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**AUTHORITY**

28 feb 1963, DoDD 5200.10, U63-2-1, 1 apr 1963.; usnswc ltr, 1 apr 1975

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DEFORMABLE PROJECTILES (SQUEEZEBORE)

20th Partial Report

RECOVERY FIRING OF 5\"/3175 DEFORMABLE PROJECTILES WITH FORWARD SKIRTS

Task Assignment HPB-13-Ro3b-215-2

Classification CONFIDENTIAL
Recovery Firing of 5"/3775 Deformable Projectiles with Forward Skirts

PART A

SYNOPSIS

1. Ten (10) 5"/3775 deformable projectile bodies and forward skirts were manufactured. These bodies and forward skirts were assembled with rear flanges and dummy nose plugs, and fired for recovery from the 5"/54 gun with and without the muzzle squeeze attachment, to determine projectile performance.

2. The design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.
# Recovery Firing of 5"/3175 Deformable Projectiles with Forward Skirts

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**APPENDIX A** - COMPLETE BEFORE AND AFTER FIRING DATA

Table I 1-2 (Incl)

**APPENDIX B** - NPG PHOTOGRAPHS AND SKETCHES

FIGURES 1-28 (Incl)

**APPENDIX C** - STRAIN MEASUREMENTS

STAR GAUGE DATA

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**APPENDIX D** - WIRE IMPRESSION METHOD OF DETERMINING SPIN

1 (Only)

**APPENDIX E** - HEAT TREATMENT OF RYTENSE AA STEEL

1 (Only)

**APPENDIX F** - DISTRIBUTION

1 (Only)
1. AUTHORITY:
   This test was authorized by references (a) and (b).

2. REFERENCES:
   a. BUORD ltr Re3b-PTL:mf Ser 6130 of 20 Feb 1950.
   b. TelCon P. T. Lanham (Re3b BUORD) and R. B. Butler
      (NAVPROV) on 20 Jul 1950.
   c. BUORD Sk. 147681 Forward Skirt and Body Details for
      5"/3875 Deformable Projectile.
   d. BUORD Sk. 238752 Assembly and Details (Rear Flange
      Pc 6A ACME thread) of 5"/3875 Deformable Test Slug.
   e. BUORD Sk. 147423 Details and Assembly 5"/3875
      Deformable Projectile Type Ex 24.

3. BACKGROUND:
   The Bureau of Ordnance requested, in reference (a), manufac-
   ture and recovery firing of ten (10) 5"/3875 deformable pro-
   jectiles with forward skirts in place of the three forward
   skirts. In reference (b) permission was granted to fire two
   rounds with four (4) equally spaced vent holes in the forward
   skirt.

4. OBJECT OF TEST:
   The object of this test was to determine the serviceability
   of deformable projectiles with a particular design of forward
   skirt.

5. PERIOD OF TEST:
   a. Date of Letter Authorizing Project 20 Feb 1950
   b. Date Program Activities 1 Jun 1950
   c. Date Last Test Conducted Prior to
      This Report 10 Aug 1950
Recovery Firing of 5"/3775 Deformable Projectiles with Forward Skirts

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**PART C**

**DETAILS OF TEST**

6. **DESCRIPTION OF ITEM UNDER TEST:**

   The projectile bodies and forward skirts were manufactured in accordance with Figure 26, Appendix (B). The rear flange was in accordance with reference (d), and the nose plug was manufactured in accordance with Figure 28, Appendix (B). The vent holes in the forward skirt were in accordance with Figure 25, Appendix (B). A view of the assembled projectile is shown in Figure 1, Appendix (B).

   The forward skirts were made of mild steel (AISI 1020 normalized).

   The physical properties called for in reference (e) for the projectile body could not be met with the steel on hand. Appendix (E) describes the steel, method of heat treatment, chemical analysis, and physical properties, of the material used in manufacture of the bodies.

7. **PROCEDURE:**

   Ten (10) projectiles were prepared for recovery firing at service charge. Three (3) were fired in the 5"/3775 Gun Type A Kod 0 without the muzzle squeeze attachment and seven (7) were fired in the same gun with the vented squeezer. The three projectiles fired without squeezer were fired empty, and the seven fired with squeezer were loaded with Epsom salt. Projectiles of similar design when fired at high velocity into the recovery bin had been breaking up. It was believed that if the projectiles were salt-loaded they would withstand the impact better.

   Measurements were taken of the diameter at various points of the body, rear flange and forward skirt, after firing, to show the diameter after passing through squeezer with a diameter of 37765. Each assembled part was stenciled with a Naval Proving Ground number to facilitate identification.
Recovery Firing of 5"/37.75 Deformable Projectiles with Forward Skirts

Velocity, copper crusher gage pressures and spin rates (Appendix (D)) were taken. Star gauge data and transverse strain gauge readings on the muzzle squeeze attachment were taken and the results are given in Appendix (C) and in Figure 27, Appendix (B). Fourteen (14) rounds were fired through this squeezer prior to this test.

Microflash photographs were taken of the projectiles in flight 150 feet from the muzzle and are included in Appendix (B), (Figures 14 to 23 inclusive). Photographs of the recovered projectiles are also included in Appendix (B), (Figures 2 to 10 inclusive). The five recovered projectiles that were fired through the squeezer were sectioned along the center line and photographed (Appendix (B), Figures 11 to 13 inclusive) to show the conditions of the forward skirt and rear flange.

8. RESULTS AND DISCUSSION:

Complete before and after firing data are given in Table I, Appendix (A). The results of this test indicate that a forward skirt of this design is not satisfactory in that gas pressure causes expansion of the skirt as it leaves the muzzle. The projectiles with vent holes in the skirt did not show improved performance.

There was no evidence to indicate unsatisfactory performance of the projectile bodies, but in two cases the rear flange was observed to fail. One projectile (Appendix (B), Figure 3) fired without muzzle squeezer broke at the rear flange thread. This occurred after it had entered the recovery bin, since the microflash picture (Appendix (B), Figure 15) and the yaw cards did not show any sign of breakage. One projectile (Appendix (B), Figure 5) fired with muzzle squeezer broke into three pieces. Three round holes approximately 3-3/4 to 4-1/4 inches in diameter were in each yaw card, and the microflash picture caught a part of the rear flange (Appendix (B), Figure 17). This piece and the nose plug were recovered, but the body was not recovered and the cause of the failure was not determined.

The device of salt-loading the projectile bodies improved the recovery procedure by definitely reducing the tendency of the bodies to break up in the bin.
PART D

CONCLUSIONS

9. It is concluded that design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.

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Commander, Naval Proving Ground

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Captain, USN
Ordnance Officer
By direction
Twentieth Partial Report

on

Deformable Projectiles (Squeezebore)

Final Report

on

Recovery Firing of 5"/3775 Deformable
Projectiles with Forward Skirts

Project No.: NFG-13-Rej3b-215-2
Copy No.: 19
No. of Pages: 6

FEB 13 1951
Recovery Firing of 5"/3475 Deformable Projectiles with Forward Skirts

**TABLE I (Continued)**

<table>
<thead>
<tr>
<th>Proj. No.</th>
<th>Condition</th>
<th>Pressure (psi)</th>
<th>Muzzle Velocity (ft/sec)</th>
<th>% Nominal Spin</th>
<th>Diameters after Firing</th>
<th>Weight Lbs.</th>
</tr>
</thead>
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<tr>
<td>437</td>
<td>B</td>
<td>19.1</td>
<td>3883</td>
<td>103.3</td>
<td>3.779 3.751 3.743 3.800 15.55 2.29 7.21 3.28 1.63 29.93</td>
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A. Fired in 5"/3475 Gun Type A Mod. 0, without muzzle squeeze attachment. Gun had 83.3 M/SR prior to test.
B. Fired in 5"/3475 Gun Type A Mod. 0, with muzzle squeeze attachment. Squeeze had 144 rounds fired through it prior to test.
C. Forward Skirt had 3/8" dia., vent holes and fired in gun with squeeze.

(a) Diameter taken at datum dia. (Before firing 3,659)
(b) Projectile No. 431 broke in three pieces in gun or soon after it left muzzle, made three holes in yaw cards.
(c) Projectile No. 434 had good flight, no yaw, but went completely through recovery bin and was not recovered.
NP9 42198 - 5\"/3\'/75 Deformable Projectile, with Forward Skirt, before firing.  
18 May 1950  Figure 1
CONFIDENTIAL
NP9 42199 - Three views (120° apart) of recovered 5"/37 75
Deformable Projectile No. 428. Fired without muzzle squeezer.
1 June 1950 

Figure 2

CONFIDENTIAL
NP9 42200 - Three views (120° apart) of recovered 5"/3775 Deformable Projectile No. 429. Fired without muzzle squeezer.
1 June 1950  Figure 3  CONFIDENTIAL
NP9 42201 - Three views (120° apart) of recovered 5"/3.75 Deformable Projectile No. 430. Fired without muzzle squeezer.
1 June 1950

Figure 4

CONFIDENTIAL
NRC-42202 - View showing part of recovered rear flange from 5\textquoteright\textquoteright /3275 deformable projectile fired with modified squeezer.
22 June 1950

CONFIDENTIAL
Figure 6

NP9 40816 - Three views (120° apart) of recovered 5"/3.75 Deformable Projectile No. 432. Fired with modified squeezer.
22 June 1950

CONFIDENTIAL
No. 42827 - Three views (120° apart) of recovered 5"/25mm deformable Projectile No. 435. Fired with modified squeezer.
24 June 1950  Figure 7  CONFIDENTIAL
NP9 42828 - Three views (120° apart) of recovered 5"/37.75 Deformable Projectile No. 435. Fired with modified squeezer.
11 August 1950  
Figure 8  
CONFIDENTIAL
NP9 42829 - Three views (120° apart) of recovered 5"/37.75 Deformable Projectile No. 436. Fired with modified squeezer. 10 August 1950  
Figure 9  
CONFIDENTIAL
NP9 42830 - Three views (120° apart) of recovered 5"/3775 Deformable Projectile No. 437. Fired with modified squeezer.
11 August 1950 Figure 10 CONFIDENTIAL
NP9 42831 - View showing section (center line) of recovered 5"/3775 Deformable Projectile No. 433.
22 June 1950 Figure 11 CONFIDENTIAL
329 42832 - View showing section (center line) of recovered 5"/3775 Deformable Projectiles Nos. 432 and 435.
11 August 1950  
Figure 12  
CONFIDENTIAL
NP9 42949 - View showing section (center line) of recovered 5”/37.75 Deformable Projectiles Nos. 436 and 437.
11 August 1950  Figure 13  CONFIDENTIAL
NP9 44953 - Microflesh picture of 5" 7075 Deformable Projectile No. 431 in flight. Fired with muzzle squeezer.
22 June 1950

Figure 17

CONFIDENTIAL
NP9 42954 - Microflash picture of 5"/3.775 deformable projectile No. 432 in flight. Fired with muzzle squeezer.
22 June 1950
Figure 18
MP9 42312 - Microflash picture of 5"/3"75 Deformable Projectile No. 436
In flight... Fired with muzzle squeezer.
10 August 1950 Figure 20

CONFIDENTIAL
Fracture surfaces of pre-tensioned A3 Steel Tensile

Area:

Figure 24

SPIDERWIL
573/75 GUN TYPE A MOD.0 NO.14765

Bores Enlargement of Squeeze Attachment No.2
(Heat No.1208-3)

Distance Aft of Muzzle

H - Indicates gun had
when gauged

Number of rounds fired
is shown by figure ad-

dacent to curve.

NP9 42533 - Projectiles of this test lie between rounds 15 to 24 inclusive.

3 November 1950

CONFIDENTIAL
Recovery Firing of 5"/3775 Deformable Projectiles with Forward Skirts

**TABLE II**

Strain Measurements on 5"/3775 Squeeze-Bore Gun No. 14765
22 June 1950

<table>
<thead>
<tr>
<th>Strain Gage Position (Distance from Muzzle)</th>
<th>Maximum Tangential Strain (Micro-inch per inch)</th>
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<tr>
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<td>Projectile No. 432</td>
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<tr>
<td>4675</td>
<td>420</td>
</tr>
<tr>
<td>3275</td>
<td>510</td>
</tr>
<tr>
<td>2575</td>
<td>916</td>
</tr>
<tr>
<td>1875</td>
<td>1030</td>
</tr>
<tr>
<td>1175</td>
<td>1575</td>
</tr>
<tr>
<td>670</td>
<td></td>
</tr>
</tbody>
</table>
Recovery Firing of 5"/3775 Deformable Projectiles with Forward Skirts

Wire Impression Method of Determining Spin

Two screens are set up 4175 apart, each screen consisting of a metal frame with wood inserts, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the percentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.
Recovery Firing of 5"/3775 Deformable Projectiles with Forward Skirts

Heat Treatment of Rytense AA Steel for 5"/3775 Squeezebore Projectiles

1. The Rytense AA bar stock from which the projectile bodies were made was treated as follows:

   1550°F  4 hours  Oil quench cold
   1000°F  4 hours  Water quench cold

2. Following heat treatment both chemical analysis and tensile tests were taken from the quarter point and the results of these tests are listed below:

   Chemical Analysis:

   \[
   \begin{array}{cccc}
   \text{Fe} & \text{Mn} & \text{P} & \text{S} & \text{Si} \\
   1.57 & 1.60 & .020 & .11 & .10 \\
   \end{array}
   \]

   Physical Properties:

   \[
   \begin{array}{cccc}
   \text{Y.S. (.01\% offset\*)} & \text{T.S.} & \% El. & \% R.A. \\
   67,400 \text{ psi} & 70,700 \text{ psi} & 113,800 & 13.5 & 25.4 \\
   68,400 & 72,400 \text{ psi} & 115,100 & 15.5 & 31.8 \\
   \end{array}
   \]

3. The fractures shown by the tensile test were considered to be unusual in that the center was fibrous and the outside was crystalline. Figure 24 (Appendix (B)) presents these fractures.

* Approximately equal to proof stress.