### AD NUMBER

<table>
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<th>CLASSIFICATION CHANGES</th>
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<td><strong>TO:</strong> UNCLASSIFIED</td>
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<tr>
<td><strong>FROM:</strong> CONFIDENTIAL</td>
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### LIMITATION CHANGES

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<tr>
<td>Distribution authorized to U.S. Gov't. agencies and their contractors;</td>
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<td>Administrative/Operational Use; AUG 1959. Other requests shall be referred to Army Armament Research and Development, Aberdeen Proving Ground, MD.</td>
</tr>
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</table>

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ARTILLERY DIVISION

REPORT ON

TEST OF SHELL HEP, T294E3 FOR 90-MM RIFLE T149 (U)

Eighth Report On Ordnance Project No. TS4-4218

(D. A. Project No. 5A04-03-057)

LEWIS R. LaBUWI

AUGUST 1959

Aberdeen Proving Ground Maryland
TEST OF SHELL, HEP, T29/E3 FOR 90-MM RIFLE, T149 (U)

Eighth Report On Ordnance Project No. T34-4218

Dates of Test: 5 and 6 May 1959

ABSTRACT (C)

This report covers the firing of 15 T29/E3, HEP projectiles to determine their armor-plate-defeating capabilities. Firings were conducted at both 70°F and -40°F, against 3-inch armor plate positioned at 0° and 60° obliquity. The results indicated that the round was capable of defeating the 3-inch armor plate when the ammunition was temperature-conditioned at 70°F, and was not capable of defeating the 3-inch armor plate when ammunition was temperature-conditioned at -40°F. It is recommended that a shell of this design be tested in the T219R4 rifle to determine the cause or causes of failures at low temperatures. If the round can be made to function at low temperatures, it is further recommended that an investigation be made to determine striking velocity limitations, spall velocity, and the upper thickness of armor plate the round is capable of defeating.
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  MEMORANDUM REPORT

(The Annex is on file in the Technical Library, APG, for reference purposes. Copies of the Annex may be furnished to recipients of this report upon request.)
1. (C) INTRODUCTION

The purpose of this test was to determine the armor-plate-defeating capabilities of the T294E3 projectile. This projectile differed from most HEP projectiles in that it was launched with virtually no spin, had a spike ogive and fins for stabilization, and was loaded with Octol. The round was fired in the T149 rifle, which was never standardized and is obsolete; however, the data obtained are applicable to HEP projectiles of this type for other weapons.

2. (C) DESCRIPTION OF MATERIEL

The T294E3, HEP projectile is approximately 1¼ inches long and weighs approximately 7 lb. It has an aluminum spike ogive, an aluminum fin assembly, and a thin-walled, steel body. It contains approximately 3.3 lb of Octol filler (when the T199 fuze is used) which is detonated by a fuze located at the base of the explosive charge. Each of the 15 projectiles fired in this test were received with T199 dummy fuzes. As requested by Mr. Yanuzzi of Frankford Arsenal, the dummy T199 fuzes were replaced by T278E7 fuzes. It was necessary to add approximately 0.04 lb of Octol to each projectile because the T278E7 fuze is approximately ½ inch shorter than the T199 fuze. Only the graze-functioning feature of the T278E7 fuze was operative since the "Lucky" crystal was omitted intentionally.

3. (C) DETAILS OF TEST

3.1 Procedure

Since a complete round utilizing the T294E3 projectile had never been developed, it was necessary to improvise an ignition cartridge consisting of a paper tube 7 ½ inches long and 3/4 inch in diameter, filled with 500 grains of grade A1 black powder. The paper used was approximately 0.005 inch thick. The tube was a single thickness with an overlapping seam of approximately 1/¼ inch width along its length. The open end of this tube fitted over a boss on the inside of the base of the cartridge case. The end of the tube toward the projectile was sealed with a disk of onionskin paper and a thin ring of cork. The tube was positioned in the center of the propelling charge. The propellant was contained by a paper liner in a steel, T63E2 cartridge case. The base of the cartridge case contained two percussion primers 180 degrees apart. A train of 49 grain of FFG black powder joined both primers and the ignition cartridge. The FFG black powder was retained in the boss of the cartridge case by a glued-on cap of onionskin paper.

Two T18 internal copper-crusher pressure gages were placed in the base of each cartridge case after the projectile was assembled into a complete round.
Figure 1: Shell, HEP, 90-mm, T294E3.
The 15 projectiles were fired against a 3-inch-thick homogeneous armor plate placed 100 feet from the muzzle of the rifle. Ten rounds were temperature-conditioned at 70°F and fired with the armor plate positioned at either 0° or 60° obliquity. The remaining five rounds were temperature-conditioned at -40°F and fired with the armor plate positioned at 0° obliquity. Two 16-mm, Fastax, motion-picture cameras were positioned in such a manner that one camera photographed the projectile as it approached and impacted on the face of the armor plate, while the other camera recorded the spalls that were driven off the rear. For measuring the velocity of the spalls a breakwire screen was affixed on the rear of the armor plate. As the spalls were driven off the armor plate they passed through the breakwire screen and started a timing light which was recorded by the camera. The camera also recorded the spalls as they impacted on a vertical target behind the vertical plate or a horizontal target behind the 60° plate. The exact distance from the spalled area to the place on the target where the spall impacted was measured for each round, and used in computing spall velocities. The distance was approximately nineteen feet for the vertical plate and approximately five feet for the 60° plate.

### 3.2 Results

Three of five projectiles produced complete spalls when fired against 0° plate and temperature-conditioned at 70°F. Of the other two, one projectile produced a hinged spall approximately 80 per cent detached, and one failed to bulge or spall the plate.

Four of five projectiles produced complete spalls when fired against 60° plate and temperature-conditioned at 70°F. One projectile failed to produce a bulge or spall under these conditions. Four of five projectiles fired against 60° plate and temperature-conditioned at -40°F failed to bulge or spall the armor plate. One projectile (test round number 3) had such a low velocity that it travelled for a distance of only approximately thirty feet from the muzzle and failed to reach the plate. Apparently the cause of this malfunction was poor ignition.

Table I is a summary of the results obtained from these firings.

### Table I. Summary of Results

<table>
<thead>
<tr>
<th>Test Round No.</th>
<th>Muzzle Vel., fps</th>
<th>Pressure, psi</th>
<th>Spall Velocity, fps</th>
<th>Duration of Spalling, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1282</td>
<td>4100</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>1056</td>
<td>4350</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>8</td>
<td>756</td>
<td>2150</td>
<td>1185</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>1065</td>
<td>5300</td>
<td>1045</td>
<td>22</td>
</tr>
<tr>
<td>10</td>
<td>1065</td>
<td>4350</td>
<td>815</td>
<td>27</td>
</tr>
</tbody>
</table>
Obliquity of armor plate: 60°
Temperature of ammunition: -70°F

<table>
<thead>
<tr>
<th>Test Round No.</th>
<th>Muzzle Val, fps</th>
<th>Pressure, psi</th>
<th>Spall Velocity, fps</th>
<th>Duration of Spalling, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1063</td>
<td>4450</td>
<td>740</td>
<td>13</td>
</tr>
<tr>
<td>12</td>
<td>859</td>
<td>2400</td>
<td>Lost</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>893</td>
<td>3450</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>14</td>
<td>1059</td>
<td>4300</td>
<td>705</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>1059</td>
<td>4200</td>
<td>670</td>
<td>13</td>
</tr>
</tbody>
</table>

Obliquity of armor plate: 60°
Temperature of ammunition: -40°F

<table>
<thead>
<tr>
<th>Test Round No.</th>
<th>Muzzle Val, fps</th>
<th>Pressure, psi</th>
<th>Spall Velocity, fps</th>
<th>Duration of Spalling, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>803</td>
<td>2000</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>915</td>
<td>3000</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>Lost A</td>
<td>B</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>931</td>
<td>3300</td>
<td>No Spall</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>920</td>
<td>3250</td>
<td>No Spall</td>
<td>--</td>
</tr>
</tbody>
</table>

A - Too low to measure
B - Missed plate

Values represent average values of velocity over the total flight interval from initiation to point of impact.

These values represent the total time that the spalls, either major or minor, were in flight between the target and impact area.

3.3 Discussion

The improvised ignition system was not satisfactory from the standpoint of velocity uniformity and functioning at low temperatures.

The T278E7 fuze, Lot DQFL-197-3, has functioned satisfactorily (with lucky initiation) at -40°F, in the HEAT shell. It is not known what effect low temperatures have on this fuze when only the graze-functioning feature is operative.

It is theorized that the distribution of the Octol filler on impact, at the time of fuze initiation, may change with temperature conditions, and may be the cause of failure at low temperatures.
4. (c) CONCLUSIONS

It is concluded that a projectile of this type (i.e., nonrotated, spike-ogived, and Octol-loaded) is capable of defeating armor plate by spall- ing when the projectile is temperature-conditioned to 70°F. The armor- defeating capabilities of the round at low temperatures is in doubt.

5. (c) RECOMMENDATIONS

It is recommended that:

a. A shell of this design be tested in the T219E4 rifle, to determine the cause or causes of failure to defeat armor plate at low temperatures. Tests should be conducted at various temperatures, including high temperatures, and fuze functioning time should be measured to determine if these are factors causing failure.

b. If the round can be made to function at low temperatures, an investigation be conducted to determine striking velocity limitations, spall velocity, and the upper thickness of armor plate the round is capable of defeating.
APPENDICES

A, CORRESPONDENCE ................. A-1
B, FIRING RECORD NO. P-64424 .... B-1
C, ANALYTICAL LABORATORY REPORT 59-AL-37 .... C-1
D, PHOTOGRAPHS .................. D-1
E, EXPERIMENTAL AMMUNITION DATA CARD .... E-1
F, DISTRIBUTION .................. F-1
IN REPLY
REFER TO ORDA-1620

2 March 1959

SUBJECT: Cartridge, HEP, 90mm T294E3D

TO: Commanding General
    U. S. Army Ordnance Proving Ground, Aberdeen
    Aberdeen, Maryland

1. Inclosed is FA-TPR-1620-501 outlining a program for the evaluation
   of the 90mm T294E3D HEP Round. Funds for this test have been forwarded to
   Aberdeen Proving Ground under AIF Order No. 87170100-99-35070-52.

2. It is requested that this Arsenal be notified in advance of the
   firing of these tests in order that a representative may be present if so
   desired.

FOR THE COMMANDER:

1 Incl
   a/a (in dupe)

GUY M. LEBOLD, JR.
Captain, Ord Corps
Assistant

A-1
Artillery Ammunition Components Division
Projectile and Case Engineering Branch

1. Material for Test

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Design</th>
<th>Dwg. No.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>90mm T29hE3D</td>
<td>Chamberlain Corp</td>
<td>Octol Loaded</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>J7577-348</td>
<td></td>
</tr>
</tbody>
</table>

2. Project Authority
TSli-4018

3. Arsenal Expenditure Order Number

Funds have been transferred to Aberdeen Proving Ground under AIF Order No. 87170133-99-35070-52.

4. Object of Development

To develop an optimum fin stabilized multi-purpose round for the 90mm T219 Rifle.

5. History Sketch

There have been no previous Component Development Tests of this round at Aberdeen Proving Ground. The 90mm T29hE3D is a spike nosed HEP round that was designed for the 90mm T1b9 Recoilless Rifle. This round has not been dynamically tested. It is felt that by conducting the test, valuable data will be obtained that can be directly applied to the 90mm and 120mm multi-purpose development.

6. Description in Detail of Improvements Made Since the Last Proving Ground Test

There have been no previous tests of this round.

7. Local Tests

None

8. Object of Test

To determine the armor defeating capability of this round.

9. Precautions in Handling and Testing

Normal precautions in handling live ammunition will be exercised.
10. **Recommended Test Program**

a. Fire five (5) rounds at a temperature of $670^\circ F$ against $0^\circ$ plate.

b. Fire five (5) rounds at $70^\circ F$ against $60^\circ$ plate.

c. Fire five (5) rounds at $75^\circ F$. The angle of the plate is to be determined upon completion of parts a. and b.

d. High speed movies are to be taken at the front and back of the plate during impact and function.

The proper thickness of plate to be used for a., b., and c. will be determined during the test, the thickness being reduced until defeat of the plate was obtained.

11. **Remarks**

All material required for this test is available at Aberdeen Proving Ground.

The above Test Program has been prepared in accordance with recommendation submitted by Aberdeen Proving Ground. The Test Program can be changed at the discretion of the proof director in order to obtain the desired results.
To determine the armor plate defeating capabilities of
Projectile, HEP, T294E3 (U)

Development Test

Firing Record No.: P-64424
Dates of Test: 5 and 6 May 59
Authority: FA-TPR-1620-51

MATERIEL (U)

Pifle, 90-mm, Serial No. 7. Mount, Frankford Arsenal Accuracy Rest.

AMMUNITION (U)

Case, Cartridge: Steel, T63E2, with paper liner. 49 grains FFFG black powder in the base assembly of the cartridge case.
Ignition Cartridge: 500 grains Grade Al black powder loaded in paper tube, wrapped 1-1/2 turns, 0.005 inch thick, 7-1/2 inches long, 3/4-inch in diameter.
Propellant: M10, MP, 0.024-inch web, Lot PA-E-5616-51, charge weight 35.25 oz.

FACILITIES (C)

Firing Position: Ford's Farm.
Armor Plate: 6-by 6-feet by 3-inch homogeneous armor plate, Number 19954-3-1. Brinell Hardness: 286.
Charpy Value: 48 ft-lbs, at -40°F.

INSTRUMENTATION (U)

Velocity: Two 30-inch-diameter, 280-turn, wire-wound induction coils connected to two counter chronographs.
Chamber Pressure: Two T18 internal copper crusher pressure gages, placed in the base of each cartridge case. Copper Lot 2AR-54.
Photography: Two 16-mm Fastax Motion-picture cameras, one used to photograph the round approaching and impacting on the face of the armor plate, and the other photographing the spalls coming off the rear of the plate.
### ROUND-BY-ROUND DATA (C)

<table>
<thead>
<tr>
<th>Round No.</th>
<th>Tube</th>
<th>Test</th>
<th>Shell Wt, lb</th>
<th>Muzzle Vel, fps</th>
<th>Pres., psia/100</th>
<th>Spall Velocity, fps</th>
<th>Duration of Spalling, sec</th>
<th>Dimensions, inches of Facial Spall</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>199</td>
<td>6</td>
<td></td>
<td>7.25</td>
<td>1282</td>
<td>41</td>
<td>-</td>
<td>-</td>
<td>5x5x1/4</td>
<td>Hinged spall 80% detached, failed to bulge or spall.</td>
</tr>
<tr>
<td>200</td>
<td>7</td>
<td></td>
<td>7.21</td>
<td>1056</td>
<td>43</td>
<td>-</td>
<td>-</td>
<td>6-1/2x6-1/2x1/2 7-1/2x7x3/4</td>
<td>Spall.</td>
</tr>
<tr>
<td>201</td>
<td>8</td>
<td></td>
<td>7.15</td>
<td>750</td>
<td>21</td>
<td>1185</td>
<td>18</td>
<td>7x7x1/4</td>
<td>Spall.</td>
</tr>
<tr>
<td>202</td>
<td>9</td>
<td></td>
<td>7.22</td>
<td>1065</td>
<td>53</td>
<td>1045</td>
<td>62</td>
<td>6x7-1/2x5/8 7x7x5/8</td>
<td>Spall.</td>
</tr>
<tr>
<td>203</td>
<td>10</td>
<td></td>
<td>7.21</td>
<td>1065</td>
<td>43</td>
<td>815</td>
<td>27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- Spall Velocity: The velocity at which the spall occurs.
- Duration of Spalling: The time duration of the spall event.
- Dimensions: The size of the spall or bulge in inches.

**Remarks:**
- Hinged spall: Spall that detaches from the specimen.
- Failed to bulge: Spall that did not result in a bulge.
- Spall: A bulge or indentation on the specimen caused by the spall event.

---

One round (test round number 3) had such a low velocity that it traveled for only a distance of approximately thirty feet from the muzzle. Apparently the cause of the malfunction was poor ignition.
This firing record forms a part of the Fourth Report on Project TB5-4018.

SUBMITTED:
LEWIS R. LABUWI
Test Director

REVIEWED:
G. MORROW
Chief, Mortar &
Recoilless Rifle Branch

APPROVED:
H. A. BECHTOL
Chief, Artillery Division
Test Title: Test of Cartridge, HEP, T29423

Project No.: FA-1/59/18

Prepared for: Mortar and Recoilless Rifle Branch, Artillery Division

Firings were conducted on 5, 6 May 1959 of fifteen instrumented rounds to determine spall velocity. These rounds were fired at a plate target positioned either at 0° or 60° obliquity. The first ten rounds were conditioned to a temperature of 70°F Fahrenheit and the remaining five were conditioned to -40°F Fahrenheit before firing.

One 16-mm Fastax camera photographed the round striking the target and the flight of the spalls that were driven off. This record of spall flight was used to determine the velocity of the major spall.

Time was recorded on the film records at millisecond intervals. The start of time was established by the activation of a 50-51 sequential coder initiated by the spall leaving the target.

Results are given in the following table.

<table>
<thead>
<tr>
<th>Rd.</th>
<th>Obliquity (degrees)</th>
<th>Spall Velocity (fps)</th>
<th>Duration of Spalls (ms)</th>
<th>Rd.</th>
<th>Obliquity (degrees)</th>
<th>Spall Velocity (fps)</th>
<th>Duration of Spalls (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0</td>
<td>No spall</td>
<td>-</td>
<td>14</td>
<td>60</td>
<td>705</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>No spall</td>
<td>-</td>
<td>15</td>
<td>60</td>
<td>670</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>1185</td>
<td>18</td>
<td>1</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>1015</td>
<td>22</td>
<td>2</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>815</td>
<td>27</td>
<td>3</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>60</td>
<td>740</td>
<td>13</td>
<td>4</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>60</td>
<td>Lost</td>
<td>12</td>
<td>5</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>60</td>
<td>No spall</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Values represent average values of velocity over the total flight interval from initiation to point of impact.

** These values represent the total time that spalls, either major or minor, were in flight between target and impact area.

Submitted:

W. D. GARRETT
Mathematician

Reviewed:

D. E. WHITTON, Chief
Mathematical Section
Engineering Laboratories
Supporting Services
Development & Proof Services
Aberdeen Proving Ground, Md.

APPROVED:

A. E. KARP, Chief
Analytical Laboratory
Test Round No. 6. Temperature of Ammunition 470°F.
Test Round No. 7. Temperature of Ammunition 70°F.
Test Round No.10. Temperature of Ammunition 770°F.
Test Round No. 12. Temperature of Ammunition /-70°F.
Test Round No. 13C. Temperature of Ammunition /10°F.
Test Round No. 15. Temperature of Ammunition /70°F.
EXPERIMENTAL AMMUNITION DATA CARD

Card No. 82304

Shell # | Wt. Body Empty | Wt. Body Loaded | Wt. HE w/Dummy | Wt. Assemb'y
---|---|---|---|---
1 | 3.10 lb. | 6.42 lb. | 3.32 lb. | 7.12 lb.
2 | 3.14 | 6.46 | 3.32 | 7.15
3 | 3.10 | 6.42 | 3.32 | 7.12
4 | 3.07 | 6.39 | 3.32 | 7.09
5 | 3.12 | 6.44 | 3.32 | 7.14
6 | 3.15 | 6.48 | 3.33 | 7.17
7 | 3.07 | 6.38 | 3.31 | 7.08
8 | 3.09 | 6.41 | 3.32 | 7.11
9 | 3.07 | 6.39 | 3.32 | 7.08
10 | 3.12 | 6.44 | 3.32 | 7.14
11 | 3.14 | 6.46 | 3.32 | 7.16
12 | 3.09 | 6.41 | 3.32 | 7.11
13 | 3.02 | 6.36 | 3.32 | 7.06
14 | 3.09 | 6.41 | 3.32 | 7.10
15 | 3.10 | 6.45 | 3.32 | 7.11