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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 988

FRAGMENTATION OF PROJECTILES AND WARHEADS

21st Partial Report

CONTROLLED FRAGMENTATION OF 3"/50 AA PROJECTILES MK 27 BY RUBBER LINERS

FINAL Report

Copy No. 6

Task Assignment NPG-Re2c-35-1-52

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NPG REPORT NO. 988

Controlled Fragmentation of 3"/50 AA Projectiles Mk 27 by Rubber Liners

PART A

SYNOPSIS

1. This test was conducted to determine the fragment mass and fragment velocity data of 3"/50 AA Projectiles Mk 27-2, Composition B loaded, having rubber shaped charge liners with twelve longitudinal grooves running the length of the explosive cavity.

2. a. The subject projectiles produced (1) strip fragments varying from 3-3/4" to 6" in length, (2) fragments 4-3/4" or greater in length averaging 144 grams each, and (3) strip fragment velocity averaging 2250 ft./sec.

b. Strip fragments from projectiles equipped with copper shaped charge liners, reference (c), averaged slightly less in length and slightly more in mass when compared with fragments produced by rubber shaped charge lined projectiles.

c. The results of the limited number of rounds tested indicate that there were no appreciable differences between the fragmentation characteristics of 3"/50 Projectiles Mk 27-2 equipped with either copper or rubber shaped charge liners.

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

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Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a) and conducted under Task Assignment NPG-Re2c-35-1-52, reference (b).

2. REFERENCES:

a. BUORD conf ltr NP9 Re2c-HRK:rjb Ser 33390 of 1 Feb 1952
b. BUORD conf ltr NP9 Re2c-HRK:saw Ser 23964 of 4 Aug 1951
c. NPG conf Report No. 898 of 17 Dec 1951

3. BACKGROUND:

As part of a general program for the development of projectiles with controlled fragmentation, the Bureau of Ordnance designed a rubber shaped charge liner for the 3"/50 AA Projectile Mk 27-2 having twelve grooves running longitudinally the full length of the explosive cavity. The purpose of the liner is to produce twelve rod-like fragments upon detonation.

4. OBJECT OF TEST:

This test was conducted to determine the fragment mass and fragment velocity data of 3"/50 AA Projectiles Mk 27-2, Composition B loaded, having rubber shaped charge liners with twelve longitudinal grooves running the length of the explosive cavity.

5. PERIOD OF TEST:

a.	Date Project Letter	1 February 1952
b.	Date All Necessary Material Received	12 February 1952
c.	Date Commenced Test	4 March 1952
d.	Date Completed Test	14 March 1952

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

3"/50 AA Projectiles Mk 27-2

a. Six (6) rounds, each equipped with rubber shaped charge liner, 0".080 to 0".100 thick in the grooves and 0".030 to 0".035 in the flats and having twelve grooves, 1/4" high, 75° apex angle, and 5".75 long. The base of the cavity was filled with hot melt to a depth sufficient to seal off the ends of the liner groove. The remainder of the cavity was filled with Composition B at the Naval Mine Depot, Yorktown, Virginia. The adapter cavity was filled with Composition C-3 at the Proving Ground. The weights of the projectiles were as follows:

Rd. No.	Test	Empty Wt.(lbs.)	Comp. B Wt.(lbs.)	Comp. C-3 Wt.(lbs.)	Total Wt.(lbs.)
1	Mass	9.16	0.72	0.17	10.05
2	Mass	9.155	0.745	0.16	10.06
3	Mass	9.13	0.74	0.18	10.05
4	Velocity	9.12	0.73	0.17	10.02
5	Velocity	9.10	0.73	0.18	10.01
6	Velocity	9.14	0.73	0.17	10.04

7. PROCEDURE:

a. Mass Distribution:

A special engineer's cap was inserted into the Composition C-3 for initiating the explosive. Each projectile was placed in a cane fiberboard box and detonated in sawdust at the Fragmentation Chamber. After each detonation, the sawdust was sifted and the fragments recovered by the use of sieves and a magnetic separator.

b. Fragment Velocity:

Each warhead was placed vertically in the center of a 30 foot radius arena with its center 6 feet above ground level and initiated from the top by a special engineer's blasting cap. The arena consisted of 15 foot high, 1" thick steel panels from 350° to 55° and 125° to 190° longitude. One 35mm Fastax Camera was placed 250 feet from the arena to record fragment velocities by the usual high speed photographic technique.

Controlled Fragmentation of
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8. RESULTS AND DISCUSSION:

a. Fragment mass distribution photographs are shown in Figures 1 to 3 inclusive and the data are tabulated in Table I. Reference (c) data on similar projectiles equipped with copper shape charge liners and without liners are also listed in Table I.

b. The strip fragment lengths (greater than 2-3/4") produced were as follows:

Rd. No.	Liner	No. Strip Fragment Lengths 5-3/4" or greater	4-3/4"-5-3/4"	3-3/4"-4-3/4"	2-3/4"-3-3/4"
1	Rubber	6	7	3	7
2	"	4	2	6	13
3	"	12	0	2	4
1	Copper	0	9	2	5
2	"	2	6	4	5
3	"	2	4	4	2
1	None	2	0	8	11
2	"	0	0	1	12
3	"	0	0	1	19

Although the above data indicates that the rubber shape charge liner produced more of the longer strip fragments, the average weight of these fragments is less than those produced by the copper shaped charge liner. For fragments 4-3/4" or greater in length those from the projectiles with rubber shaped charge liners averaged 144 grams in weight whereas the copper shaped charge liner produced fragments averaging 168 grams each.

c. The detailed strip fragment velocities are listed in Table II. The average median velocity of the projectiles equipped with rubber shape charge liners was 2250 feet per second.

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

PART D

CONCLUSIONS

9. a. The subject projectiles produced (1) strip fragments varying from 3-3/4" to 6" in length, (2) fragments 4-3/4" or greater in length averaging 144 grams each, and (3) strip fragment velocity averaging 2250 ft./sec.

b. Strip fragments from projectiles equipped with copper shaped charge liners, reference (c), averaged slightly less in length and slightly more in mass when compared with fragments produced by rubber shaped charge lined projectiles.

c. The results of the limited number of rounds tested indicate that there were no appreciable differences between the fragmentation characteristics of 3"/50 Projectiles Mk 27-2 equipped with either copper or rubber shaped charge liners.

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

- -

The tests upon which this report is based were conducted by:
A. N. HUGHES, Lieutenant, USN, Fragmentation Firing Officer,
Fragmentation Division
Terminal Ballistics Department

This report was prepared by:
W. WRIGHT, JR., Ensign, USNR, Fragmentation Firing Officer,
Fragmentation Division
Terminal Ballistics Department

This report was reviewed by:
V. PHILIPCHUK, Fragmentation Battery Officer,
Fragmentation Division
Terminal Ballistics Department
W. B. ROBERTSON, Lieutenant Commander, USN
Terminal Ballistics Batteries Officer
Terminal Ballistics Department
R. T. RUBLE, Lieutenant Commander, USN
Terminal Ballistics Officer
Terminal Ballistics Department
C. C. BRAMBLE, Director of Research, Ordnance Group

APPROVED: J. A. EDWARDS
Captain, USN
Commander, Naval Proving Ground
Acting

C. T. Mauro

C. T. MAURO
Captain, USN
Ordnance Officer
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DAHLGREN, VIRGINIA

Twenty-First Partial Report

on

Fragmentation of Projectiles and Warheads

- -

Final Report

on

Controlled Fragmentation of

3"/50 AA Projectiles Mk 27

by Rubber Liners

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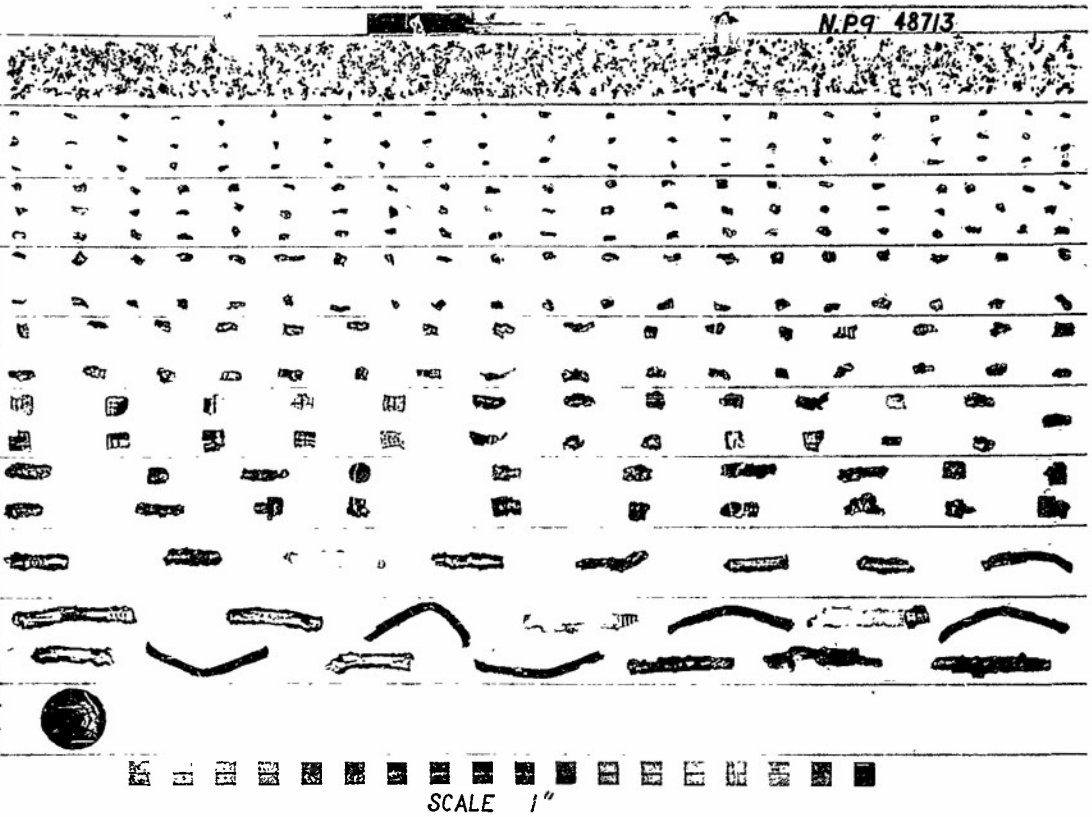
0 - 5/8	Gms.	
	PCS.	
116	Gms.	
5/8 - 1 1/4	Gms.	
63	PCS.	
49	Gms.	
1 1/4 - 2 1/2	Gms.	
62	PCS.	
110	Gms.	
2 1/2 - 5	Gms.	
40	PCS.	
134	Gms.	
5 - 10	Gms.	
32	PCS.	
221	Gms.	
10 - 20	Gms.	
25	PCS.	
329	Gms.	
20 - 40	Gms.	
20	PCS.	
593	Gms.	
40 - 80	Gms.	
8	PCS.	
569	Gms.	
80 - 160	Gms.	
14	PCS.	
1903	Gms.	
160 - 320	Gms.	
1	PCS.	
303	Gms.	



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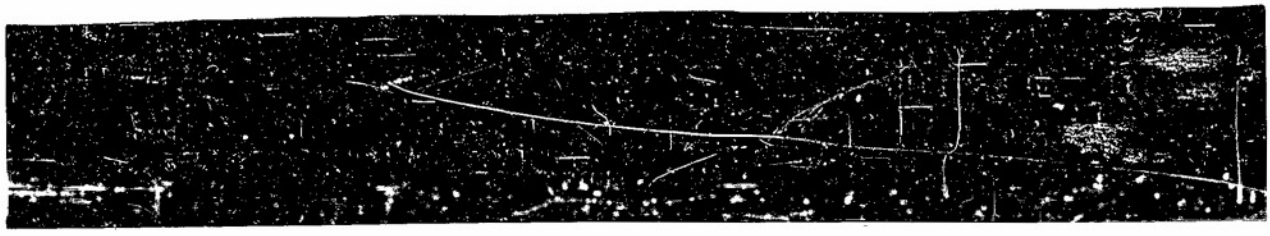

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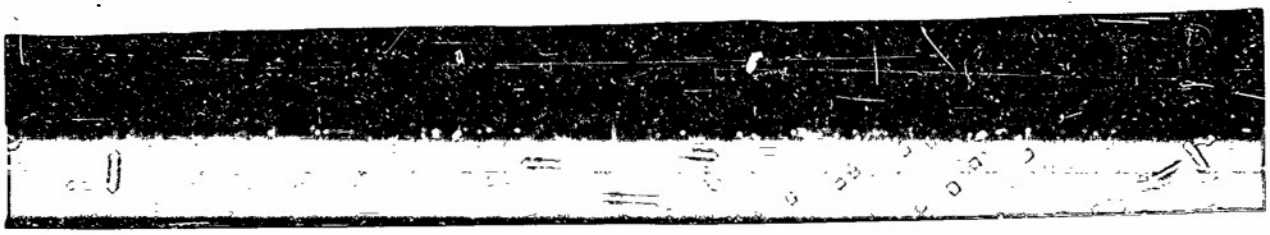
0 - 5/8	Gms.	
	Pcs.	
98	Gms.	
5/8 - 1 1/4	Gms.	
67	Pcs.	
59	Gms.	
1 1/4 - 2 1/2	Gms.	
57	Pcs.	
95	Gms.	
2 1/2 - 5	Gms.	
57	Pcs.	
202	Gms.	
5 - 10	Gms.	
43	Pcs.	
298	Gms.	
10 - 20	Gms.	
38	Pcs.	
514	Gms.	
20 - 40	Gms.	
16	Pcs.	
456	Gms.	
40 - 80	Gms.	
18	Pcs.	
1043	Gms.	
80 - 160	Gms.	
12	Pcs.	
1324	Gms.	

SCALE 1"



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0 - 5/8	Gms.	
	PCS.	
122	Gms.	
5/8 - 1 1/4	Gms.	
70	PCS.	
59	Gms.	
1 1/4 - 2 1/2	Gms.	
54	PCS.	
90	Gms.	
2 1/2 - 5	Gms.	
61	PCS.	
228	Gms.	
5 - 10	Gms.	
41	PCS.	
267	Gms.	
10 - 20	Gms.	
30	PCS.	
416	Gms.	
20 - 40	Gms.	
16	PCS.	
418	Gms.	
40 - 80	Gms.	
6	PCS.	
339	Gms.	
80 - 160	Gms.	
1	PCS.	
144	Gms.	
160 - 320	Gms.	
11	PCS.	
2004	Gms.	

SCALE 1"

TABLE I

MASS DISTRIBUTION DATA

FRAGMENTATION OF 3"/50 Mk 27-2 PROJECTILES EQUIPPED WITH RUBBER LINERS

NUMBER AND WEIGHT OF RECOVERED FRAGMENTS

Rd. No.	Comp. Wt. lb.	B & C-3 Filler Wt. lb.	0-0.625 grams Wt. Gms.	0.625-1.25 grams Wt. Gms.	No.	1.25-2.5 grams Wt. Gms.	No.	2.5-5 grams Wt. Gms.	No.	5-10 grams Wt. Gms.	No.	10-20 grams Wt. Gms.	No.	20-40 grams Wt. Gms.	No.	40-80 grams Wt. Gms.	No.	80-160 grams Wt. Gms.	No.	160-320 grams Wt. Gms.	No.	320-640 grams Wt. Gms.	No.	Total Wt. Gms.	No.	Photo. No. NPG
1	10.05	.89	116	49	63	110	62	134	40	221	32	329	25	593	20	569	8	1903	14	303	1	-	-	4327	265	48713
2	10.06	.905	98	59	67	95	57	202	57	298	43	514	38	456	16	1043	18	1324	12	-	-	-	-	4089	308	48724
3	10.05	.92	122	59	70	90	54	228	61	267	41	416	30	418	16	339	6	144	1	2004	11	-	-	4087	290	48729
TOTAL	30.16	2.715	366	167	200	295	173	564	158	786	116	1259	93	1467	52	1951	32	3371	27	2307	12	-	-	12503	863	--
AVERAGE (Rubber)	10.05	.905	112	56	67	98	58	188	53	262	39	420	31	489	17	650	11	1124	9	769	4	-	--	4168	288	--
*AVERAGE (Copper)	10.19	.90	130	68	78	107	61	180	51	255	36	361	27	523	18	420	8	775	6	1183	7	107	.33	4110	292	--
*AVERAGE (No Liners)	10.275	1.178	180	179	211	347	200	512	147	748	107	735	54	822	30	480	9	66	.67	-	-	-	-	4068	758	--

* Reference (c) data

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

TABLE II

FRAGMENT VELOCITY DATA

35mm Fastax Camera

Rd. 1, 3"/50 Mk 27-2

Total Weight 10.02 Lbs.

3180 frames per sec.

Comp. B - 0.73 Lbs.

Comp. C-3 - 0.17 Lbs.

Longitude Zone	Frame in Which Hit Occurred	No. Rod-like Fragments	Velocity (f/s)
0°-5°	42	1	2270
175°-180°	42	1	2270
155°-160°	42	1	2270
35°-40°	43	1	2220
170°-175°	46	1	2070
Median			2250
Average			2220

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

TABLE II (Continued)

35mm Fastax Camera — 3210 frames per sec.

Rd. 2, 3"/50 AA Mk 27-2 — Comp. B - 0.73 Lbs.

Total Weight 10.01 Lbs. — Comp. C-3 - 0.18 Lbs.

Longitude Zone	Frame in Which Hit Occurred	No. Rod-like Fragments	Velocity (f/s)
0°-5°	43	1	2240
175°-180°	43	1	2240
150°-155°	43	1	2240
30°-35°	44	1	2190
Median			2240
Average			2230

Controlled Fragmentation of
3"/50 AA Projectiles Mk 27 by Rubber Liners

TABLE II (Continued)

35mm Fastax Camera

Rd. 3, 3"/50 AA Mk. 27-2

Total Weight 10.04 Lbs.

3210 frames per sec.

Comp. B - 0.73 Lbs.

Comp. C-3 - 0.17 Lbs.

Longitude Zone	Frame in Which Hit Occurred	No. Rod-like Fragments	Velocity (f/s)
30°-35°	41	1	2350
175°-180°	42	1	2290
145°-150°	42	1	2290
0°-5°	42	1	2290
15°-20°	46	1	2090
125°-130°	47	1	2050
Median			2260
Average			2230

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