brass, Rubber Crimped
Lead Foil:	30 grams per round on SPCG-10135 None with Ex-6721 45 grams per round on all others
Wad and Spacer:	Cardboard, NGF Dwg. No. 132664 Pcs. Nos. 13 and 4
Powder Temp.:	84°F on 15 January 1951 90°F on all others

Date	Gun No.	Powder	Primer	PPD (in)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. Rds.
9-18-50	8917	Ex-6721	XC-D22/195	4.6	5.54	2681±10	14.1±0.4	0.016±0.002	5
"	"	"	Mk 42	4.8	5.50	2737±9	15.5±0.3	0.013±0.001	5
"	"	"	Mk 42(a)	1.5	5.50	2710±11	14.7±0.5	0.016±0.005	5
9-25-50	"	Ex-6722	XC-D22/200	6.3	4.90	2654±5	15.0±0.2	0.013±0.000	5
"	"	"	XC-D22/250	6.3	4.90	2665±5	15.3±0.2	0.013±0.001	5
"	"	"	XC-D22/300	6.3	4.90	2676±5	15.7±0.1	0.013±0.001	5
10-10-50	"	SPCG-10135	Mk 42	10.0	4.19	2691±4	16.6±0.3	0.013±0.001	5
"	"	Ex-6722	XC-D22/250	6.5	4.90	2686±5	15.7±0.1	0.013±0.002	5
"	"	Ex-6735	XC-D22/195	6.6	4.88	2678±3	15.4±0.3	0.013±0.001	5
"	"	"	"	6.4	4.88	2694±1	16.0±0.2	0.013±0.001	3
"	"	"	Mk 42(a)	3.4	4.82	2715±2	17.1±0.1	0.013±0.001	3
10-13-50	7403	SPCG-10135	Mk 42-1	10.0	4.19	2686±4	16.4±0.1	0.012±0.000(e)	5
"	"	Ex-6722	XC-D22a/250	6.5	4.90	2673±4	15.3±0.2	0.013±0.000	5
"	"	Ex-6735	"	6.6	4.88	2685±4	15.7±0.3	0.012±0.000(d)	5
"	"	"	Mk 42(a)	3.4	4.82	2691±6(c)	16.4±0.2	0.013±0.001	3
10-16-50	7575	SPCG-10135	Mk 42	10.0	4.19	2619±9	14.5±0.3	0.013±0.001	5
"	"	Ex-6722	XC-D22/250	6.5	4.90	2588±2	13.4±0.2	0.014±0.002	5
"	"	Ex-6735	"	6.6	4.88	2611±4	14.0±0.2	0.013±0.001	5
"	"	"	"	6.4	4.88	2616±2	13.9±0.2	0.012±0.000	3
"	"	"	Mk 42(a)	3.4	4.82	2587±8	13.4±0.2	0.014±0.001	3
10-17-50	7396	SPCG-10135	Mk 42	10.0	4.19	2691±6	16.4±0.2	0.013±0.001	5
"	"	Ex-6722	XC-D22a/250	6.5	4.90	2671±3	15.0±0.1	0.014±0.001	5
"	"	Ex-6735	"	6.6	4.88	2699±3	16.1±0.3	0.013±0.001	5
"	"	"	"	6.4	4.88	2685±5	15.7±0.2	0.013±0.001	3
"	"	"	Mk 42(a)	3.4	4.82	2697±4	15.9±0.3	0.014±0.001	3

Date	Gun No.	Powder	Primer	PPD (in)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. Rds.
10-19-50	7643	NPFB-223	Mk 42	10.0	4.08	2648±4	15.6±0.1	0.013±0.000	5
"	"	SPCG-10135	"	10.0	4.19	2632±8	15.3±0.2	0.013±0.001	5
"	"	Ex-6735	XC-D22a/250	6.6	4.88	2617±3	14.4±0.1	0.013±0.001	5
"	"	"	"	6.4	4.88	2612±5	13.9±0.1	0.014±0.000(c)	3
"	"	"	Mk 42(a)	3.4	4.82	2595±8	13.8±0.2	0.014±0.001	3
10-24-50	12811	NPFB-223	Mk 42-1	10.0	4.08	2634±4	15.0±0.2	0.013±0.001	5
"	"	SPCG-10135	"	10.0	4.19	2607±6	14.4±0.2	0.013±0.001	5
"	"	Ex-6735	XC-D22/250	6.6	4.88	2623±3	14.2±0.2	0.012±0.000	5
"	"	"	"	6.4	4.88	2605±2	13.7±0.1	0.013±0.001	3
"	"	"	Mk 42(a)	3.4	4.82	2597±8	13.7±0.2	0.015±0.001	3
11-9-50	7396	Ex-6735	XC-D22/250	6.4	4.89	2707±3	15.9±0.4	0.014±0.001	5
"	"	A	"	6.4	4.89	2718±7	16.4±0.2	0.012±0.000	5
11-17-50	"	A	XC-D22/250	6.9	4.79	2696±5	16.2±0.3	0.014±0.001	3
"	"	B	"	6.9	4.79	2682±2	16.0±0.1	0.014±0.001	3
"	"	C	"	6.9	4.79	2667±12	15.7±0.3	0.013±0.000	3
"	"	D	"	6.4	4.89	2708±3	16.2±0.3	0.013±0.001	5
1-4-51	8917	Ex-6735	Mk 42	6.3	4.89	2724±3	16.2±0.2	0.012±0.001	3
"	"	"	Mk 42(b)	5.9	4.51	2729±4	16.0±0.2	0.013±0.001	3
"	"	"	XC-D22/250	6.6	4.89	2694±5	15.4±0.2	0.014±0.001	5
"	"	Ex-6705	"	7.2	4.65	2694±7	16.0±0.2	0.013±0.001	5
"	"	Ex-6708	"	6.2	4.84	2671±5	14.5±0.2	0.013±0.001	5
"	"	Ex-6701	"	7.2	4.65	2655±3	14.3±0.2	0.014±0.001	5
"	"	IX-31	"	8.3	4.36	2726±8	17.4±0.2	0.012±0.001	5
"	"	Ex-6715	"	6.8	4.79	2667±11	14.1±0.2	0.013±0.001	5

Date	Gun No.	Powder	Primer	PPD (in)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ejec. Time (sec.)	No. Rds.
1-15-51	8917	E	XC-D22/250	8.3	4.46	2692±4	-	0.013±0.001	3
"	"	F	"	8.7	4.37	2689±1	-	0.012±0.000	3
"	"	G	"	9.0	4.28	2696±1	-	0.013±0.001	3
"	"	H	"	9.4	4.20	2705±2	-	0.011±0.000	3
"	"	NPFB-266	"	10.1	4.02	2704±3	-	0.012±0.001	3
"	"	I	"	9.7	4.11	2706±3	-	0.013±0.001	3

Powder A = 0.4 lbs. SPDN-4438 in bottom of case. Balance of charge consisted of Ex-6735 on top of SPDN-4438.
Powder B = 0.3 lbs. SPDN-4438 in bottom of case. Balance of charge consisted of Ex-6735 on top of SPDN-4438.
Powder C = 0.2 lbs. SPDN-4438 in bottom of case. Balance of charge consisted of Ex-6735 on top of SPDN-4438.
Powder D = 0.4 lbs. SPDN-5208 in bottom of case. Balance of charge consisted of Ex-6735 on top of SPDN-5208.
Powder E = 50/50 blend of NPFB-266 (2.01 lbs.) and Ex-6735 (2.45 lbs.)
Powder F = 60/40 blend of NPFB-266 (2.41 lbs.) and Ex-6735 (1.96 lbs.)
Powder G = 70/30 blend of NPFB-266 (2.81 lbs.) and Ex-6735 (1.47 lbs.)
Powder H = 80/20 blend of NPFB-266 (3.22 lbs.) and Ex-6735 (0.98 lbs.)
Powder I = 90/10 blend of NPFB-266 (3.62 lbs.) and Ex-6735 (0.49 lbs.)

The percentage values indicated for the above blends are only approximate for the charges fired. They do, however, represent accurately the portion of the respective full charge weight of each component powder considered separately.

(a) Plus 2 empty pyralin containers and on end around primer.
(b) Plus 150 grams of NPFB-223 in pyralin container around forward end of primer.
(c) Based on 2 rounds.
(d) Based on 3 rounds.
(e) Based on 4 rounds.

(2) Velocity and pressure uniformity was satisfactory for all groups.

b. Charge Determination:

(1) 3"/50 Caliber Gun

Firing conditions are the same as for Uniformity Firings.

Powder	Gun	Primer	Vel. (f/s)	Charge (lbs.)	Pressure (t.s.i.)
Ex-6721	8917 (New)	Mk 42 (c)	2700	5.47 (a)	14.6 (a)
Ex-6721	8917 (New)	XC-D22/195	2700	5.58 (a)	14.3 (a)
Ex-6721	8917 (New)	Mk 42	2700	5.43 (a)	14.9 (a)
Ex-6735	8917 (New)	XC-D22/250	2700	4.91 (a)	14.7 (a)
Ex-6735	7403 (New)	XC-D22a/250	2700	4.88 (a)	14.9 (a)
Ex-6735	7396 (New)	XC-D22a/250	2700	4.86 (a)	15.2 (a)
Ex-6735	7575 (Worn)	XC-D22/250	2700	4.90 (a)	15.2 (a)
Ex-6735	7643 (Worn)	XC-D22a/250	2700	4.91 (a)	14.9 (a)
Ex-6735	12811 (Worn)	XC-D22/250	2700	4.85 (a)	15.2 (a)
Ex-6735	(Average of New and Worn Guns)		2700	4.89 (a)	15.0 (a)
IHBP-S-83C	8917 (New)	Mk 42	2700	4.83 (b)	15.5 (b)
IHBP-S-83C	8917 (New)	XC-D22/250	2700	4.91 (b)	14.8 (b)

(a) Determined by Matched Powder Method. Matched against SPCG-10135 (4.19 lbs., Primer Mk 42).
(b) Determined by New Gun Method.
(c) Plus 2 empty pyralin containers end on end around primer.

(2) Ex-6721 was too fast for the 3"/70 caliber gun. A charge of 9.00 lbs. gave a pressure of 22.3 tsi and only 3271 f/s velocity. It was too slow for use in the 3"/50 caliber gun regardless of ignition used.

(3) Ex-6735 with the XC-D22/250 primer was ballistically suitable for use in the 3"/50 caliber gun, Mk 21-0. The average of six firings just met the lower pressure limit of 15.0 tsi.

(4) IHBP-Sample 83C with the XC-D22/250 primer was too slow for use in the 3"/50 caliber gun, but was ballistically satisfactory with the Mk 42 primer. It was too fast for the 3"/70 caliber gun, giving only 3347 f/s at a pressure 23.3 tsi with a charge of 8.50 lbs.

c. Pressure-time Records:

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

(2) Ex-6722 gave smooth curves with the XC-D22/200 and XC-D22/250 primers while the curves with the XC-D22/300 primer had slight steps in the pressure-rise portion. The XC-D22/250 primer appeared to be the best primer from the standpoint of both smoothness of pressure-time curves and insurance against hangfires.

(3) The pressure-time curves obtained with Ex-6735 using the Mk 42 primer plus 2 empty containers were fairly smooth but were not as good as those for Ex-6722 with the same ignition system. Ex-6735 with all other ignition systems gave slight steps in the pressure-rise section of the curves and were worse than those for Ex-6722 under the same conditions.

(4) Ex-6735 with a scavenger NH powder at the base of the case and the XC-D22/250 primer gave curves with steps. However, the velocity-pressure relationship, velocity and pressure uniformity and fuze performance were satisfactory with this assembly.

(5) In general, the curves obtained with Ex-6735 were worse than those obtained with Ex-6722 for all ignition systems tested. Since compositional differences are slight this may possibly be attributable to the smaller perforation diameter of Ex-6735 relative to other grain dimensions.

(6) The pressure-time curve obtained with IHBP-S-83C with the XC-D22/250 had a slight step in the pressure-rise section but was much better than the ones produced by IHBP-S-83C with the Mk 42 primer, and by NPFB-223 with the XC-D22/250 primer.

d. Smoke and Flash:

(1) Appendix (D) gives a summary of the composition and smoke data for various powders. A breakdown as to ignition along with the resulting smoke, flash, and carbon data are tabulated in Appendices (D) and (E). Appendix (F) contains photographs of smoke and flash.

(2) Ex-6735 with the XC-D22/250 primer gave as much black smoke as, or more than, the other non-picrite powders tested at service charge, with the exception of Ex-6721 which produced slightly denser smoke.

(3) The black smoke observed during the subject tests appeared denser at the lower pressure levels. The smoke was similar in appearance for both the single and double-base non-picrite (DBP) propellants on flashless rounds with the exception of IX-29 (single-base) and IX-31 and IX-32 (double-base) which gave dark grey smoke. Flashing rounds, in general, produced brownish smoke although low intensity flashes were frequently accompanied by brown and black or brown and grey smoke.

(4) The percentage of flashless rounds (and hence rounds with black smoke) was greater on cool non-picrite (DBP) rounds fired with XC-D22/- primers, than on rounds fired with Mk 42-1 primers (with or without voids or boosters around the primer).

(5) There is no apparent correlation between the appearance of black smoke and ballistic regularity or the smoothness of the pressure-time curves.

(6) IHPB-S-83C, a single-base propellant (2123°K) without dinitrotoluene or dibutylphthalate gave no black smoke when tested with the Mk 42 or the XC-D22/250 primer. The majority of rounds with the XC-D22/250 primers were essentially flashless while all rounds, except those at low charge weight, with the Mk 42 primer gave large flashes. Smoke was light grey on flashless rounds and brownish on flashing rounds. As with picrite powders, strong ammonia fumes were evident on all rounds.

(7) Two hundred and eighteen (218) rounds of non-picrite powders fired under rapid fire conditions were not observed for smoke and flash and are omitted from the tabulations in Appendices (D) and (E).

e. Carbon Deposits:

(1) During single round firing in the subject tests, no mechanical difficulties were experienced by the formation of carbon. However, after 139 rapid fire rounds of Ex-6735 the gun jammed and could not be fired. An examination of the breech mechanism showed it to be covered with a layer of soot and all bearing surfaces to be free of any lubricant. Appendix (I) contains photographs of the breech mechanism after jamming. Apparently, the carbon deposition tended to "dry up" the lubricant and caused the moving parts to overheat and jam.

(2) The extent of carbon deposit, while not serious enough to cause mechanical difficulties in a few rounds of slow gun firing is greatly aggravated during extended rapid fire conditions. It is evident that the situation is not due to a few unusual rounds but to a cumulative effect as seen by the rapid fire tests.

(3) In order to proceed with the rapid fire wear trials, efforts were made to eliminate carbon deposition. The use of a scavenger NH powder SPDN-4438 (2621°K) at the base of the case and Ex-6735 (non-picrite 1883°K) powder on top proved satisfactory in that, while there was no apparent reduction of black smoke, there was essentially complete elimination of carbon deposition at the gun breech. Detailed results are given in Appendix (H).

(4) Appendix (E) shows the amount of carbon (based on Ex-6735 as 100%) observed in the barrel and chamber for various powders. The carbon deposits were cleaned out of the gun with compressed air after every round. Appendix (G) shows photographs of the carbon remaining in the fired cases for the various powders. Various blends of NH powder NPFB-266 (2588°K) and Ex-6735 (1883°K) gave little reduction in black smoke, and decreases in carbon deposits only in proportion to the decrease in the amount of the cool powder used. Unless the critical powder flame temperature for carbon formation is around 2500°K this indicates that the carbon formation is due to the initial reactions at the surface of the powder and not the final gas phase reactions which would otherwise have been altered by the introduction of the hotter NH powder with complete elimination of carbon. Although no carbon deposit was observed for IX-29 (single-base 2243°K), it was observed for Ex-6705 (single-base 2186°K). This may indicate that the critical powder flame temperature is around 2200°K. However, it should be noted that IX-29 contains ethyl centralite as stablizer and only 6.26% DBP while Ex-6705 contains DPA as stabilizer and 8.53% DBP. It is likely that DBP is responsible for the carbon formation since IHPB-S-83C which contains no DBP, but a rather high percentage of ethyl centralite (7.00%), produced no carbon although the flame temperature was only 2123°K. Although the estimate of approximately 2200°K as the critical temperature for the single-base powders containing DBP is subject to question because of the presence of ethyl centralite in the hotter powder, it is somewhat substantiated by the behavior of the IX and Ex double-base powders which differ in flame temperature only as a result of percentage differences in composition. Appendix (E) indicates a considerable decrease in carbon deposits for the double-base powders in going from 2025°K to 2170°K.

(5) There is no apparent correlation between the formation of carbon and ballistic regularity or the smoothness of the pressure-time curves.

f. VT Fuze Performance:

Appendix (J) gives in detail the fuze performance data obtained on programs fired using a scavenger NH powder at the base of the case and Ex-6735 on top with the XC-D22/250 primer. No carbon deposits were observed after any of the rounds. An acceptable score of 64% effective was obtained on the fuze tests.

PART D

CONCLUSIONS

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

a. Ex-6721 was too fast for the 3"/70 large chamber gun and too slow for use in the 3"/50 caliber gun.

b. Ex-6735 was ballistically suitable for use in the 3"/50 caliber gun with the XC-D22/250 primer. The pressure-time records obtained with the Mk 42 primer plus 2 empty pyralin containers were fairly smooth while those obtained with all other ignition systems had slight steps in the pressure-rise section of the curves.

c. IHPB-S-83C with the XC-D22/250 primer was too slow for use in the 3"/50 caliber gun but was ballistically satisfactory with the Mk 42 primer. The pressure-time curve obtained with IHPB-S-83C and XC-D22/250 primer had a slight step in the pressure-rise section but was much better than the ones obtained with IHPB-S-83C using the Mark 42 primer and with NPFB-223 using the XC-D22/250 primer. No carbon deposits were obtained with IHPB-S-83C.

d. Ex-6735 with the XC-D22/250 primer gave as much or more black smoke than the other non-picrite powders at service charge with the exception of Ex-6721 which produced slightly denser smoke.

e. The smoke was similar in appearance (i.e. black) for both single and double-base cool non-picrite (DBP) propellants on flashless rounds, with the exception of IX-29 (single-base) and IX-31 and IX-32 (double-base) which gave dark grey smoke. Flashing rounds in general produced brownish smoke although low intensity flashes were frequently accompanied by brown and black or brown and grey smoke.

f. A relationship exists between the amount of black smoke produced and the ignition systems used with cool non-picrite (DBP) powders and is dependent on the occurrence or non-occurrence of flash. Carbon deposition was only slightly affected by changes in ignition.

g. There is no apparent correlation between the appearance of black smoke and carbon deposits produced with non-picrite propellants and ballistic regularity or the smoothness of the pressure-time curves.

h. The extent of carbon deposition, while not serious enough to cause mechanical difficulties in a few rounds of slow gun firings, is greatly aggravated during extended rapid fire conditions. It is evident that the carbon deposits causing gun operating failure are not due to a few unusual rounds but to a cumulative effect.

Ballistic Test of Cool Propellants

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IRVING T. DUKE
Captain, USN
Ordnance Officer
By direction

CONFIDENTIAL NPG REPORT NO. 770

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Tenth Partial Report

on

Development of a Cool Propellant

for the 3"/50 Caliber Gun

- -

Sixteenth Partial Report

on

Development of a Cool Propellant

for the 3"/70 Caliber Gun

- -

Third Partial Report

on

Development of Ignition Systems

for "Cool" Propellant Charges

- -

Final Report

on

Ballistic Test of Cool Propellants

Ex-6735, Ex-6721, and IHPB-S-83C

Project Nos.: NPG-15-Re2d-64-1
NPG-14-Re2d-62-1
NPG-13-Re2a-184-3

Date: JUN 9 1951

Copy No.: 29
No. of Pages: 17
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CONFIDENTIAL

TABULATION OF FIRING DATA

Gun: 3"/50 Caliber Mk 21-0

No. 8917	ESR = 987	D_o = 3".023
" 7403	" = 394	" = 3".035
" 7575	" = 2852	" = 3".114
" 7396	" = 58	" = 3".006
" 7643	" = 2768	" = 3".110
" 12811	" = 2986	" = 3".127
" 16519	" = 1848	" = 3".088

Projectile: Mk 33 (13.00 lbs.) Epsom Salt Loaded

Cartridge Case: Mk 7, Brass, Rubber Crimped

Lead Foil: 30 grams per round on SPCG-10135
45 grams per round on all others

Wad and Spacer: Cardboard, NGF Dwg. No. 132664
Pc. Nos. 13 and 4

Powder Temp.: 84°F on 15 January 1951
90°F on all other dates

Date: 18 September 1950 Gun No. 8917

Rd. No.	Powder	Primer	PFD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6721	XC-D22/195	10.9	3.50	1850	6.9	0.025	0	300*
2	"	"	7.8	4.50	2217	9.3	0.016	0	300*
3	"	"	"	"	2228	9.3	0.017	0	300*
4	"	"	"	"	2233	9.3	0.016	0	300*
Mean of 3 rounds				4.50	2226±6	9.3±0.0	0.016±0.000		
5	Ex-6721	XC-D22/195	4.7	5.50	2685	14.2	0.017	100	75
6	"	"	4.6	5.54	2682	14.2	0.019	80	150
7	"	"	"	"	2695	14.3	0.015	100	100
8	"	"	"	"	2690	14.8	0.015	100	100
9	"	"	"	"	2663	13.5	0.019	0	300*
10	"	"	"	"	2673	13.8	0.013	60	175
Mean of 5 rounds				5.54	2681±10	14.1±0.4	0.016±0.002		
11	Ex-6721	XC-D22/195	4.0	5.74	2758	14.4	0.017	100	100
12	"	"	"	"	2768	15.1	0.013	100	100
Mean of 2 rounds				5.74	2763±5	14.8±0.4	0.015±0.002		
13	Ex-6721	Mk. 42	7.9	4.50	2220	9.5	0.015	0	300*
14	"	"	"	"	2217	9.3	0.017	0	300*
15	"	"	"	"	2227	9.6	0.015	0	300*
Mean of 3 rounds				4.50	2221±4	9.5±0.1	0.016±0.001		
16	Ex-6721	Mk. 42	4.8	5.50	2724	15.4	0.013	100	100
17	"	"	"	"	2740	15.7	0.016	100	100
18	"	"	"	"	2741	15.8	0.012	100	100
19	"	"	"	"	2754	15.7	0.013	100	100
20	"	"	"	"	2728	15.0	0.013	100	100
Mean of 5 rounds				5.50	2737±9	15.5±0.3	0.013±0.001		
21	Ex-6721	Mk. 42	4.2	5.70	2865	17.8	0.012	100	100
22	"	"	"	"	2860	17.5	0.013	100	100
Mean of 2 rounds				5.70	2863±3	17.7±0.2	0.013±0.001		

Date: 18 September 1950 Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6721	XC-D22/195	10.9	3.50	1850	6.9	0.025	0	300*
2	"	"	7.8	4.50	2217	9.3	0.016	0	300*
3	"	"	"	"	2228	9.3	0.017	0	300*
4	"	"	"	"	2233	9.3	0.016	0	300*
Mean of 3 rounds				4.50	2226±6	9.3±0.0	0.016±0.000		
5	Ex-6721	XC-D22/195	4.7	5.50	2685	14.2	0.017	100	75
6	"	"	4.6	5.54	2682	14.2	0.019	80	150
7	"	"	"	"	2695	14.3	0.015	100	100
8	"	"	"	"	2690	14.8	0.015	100	100
9	"	"	"	"	2663	13.5	0.019	0	300*
10	"	"	"	"	2673	13.8	0.013	60	175
Mean of 5 rounds				5.54	2681±10	14.1±0.4	0.016±0.002		
11	Ex-6721	XC-D22/195	4.0	5.74	2758	14.4	0.017	100	100
12	"	"	"	"	2768	15.1	0.013	100	100
Mean of 2 rounds				5.74	2763±5	14.8±0.4	0.015±0.002		
13	Ex-6721	Mk. 42	7.9	4.50	2220	9.5	0.015	0	300*
14	"	"	"	"	2217	9.3	0.017	0	300*
15	"	"	"	"	2227	9.6	0.015	0	300*
Mean of 3 rounds				4.50	2221±4	9.5±0.1	0.016±0.001		
16	Ex-6721	Mk. 42	4.8	5.50	2724	15.4	0.013	100	100
17	"	"	"	"	2740	15.7	0.016	100	100
18	"	"	"	"	2741	15.8	0.012	100	100
19	"	"	"	"	2754	15.7	0.013	100	100
20	"	"	"	"	2728	15.0	0.013	100	100
Mean of 5 rounds				5.50	2737±9	15.5±0.3	0.013±0.001		
21	Ex-6721	Mk. 42	4.2	5.70	2865	17.8	0.012	100	100
22	"	"	"	"	2860	17.5	0.013	100	100
Mean of 2 rounds				5.70	2863±3	17.7±0.2	0.013±0.001		

Date: 18 September 1950 (Cont'd) Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
23	Ex-6721	Mk. 42(a)	4.9	4.50	2376	11.4	0.017	0	300*
24	"	"	"	"	2291	9.9	0.020	0	300*
25	"	"	"	"	2294	10.0	0.017	0	300*
Mean of 3 rounds				4.50	2320±37	10.4±0.6	0.018±0.001		
26	Ex-6721	Mk. 42(a)	2.4	5.30	2632	13.8	0.022	100	100
27	"	"	1.6	5.50	2685	14.3	0.014	100	100
28	"	"	"	"	2707	14.9	0.014	100	100
29	"	"	"	"	2726	15.2	0.014	100	100
30	"	"	"	"	2713	15.2	0.021	100	100
31	"	"	"	"	2717	14.0	0.018	100	100
Mean of 5 rounds				5.50	2710±11	14.7±0.5	0.016±0.005		

(a) Plus 2 empty pyralin containers end on end around primer.

Ballistic Test of Cool Propellants

Date: 25 September 1950

Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6722	XC-D22/200	6.5	4.90	2641	14.5	0.013	0	250*
2	"	"	6.3	4.90	2641	14.6	0.013	0	250*
3	"	"	"	"	2654	15.0	0.014	0	250*
4	"	"	"	"	2655	15.3	0.013	0	250*
5	"	"	"	"	2659	15.0	0.013	0	250*
6	"	"	"	"	2659	15.1	0.014	0	250*
Mean of 5 rounds				4.90	2654±5	15.0±0.2	0.013±0.000		
7	Ex-6722	XC-D22/250	6.3	4.90	2666	15.4	0.012	0	250*
8	"	"	"	"	2655	15.1	0.012	0	250*
9	"	"	"	"	2674	15.1	0.015	50	150
10	"	"	"	"	2661	15.2	0.012	0	250*
11	"	"	"	"	2667	15.7	0.013	0	250*
Mean of 5 rounds				4.90	2665±5	15.3±0.2	0.013±0.001		
12	Ex-6722	XC-D22/300	6.3	4.90	2681	15.9	0.014	0	250*
13	"	"	"	"	2671	15.6	0.012	0	250*
14	"	"	"	"	2681	15.6	0.014	0	250*
15	"	"	"	"	2667	15.8	0.012	0	250*
16	"	"	"	"	2678	15.6	0.012	0	250*
Mean of 5 rounds				4.90	2676±5	15.7±0.1	0.013±0.001		

* Black Smoke

Date: 10 October 1950 Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	SPCG-10135	Mk. 42	10.0	4.19	2641	15.9	-	0	175
2	"	"	"	"	2683	15.8	0.012	0	175
3	"	"	"	"	2692	16.6	0.012	0	175
4	"	"	"	"	2689	16.6	0.014	0	175
5	"	"	"	"	2697	16.8	0.013	0	175
6	"	"	"	"	2693	17.1	0.015	0	175
Mean of 5 rounds				4.19	2691±4	16.6±0.3	0.013±0.001		
7	Ex-6722	XC-D22/250	6.5	4.90	2694	15.9	0.013	0	250*
8	"	"	"	"	2683	15.6	0.015	0	250*
9	"	"	"	"	2677	15.7	0.011	0	250*
10	"	"	"	"	2687	15.5	0.013	0	250*
11	"	"	"	"	2696	15.9	0.016	60	175
12	"	"	"	"	2686	15.6	0.012	0	250*
Mean of 5 rounds				4.90	2686±5	15.7±0.1	0.013±0.002		
13	Ex-6735	XC-D22/195	9.4	4.00	2314	10.6	0.014	0	250*
14	"	"	"	"	2307	10.8	0.017	0	250*
15	"	"	"	"	2304	10.5	0.016	0	250*
Mean of 3 rounds				4.00	2308±4	10.6±0.1	0.016±0.001		
16	Ex-6735	XC-D22/195	7.4	4.60	2570	13.6	0.012	0	250*
17	"	"	6.8	4.80	2656	15.3	0.012	0	250*
18	"	"	6.6	4.88	2670	14.7	0.013	0	250*
19	"	"	"	"	2679	15.2	0.014	0	250*
20	"	"	"	"	2683	15.8	0.013	70	150
21	"	"	"	"	2677	15.6	0.015	0	250*
22	"	"	"	"	2679	15.5	0.012	70	125
Mean of 5 rounds				4.88	2678±3	15.4±0.3	0.013±0.001		

* Black Smoke

Date: 10 October 1950 (Cont'd) Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
23	Ex-6735	XC-D22/195	5.9	5.08	2758	17.0	0.014	0	250*
24	"	"	"	"	2781	17.3	0.011	0	250*
Mean of 2 rounds				5.08	2770±12	17.2±0.2	0.013±0.002		
25	Ex-6735	XC-D22/195	6.4	4.88	2694	16.3	0.014	0	250*
26	"	"	"	"	2692	15.7	0.012	0	250*
27	"	"	"	"	2696	16.1	0.012	Tr	250*
Mean of 3 rounds				4.88	2694±1	16.0±0.2	0.013±0.001		
28	Ex-6735	Mk. 42 (a)	3.4	4.82	2713	16.9	0.014	100	100
29	"	"	"	"	2716	17.2	0.012	100	100
30	"	"	"	"	2717	17.2	0.013	100	100
Mean of 3 rounds				4.82	2715±2	17.1±0.1	0.013±0.001		

* Black Smoke

(a) Plus 2 empty pyralin containers end on end around primer.

Date: 13 October 1950 Gun No. 7403

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	SPCG-10135	Mk. 42-1	10.0	4.19	2621	16.1	0.010	0	175
2	"	"	"	"	2688	16.2	0.012	0	150
3	"	"	"	"	2692	16.7	0.012	0	150
4	"	"	"	"	2689	17.0	0.012	0	150
5	"	"	"	"	2682	16.0	-	0	150
6	"	"	"	"	2680	16.1	0.013	0	150
Mean of 5 rounds				4.19	2686±4	16.4±0.4	0.012±0.000(c)		
7	Ex-6722	XC-D22a/250	6.5	4.90	2682	15.6	0.013	0	225*
8	"	"	"	"	2675	15.6	0.013	0	225*
9	"	"	"	"	2672	14.8	0.012	0	225*
10	"	"	"	"	2677	15.3	0.012	0	225*
11	"	"	"	"	2678	15.2	0.013	0	225*
12	"	"	"	"	2665	15.5	0.013	0	225*
Mean of 5 rounds				4.90	2673±4	15.3±0.2	0.013±0.000		
13	Ex-6735	XC-D22a/250	9.4	4.00	2312	10.9	-	0	225*
14	"	"	"	"	2302	10.4	0.015	0	225*
15	"	"	"	"	2297	10.2	0.014	0	225*
Mean of 3 rounds				4.00	2304±6	10.5±0.3	0.015±0.001(a)		
16	Ex-6735	XC-D22a/250	7.4	4.60	2573	13.8	0.015	0	225*
17	"	"	6.8	4.80	2658	15.2	0.012	0	225*
18	"	"	6.6	4.88	2695	16.1	0.012	0	225*
19	"	"	"	"	2685	15.8	-	0	225*
20	"	"	"	"	2683	15.9	-	0	225*
21	"	"	"	"	2675	15.1	0.012	50	125
22	"	"	"	"	2685	15.4	0.013	60	125
Mean of 5 rounds				4.88	2685±4	15.7±0.3	0.012±0.000(b)		

(a) Based on 2 rounds
(b) Based on 3 rounds
(c) Based on 4 rounds

Date: 13 October 1950 (Cont'd) Gun No. 7403

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
23	Ex-6735	XC-D22a/250	5.9	5.08	2761	17.0	0.012	50	125
24	"	"	"	"	2765	16.8	0.014	75	125
Mean of 2 rounds				5.08	2763±2	16.9±0.1	0.013±0.001		
25	Ex-6735	XC-D22a/250	6.4	4.88	2666	15.2	0.013	0	225*
26	"	"	"	"	2691	15.8	0.011	0	225*
27	"	"	"	"	2679	15.6	0.015	0	225*
Mean of 3 rounds				4.88	2679±8	15.5±0.7	0.013±0.001		
28	Ex-6735	Mk. 42 (a)	3.4	4.82	2687	16.1	0.014	100	100
29	"	"	"	"	2700	16.7	0.012	100	100
30	"	"	"	"	2686	16.3	0.012	100	100
Mean of 3 rounds				4.82	2691±6(a)	16.4±0.2	0.013±0.001		

* Black Smoke

(a) Based on 2 rounds
(b) Based on 3 rounds
(c) Based on 4 rounds

Date: 16 October 1950 Gun No. 7575

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	SPCG-10135	Mk. 42	10.0	4.19	2574	14.8	0.013	0	150
2	"	"	"	"	2617	14.5	0.012	0	150
3	"	"	"	"	2600	14.1	0.013	0	150
4	"	"	"	"	2631	15.0	0.014	0	150
5	"	"	"	"	2626	14.7	0.012	0	150
6	"	"	"	"	2623	14.2	0.013	0	150
Mean of 5 rounds				4.19	2619±9	14.5±0.3	0.013±0.001		
7	Ex-6722	XC-D22/250	6.5	4.90	2575	13.4	0.013	0	200*
8	"	"	"	"	2585	12.9	0.013	0	200*
9	"	"	"	"	2587	13.6	0.017	0	200*
10	"	"	"	"	2591	13.5	0.014	0	200*
11	"	"	"	"	2591	13.4	0.012	0	200*
12	"	"	"	"	2587	13.8	0.012	0	200*
Mean of 5 rounds				4.90	2588±2	13.4±0.2	0.014±0.002		
13	Ex-6735	XC-D22/250	9.4	4.00	2209	9.3	0.019	0	200*
14	"	"	"	"	2196	9.0	0.015	0	200*
15	"	"	"	"	2198	9.1	0.015	0	200*
Mean of 3 rounds				4.00	2201±5	9.1±0.1	0.016±0.002		
16	Ex-6735	XC-D22/250	7.4	4.60	2470	12.0	0.020	0	200*
17	"	"	6.8	4.80	2588	13.7	0.012	0	200*
18	"	"	6.6	4.88	2612	14.2	0.012	0	200*
19	"	"	"	"	2616	14.0	0.013	0	200*
20	"	"	"	"	2608	13.9	0.012	0	200*
21	"	"	"	"	2606	13.8	0.014	0	200*
22	"	"	"	"	2615	14.3	0.012	0	200*
Mean of 5 rounds				4.88	2611±4	14.0±0.2	0.013±0.001		
23	Ex-6735	XC-D22/250	5.9	5.08	2689	15.1	0.012	0	200*
24	"	"	"	"	2686	15.2	0.013	0	200*
Mean of 2 rounds				5.08	2688±2	15.2±0.1	0.013±0.001		

* Black Smoke

Date: 16 October 1950 (Cont'd) Gun No. 7575

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
25	Ex-6735	XC-D22/250	6.4	4.88	2619	14.1	0.013	0	200*
26	"	"	"	"	2615	13.6	0.012	0	200*
27	"	"	"	"	2615	13.9	0.012	0	200*
Mean of 3 rounds				4.88	2616±2	13.9±0.2	0.012±0.000		
28	Ex-6735	Mk. 42 (a)	3.4	4.82	2589	13.4	0.013	30	150
29	"	"	"	"	2575	13.1	0.014	0	100
30	"	"	"	"	2598	13.8	0.015	0	200
Mean of 3 rounds				4.82	2587±8	13.4±0.2	0.014±0.001		

* Black Smoke

(a) Plus 2 empty pyralin containers end on end around primer.

Date: 17 October 1950 Gun No. 7396

Rd. No.	Powder	Primer	PFD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	SPCG-10135	Mk. 42	10.0	4.19	2639	16.0	-	0	200
2	"	"	"	"	2687	16.4	0.012	0	200
3	"	"	"	"	2689	16.3	0.012	0	200
4	"	"	"	"	2707	16.7	0.012	0	200
5	"	"	"	"	2690	16.5	0.013	0	200
6	"	"	"	"	2684	16.2	0.014	0	200
Mean of 5 rounds				4.19	2691±6	16.4±0.1	0.013±0.001		
7	Ex-6722	XC-D22a/250	6.5	4.90	2677	15.2	0.012	0	250*
8	"	"	"	"	2667	15.3	0.015	0	250*
9	"	"	"	"	2670	15.0	0.015	0	250*
10	"	"	"	"	2669	14.8	0.015	25	225*
11	"	"	"	"	2675	15.1	0.012	0	250*
12	"	"	"	"	2673	15.0	0.015	0	250*
Mean of 5 rounds				4.90	2671±3	15.0±0.1	0.014±0.001		
13	Ex-6735	XC-D22a/250	9.4	4.00	2289	10.8	0.017	0	250*
14	"	"	"	"	2297	10.5	0.017	0	250*
15	"	"	"	"	2287	10.3	0.014	0	250*
Mean of 3 rounds				4.00	2291±4	10.5±0.2	0.016±0.001		
16	Ex-6735	XC-D22a/250	7.4	4.60	2571	14.3	0.014	0	250*
17	"	"	6.8	4.80	2665	15.1	0.013	0	250*
18	"	"	6.6	4.88	2704	16.5	0.015	0	250*
19	"	"	"	"	2695	16.3	0.012	0	250*
20	"	"	"	"	2698	16.2	0.013	0	250*
21	"	"	"	"	2700	16.0	0.012	0	250*
22	"	"	"	"	2697	15.6	0.012	0	250*
Mean of 5 rounds				4.88	2699±3	16.1±0.3	0.013±0.001		
23	Ex-6735	XC-D22a/250	5.9	5.08	2774	17.6	0.013	0	250*
24	"	"	"	"	2787	17.5	0.012	0	250*
Mean of 2 rounds				5.08	2781±7	17.6±0.1	0.013±0.001		

* Black Smoke

Date: 17 October 1950 (Cont'd) Gun No. 7396

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
25	Ex-6735	XC-D22a/250	6.4	4.88	2691	16.0	0.015	0	250*
26	"	"	"	"	2687	15.7	0.013	0	250*
27	"	"	"	"	2677	15.5	0.012	0	250*
Mean of 3 rounds				4.88	2685±5	15.7±0.2	0.013±0.001		
28	Ex-6735	Mk. 42 (a)	3.4	4.82	2691	15.5	0.015	100	100
29	"	"	"	"	2700	16.4	0.013	100	100
30	"	"	"	"	2701	15.9	0.013	100	100
Mean of 3 rounds				4.82	2697±4	15.9±0.3	0.014±0.001		

* Black Smoke

(a) Plus 2 empty pyralin containers end on end around primer.

Date: 19 October 1950 Gun No. 7643

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	NPFB-223	Mk. 42	10.0	4.08	2606	15.8	0.012	0	150
2	"	"	"	"	2642	15.4	0.013	75	100
3	"	"	"	"	2647	15.5	0.013	50	125
4	"	"	"	"	2653	15.7	0.013	50	125
5	"	"	"	"	2654	15.8	0.014	25	125
6	"	"	"	"	2645	15.6	0.012	25	125
Mean of 5 rounds				4.08	2648±4	15.6±0.1	0.013±0.000		
7	SPCG-10135	Mk. 42	10.0	4.19	2644	15.5	0.012	0	150
8	"	"	"	"	2641	15.5	0.012	0	150
9	"	"	"	"	2639	15.5	0.012	0	150
10	"	"	"	"	2636	15.4	0.012	0	150
11	"	"	"	"	2623	15.0	0.013	0	150
12	"	"	"	"	2622	15.0	0.014	0	150
Mean of 5 rounds				4.19	2632±8	15.3±0.2	0.013±0.001		
13	Ex-6735	XC-D22a/250	9.4	4.00	2212	9.4	0.014	0	250*
14	"	"	"	"	2210	8.9	0.014	0	250*
15	"	"	"	"	2209	9.5	0.016	0	250*
16	"	"	"	"	2202	9.1	0.013	0	250*
Mean of 3 rounds				4.00	2207±3	9.2±0.2	0.014±0.001		
17	Ex-6735	XC-D22a/250	7.4	4.60	2501	12.3	0.014	Tr	250*
18	"	"	6.8	4.80	2589	13.3	-	0	250*
19	"	"	6.6	4.88	2610	14.3	0.012	0	250*
20	"	"	"	"	2619	14.1	0.012	0	250*
21	"	"	"	"	2619	14.5	0.012	0	250*
22	"	"	"	"	2616	14.5	0.014	0	250*
23	"	"	"	"	2621	14.4	0.013	0	250*
Mean of 5 rounds				4.88	2617±3	14.4±0.1	0.013±0.001		

* Black Smoke

Date: 19 October 1950 (Cont'd) Gun No. 7643

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
24	Ex-6735	XC-D22a/250	5.9	5.08	2692	16.0	0.011	0	250*
25	"	"	"	"	2697	15.4	0.011	0	250*
Mean of 2 rounds				5.08	2695±3	15.7±0.3	0.011±0.000		
26	Ex-6735	XC-D22a/250	6.4	4.88	2618	14.1	-	0	250*
27	"	"	"	"	2604	13.8	0.014	0	250*
28	"	"	"	"	2614	13.9	0.014	0	250*
Mean of 3 rounds				4.88	2612±5	13.9±0.1	0.014±0.000(b)		
29	Ex-6735	Mk. 42 (a)	3.4	4.82	2583	13.5	0.015	100	100
30	"	"	"	"	2601	14.0	0.013	0	250*
31	"	"	"	"	2601	14.0	0.013	100	100
Mean of 3 rounds				4.82	2595±8	13.8±0.2	0.014±0.001		

* Black Smoke

(a) Based on 2 rounds
(b) Plus 2 empty pyralin containers end on end around primer.

Date: 24 October 195. Gun No. 12811

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ij. Time (sec.)	Flash (%)	Smoke (%)
1	NPFB-223	Mk. 42-1	10.0	4.08	2592	15.2	0.014	100	100
2	"	"	"	"	2638	15.0	0.011	100	100
3	"	"	"	"	2623	14.6	0.014	100	100
4	"	"	"	"	2637	15.3	0.014	100	100
5	"	"	"	"	2637	14.8	0.012	100	100
6	"	"	"	"	2633	15.2	0.014	100	100
Mean of 5 rounds				4.08	2634±4	15.0±0.2	0.013±0.001		
7	SPCG-10135	Mk. 42-1	10.0	4.19	2609	14.6	0.012	0	150
8	"	"	"	"	2608	14.3	0.012	0	150
9	"	"	"	"	2608	14.2	0.014	0	150
10	"	"	"	"	2620	14.7	0.011	0	150
11	"	"	"	"	2608	14.4	0.015	0	150
12	"	"	"	"	2592	14.2	0.013	0	150
Mean of 5 rounds				4.19	2607±6	14.4±0.2	0.013±0.001		
13	Ex-6735	XC-D22/250	9.4	4.00	2214	9.4	0.015	0	225*
14	"	"	"	"	2204	9.2	0.017	0	225*
15	"	"	"	"	2192	8.9	0.018	0	225*
16	"	"	"	"	2206	9.1	0.014	0	225*
Mean of 3 rounds				4.00	2201±6	9.1±0.1	0.01[illegible]±0.002		
17	Ex-6735	XC-D22/250	7.4	4.60	2493	12.7	0.01	0	225*
18	"	"	6.8	4.80	2595	13.8	0.012	0	225*
19	"	"	6.6	4.88	2620	14.2	0.012	0	225*
20	"	"	"	"	2630	13.8	0.011	0	225*
21	"	"	"	"	2619	14.4	0.011	0	225*
22	"	"	"	"	2621	14.2	0.012	0	225*
23	"	"	"	"	2623	14.4	0.012	40	175
Mean of 5 rounds				4.88	2623±3	14.2±0.2	0.012±0.000		

* Black Smoke

Date: 24 October 1950 (Cont'd)

Gun No. 12811

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
24	Ex-6735	XC-D22/250	5.9	5.08	2683	15.3	0.014	0	225*
25	"	"	"	"	2692	15.3	0.012	0	225*
Mean of 2 rounds				5.08	2688±5	15.3±0.0	0.013±0.001		
26	Ex-6735	XC-D22/250	6.4	4.88	2604	13.8	0.014	0	200*
27	"	"	"	"	2607	13.8	0.012	0	225*
28	"	"	"	"	2603	13.6	0.014	0	225*
Mean of 3 rounds				4.88	2605±2	13.7±0.1	0.013±0.001		
29	Ex-6735	Mk. 42 (a)	3.4	4.82	2586	13.5	0.016	0	225*
30	"	"	"	"	2598	13.6	0.015	0	225*
31	"	"	"	"	2608	14.0	0.014	0	225*
Mean of 3 rounds				4.82	2597±8	13.7±0.2	0.015±0.001		

* Black Smoke

(a) Plus 2 empty pyralin containers end on end around primer.

Date: 9 November 1950 Gun No. 7396

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6735	XC-D22/250	6.4	4.89	2703	15.4	0.012	0	200*
2	"	"	"	"	2716	16.2	0.012	0	200*
3	"	"	"	"	2710	15.6	0.015	0	200*
4	"	"	"	"	2705	16.2	0.015	0	200*
5	"	"	"	"	2706	16.1	0.013	0	200*
6	"	"	"	"	2708	15.2	0.014	0	200*
Mean of 5 rounds				4.89	2709±3	15.9±0.4	0.014±0.001		
7	A	XC-D22/250	6.4	4.89	2753	16.4	0.012	0	200*
8	"	"	"	"	2736	16.3	0.014	0	200*
9	"	"	"	"	2743	16.3	0.012	0	200*
10	"	"	"	"	2749	16.0	0.012	0	200*
11	"	"	"	"	2758	16.9	0.012	0	200*
Mean of 5 rounds				4.89	2748±7	16.4±0.2	0.012±0.000		

* Black Smoke

Powder A = 0.4 lbs. SPDN-4438 in bottom of case. Balance of charge consisted of Ex-6735 on top of SPDN-4438.

Date: 17 November 1950 Gun No. 7396

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	A	XC-D22/250	6.9	4.79	2697	15.8	0.011	0	200*
2	"	"	"	"	2689	16.0	0.015	0	200*
3	"	"	"	"	2697	16.0	0.015	0	200*
4	"	"	"	"	2702	16.7	0.012	0	200*
Mean of 3 rounds				4.79	2696±5	16.2±0.3	0.014±0.001		
5	B	XC-D22/250	6.9	4.79	2685	16.2	0.015	0	200*
6	"	"	"	"	2680	16.0	0.013	0	200*
7	"	"	"	"	2682	15.9	0.013	0	200*
Mean of 3 rounds				4.79	2682±2	16.0±0.1	0.014±0.001		
8	C	XC-D22/250	6.9	4.79	2673	15.6	0.013	0	200*
9	"	"	"	"	2678	16.1	0.013	0	200*
10	"	"	"	"	2649	15.4	0.014	0	200*
Mean of 3 rounds				4.79	2667±12	15.7±0.3	0.013±0.000		
11	D	XC-D22/250	6.4	4.89	2711	16.4	0.013	0	200*
12	"	"	"	"	2706	16.4	0.012	0	200*
13	"	"	"	"	2705	15.7	0.015	0	200*
14	"	"	"	"	2706	16.0	0.013	0	200*
15	"	"	"	"	2712	16.7	0.014	0	200*
Mean of 5 rounds				4.89	2708±3	16.2±0.3	0.013±0.001		

* Black Smoke

Powder A = 0.4 lbs. SPDN-4438 in bottom of case. Balance of charge consists of Ex-6735 on top of SPDN-4438.
Powder B = 0.3 lbs. SPDN-4438 in bottom of case. Balance of charge consists of Ex-6735 on top of SPDN-4438.
Powder C = 0.2 lbs. SPDN-4438 in bottom of case. Balance of charge consists of Ex-6735 on top of SPDN-4438.
Powder D = 0.4 lbs. SPDN-5208 in bottom of case. Balance of charge consists of Ex-6735 on top of SPDN-5208.

Date: 4 January 1951 Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6735	Mk. 42	6.5	4.89	2695	15.0	0.013	0	200*
2	"	"	6.3	"	2728	16.0	0.014	100	100
3	"	"	"	"	2721	16.5	0.011	100	100
4	"	"	"	"	2722	16.1	0.012	100	100
Mean of 3 rounds				4.89	2724±3	16.2±0.2	0.012±0.001		
5	Ex-6735	Mk. 42 (a)	5.9	4.51	2728	15.6	0.012	100	100
6	"	"	"	"	2736	16.3	0.012	100	100
7	"	"	"	"	2724	16.0	0.014	100	100
Mean of 3 rounds				4.51	2729±4	16.0±0.2	0.013±0.001		
8	Ex-6735	XC-D22/250	6.6	4.89	2699	15.7	0.014	0	800*
9	"	"	"	"	2701	15.5	0.014	0	200*
10	"	"	"	"	2691	15.4	0.015	50	150*
11	"	"	"	"	2689	15.2	0.015	60	150*
12	"	"	"	"	2689	15.1	0.012	0	200*
Mean of 5 rounds				4.89	2694±5	15.4±0.2	0.014±0.001		
13	Ex-6705	XC-D22/250	7.2	4.65	2676	15.7	0.012	100	100
14	"	"	"	"	2699	16.1	0.012	100	100
15	"	"	"	"	2696	15.9	0.012	0	150*
16	"	"	"	"	2700	16.2	0.014	0	150*
17	"	"	"	"	2698	16.0	0.014	0	160*
Mean of 5 rounds				4.65	2694±7	16.0±0.2	0.013±0.001		

(a) Plus 150 grams of NPFB-223 in pyralin containers around forward end of primer.

Date: 4 January 1951 (Cont'd) Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
18	Ex-6708	XC-D22/250	6.2	4.84	2674	14.7	0.012	0	200*
19	"	"	"	"	2662	14.6	0.013	0	200*
20	"	"	"	"	2673	14.6	0.013	60	150*
21	"	"	"	"	2669	14.1	0.012	0	200*
22	"	"	"	"	2678	14.6	0.014	0	200*
Mean of 5 rounds				4.84	2671±5	14.5±0.2	0.013±0.001		
23	Ex-6701	XC-D22/250	7.2	4.65	2652	14.1	0.014	0	150*
24	"	"	"	"	2656	14.0	0.015	100	100
25	"	"	"	"	2650	14.3	0.016	0	150*
26	"	"	"	"	2657	14.4	0.013	0	150*
27	"	"	"	"	2659	14.8	0.012	0	150*
Mean of 5 rounds				4.65	2655±3	14.3±0.2	0.014±0.001		
28	IX-31	XC-D22/250	8.3	4.36	2731	17.8	0.012	0	125**
29	"	"	"	"	2735	17.6	0.013	0	125**
30	"	"	"	"	2724	17.4	0.011	0	125**
31	"	"	"	"	2732	17.2	0.011	0	100**
32	"	"	"	"	2707	17.2	0.012	100	100
Mean of 5 rounds				4.36	2726±8	17.4±0.2	0.012±0.001		
33	Ex-6715	XC-D22/250	6.8	4.79	2675	14.4	0.012	0	150*
34	"	"	"	"	2683	14.4	0.012	0	150*
35	"	"	"	"	2671	14.1	0.013	0	150*
36	"	"	"	"	2644	13.7	0.013	0	150*
37	"	"	"	"	2662	14.1	0.013	0	175*
Mean of 5 rounds				4.79	2667±11	14.1±0.2	0.013±0.001		

* Black Smoke
** Grey Smoke
Carbonaceous deposit in barrel and chamber on all rounds. Cleaned with compressed air after each round.

Ballistic Test of Cool Propellants

Date: 15 January 1951

Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)	Carbon Deposit
1	Ex-6735	XC-D22/250	6.5	4.89	2621	14.2	-	0	200*	100%**
2	A	"	8.3	4.46	2698	16.0	0.014	0	150*	100%
3	"	"	"	"	2687	15.8	0.014	0	150*	75%
4	"	"	"	"	2692	15.8	0.012	0	150*	75%
Mean of 3 rounds				4.46	2692±4	15.9±0.1	0.013±0.001			
5	B	XC-D22/250	8.7	4.37	2691	15.8	0.012	0	150*	50%
6	"	"	"	"	2688	15.6	0.012	100	100	50%
7	"	"	"	"	2689	15.9	0.011	100	100	50%
Mean of 3 rounds				4.37	2689±1	15.8±0.1	0.012±0.000			
8	C	XC-D22/250	9.0	4.28	2695	15.5	0.014	0	150*	35%
9	"	"	"	"	2696	15.9	0.013	0	150*	35%
10	"	"	"	"	2697	16.1	0.012	0	150*	35%
Mean of 3 rounds				4.28	2696±1	15.8±0.2	0.013±0.001			
11	D	XC-D22/250	9.4	4.20	2708	15.6	0.011	0	150*	25%
12	"	"	"	"	2705	15.8	0.012	100	100	25%
13	"	"	"	"	2701	16.1	0.011	0	150*	25%
Mean of 3 rounds				4.20	2705±2	15.8±0.2	0.011±0.000			
14	NPFB-266	XC-D22/250	10.1	4.02	2708	16.1	0.011	100	100	0%
15	"	"	"	"	2699	15.9	0.011	100	100	0%
16	"	"	"	"	2704	16.2	0.014	100	100	0%
Mean of 3 rounds				4.02	2704±3	16.1±0.1	0.012±0.001			
17	E	XC-D22/250	9.7	4.11	2701	15.9	0.013	0	150*	10%
18	"	"	"	"	2708	16.2	0.012	0	150*	10%
19	"	"	"	"	2708	16.0	0.014	80	125*	10%
Mean of 3 rounds				4.11	2706±3	16.0±0.1	0.013±0.001			

* Black Smoke

** Based on Ex-6735 as giving 100% carbon deposit.

Carbonaceous deposit in barrel and chamber on all rounds except 14, 15 and 16. Cleaned out with compressed air after each round.

Date: 15 January 1951 (Cont'd) Gun No. 8917

Powder A - 50/50 Blend of NPFB-266 (2.01 lbs.) and Ex-6735 (2.45 lbs.)

Powder B - 60/40 Blend of NPFB-266 (2.41 lbs.) and Ex-6735 (1.96 lbs.)

Powder C - 70/30 Blend of NPFB-266 (2.81 lbs.) and Ex-6735 (1.47 lbs.)

Powder D - 80/20 Blend of NPFB-266 (3.22 lbs.) and Ex-6735 (0.98 lbs.)

Powder E - 90/10 Blend of NPFB-266 (3.62 lbs.) and Ex-6735 (0.49 lbs.)

Date: 19 January 1951 Gun No. 8917

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Ej. Time (sec.)	Smoke (%)	Flash (%)	Carbon** Deposit (%)
1	SPCG-10135	XC-D22/250	10.2	4.19	2670	0.012	175	0	0
2	"	"	"	"	2692	0.012	175	0	0
3	NPFB-266	"	10.1	4.02	2713	0.014	100	100	0
4	"	"	"	"	2707	0.011	100	100	0
5	A	"	9.5	4.20	2714	0.010	175	0	25
6	"	"	"	"	2705	0.010	175	0	25
7	B	"	8.4	4.46	2695	0.014	175*	Tr	50
8	"	"	"	"	2703	0.011	175*	Tr	50
9	Ex-6735	"	6.6	4.89	2705	0.011	200*	Tr	100
10	"	"	"	"	2700	0.011	200*	0	100
11	Ex-6708	"	6.7	4.80	2669	0.009	175*	0	75
12	"	"	"	"	2663	0.011	150*	0	75
13	Ex-6705	"	7.2	4.65	2699	0.011	175*	0	85
14	"	"	"	"	2711	0.012	175*	Tr	85
15	Ex-6721	"	4.6	5.58	2686	0.011	225*	0	75
16	"	"	"	"	2675	0.012	225*	0	75
17	Ex-6715	"	6.9	4.80	2680	0.012	150*	0	85
18	"	"	"	"	2673	0.012	175*	0	85
19	Ex-6701	"	6.9	4.65	2668	0.013	150*	0	50
20	"	"	"	"	2670	0.014	150*	0	50

Date: 26 January 1951 Gun No. 16519

1	Ex-6735	XC-D22/250	6.6	4.89	2633	-	200*	0	100
2	"	"	"	"	2602	-	200*	0	100

* Black Smoke ** Based on Ex-6735 as giving 100% carbon deposit.

Carbonaceous deposit in barrel and chamber on all rounds except 1 to 4 incl. Cleaned out with compressed air after each round.

Powder A - Blend of NPFB-266 (3.22 lbs.) and Ex-6735 (0.98 lbs.)
Powder B - Blend of NPFB-266 (2.01 lbs.) and Ex-6735 (2.45 lbs.)

Date: 16 February 1951

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke* (%)	Carbon Deposit (%)
1	IHPB-S-83C	XC-D22/250	10.4	3.50	2010	7.9	0.016	0	200	0
2	"	"	8.8	4.00	2326	10.5	0.015	0	200	0
3	"	"	"	"	2295	10.3	0.015	0	200	0
4	"	"	"	"	2302	10.4	0.013	100	100	0
Mean of 3 rounds				4.00	2308±12	10.4±0.1	0.014±0.001			
5	IHPB-S-83C	XC-D22/250	6.4	4.70	2597	13.5	0.013	0	200	0
6	"	"	5.7	4.90	2686	14.5	0.011	0	200	0
7	"	"	"	"	2701	15.1	0.013	0	200	0
8	"	"	"	"	2697	14.4	0.015	0	200	0
9	"	"	"	"	2698	15.0	-	Tr	175	0
10	"	"	"	"	2696	15.1	0.013	0	200	0
Mean of 5 rounds				4.90	2696±4	14.8±0.3	0.013±0.001			
11	IHPB-S-83C	XC-D22/250	5.1	5.10	2766	16.0	0.011	100	100	0
12	"	"	"	"	2789	16.2	0.012	Tr	175	0
Mean of 2 rounds				5.10	2778±12	16.1±0.1	0.012±0.001			
13	IHPB-S-83C	Mk. 42-1	8.9	4.00	2323	10.8	0.016	0	200	0
14	"	"	"	"	2306	10.5	0.013	0	200	0
Mean of 2 rounds				4.00	2315±9	10.7±0.2	0.015±0.002			
15	IHPB-S-83C	Mk. 42-1	5.8	4.90	2737	16.0	0.016	100	100	0
16	"	"	"	"	2733	16.1	0.013	100	100	0
17	"	"	"	"	2728	15.8	0.012	100	100	0
18	"	"	"	"	2731	15.9	0.013	100	100	0
19	"	"	"	"	2734	15.5	0.011	100	100	0
Mean of 5 rounds				4.90	2733±2	15.9±0.2	0.013±0.001			
20	IHPB-S-83C	Mk. 42-1	5.2	5.10	2818	17.1	0.014	100	100	0

* Smoke obtained with IHPB-S-83C similar to that of Cordite N/P/M. Grey on flashless rounds and brownish on flashing rounds, both of low intensity (i.e. tr.) Strong ammonia fumes on all rounds.

Date: 6 March 1951

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)	Carbon* Deposit (%)
1	Ex-6735	Mk. 42	6.5	4.89	2675	15.4	0.012	C	300(a)	100%
2	IX-29	"	9.2	4.20	2672	16.7	0.011	100	100	0
3	"	"	"	"	2665	16.4	0.013	100	100	0
4	"	"	"	"	2664	16.5	0.012	100	100	0
5	"	"	"	"	2668	16.8	0.012	100	100	0
6	"	"	"	"	2669	16.9	0.014	100	100	0
Mean of 5 rounds				4.20	2668±2	16.7±0.2	0.012±0.001			
7	IX-29	XC-D22/250	9.0	4.25	2701	16.9	0.013	0	150(b)	0
8	"	"	"	"	2699	16.2	0.014	0	150(b)	0
9	"	"	"	"	2714	17.1	0.013	0	150(b)	0
10	"	"	"	"	2706	17.0	0.010	0	150(b)	0
11	"	"	"	"	2698	17.0	0.011	0	150(b)	0
Mean of 5 rounds				4.25	2704±5	16.8±0.3	0.012±0.001			
12	IX-31	XC-D22/250	8.1	4.35	2746	17.9	0.010	0	175(b)	40
13	"	"	"	"	2744	18.0	0.012	0	175(b)	40
14	"	"	"	"	2733	17.6	0.011	0	175(b)	40
15	"	"	"	"	2745	18.1	0.011	0	175(b)	40
16	"	"	"	"	2737	17.7	0.014	90	100	40
Mean of 5 rounds				4.35	2741±5	17.9±0.2	0.012±0.001			
17	IX-31	Mk. 42	8.3	4.30	2681	16.7	0.013	100	100	25
18	"	"	"	"	2680	16.2	0.011	100	100	25
19	"	"	"	"	2689	17.1	-	100	100	25
20	"	"	"	"	2684	16.6	0.013	100	100	25
21	"	"	"	"	2684	16.5	0.012	100	100	25
Mean of 5 rounds				4.30	2684±2	16.6±0.2	0.012±0.001(c)			

Date: 6 March 1951 (Cont'd)

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)	Carbon* Deposit (%)
22	IX-32	Mk. 42	7.3	4.60	2658	13.9	0.012	100	100	15
23	"	"	"	"	2664	13.8	0.014	100	100	15
24	"	"	"	"	2651	13.8	0.013	100	100	15
25	"	"	"	"	2650	13.8	0.015	100	100	15
26	"	"	"	"	2649	13.6	0.013	100	100	15
Mean of 5 rounds				4.60	2654±5	13.8±0.1	0.013±0.001			
27	IX-32	XC-D22/250	7.1	4.65	2694	14.4	0.014	40	150(b)	25
28	"	"	"	"	2695	14.8	0.012	0	200(b)	25
29	"	"	"	"	2684	14.1	0.012	40	150(b)	25
30	"	"	"	"	2690	14.3	0.014	0	200(b)	25
31	"	"	"	"	2689	14.5	0.011	100	100	25
Mean of 5 rounds				4.65	2690±3	14.4±0.2	0.013±0.001			
32	NPFB-223	XC-D22/250	9.8	4.08	2716	16.2	0.013	100	100	0
33	IHPB-S-83C	"	5.3	4.90	2738	15.5	0.012	0	150(b)	0
34	"	Mk. 42	5.8	4.83	2747	16.1	0.011	100	100	0

* Based on Ex-6735 as 100%
(a) Black Smoke
(b) Grey Smoke
(c) Based on 4 rounds

TABULATION OF FIRING DATA

Gun: 3"/70 Caliber, Type G-0, No. 24481
Projectile: Ex-11, (15.00 lbs.) Epsom Salt Loaded
Cartridge Case: Exp. No. 5, Rubber Crimped
Lead Foil: None on 26 July 1950 - 65 grams per round on 15 February 1951
Wad and Spacer: Cardboard, NGF Dwg. No. 132664
Powder Temp.: Pc. Nos. 13 and 4
90°F

Date: 26 July 1950

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	Ex-6721	XC-M11	5.7	8.50	3130	19.3	0.014		
2	"	"	4.2	9.00	3271	22.3	0.016		

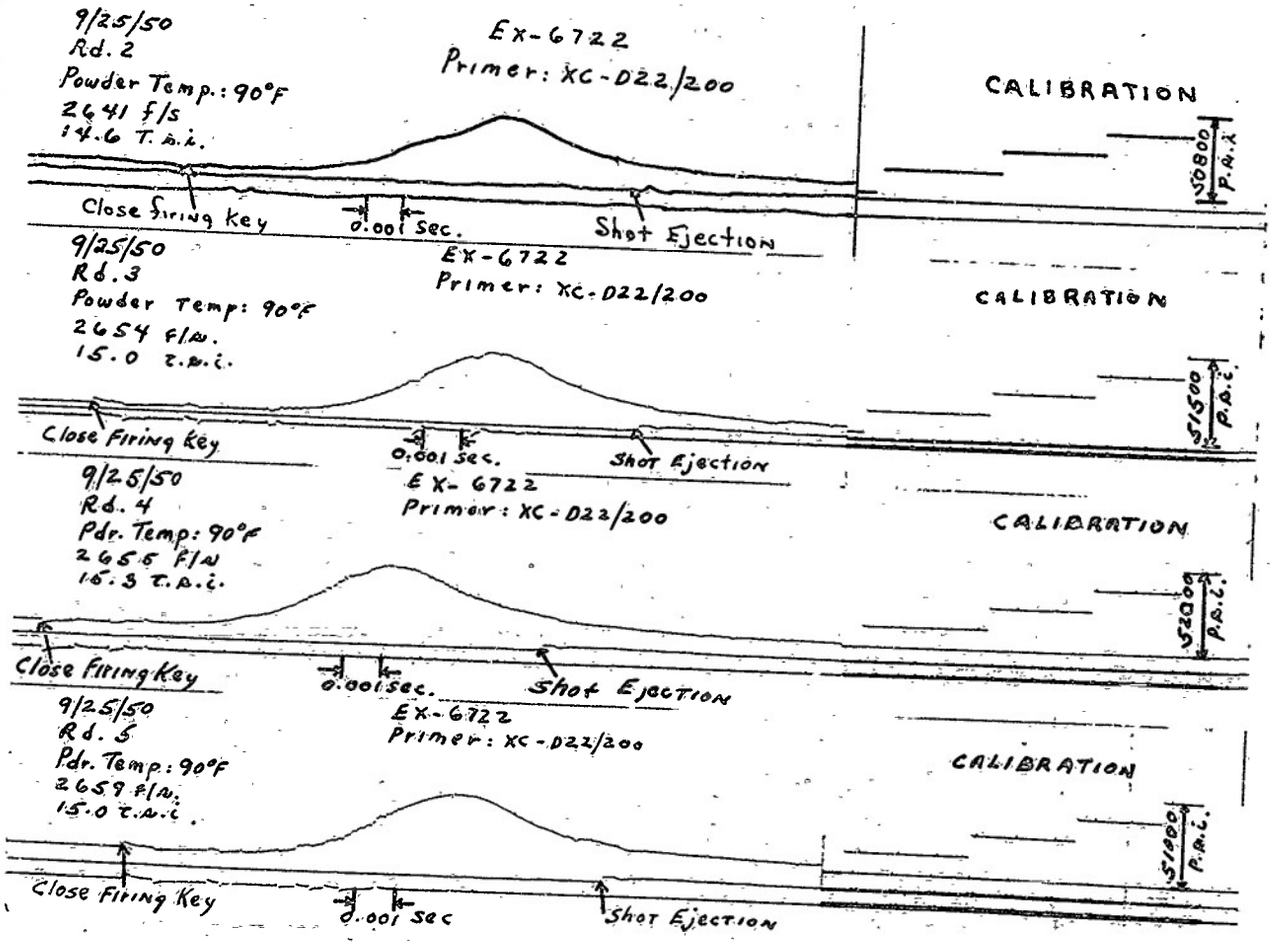
Date: 15 February 1951

Rd. No.	Powder	Primer	PPD (in.)	Charge (lbs.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (sec.)	Flash (%)	Smoke (%)
1	IHPB-S-83C	XC-M11	6.7	8.50	3347	23.3	0.013	100	100

PRESSURE-TIME CURVES

Gun:	3"/50 Caliber, Mk 21-0				
	No. 8917	ESR =	987	D_o =	3".023
	" 7403	" =	394	" =	3".035
	" 7575	" =	2852	" =	3".114
	" 7396	" =	58	" =	3".006
	" 7643	" =	2768	" =	3".110
	" 12811	" =	2986	" =	3".127
Projectile:	Mk 33 (13.00 lbs.) Epsom Salt Loaded				
Cartridge Case:	Mk 7, Brass, Rubber Crimped				
Lead Foil:	45 grams per round				
Wad and Spacer:	Cardboard, NGF Dwg. No. 132664 Pc. Nos. 13 and 4				
Powder Temp.:	90°F				

Ballistic Test of Cool Propellants



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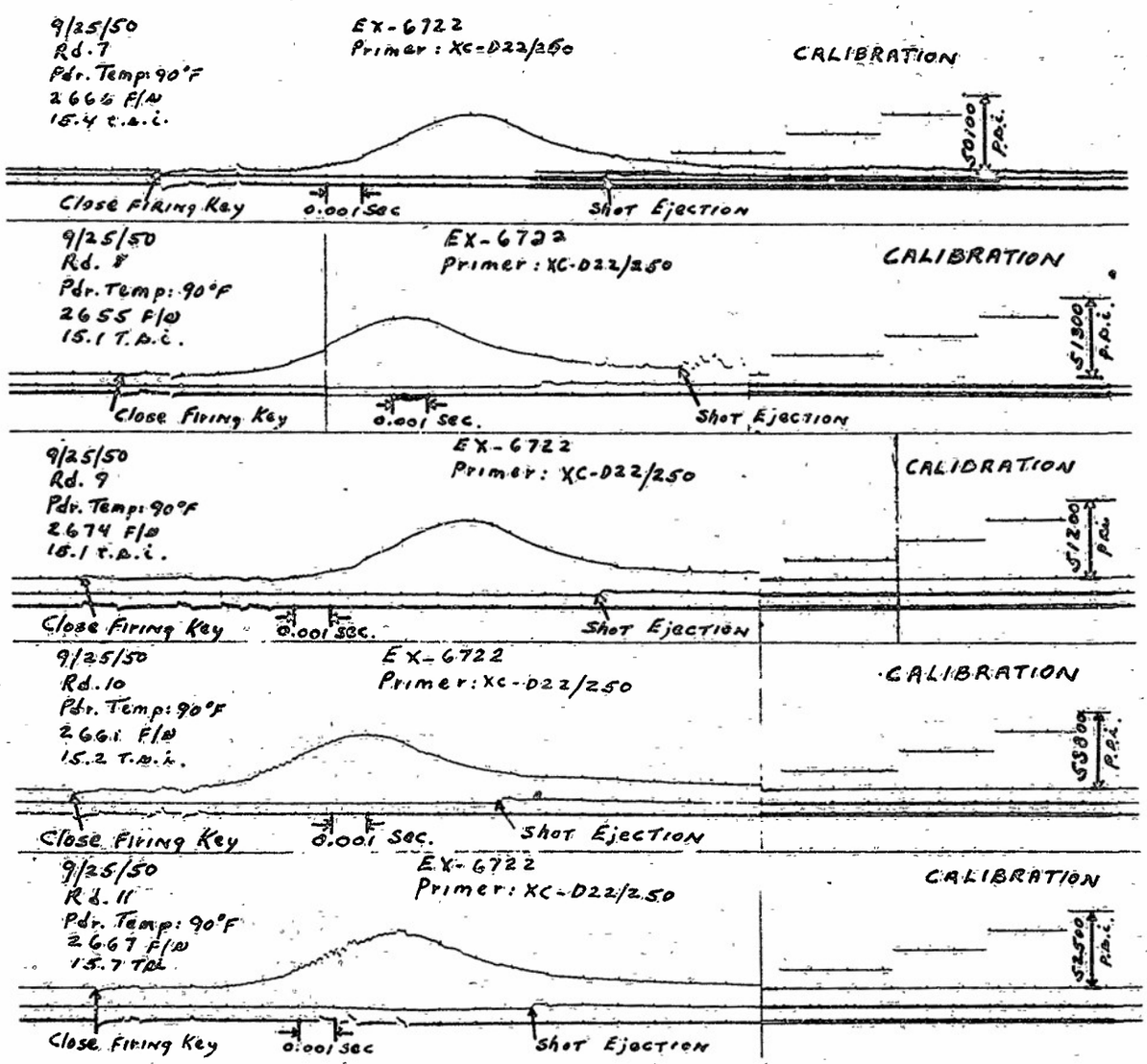

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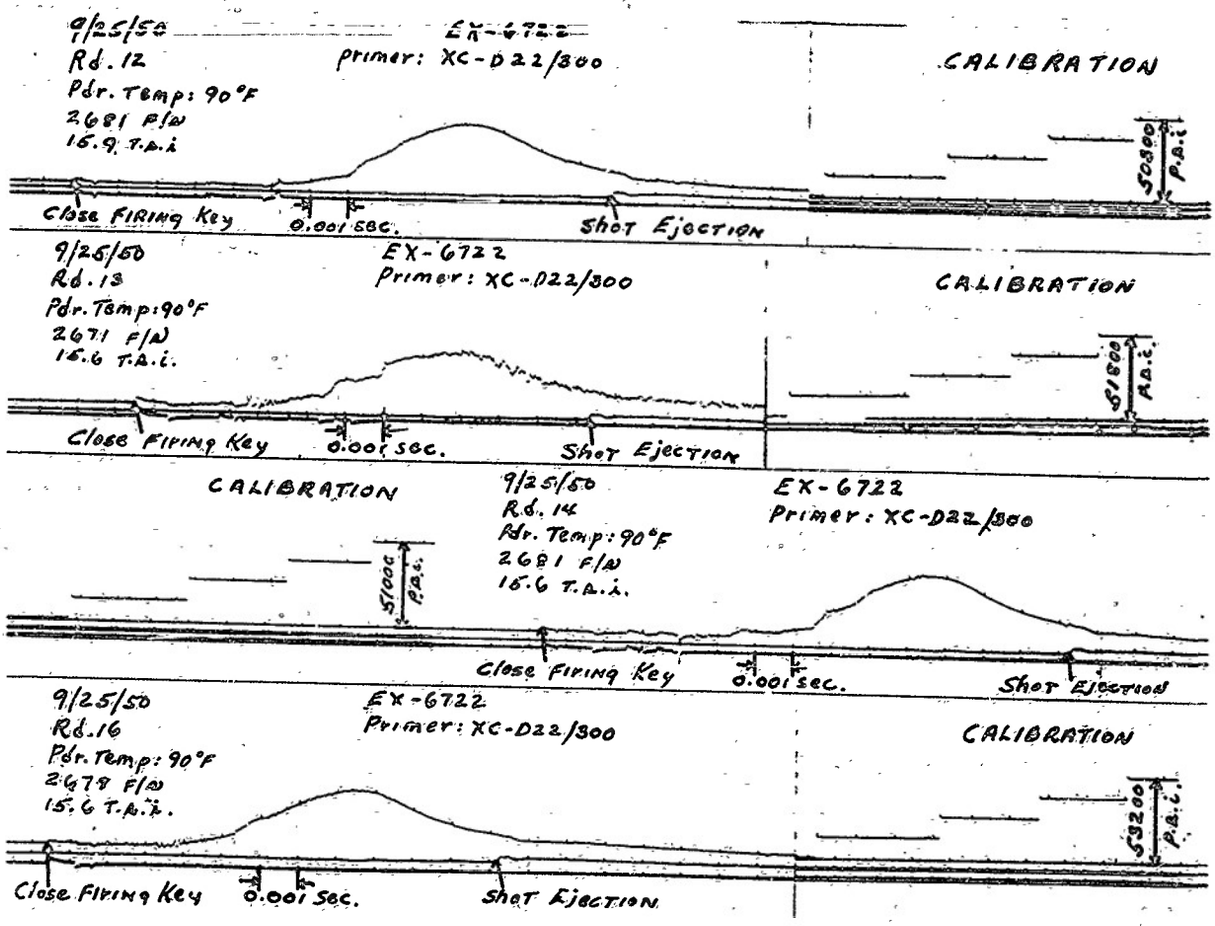

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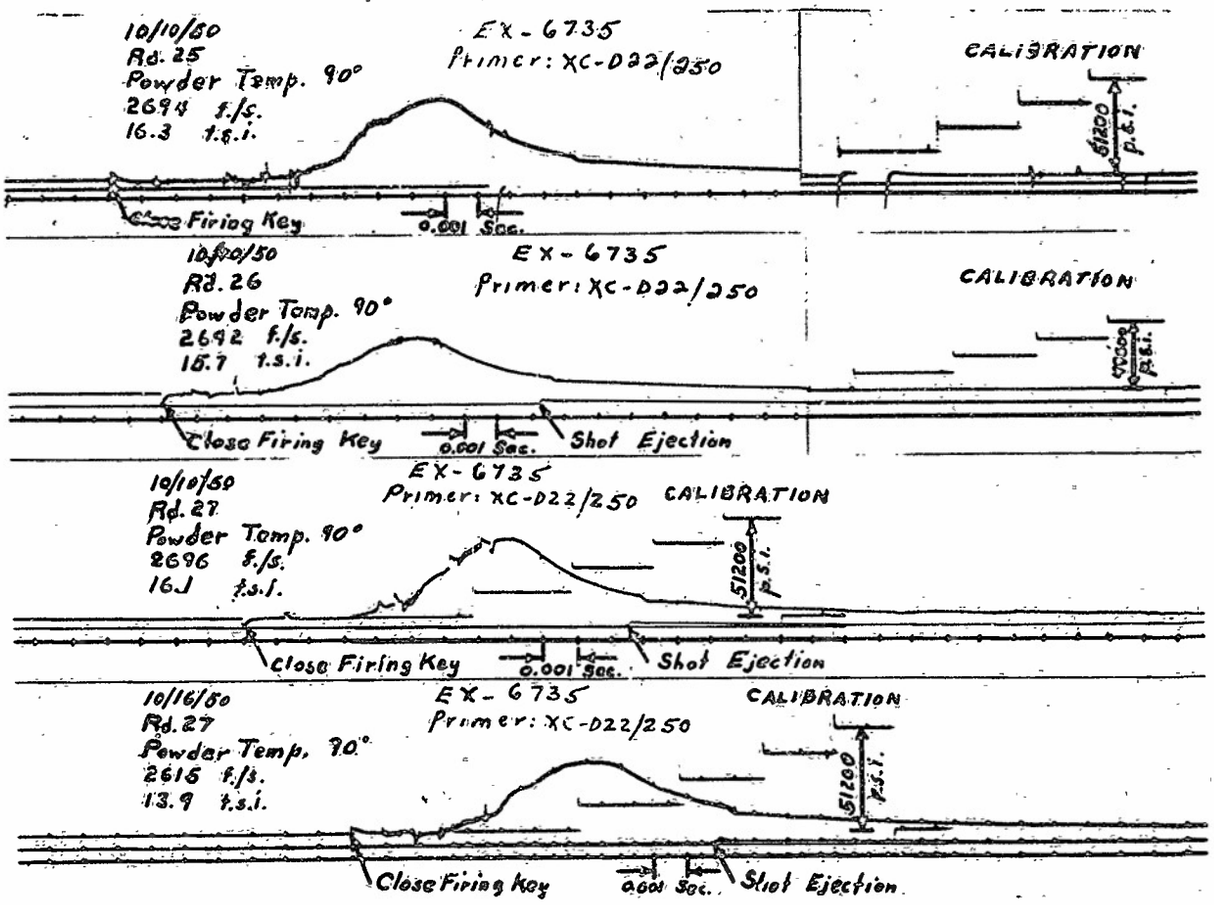

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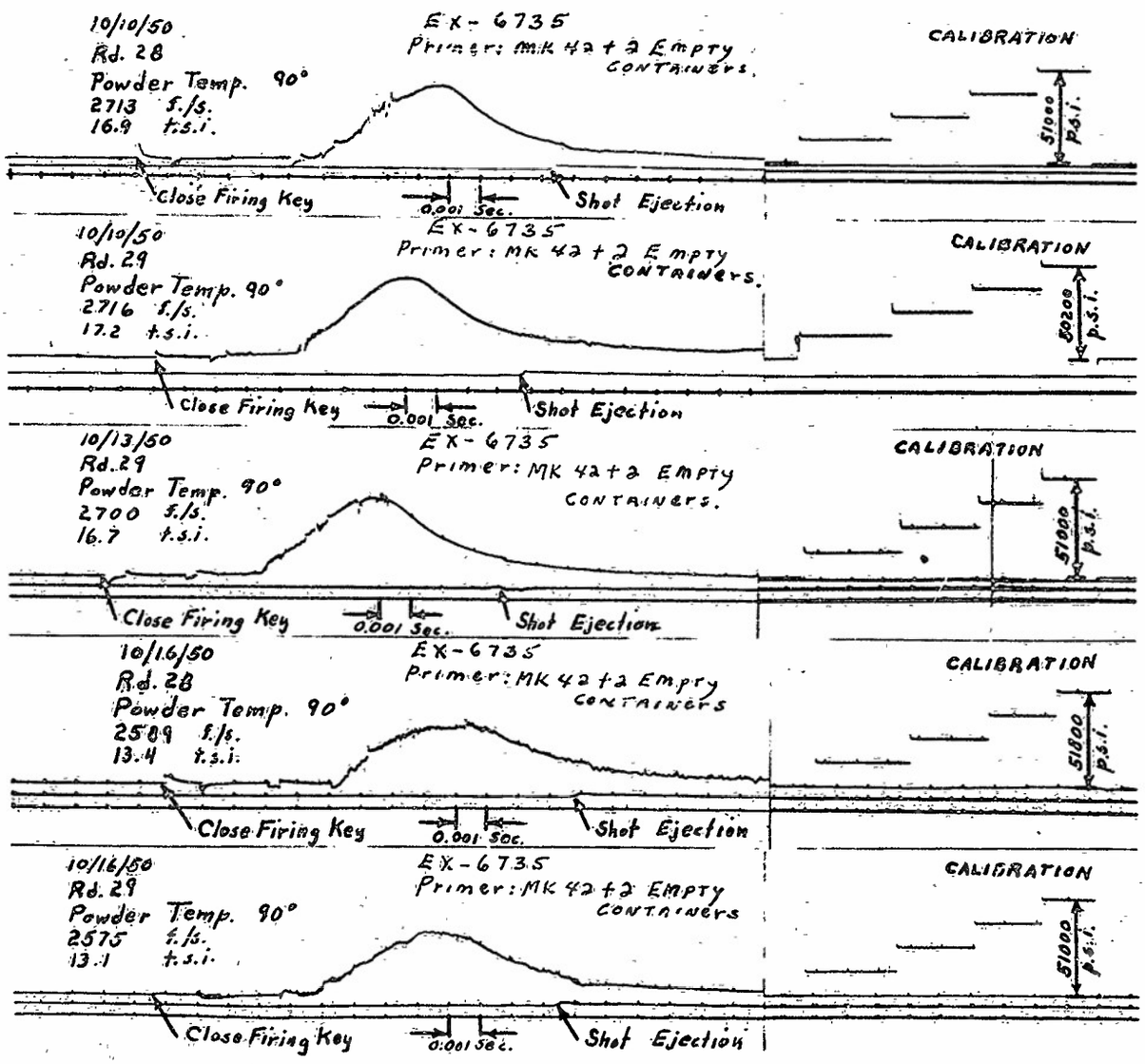

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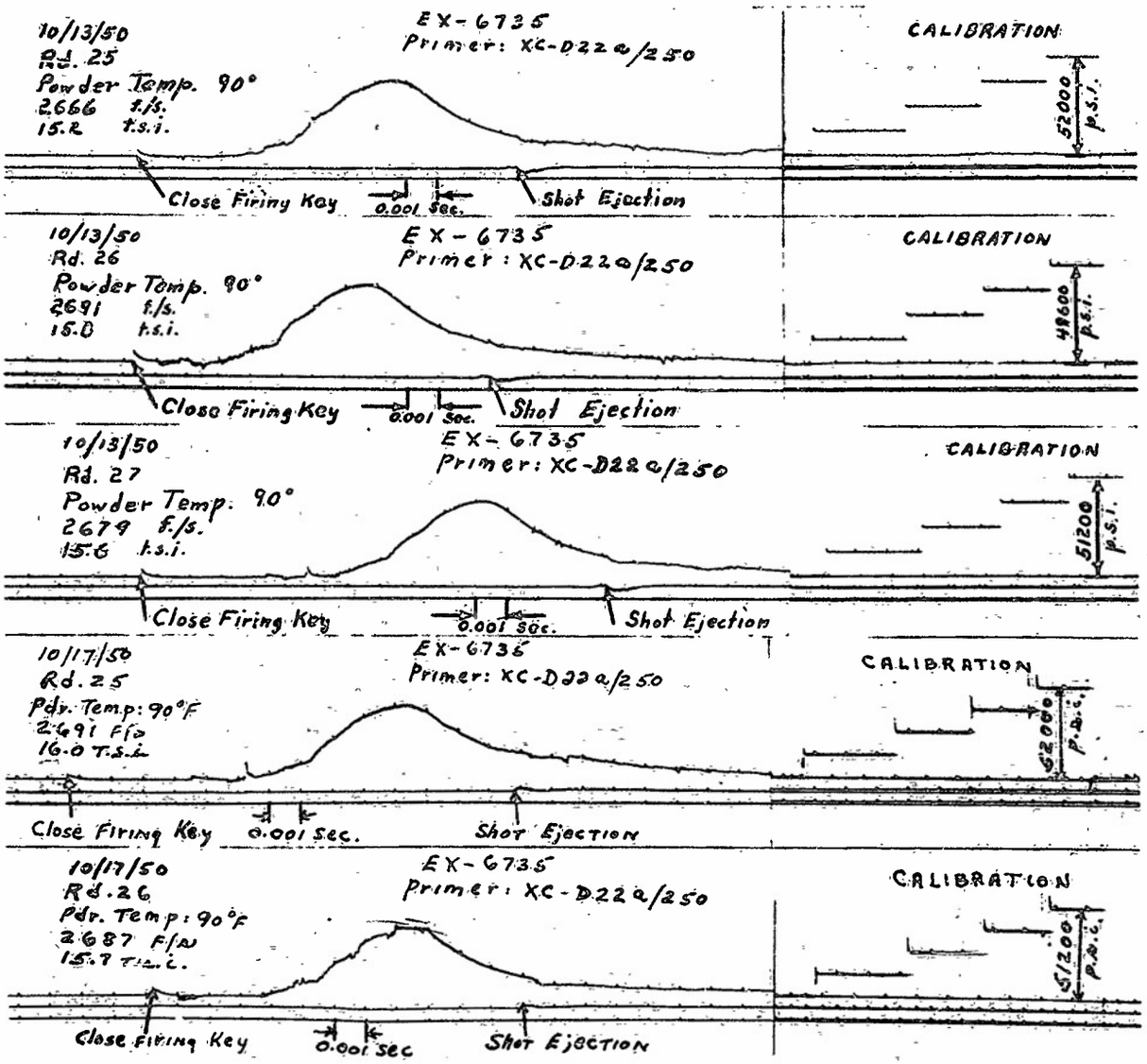

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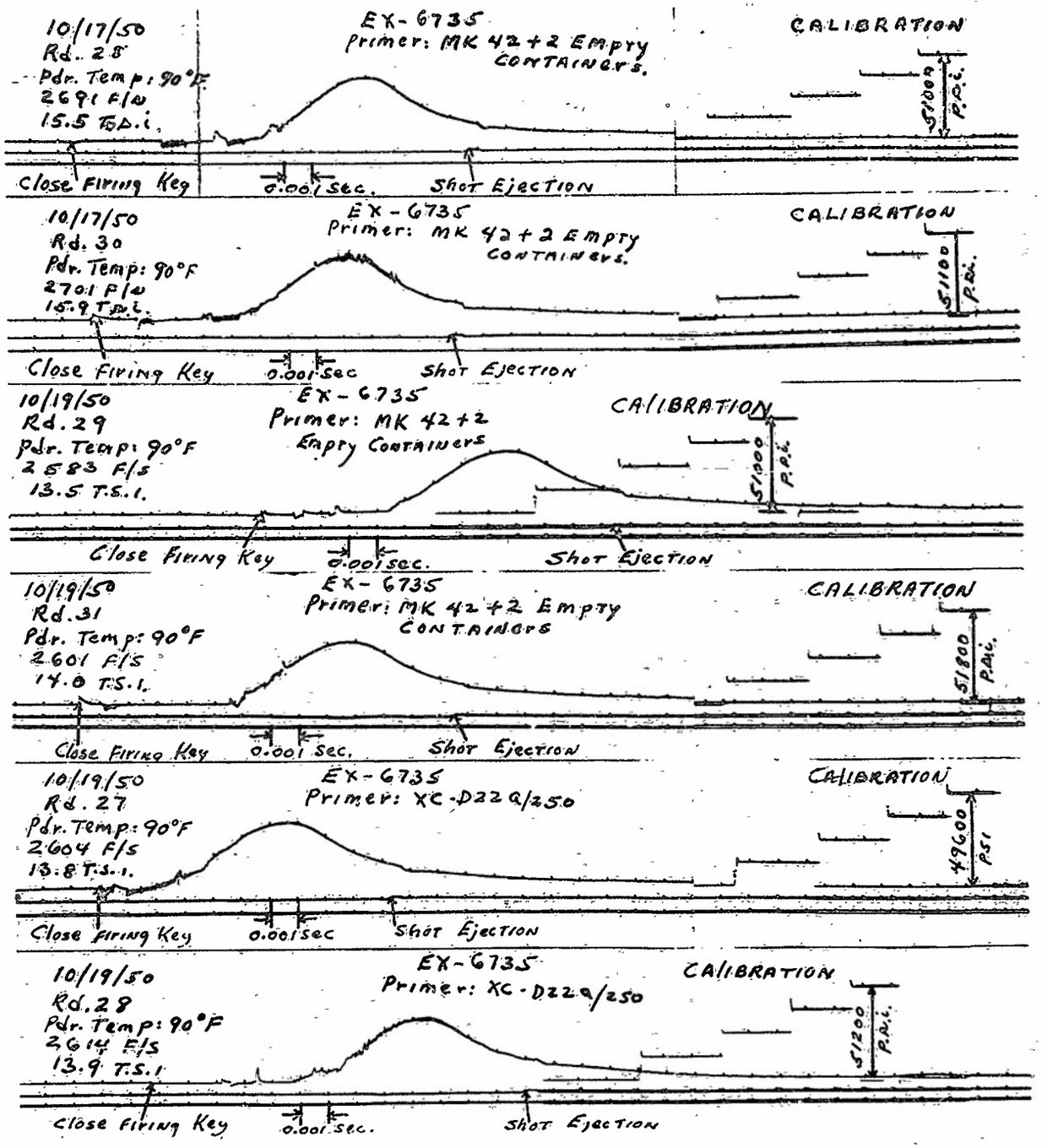

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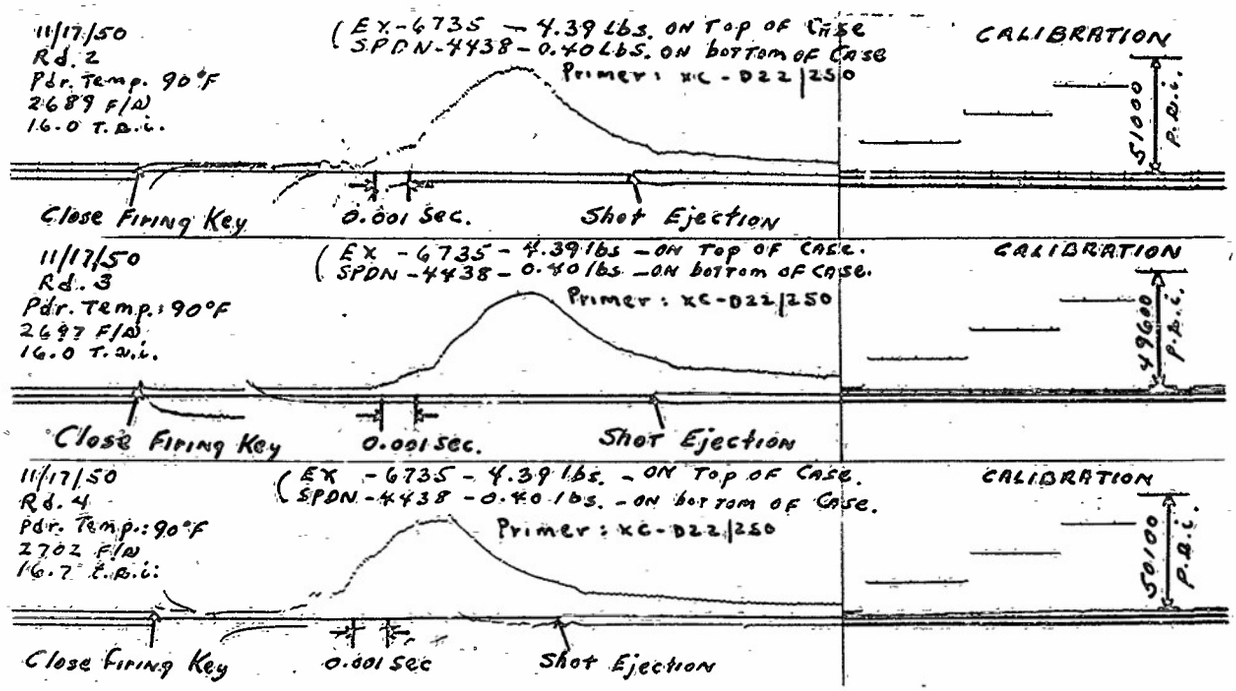

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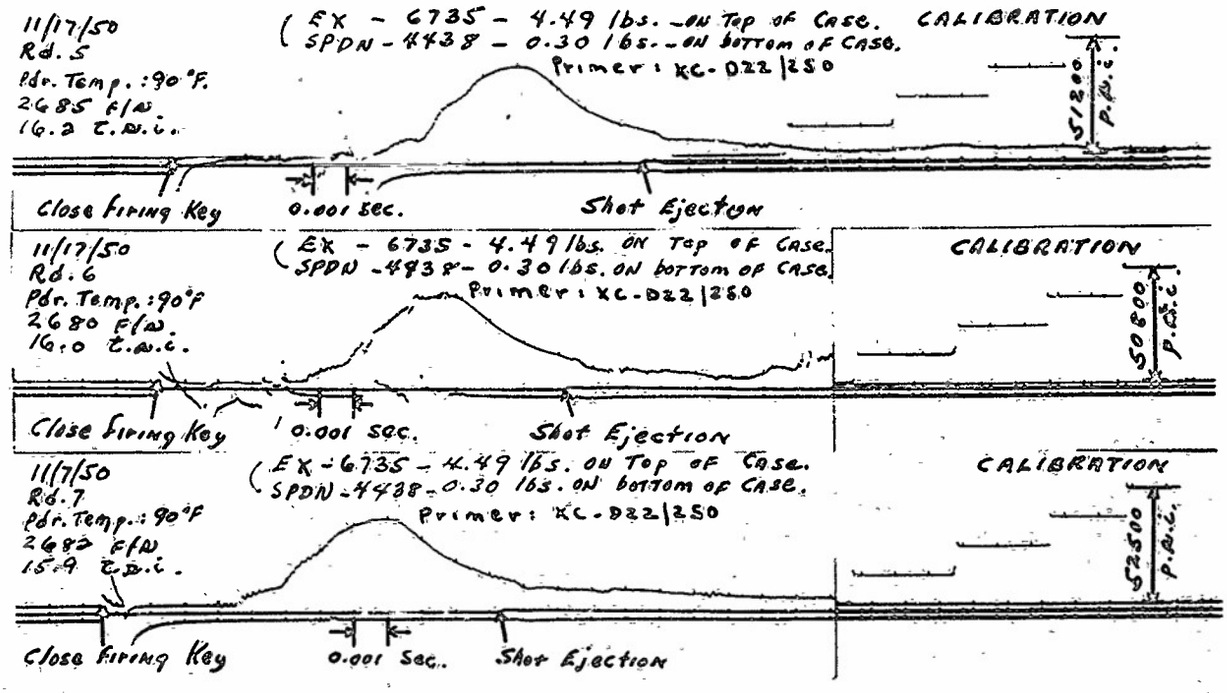

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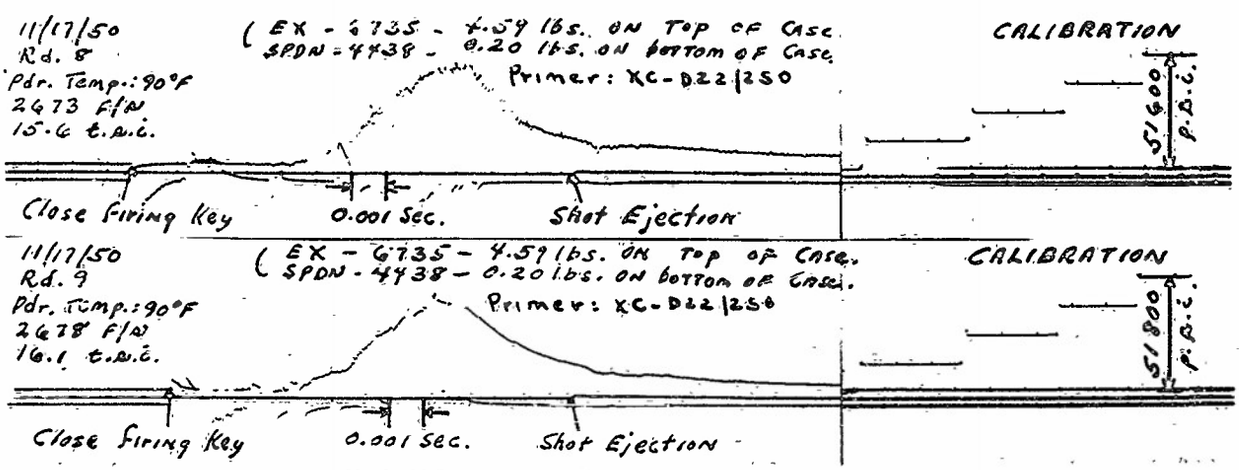

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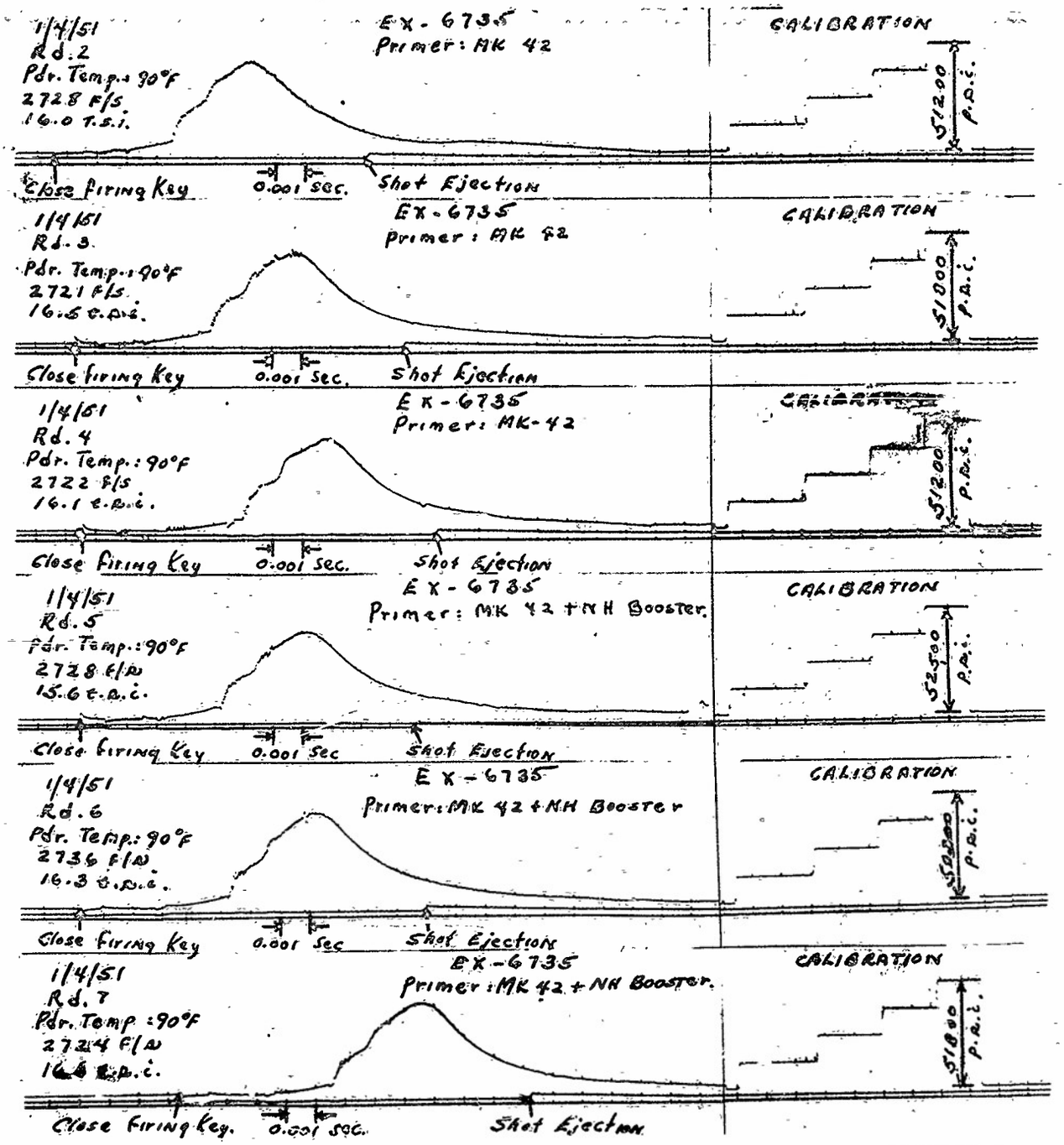

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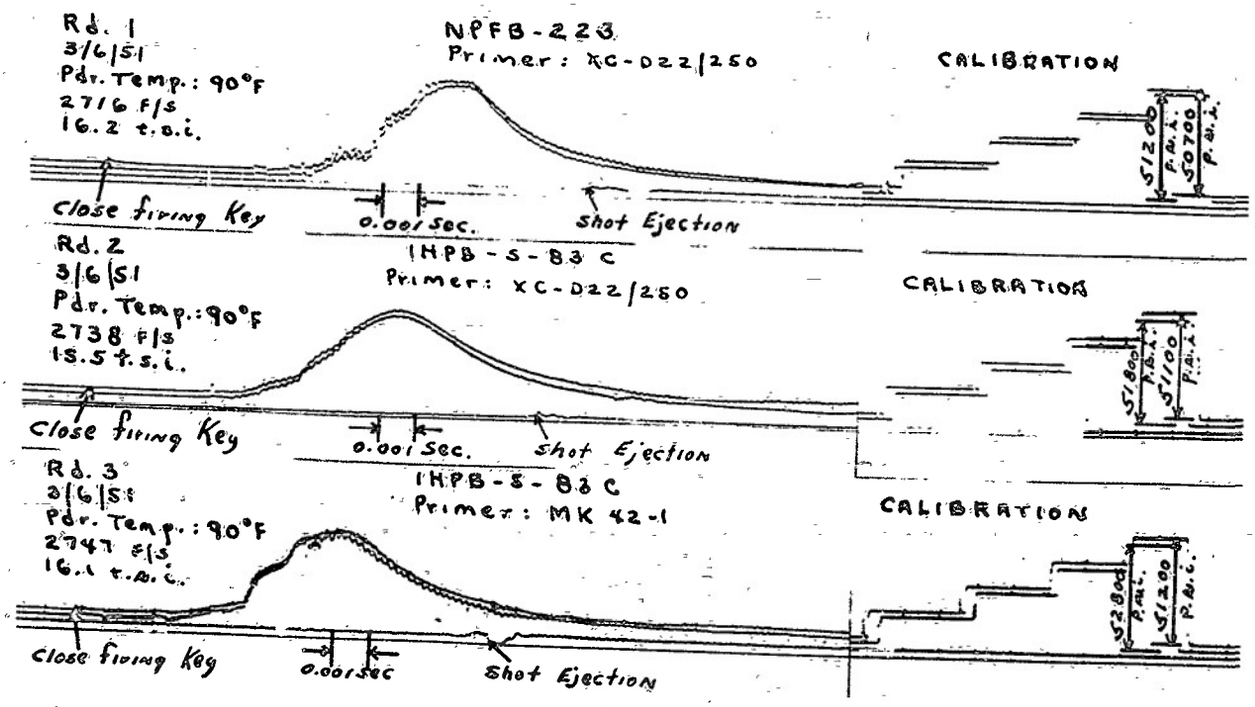

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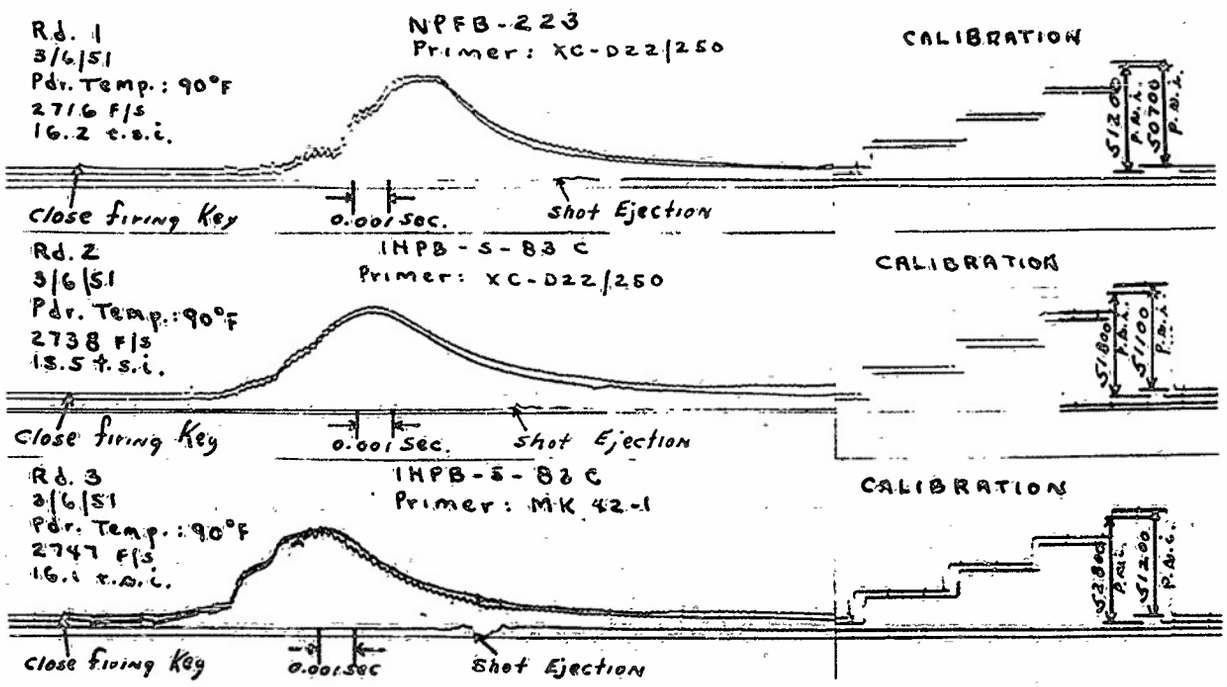
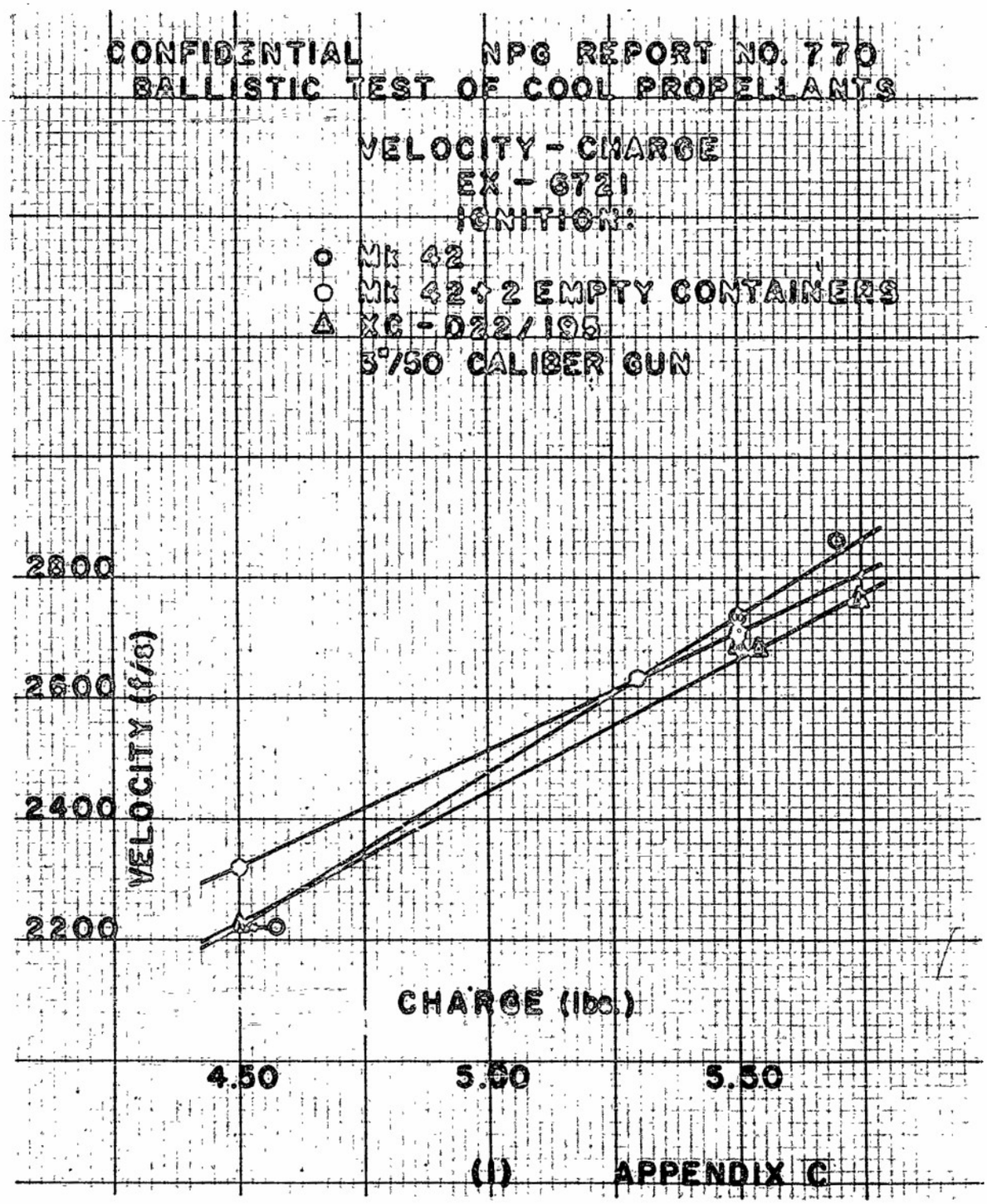


BALLISTIC TEST OF COOL PROPELLANTS



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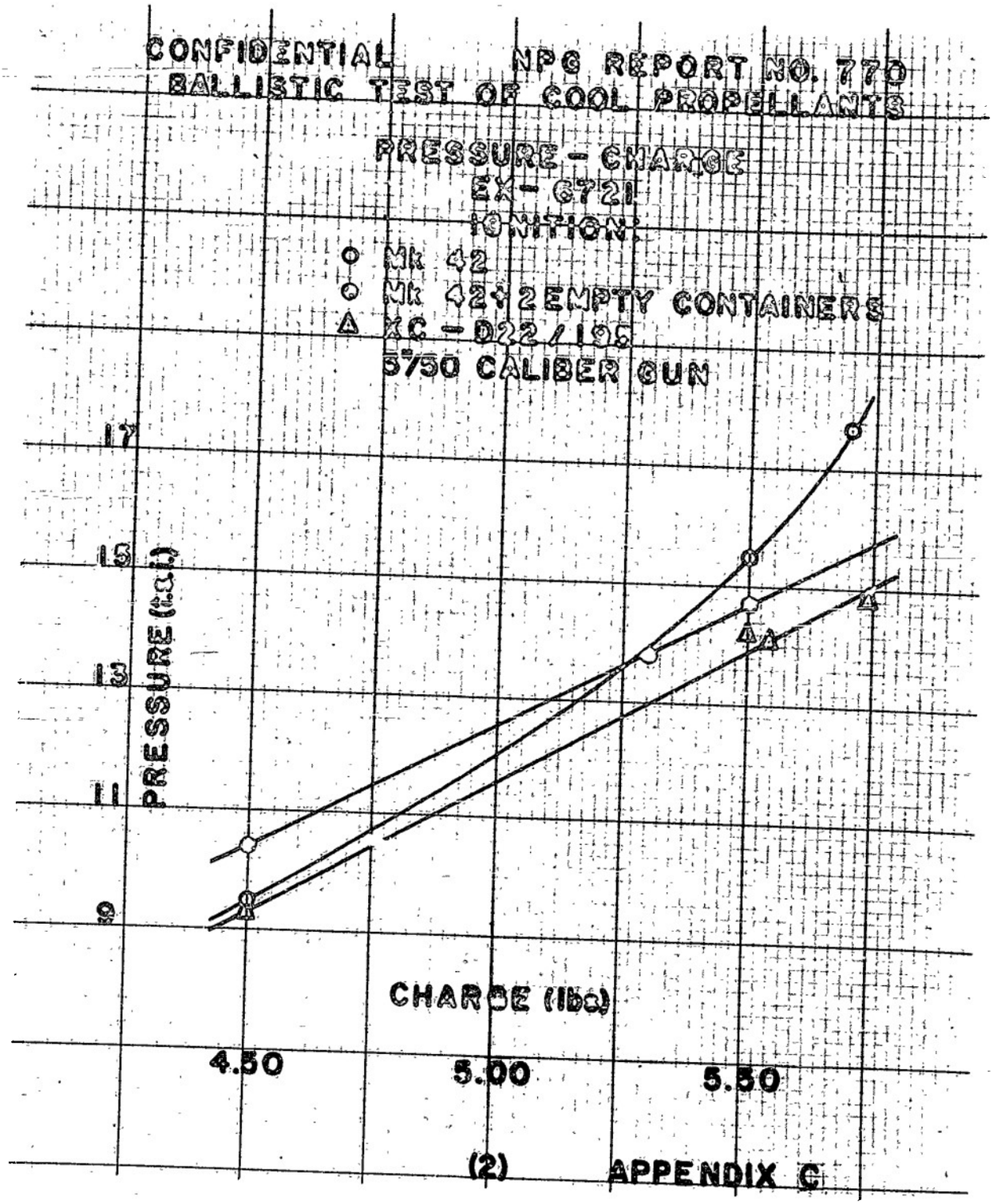
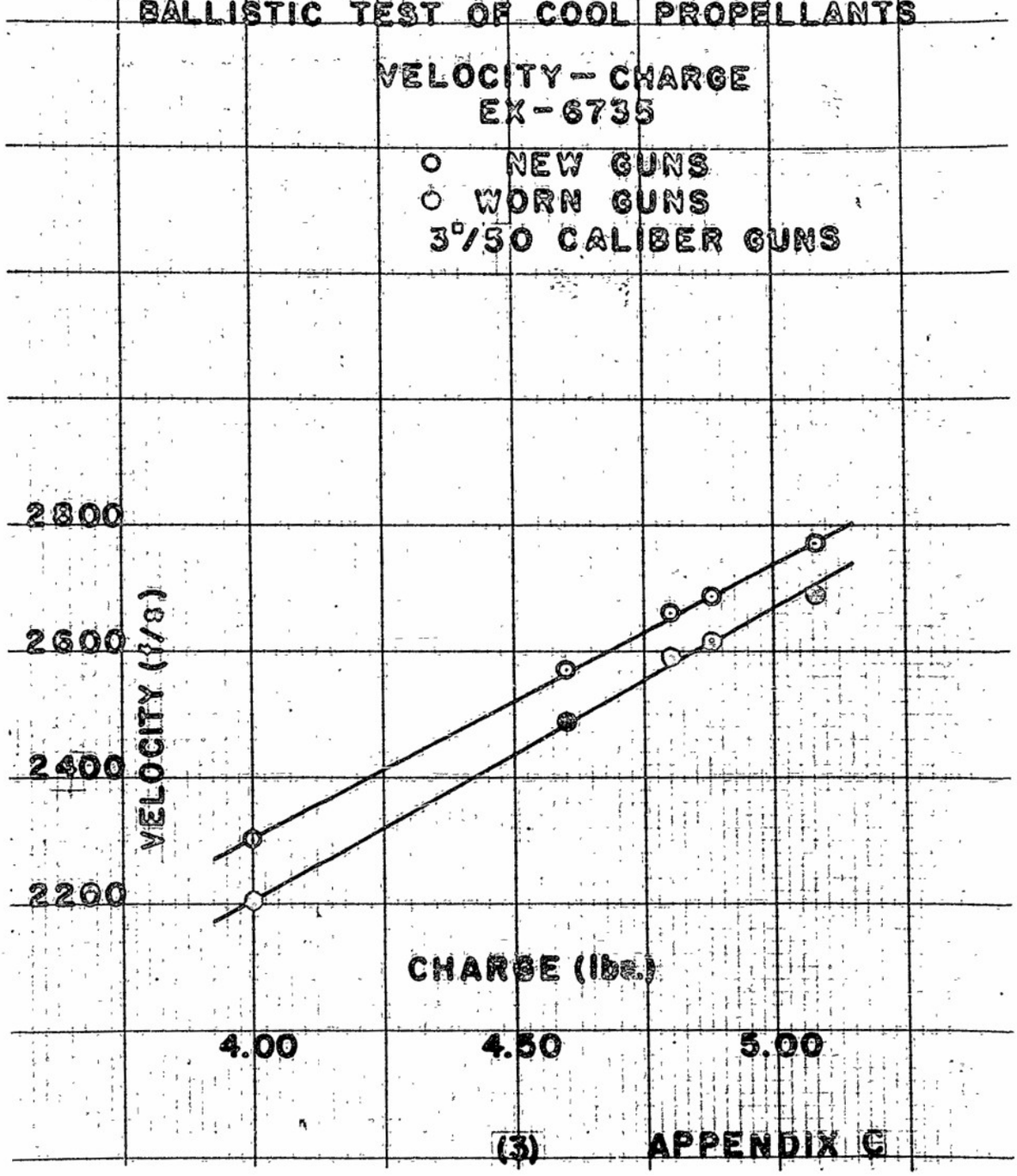


BALLISTIC TEST OF COOL PROPELLANTS

VELOCITY – CHARGE
EX-6735



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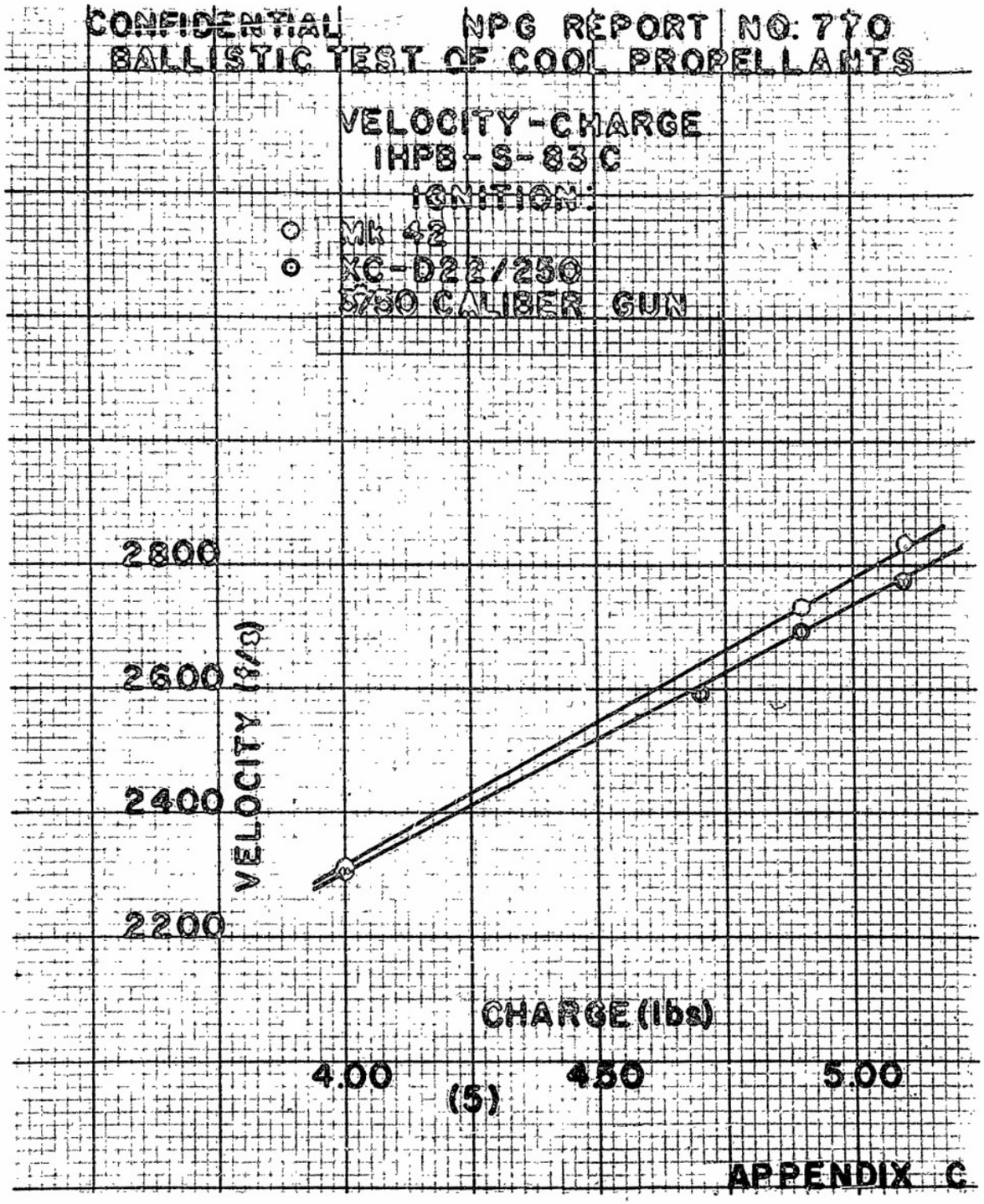
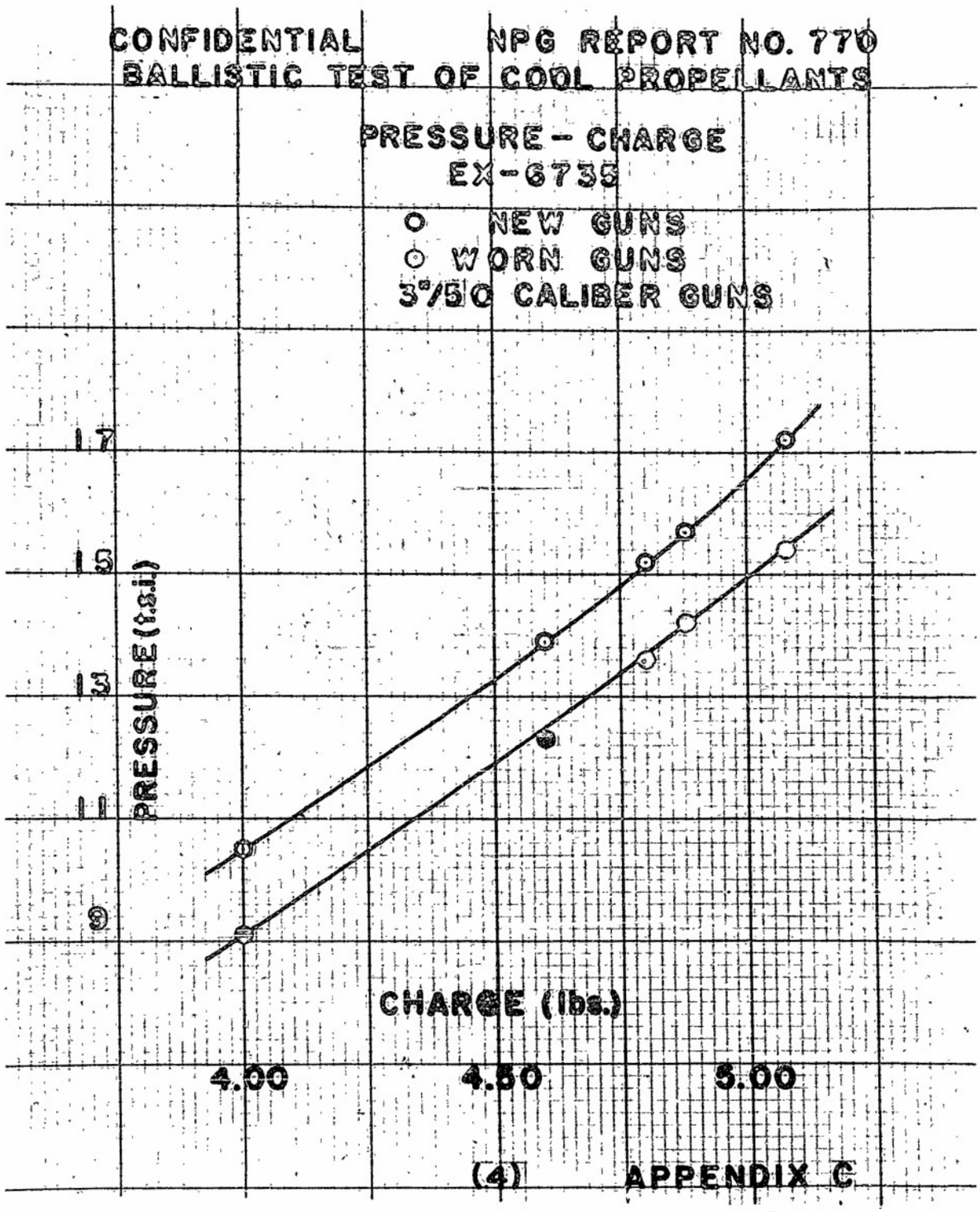


APPENDIX C

BALLISTIC TEST OF COOL PROPELLANTS



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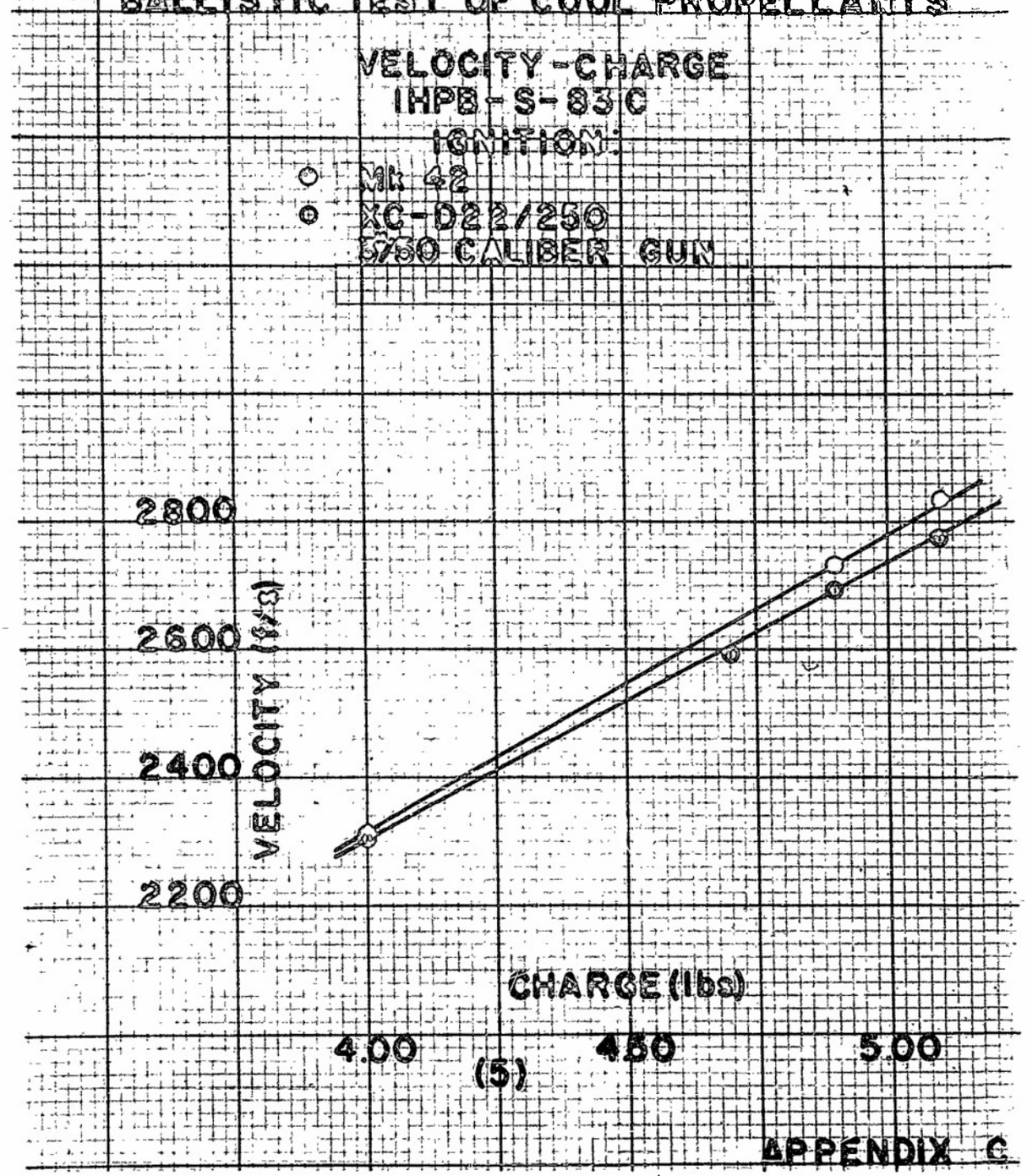
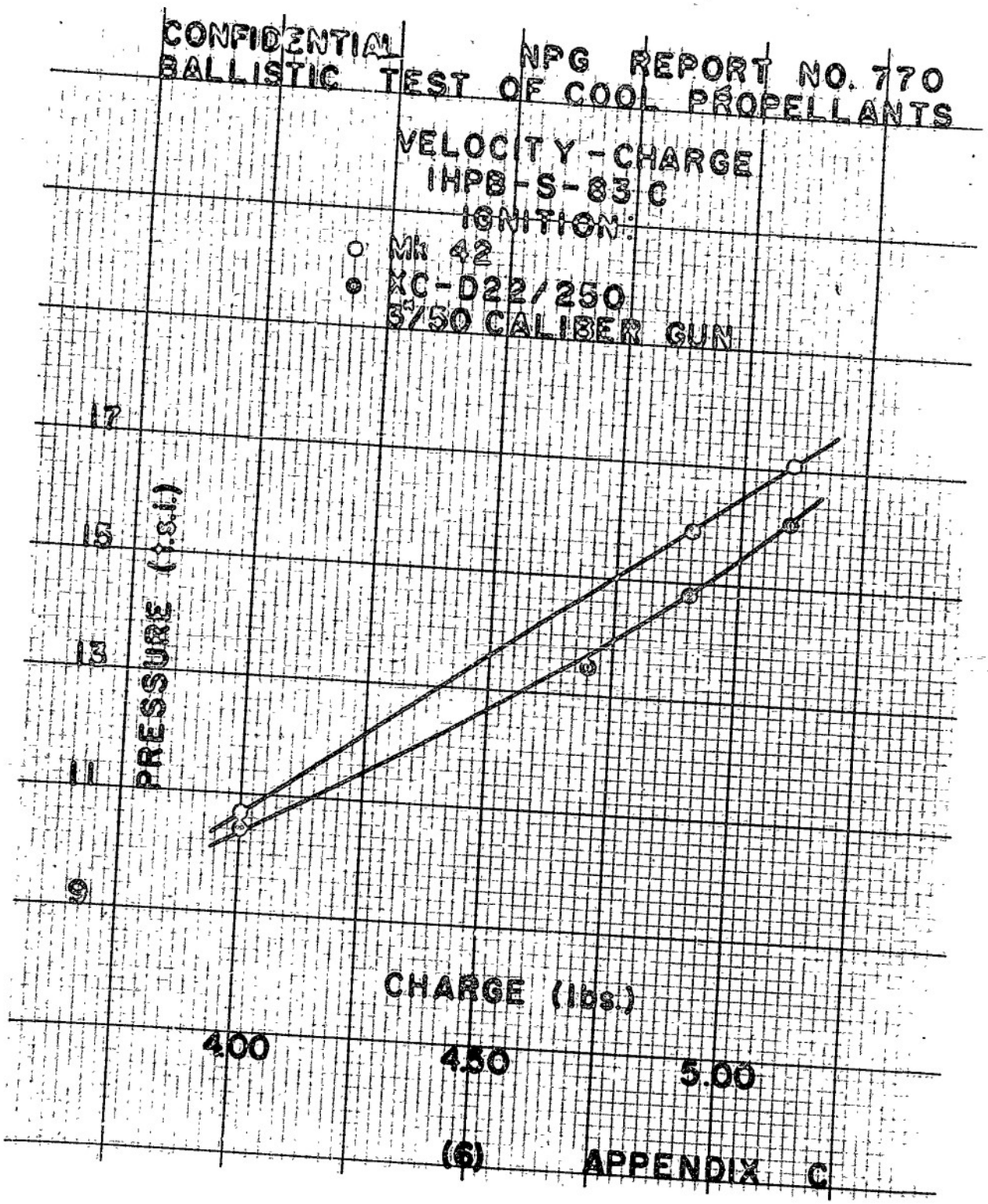


APPENDIX C


VELOCITY - CHARGE
IHPB-S-83 C
IGNITION:
Mk 42
XC-D22/250
5/50 CALIBER GUN
17
15
13
11
9
PRESSURE (t.s.i.)
CHARGE (lbs.)
4.00
4.50
5.00

SUMMARY OF COMPOSITION AND SMOKE DATA

APPENDIX D

EX-6735 1885°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	74.72%
Dibutylphthalate	11.27
Dinitrotoluene	13.01
Diphenylamine	1.00
Total Volatiles	0.42
Average Web	0.0278

A	B	C	D	E
Mk. 42	0	5	5	60.0
Mk. 42 (e)	3	0	3	00.0
Mk. 42 (b)	18	4	14	22.0
XC-D22/260	101	96	5	95.0

EX-6722 1892°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	74.28%
Dibutylphthalate	11.98
Dinitrotoluene	12.40
Diphenylamine	1.04
Total Volatiles	0.77
Average Web	0.0249

A	B	C	D	E
Mk. 42	14	1	13	7.1
Mk. 42 (e)	14	3	11	21.4
Mk. 42 (b)	19	4	15	21.1
XC-D22/195	5	4	1	50.0
XC-D22/200	5	5	0	100.0
XC-D22/260	29	27	2	93.1
XC-D22/100	5	5	0	100.0

EX-6718 1941°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	74.09%
Dibutylphthalate	10.09
Dinitrotoluene	12.01
Diphenylamine	1.01
Total Volatiles	0.98
Average Web	0.0216

A	B	C	D	E
Mk. 42 (e)	11	0	11	0.0
Mk. 42 (b)	9	1	8	11.1

EX-6691 1996°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	73.87%
Dibutylphthalate	9.91
Dinitrotoluene	12.45
Diphenylamine	1.19
Total Volatiles	0.41
Average Web	0.0205

A	B	C	D	E
Mk. 42 (e)	6	0	6	0.0
Mk. 42 (b)	19	0	19	0.0

EX-6687 2037°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	77.07%
Dibutylphthalate	8.28
Dinitrotoluene	13.21
Diphenylamine	1.44
Total Volatiles	0.94
Average Web	0.0365

A	B	C	D	E
Mk. 42 (b)	11	0	11	0.0

EX-6706 2042°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	77.60%
Dibutylphthalate	9.84
Dinitrotoluene	11.44
Diphenylamine	0.82
Total Volatiles	0.88
Average Web	0.0272

A	B	C	D	E
Mk. 42 (e)	13	0	12	0.0
Mk. 42 (b)	8	0	8	0.0
XC-D22/195	7	7	0	100.0

EX-6700 2186°K
(Single base - Non-Plerite)

Nitrocellulose (13.20%N)	78.87%
Dibutylphthalate	8.58
Dinitrotoluene	11.62
Diphenylamine	0.78
Total Volatiles	1.14
Average Web	0.0271

A	B	C	D	E
Mk. 42	16	2	18	13.3
Mk. 42 (e)	14	0	14	0.0
Mk. 42 (b)	95	5	90	14.9
XC-D22/260	7	5	2	71.4

IX-25 2243°K
(Single base - Non-Plerite)

Nitrocellulose (13.15%N)	79.01%
Dibutylphthalate	6.28
Dinitrotoluene	11.98
Ethyl Centralite	1.99
Total Volatiles	0.78
Average Web	0.030

A	B	C	D	E
Mk. 42	10	0	10	0.0
Mk. 42 (e)	13	0	13	0.0
Mk. 42 (b)	6	0	6	0.0
XC-D22/260	8	8(e)	0	100.0

IX-26 2254°K
(Single base - Non-Plerite)

Nitrocellulose (13.15%N)	78.81%
Dibutylphthalate	8.44
Dinitrotoluene	12.00
Ethyl Centralite	1.22
Total Volatiles	1.27
Average Web	0.0234

A	B	C	D	E
Mk. 42 (e)	10	0	10	0.0

IX-27 2263°K
(Single base - Non-Plerite)

Nitrocellulose (13.15%N)	79.09%
Dibutylphthalate	8.39
Dinitrotoluene	12.50
Ethyl Centralite	2.07
Total Volatiles	0.46
Average Web	0.0206

A	B	C	D	E
Mk. 42 (e)	2	0	2	0.0

EX-6721 1876°K
(Single base - Non-Plerite + 1% Lead Carbonate)

Nitrocellulose (13.20%N)	73.07%
Dibutylphthalate	11.08
Dinitrotoluene	12.80
Diphenylamine	1.05
Lead Carbonate	0.78
Total Volatiles	0.75
Average Web	0.0327

A	B	C	D	E
Mk. 42	10	3	7	30.0
Mk. 42 (b)	9	3	6	33.3
XC-D22/195	13	6	7	46.1
XC-D22/260	2	2	0	100.0

EX-6683 2063°K
(Double base - Non-Plerite)

Nitrocellulose (13.15%N)	63.28%
Dibutylphthalate	15.90
Nitroglycerin	18.27
Centralite	4.28
Total Volatiles	0.20
Average Web	0.0350

A	B	C	D	E
Mk. 42 (e)	12	0	12	0.0

EX-6682 2081°K
(Double base - Non-Plerite)

Nitrocellulose (13.15%N)	64.46%
Dibutylphthalate	15.87
Nitroglycerin	17.83
Centralite	1.42
Total Volatiles	0.25
Average Web	0.0504

A	B	C	D	E
Mk. 42	16	1	15	6.3
Mk. 42 (e)	20	3	17	15.0
XC-D22/195	15	10	5	67.6

EX-6701 2075°K
(Double base - Non-Plerite)

Nitrocellulose (13.20%N)	61.15%
Dibutylphthalate	19.72
Nitroglycerin	20.17
Centralite	4.82
Total Volatiles	0.10
Average Web	0.0256

A	B	C	D	E
Mk. 42	14	2	12	14.3
Mk. 42 (e)	15	2	13	13.3
Mk. 42 (b)	25	5	20	20.0
XC-D22/260	7	0	1	85.7

IX-30 2096°K
(Double base - Non-Plerite)

Nitrocellulose (13.15%N)	61.32%
Dibutylphthalate	19.66
Nitroglycerin	19.75
Ethyl Centralite	5.05
Total Volatiles	0.21
Average Web	0.021

A	B	C	D	E
Mk. 42 (e)	11	0	11	0.0

IX-32 2103°K
(Double base - Non-Plerite)

Nitrocellulose (13.15%N)	61.21%
Dibutylphthalate	18.76
Nitroglycerin	18.86
Ethyl Centralite	4.98
Total Volatiles	0.11
Average Web	0.0505

A	B	C	D	E
Mk. 42	8	0	8	0.0
Mk. 42 (e)	13	0	13	0.0
XC-D22/260	8	4(e)	1	80.0

IX-31 2170°K
(Double base - Non-Plerite)

Nitrocellulose (13.15%N)	61.21%
Dibutylphthalate	19.04
Nitroglycerin	20.66
Ethyl Centralite	5.01
Total Volatiles	0.13
Average Web	0.026

A	B	C	D	E
Mk. 42	7	0	7	0.0
Mk. 42 (e)	15	0	15	0.0
Mk. 42 (b)	5	0	2	0.0
XC-D22/260	10	8(e)	2	00.0

EX-6719 2025°K
(Double base - Non-Plerite + 1% Lead Carbonate)

Nitrocellulose (13.20%N)	61.72%
Dibutylphthalate	16.21
Nitroglycerin	15.21
Centralite	4.65
Lead Carbonate	0.91
Total Volatiles	0.58
Average Web	0.0266

A	B	C	D	E
Mk. 42	13	0	13	0.0
Mk. 42 (e)	15	0	12	0.0
Mk. 42 (b)	15	3	12	20.0
XC-D22/260	7	7	0	100.0

IHPB-3-83 C 2123°K
(Single base - w/o N.T. or D.B.P.)

Nitrocellulose (12.6%N)	83.62%
Ethyl Centralite	7.00
Alcohol	9.76
Water	0.70
Average Web	0.026

A	B	C	D	E
Mk. 42	5	0	5	0.0
XC-D22/260	19	0	6	0.0

A - Primer
B - No. of rounds fired
C - No. of rounds black smoke

D - No. of rounds flashing
E - Percentage of rounds giving black smoke

(e) Plus 150 grams of XF73-215 in pyralin container around forward end of primer.
(b) Plus 2 empty pyralin containers around ends and around primer.
(e) Dark grey smoke

SUMMARY OF SMOKE AND FLASH DATA FOR ALL IGNITION SYSTEMS TESTED

APPENDIX E

Powder	Type	Flame Temp. °K	Av. Web (in.)	Mk. 42 A	Mk. 42 B	Mk. 42 C	Mk. 42 D	Mk. 42 + 2 Empty Pyralin Containers A	B	C	D	Mk. 42 + NH Booster A	B	C	D	XC-D22/195 A	B	C	D	XC-D22/200 A	B	C	D	XC-D22/250 A	B	C	D	XC-D22/300 A	B	C	D
EX-6735	Single base Non-Migrite	1883	0.0275	5	2	3	40.0	18	4	14	22.0	3	0	3	0.0									101	96	5	95.0				
EX-6722	"	1892	0.0249	14	1	13	7.1	19	4	15	21.1	14	3	11	21.4	5	4	1	80.0	6	6	0	100.0	29	27	2	93.1	5	5	0	100.0
EX-6716	"	1941	0.0218					9	1	8	11.1	12	0	11	0.0																
EX-6691	"	1998	0.0305					19	0	19	0.0	6	0	6	0.0																
EX-6692	"	2037	0.0358					11	0	11	0.0																				
EX-6708	"	2052	0.0272					3	0	3	0.0	12	0	12	0.0	7	7	0	100.0												
EX-6705	"	2186	0.0271	15	2	13	13.3	15	5	10	33.3	14	0	14	0.0	7	5	2	71.4												
EX-6721	" (b)	1876	0.0327	10	3	7	30.0	9	3	6	33.3					12	5	7	41.7					2	2	0	100.0				
			Total	44	8	36	18.2	113	17	106	13.8	60	3	57	5.0	31	21	10	67.7	6	6	0	100.0	132	125	7	94.7	5	5	0	100.0
IX-29	Single base Non-Migrite	2243	0.030	10	0	10	0.0	4	0	4	0.0	13	0	13	0.0									5	5(a)	0					
IX-28	"	2254	0.0255									10	0	10	0.0																
IX-27	"	2265	0.0205									2	0	2	0.0																
			Total	10	0	10	0.0	4	0	4	0.0	25	0	25	0.0									5	5(a)	0	100.0				
EX-6683	Double base Non-Migrite	2055	0.0350									12	0	12	0.0																
EX-6682	"	2061	0.0304	16	1	15	6.3					20	3	17	15.0	16	10	6	62.5												
EX-6701	"	2079	0.0256	14	2	12	14.3	23	3	20	13.0	15	2	13	13.3					7	6	1	85.7								
EX-6715	" (b)	2085	0.0266	13	0	13	0.0	15	3	12	20.0	13	0	13	0.0					7	7	0	100.0								
			Total	43	3	40	7.0	38	6	32	15.8	60	5	55	8.3	16	10	6	62.5	14	13	1	92.9								
IX-32	Double base Non-Migrite	2103	0.0305	5	0	5	0.0					12	0	12	0.0									5	4(a)	1	80.0				
IX-31	"	2170	0.026	7	0	7	0.0	2	0	2	0.0	18	0	18	0.0									10	8(a)	2	80.0				
IX-30	"	2096	0.021									11	0	11	0.0									15	12(a)	3	80.0				
			Total	12	0	12	0.0	2	0	2	0.0	41	0	41	0.0																
IHPB-S-830	Single base w/o DNT or DBP	2123	0.029	9	0	7	0.0																	13	0	2	0.0				
SPCO-10139	3"/50 Conlite N/P/A	2462	0.0325	38	0	0	0.0																								
NPFB-223	3"/50 NH	2592	0.035	12	0	12	0.0																	1	0	1	0.0				
NPFB-266	3"/50 NH Blends	2583	0.034	5	0	5	0.0																								
SPDN-4438	5"/25 NH	2621	0.0410																												
SPDN-5208	5"/38 NH	2664	0.050																												
1	SPDN-4438 + EX-6735																							3	3	0	100.0				
2	"																							3	3	0	100.0				
3	"																							5	5	0	100.0				
4	"																							100	83	17	83.0				
5	"			6	0	6	0.0																	350	265	85	75.7				
6	SPDN-5208 + EX-6735																							5	5	0	100.0				
7	Blends of NPFB-266 EX-6735																							5	5	0	100.0				
8	"																							3	1	2	33.3				
9	"																							3	3	0	100.0				
10	"																							5	4	1	80.0				
11	"																							3	3	0	100.0				

Powder 1 = SPDN-4438 (0.2 lbs.) on bottom of case. EX-6735 (4.59 lbs.) on top.
" 2 = " (0.3 lbs.) " " " " " (4.49 lbs.) " "
" 3 = " (0.4 lbs.) " " " " " (4.39 lbs.) " "
" 4 = " (0.4 lbs.) " " " " " (4.41 lbs.) " "
" 5 = " (0.4 lbs.) " " " " " (4.49 lbs.) " "
" 6 = SPDN-5208 (0.4 lbs.) " " " " " (4.49 lbs.) " "

Powder 7 = 50/50 blend of NPFB-266 (2.01 lbs.) and EX-6735 (2.45 lbs.)
" 8 = 60/40 " " " (2.41 lbs.) " " (1.96 lbs.)
" 9 = 70/30 " " " (2.81 lbs.) " " (1.47 lbs.)
" 10 = 80/20 " " " (3.22 lbs.) " " (0.98 lbs.)
" 11 = 90/10 " " " (3.62 lbs.) " " (0.49 lbs.)

A = Number of rounds fired.
B = Number of rounds black smoke.
C = Number of rounds flashing.
D = Percentage of rounds giving black smoke

(a) Dark gray smoke
(b) Plus 1% Lead Carbonate

SUMMARY OF SMOKE, FLASH, AND CARBON DATA *

APPENDIX E

Powder	Type	Flame Temp. °K	Av. Web (in.)	No. of Rds.	No. Rds. Black Smoke	No. Rds. Carbon	No. Rds. Flashing	Carbon (%)**	Primer
EX-6735	Single Base Non-Picrite	1883	0.0275	101	96	101	5	100	XC-D22/250
EX-6708	"	2052	0.0272	2	2	2	0	75	XC-D22/250
EX-6705	"	2186	0.0271	2	2	2	0	85	XC-D22/250
EX-6721	"(b)	1876	0.0327	2	2	2	0	75	XC-D22/250
IX-29	Single Base Non-Picrite	2243	0.030	5 5	5 (a) 0	0 0	0 5	0 0	XC-D22/250 Mk - 42
EX-6701	Double Base Non-Picrite	2079	0.0256	2	2	2	0	50	XC-D22/250
EX-6715	" (b)	2025	0.0286	2	2	2	0	85	XC-D22/250
IX-32	Double Base Non-Picrite	2103	0.0305	5 5	4 (a) 0	5 5	1 5	40 25	XC-D22/250 Mk - 42
IX-31	"	2170	0.026	10 7	8 (a) 0	10 7	2 7	25 15	XC-D22/250 Mk - 42
IHPB-S-83C	Single Base w/o DNT or DBP	2123	0.029	13 9	0 0	0 0	2 7	0 0	XC-D22/250 Mk - 42
SPCO-10135	3"/50 Cordite N/P/M	2462	0.0325	2	0	0	2	0	XC-D22/250
NPFB -223	3"/50 NH	2592	0.035	1	0	0	1	0	XC-D22/250
NPFB-266	3"/50 NH Blends	2588	0.034	5	0	0	5	0	Mk - 42
7	Blends of NPFB-266 EX-6735			5	5	5	0	75	XC-D22/250
8	"			3	1	1	2	50	XC-D22/250
9	"			3	3	3	0	35	XC-D22/250
10	"			5	5	5	0	25	XC-D22/250
11	"			3	3	3	0	10	XC-D22/250

* Single round firing on special programs for carbon determination
(See Appendix H for rapid fire data)
** Based on EX-6735 as 100%

(a) Dark Grey Smoke
(b) Plus 1% Lead Carbonate

Powder 7 - 50/50 blend of NPFB-266 (2.01 lbs.) and EX-6735 (2.45 lbs.)
" 8 - 60/40 " " " (2.41 lbs.) " " (1.96 lbs.)
" 9 - 70/30 " " " (2.81 lbs.) " " (1.47 lbs.)
" 10 - 80/20 " " " (3.22 lbs.) " " (0.98 lbs.)
" 11 - 90/10 " " " (3.62 lbs.) " " (0.49 lbs.)

SUMMARY OF SMOKE, FLASH, AND CARBON DATA *

APPENDIX E

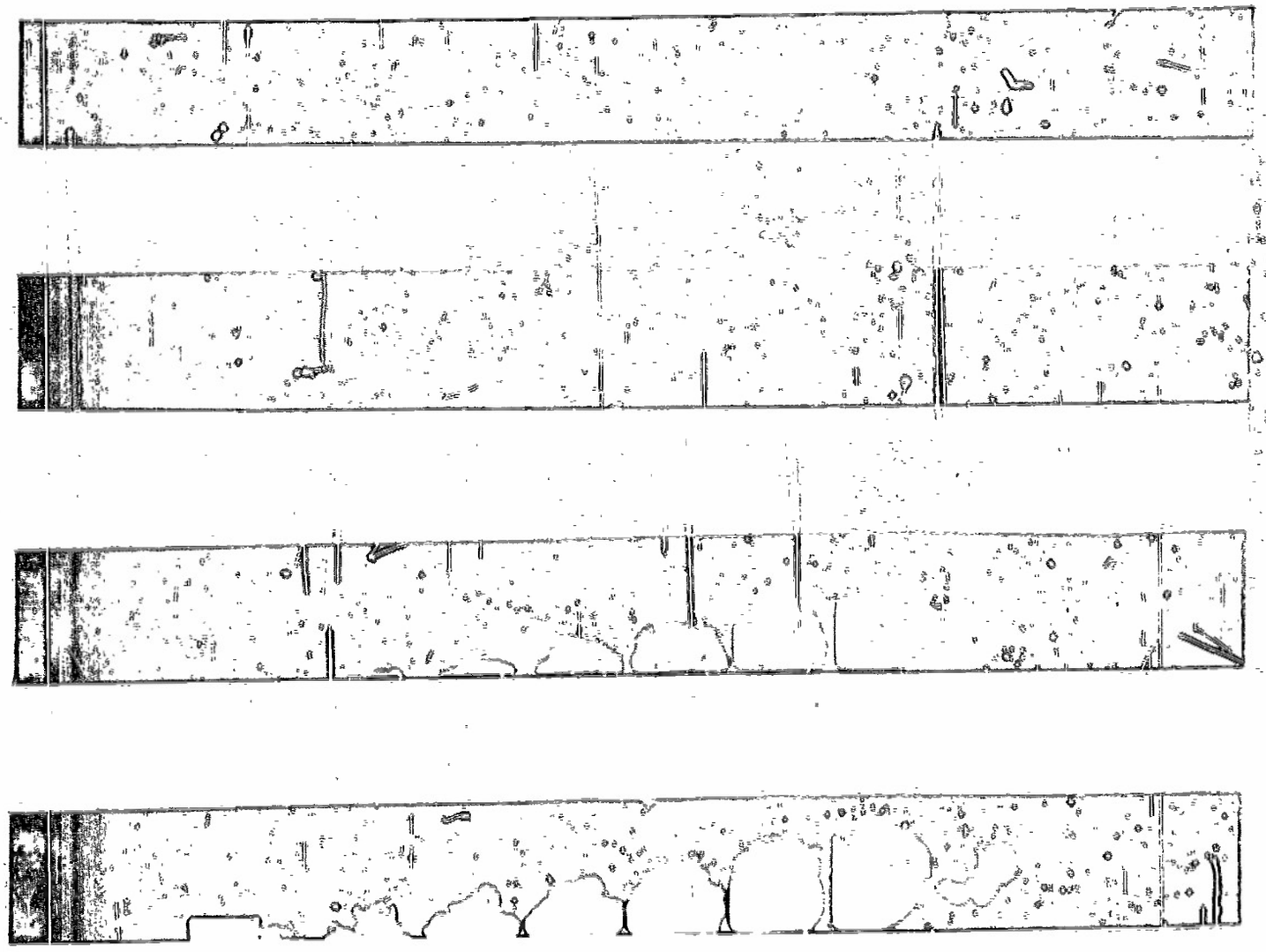
Powder	Type	Flame Temp. °K	Av. Web (in.)	No. of Rds.	No. Rds. Black Smoke	No. Rds. Carbon	No. Rds. Flashing	Carbon (%)**	Primer
	Single Base								
EX-6735	Non-Picrite	1883	0.0275	101	96	101	5	100	XC-D22/250
EX-6700	"	2052	0.0272	2	2	2	0	75	XC-D22/250
EX-6705	"	2186	0.0271	2	2	2	0	85	XC-D22/250
EX-6721	"(b)	1876	0.0327	2	2	2	0	75	XC-D22/250
	Single Base								
IX-29	Non-Picrite	2243	0.030	5	5 (a)	0	0	0	XC-D22/250
				5	0	0	5	0	Mk = 42
	Double Base								
EX-6701	Non-Picrite	2079	0.0256	2	2	2	0	50	XC-D22/250
EX-6715	" (b)	2025	0.0286	2	2	2	0	85	XC-D22/250
	Double Base								
IX-32	Non-Picrite	2103	0.0305	5	4 (a)	5	1	40	XC-D22/250
				5	0	5	5	25	Mk = 42
IX-31	"	2170	0.026	10	8 (a)	10	2	25	XC-D22/250
				7	0	7	7	15	Mk = 42
	Single Base								
IHPB-S-830	w/o DNT or DBP	2123	0.029	13	0	0	2	0	XC-D22/250
				9	0	0	7	0	Mk = 42
SPCC-10135	3"/50 Cordite N/P/M	2462	0.0325	2	0	0	2	0	XC-D22/250
NPFB-223	3"/50 NH	2592	0.035	1	0	0	1	0	XC-D22/250
NPFB-266	3"/50 NH Blends	2538	0.034	5	0	0	5	0	Mk = 42
	Blends of NPFB-266 EX-6735								
7				5	5	5	0	75	XC-D22/250
8	"			3	1	1	2	50	XC-D22/250
9	"			3	3	3	0	35	XC-D22/250
10	"			5	5	5	0	25	XC-D22/250
11	"			3	3	3	0	10	XC-D22/250

* Single round firing on special programs for carbon determination
(See Appendix H for rapid fire data)
** Based on EX-6735 as 100%

(a) Dark Grey Smoke
(b) Plus 1% Lead Carbonate

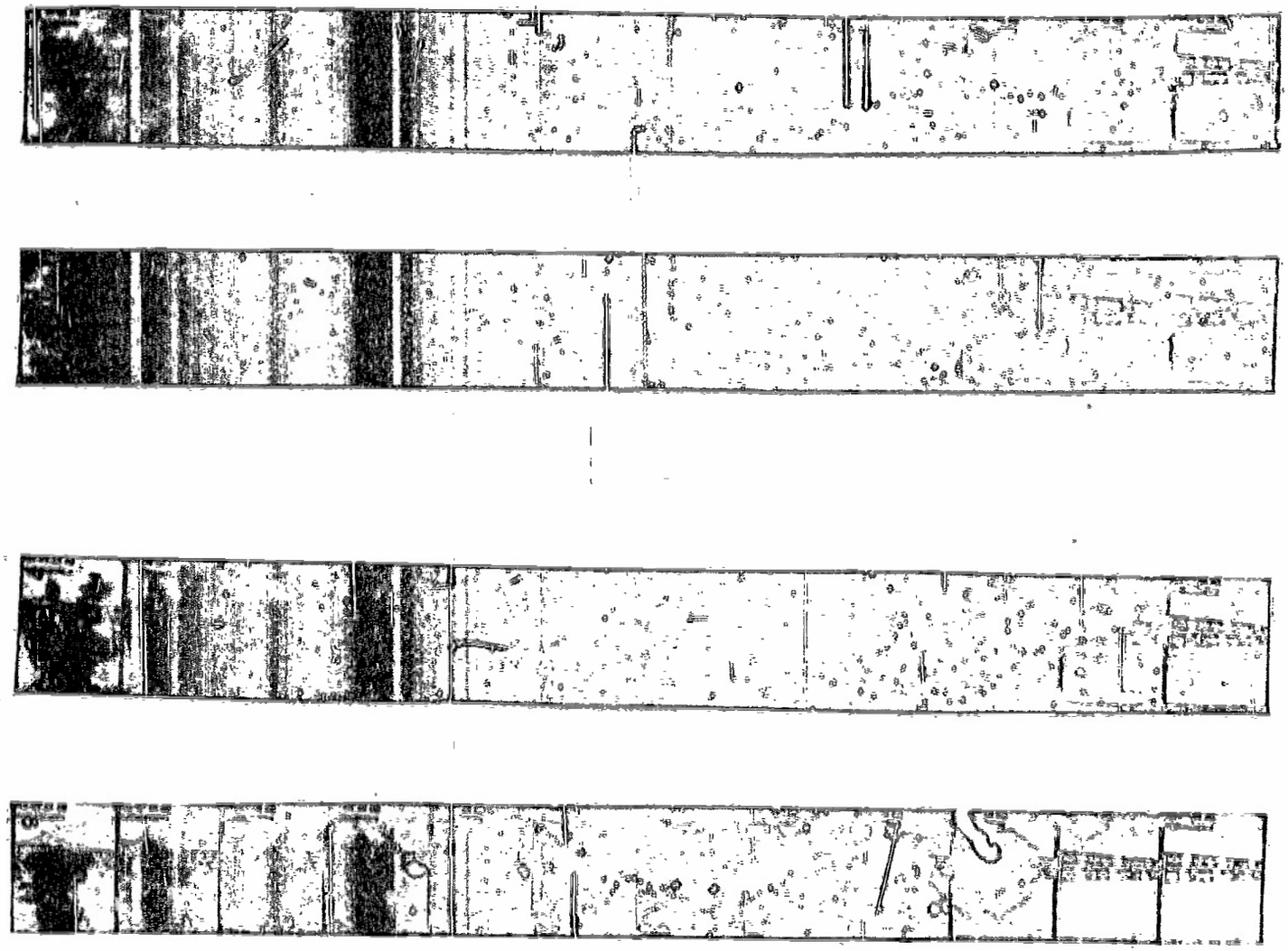
Powder 7 = 50/50 blend of NPFB-266 (2.01 lbs.) and EX-6735 (2.45 lbs.)
" 8 = 60/40 " " " (2.41 lbs.) " " (1.96 lbs.)
" 9 = 70/30 " " " (2.81 lbs.) " " (1.47 lbs.)
" 10 = 80/20 " " " (3.22 lbs.) " " (0.98 lbs.)
" 11 = 90/10 " " " (3.62 lbs.) " " (0.49 lbs.)

NPO - 43792 "Development of a Cool Propellant for the [illegible] Caliber Gun": Observations of Smoke and Flash. Rounds 1 and 2: [illegible] (2462°K) 4.19 lbs. Rounds 3 and 4: [illegible] -266 ([illegible]) 4.6[illegible] lbs. Date: 19 January 1951

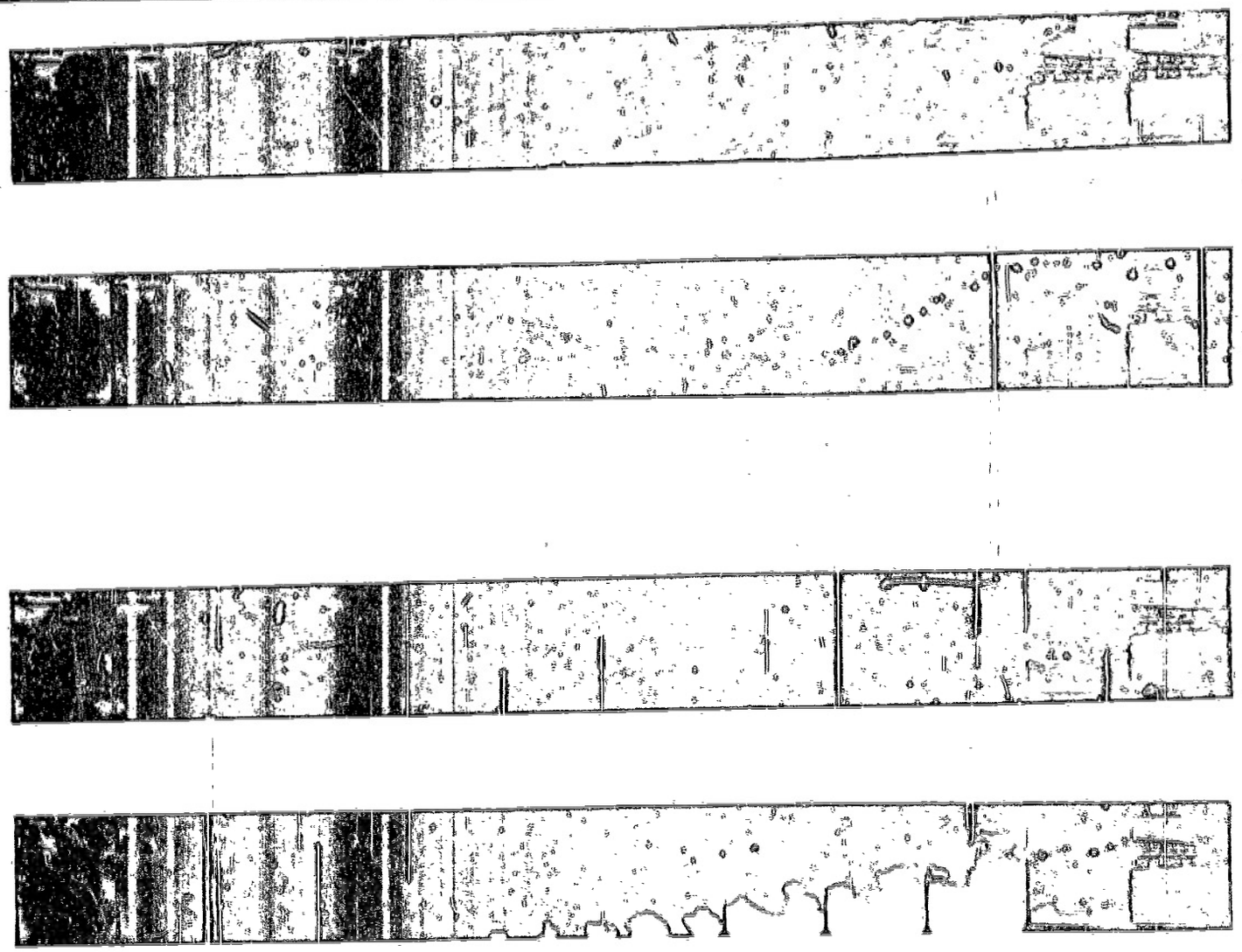


NTS - 43793 "Development of a Cool Propellant for the 3"/50 Caliber Gun": Observations of Smoke and Flash. Rounds 5 and 6: 80/20 blend of NPTB-266 (2588°K) 3.22 lbs. and EX-6735 (1883°K) 0.98 lbs. Rounds 7 and 8: 50/50 blend of NPTB-266 (2588°K) 2.00 lbs. and EX-6735 (1883°K) 2.45 lbs.
Date: 19 January 1951

CONFIDENTIAL



NP9 - 43794 "Development of a Cool Propellant for the 3"/50 Caliber Gun". Observations of Smoke and Flash. Rounds 9 and 10: LA-6735 (1685°K) 4.89 lbs. Rounds 11 and 12: LA-6706 (2052°K) 4.80 lbs. Date: 19 January 1951.

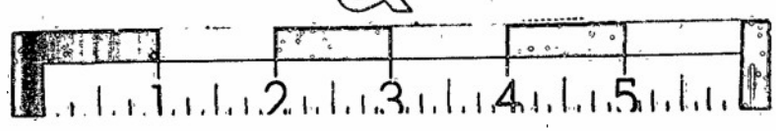


NP9 - [illegible] Carbon deposit [illegible] blend of [illegible] Date [illegible]

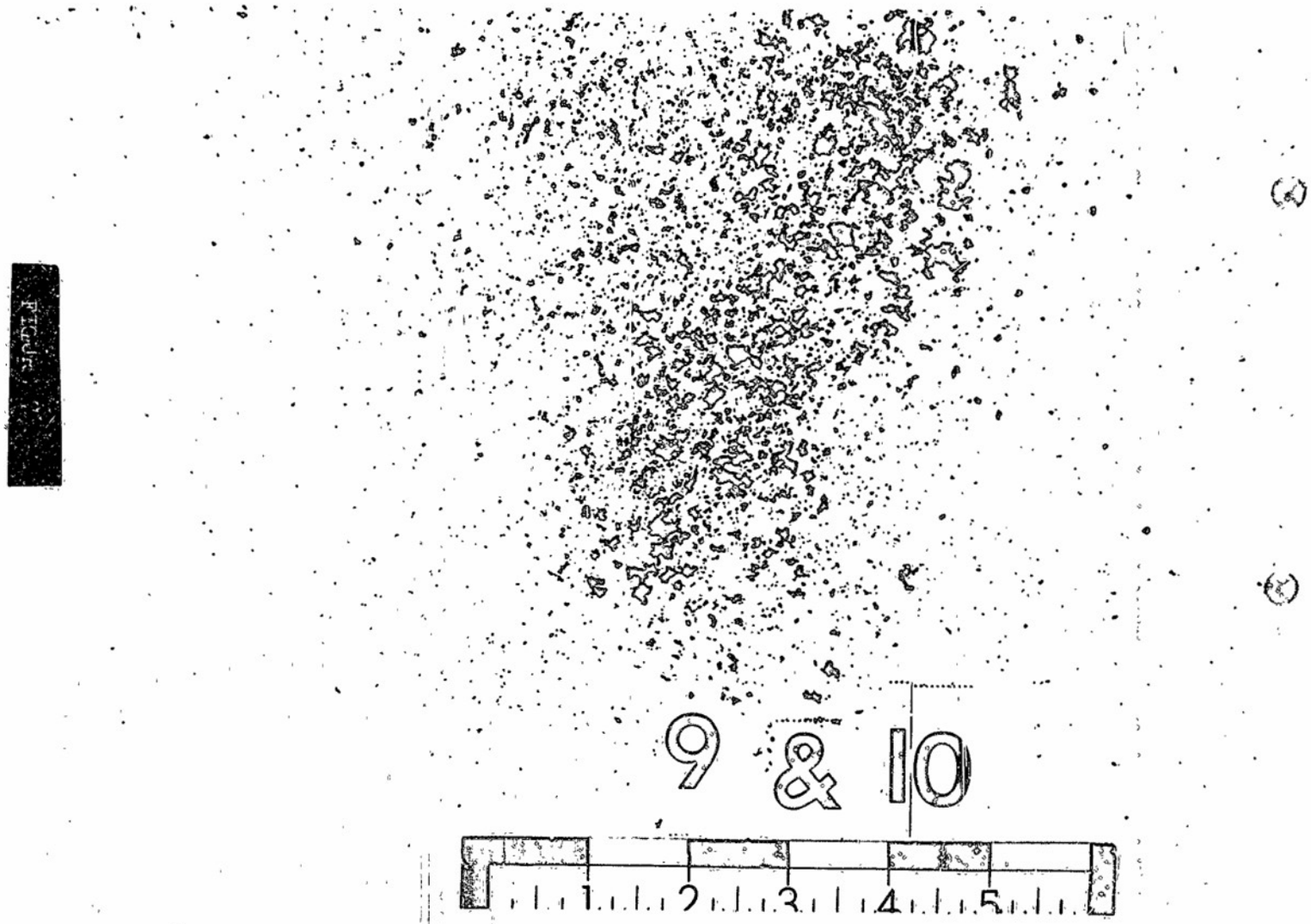
5 & 6

[illegible] Development [illegible] Carbon deposit obtained [illegible] blend [illegible] 50/50

7 & 8



NP9 - 43784 "Development of a Cool Propellant for the 3W/50 Caliber Gun"
Carbon deposit obtained from [illegible] cases. [illegible] 10. [illegible]
[illegible] 51



FIGURE

NP9 - 43785 "Development of a Cool Propellant for the 3"/50 Caliber Gun". Carbon deposit obtained from fired cases. Rounds 11 and 12. Powder: EX-6708 (2052 [illegible]) 4.30 lbs. Date: 19 January 1951

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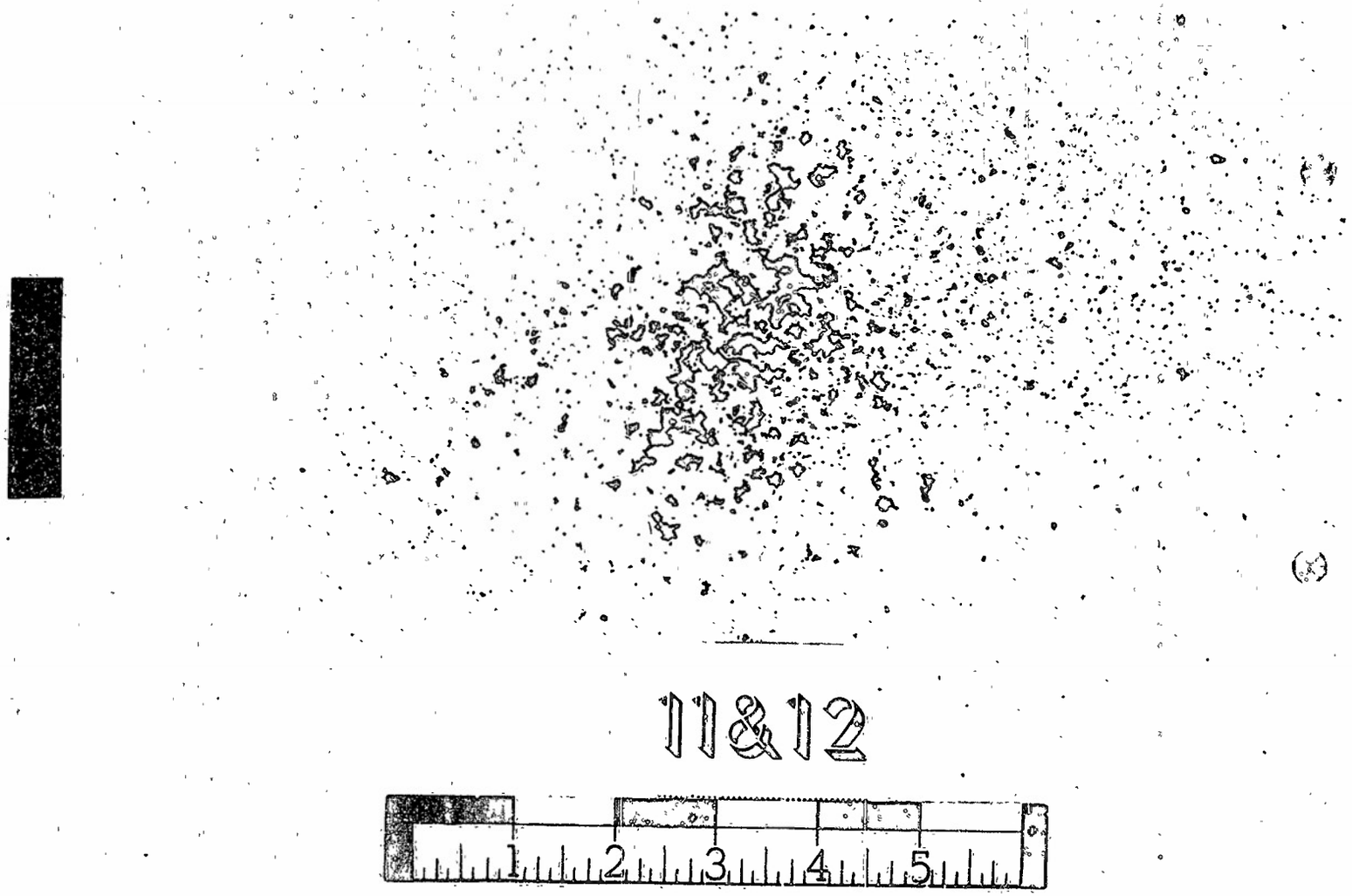
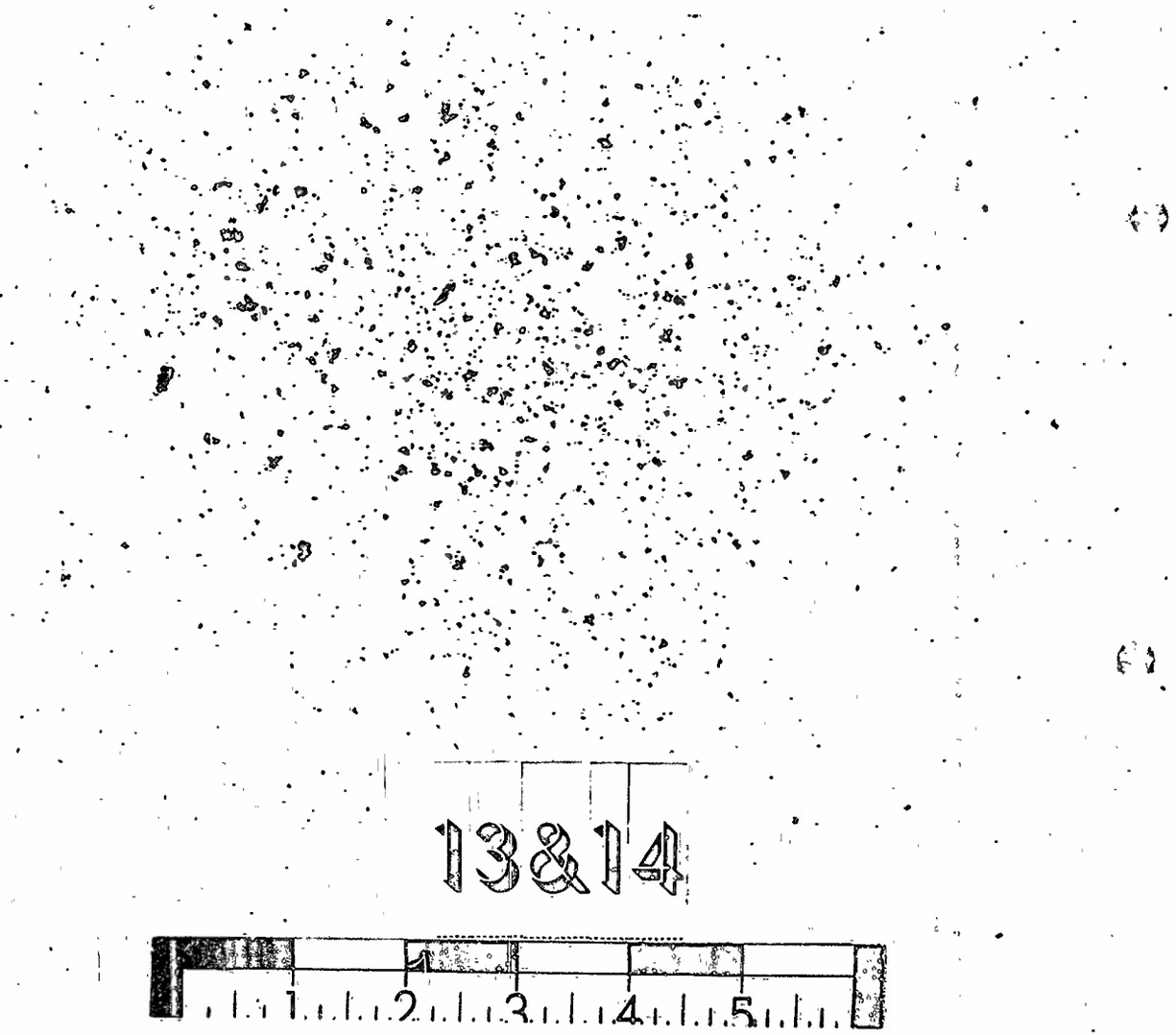


NP9 - 43786 "Development of a Cool Propellant for the 3"/50 Caliber Gun". Carbon deposit obtained from fired cases. Rounds 13 and 14. Powder: [illegible] 6705 (2186°K) 4.65 lbs. Date: 19 January 1951

[illegible]

FIGURE 9



NPO - 43727 Development of a [illegible] propellant for the [illegible] Caliber Gun. Carbon deposit obtained from [illegible] ences. Sunds 15 and 16. Powder: [illegible] 6721 (1870 [illegible]) 5.5 C lbs. [illegible] 1.51

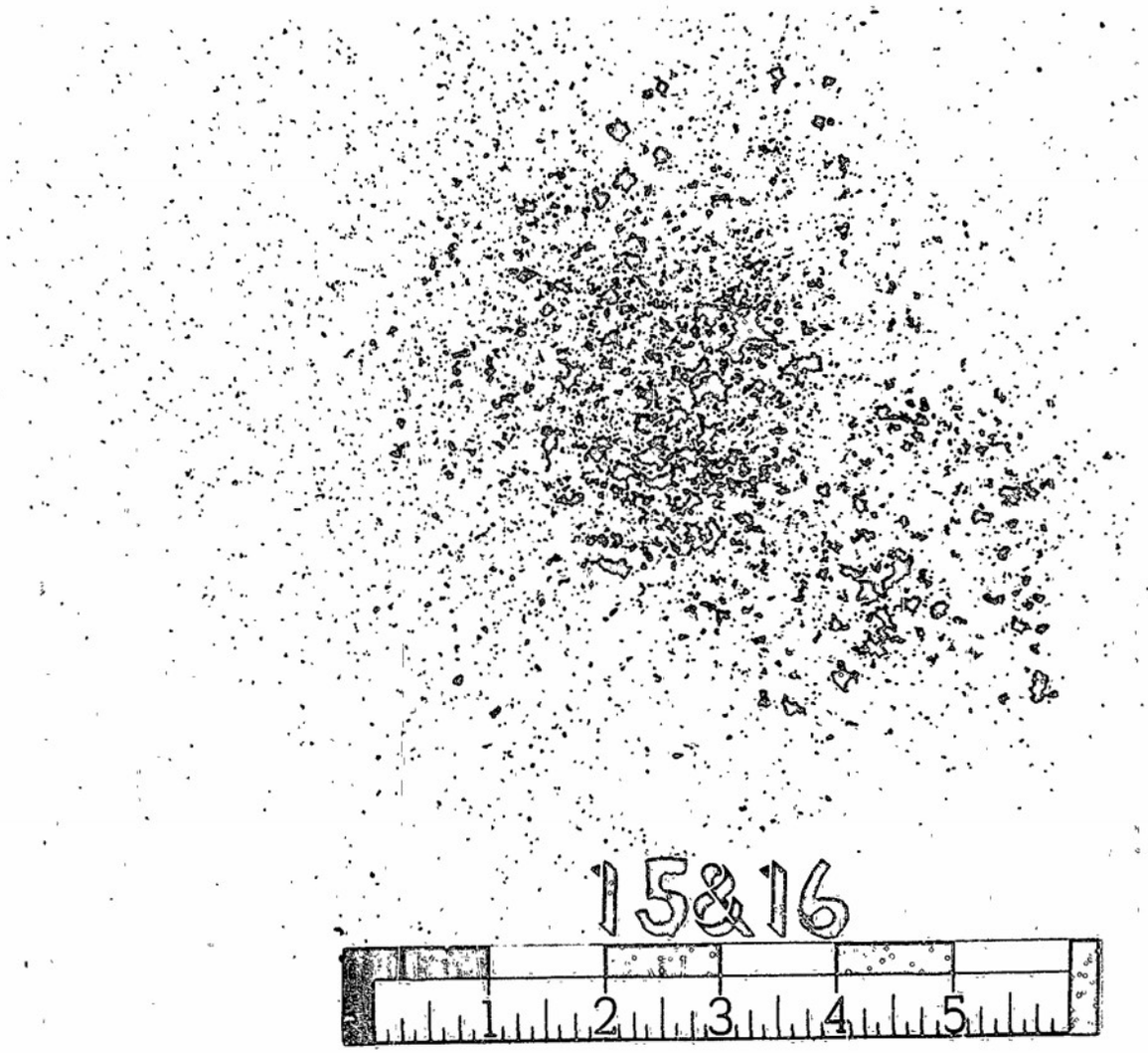
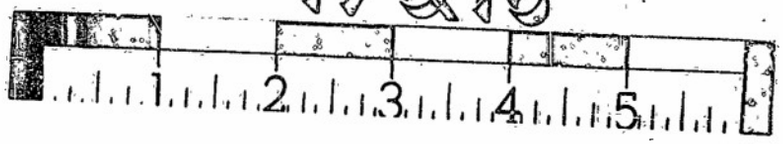


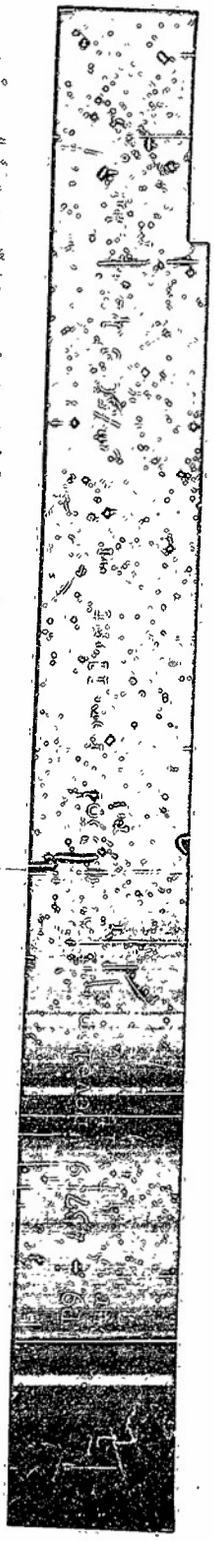
FIGURE 10

NP9 - 13788 "Development of a Cool Propellant for the 3"/50 Caliber Gun"
Carbon deposit obtained from fired cases. Rounds 17 and 18. Powder: LX
6715 (2025°K) 4.80 lbs. Date: 19 January 1951

Fig. 1

17&18





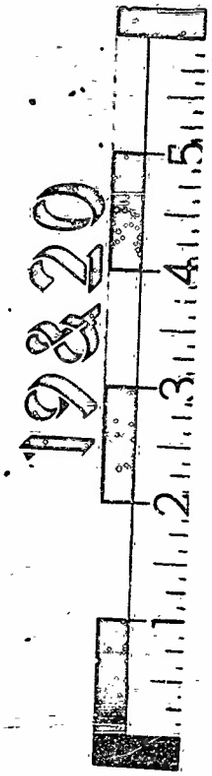


FIGURE 12

Ballistic Test of Cool Propellants

RAPID FIRE AND LOADER TESTS

Gun: 3"/50 Caliber

Date	Number	Mk	Mod	ESR	D_Q
11/20/50	10390	22	4	1176.00	3".128
11/22/50	21404	22	5	1398.27	3".109
11/22/50	23179	22	4	1447.28	3".115
11/27/50	14250	22	4	1467.80	3".110
11/27/50	20249	22	4	7.97	3".002
11/21/50	21705	22	5	1186.00	3".105
11/2/50	13092	22	4	25.86	3".008

Projectile: Mk 33-0 and 31-1 (13.00 lbs.) Epsom Salt Loaded

Lead Foil: 45 grams per round

Powder: SPDN-4438 plus Ex-6735 (as indicated)

Wad and Spacer: Cardboard, NGF Dwg. No. 132664 Pc. Nos. 13 and 4

Ignition: XC-D22/250 and XC-D22a/250 primers

Powder Temp.: 90°F

Ballistic Test of Cool Propellants

Date	Gun No.	Powder	Charge	Loader No.	No. of Rds. Fired
11/2/50 (a)	13092	Ex-6735	4.89 lbs.	928	139
11/20/50 (b)	10390	SPDN-4438	0.20		
		Ex-6735	4.65	490	40
11/21/50 (b)	21705	SPDN-4438	0.20		
		Ex-6735	4.65	488	40
11/22/50 (c)	21404	SPDN-4438	0.40		
		Ex-6735	4.39	578	48
11/22/50 (c)	23179	SPDN-8035	4.11	496	48
11/27/50 (c)	14250	SPDN-4438	0.40		
		Ex-6735	4.39	489	48
11/27/50 (c)	20249	SPDN-8035	4.11	576	48
12/20/50 (d)	13092	SPDN-4438	0.40		
		Ex-6735	4.41	928	175
2/23/51 (e)	13092	SPDN-4438	0.40		
		Ex-6735	4.41	928	175

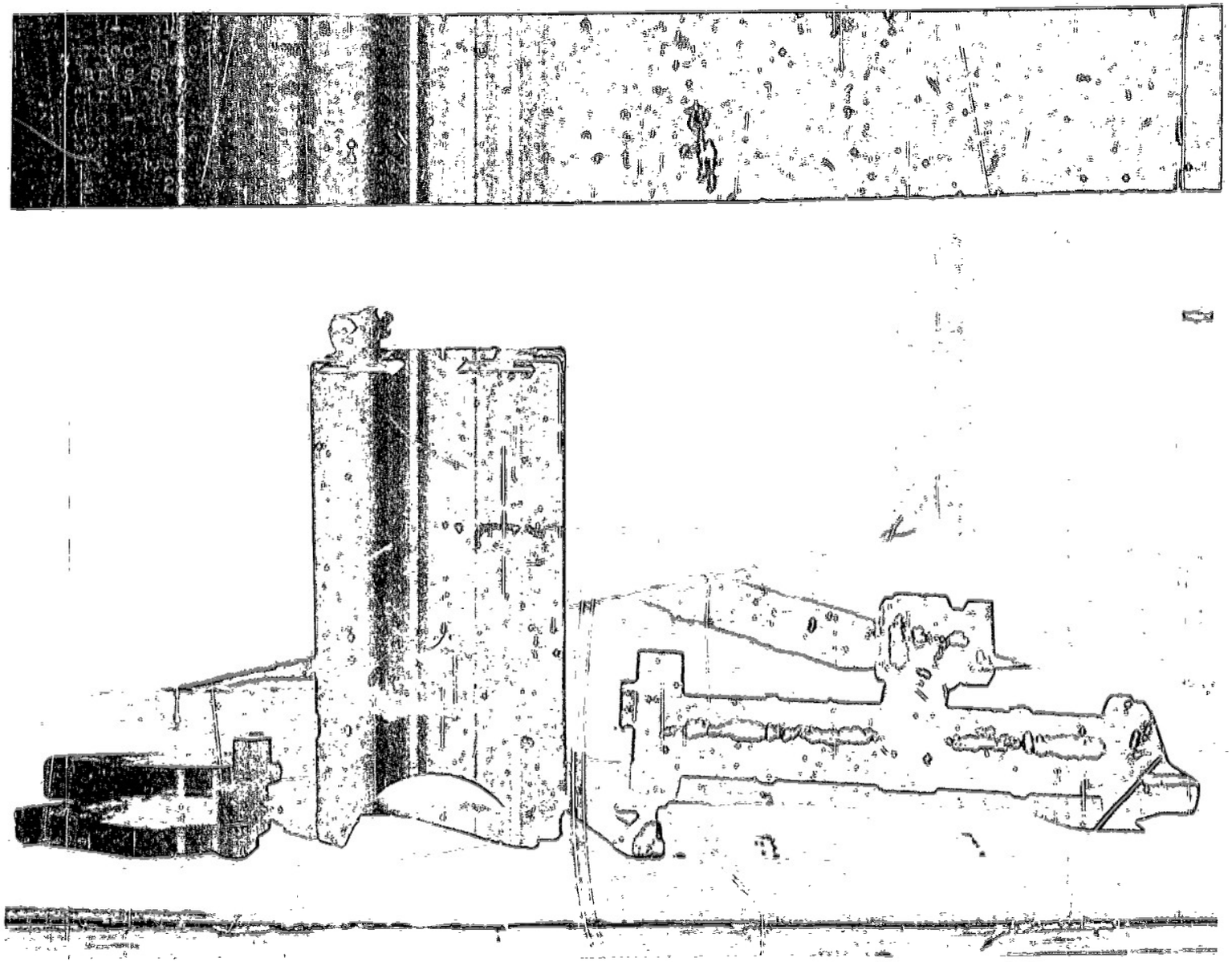
(a) Rapid fire test of Ex-6735 gave accumulation of carbon deposit around breech mechanism resulting in breechblock jamming open.

(b) Test of scavenger NH powder on bottom of case and non-picrite cool powder on top gave a small amount of soot on breech mechanism with some drying of lubricants.

(c) Comparison tests of a scavenger NH powder on bottom of case with non-picrite cool powder on top versus an NH powder alone showed no perceptible difference in appearance of breech mechanism.

(d) A scavenger NH powder on bottom of case and non-picrite cool powder on top gave no carbon formation and no mechanical difficulty in rapid fire and fuze tests.

(e) A scavenger NH powder on bottom of case and non-picrite cool powder on top gave no carbon formation and no mechanical difficulty in rapid fire tests. Black smoke observed on 13 flashless rounds of the first 25 round burst. Flashing rounds gave both black and brown smoke. Second burst gave 9 flashless rounds, third burst gave 2, fourth burst gave 3, and the remaining three 25 round bursts gave all flashing rounds with brown smoke only.



NP 3317 - 3"/50 Caliber Rapid Fire Longer Mark 2 Mod 4. View showing breechblock, extractors and breech operating shaft rod. Note that the parts shown are heavily covered with soot resulting from the automatic firing of 138 rounds of ammunition made up with a special cool propellant (non-picrite type, Ex 6735). The firing marked the beginning of a life test of barrel #13092. The breech mechanism was so heavily sooted that the breechblock jammed open due to parts not operating freely.
Date: 2 November 1950

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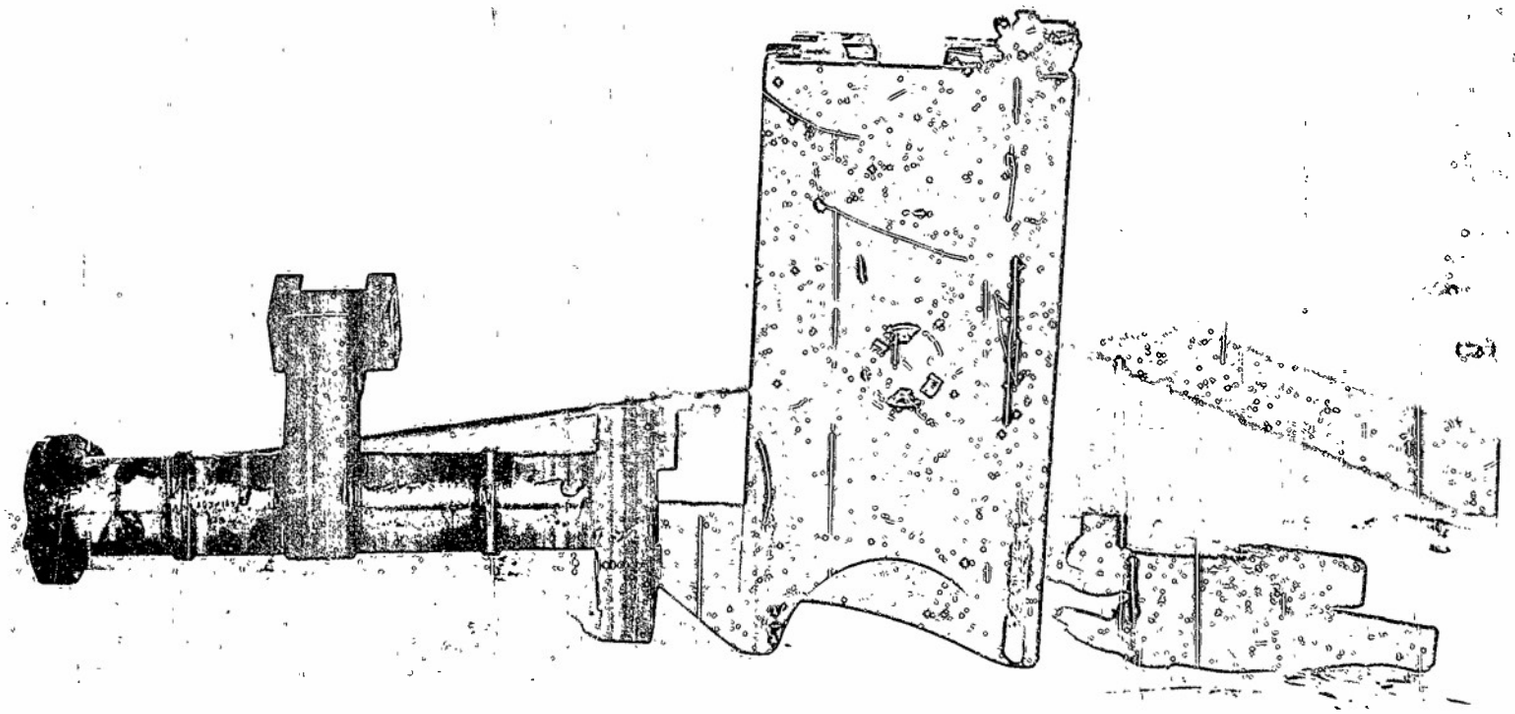

NP9-43318 - 3"/50 Caliber [illegible]
sooted breechblock. Note [illegible]
soot resulting from the a[illegible]
up with a special cool pr[illegible]
marked the beginning of a [illegible]
would not close due to sm[illegible]
Date: 2 November 1950

View showing [illegible]
covered with [illegible]
ammunition made [illegible]
735). The firing [illegible]
breech mechanism [illegible]
freely.

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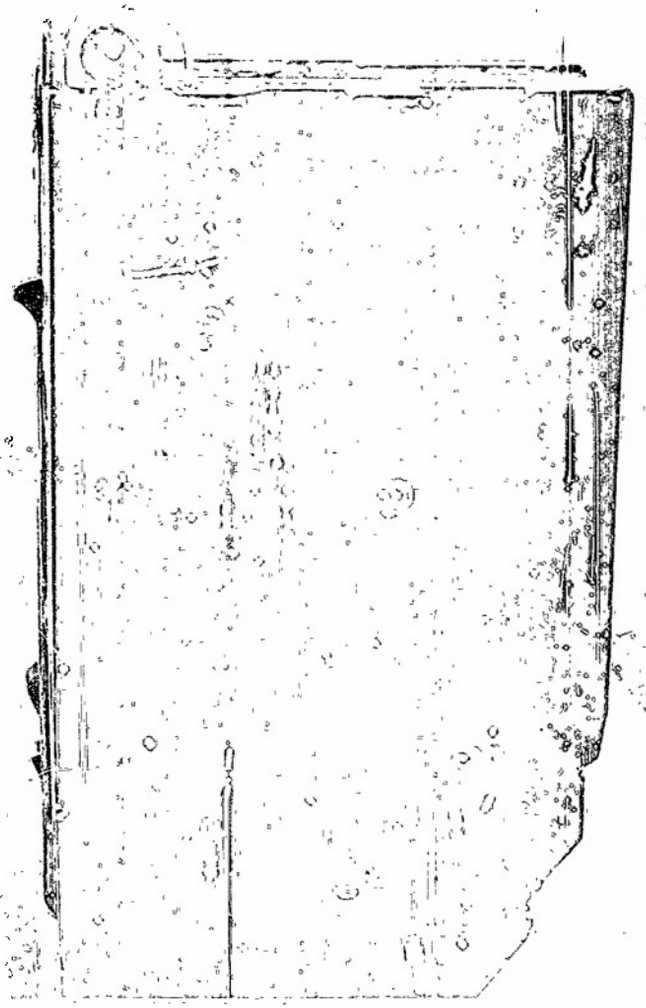

Ballistic Test of Cool Propellants

FUZE PERFORMANCE TESTS

Date:	13 November, 1950
Gun:	3"/50 Caliber, Mk 21-0, No. 7396
ESR = 99.0	D_o = 3".005
Projectile:	Mk 33-0 (13.00 lbs.) Comp. "A" Loaded
Auxiliary Detonator:	Mk 44 Mod-1 Lot 1538
Powder:	SPDN-4438 (0.40 lbs.) on bottom of case Ex-6735 (4.39 lbs.) on top
Ignition:	XC-D22/250 primer
Fuze:	Mk 72 Mod 2, Lot 100 (Eastman)
Cavity Liner:	Mk 3 Mod 0

RESULTS

Normal	=	16
Early Premature (heard)	=	0
" " (not heard)	=	2
Late Premature (heard)	=	6
" " (not heard)	=	0
Dud (heard)	=	0
" (not heard)	=	0
Pulse on water (heard)	=	1
" " (not heard)	=	0
No. of rounds fired		25
Score	=	64%

Ballistic Test of Cool Propellants

Date:	20 December 1950 23 February 1951 (as indicated)
Gun:	3"/50 Caliber, Mk 22-4 No. 13092 ESR = 164.86 D_o = 3".017
Projectile:	Mk 33-0 (13.00 lbs.) Comp. "A" Loaded
Auxiliary Detonator:	Mk 44 Mod 1 Lot GL-3A-C1
Powder:	SPDN-4438 (0.40 lbs.) on bottom of case Ex-6735 (4.41 lbs.) on top
Ignition:	XC-D22/250 primer
Fuze:	Mk 72 Mod 3 Lot 335 (Eastman)
Cavity Liner:	Mk 33 Mod 0

RESULTS

	20 Dec 1950 (Rds. 20-44 incl.)	20 Dec 1950 (Rds. 169-193 incl.)	23 Feb 1951 (Rds. 1-25 incl.)
Normal	= 15	= 16	= 17
Early Premature (heard)	= 5	= 3	= 3
" " (not heard)	= 0	= 0	= 0
Late Premature (heard)	= 1	= 2	= 3
" " (not heard)	= 0	= 0	= 0
Dud (heard)	= 3	= 4	= 2
" (not heard)	= 0	= 0	= 0
Pulse on water (heard)	= 1	= 0	= 0
" " (not heard)	= 0	= 0	= 0
No. of Rds. Fired	25	25	25
	Score = 60%	Score = 64%	Score = 68%

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