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Aberdeen Proving Ground

APR 30 1957

MARYLAND
VULNERABILITY OF DIESEL FUEL

57A TO 21551
THE 90MM, AP, T33E7 PROJECTILE (U)

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DEVELOPMENT AND PROOF SERVICES

SEVENTEENTH Report OCO Project No. TB3-1224B

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VULNERABILITY OF DIESEL FUEL TO THE 90MM,

AP. T33E7 PROJECTILE (U)

SEVENTEENTH REPORT ON

ORDNANCE CORPS PROJECT NO. TB3-1224B

DEPARTMENT OF THE ARMY PROJECT NO. 503-04-004

(AD REPORT 1247)

AUTHORITY

Memo from Director, BRL dtd/10 May 1956

DATES OF TEST

28 August 1956 to 3 October 1956

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VULNERABILITY OF DIESEL FUEL TO THE 90MM,

AP, T33E7 PROJECTILE (U)

ABSTRACT

OBJECTIVE

The purpose of this test was to determine the ability of the 90mm, AP, T33E7 projectile to ignite diesel fuel stowed in sixteen gallon cans in a tank hull.

SUMMARY

Twelve rounds of 90mm, AP type ammunition were fired through armor plate into cans of diesel fuel. These cans were stowed in the fuel compartments of German Royal Tiger tank hulls to simulate fuel tanks. Sixteen gallon, galvanized steel, powder cans, M2, containing twelve gallons of locally available diesel fuel, were used for this purpose. Diesel fuel temperature was held between 90°F and 100°F for all rounds. The effective target armor thickness varied from 3.44" to 5.05".

CONCLUSIONS

Under the conditions of this test, the 90mm, AP, T33E7 projectile will consistently produce diesel oil fires at fuel temperatures of 90°F and above if the target armor and fuel tank are penetrated.

RECOMMENDATIONS

It is recommended that this test be extended to determine the incendiary effectiveness of kinetic energy type projectile when fired into a similar test target containing diesel fuel at temperatures below 80°F.

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VULNERABILITY OF DIESEL FUEL TO THE 90MM,
AP, T33E7 PROJECTILE (U)

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I INTRODUCTION

During the past few years a series of tests has been conducted at Aberdeen Proving Ground to determine the ignitability of diesel fuel in armored tank hulls. In nearly all of these tests, the tank hulls were attacked by HEAT type ammunition of various calibers. It was discovered that diesel fuel at higher temperatures could be ignited under most test conditions. This test was designed to determine the ignitability of armor-protected diesel fuel at higher temperatures when attacked by the 90mm, AP, T33E7 projectile.

II DESCRIPTION OF MATERIEL

A. AMMUNITION:

Projectile - 90mm, AP, T33E7 - Stock Lot
Cartridge Case - 90mm, T23B1 - Stock Lot
Primer, Percussion, M58 - Stock Lot
Propellant - M17, MP - Lot-34492 (.0718" web)

Some 120 oz. of propellant were used to produce a striking velocity of approximately 2750 fps when fired at 100 yards.

B. TARGET

1. Three German Tiger tank hulls were cut in half and the end sections containing the fuel and engine compartments were used as test targets. A general view of one of the test targets, after being fired on, can be seen in Figure 1. The engine and fuel compartments were all made liquid-tight by welding 3/8" mild steel plate over all holes. A false floor of 3/8" mild steel was welded in the engine compartment.



Figure 1 (B19701)

2. The 80mm (3.15") thick armor side plate, at approximately 20° obliquity, was used as the target face. This target face thickness was increased to 4.525" for some rounds by welding a piece of armor plate 16" x 16" x 3/8" to the target face and then welding an additional plate 15" x 15" x 1" to the 3/8 thick armor plate.

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3. Galvanized steel powder cans M2 were used as in past tests to simulate diesel fuel tanks. These cans have a maximum capacity of sixteen gallons.

C. FUEL

Locally available diesel fuel, all from the same batch, was used for this test. A sample from this batch of fuel was analyzed and yielded the following results:

Aniline Point	-	143°F
Flash Point	-	138°F
Specific Gravity	-	.8406 at 78°F
		.8476 at 60/60
A.P.I.	-	34.5
Diesel Index	-	49.3

III DETAILS OF TEST

A. PREPARATION

1. The three tank sections were positioned 100 yards down range from a 90mm, T139 gun mounted on an M48 tank. The tank sections were placed approximately 25 feet apart to eliminate the chances of fire spreading from one hull to another. The horizontal angle of obliquity between axis of the gun bore and the target face (Angle A) was less than 10 degrees. The vertical angle of obliquity between the gun and the target face (Angle B) was greater than 9 degrees and less than 27 degrees. The total angle of obliquity (Angle θ) was calculated by the following equation:

$$\cos \theta = \cos A \cos B$$

2. Before each round, the target sections were cleaned. Then an oil-and-grease mix, comprising one part diesel oil, one part SAE 50 oil, and two parts SAE 90 grease, by volume, was painted on all four sides and on the floor of the fuel tank compartment, and on the floor of the engine compartment. These painted surfaces were then sprinkled lightly with locally available sand. This "dirty" condition was maintained on every round of this test for the purpose of simulating a typical diesel engine and fuel compartment.

3. For each round the simulated fuel tank was filled three fourths full (twelve gallons) of locally available diesel fuel and positioned inside the fuel compartment of the target section so that the large flat side of the tank was parallel with the target armor. An air space of one inch between the fuel tank and the inside surface of the target armor plate was maintained by inserting several pieces of one inch O.D. pipe between the fuel tank and the target armor. The fuel tanks were held in position by braces made of steel pipe, aluminum tubing and/or electric conduit.

4. Before firing each round, the ambient and fuel temperatures were measured by thermometers and recorded. It was necessary to pre-heat the fuel for several rounds to satisfy the test directive requirement that the fuel temperature be between 80°F and 100°F. The fuel was heated by a small immersion type electric heating unit.

B. TEST PROCEDURE AND RESULTS

1. A total of four rounds of 90mm, AP, T33E7, was fired into each of the three tank section targets (two rounds in each side). All rounds were aimed so that the impact would be at a point on the armor plate which corresponded approximately to the geometric center of the enclosed fuel tank. (See Figure 2.)



Figure 2 (B19698)

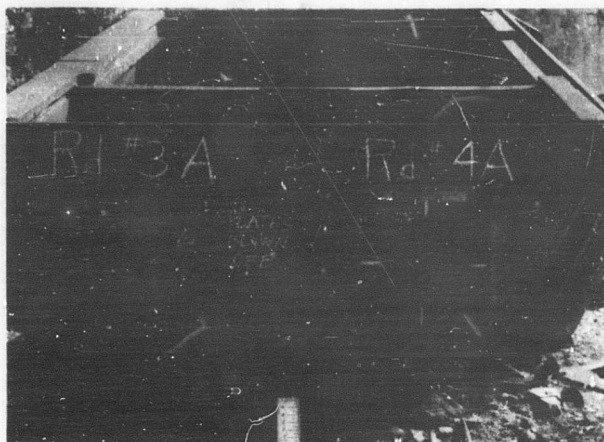


Figure 3 (B20707)

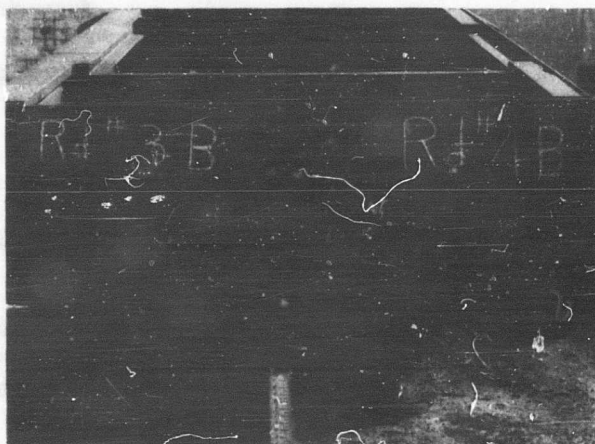


Figure 4 (B20708)

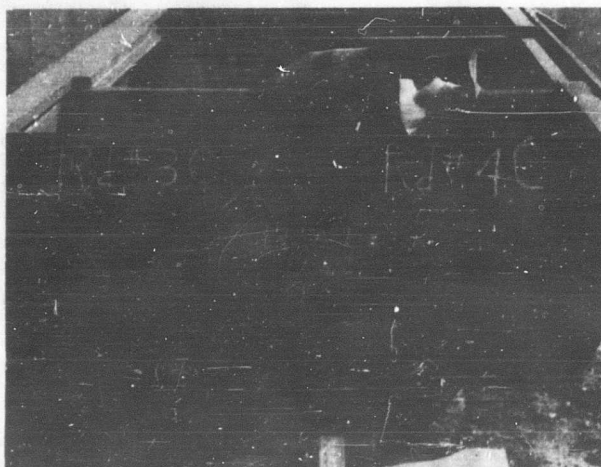


Figure 5 (B20709)

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2. The first six rounds (two at each target hull) were fired into the 80mm (3.15") thick target face (Sponson Box Plate) at approximately 26° obliquity. The tank sections sat level on the ground. The gun elevation or depression was less than one degree. All six of these rounds completely penetrated the 3.15" target armor and fuel tank and damaged the rear of the fuel compartments considerably. The fuel temperatures were between 93°F and 100°F and large fires were produced on all six rounds.

It was then decided to increase the target armor thickness to 4.525" by welding first a piece of three-eighths inch thick armor plate and then a piece of one inch thick armor plate to the original target armor surface. Three rounds (3A, 3B and 3C) were fired into this 4.525" thick composite plate at approximately 25° obliquity. Two of these rounds did not completely penetrate the target and only one small fire was produced. For two of these rounds (3A and 3B) the impact of the projectile produced bulging and cracks on the target armor, but did not produce a complete penetration (Figure 3 and 4). The third round (3C) did penetrate the target armor, but the projectile base was found wedged in the target plate (Figure 5). This round (3C) did produce a small fire in the engine compartment of the target section. The fuel tanks were ruptured by all three of these rounds but mostly at the seams. The ambient temperature (74°F) was lower for these three rounds than for all other rounds.

3. To insure complete penetration, it was decided to fire three more rounds into the 4.525" thick composite target armor, reducing the angle of obliquity from approximately 25 degrees to approximately 10 degrees. This reduced obliquity was obtained by elevating the rear of the test target and in effect reduced the effective target armor thickness approximately 0.40 inch.

4. Figure 6 is a summary of round-by-round data and results.

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SUMMARY OF 90MM FIRINGS

<u>DATE FIRED</u>	<u>RD. NO.</u>	<u>AMB. TEMP (°F)</u>	<u>FUEL TEMP (°F)</u>	<u>TARGET PLATE THICK- NESS (T)</u>	<u>ANGLE OF OBLIQ. (θ)</u>	<u>THICK- NESS OF PLATE PENE. (T sec θ)</u>	<u>RESULTS</u>
28 Aug	1A	83	93	3.15"	26.5°	3.52"	Large fire (in engine and fuel comp.)
28 Aug	1B	85	94	3.15"	23.8°	3.44"	" " " " "
28 Aug	1C	87	95	3.15"	24.8°	3.47"	" " " " "
29 Aug	2A	89	100	3.15"	26.7°	3.53"	" " " " "
29 Aug	2B	89	100	3.15"	24.7°	3.47"	" " " " "
29 Aug	2C	89	100	3.15"	26.7°	3.53"	" " " " "
11 Sept	3A	74	92 *	4.525"	26.4°	5.05"	No fire - did not penetrate target
11 Sept	3B	74	92 *	4.525"	24.0°	4.95"	" " " " "
11 Sept	3C	74	92 *	4.525"	24.3°	4.96"	Small fire (in engine comp. only)
12 Sept	4A	80	100 *	4.525"	10.1°	4.60"	Large fire (in engine and fuel comp.)
12 Sept	4B	80	100 *	4.525"	9.3°	4.60"	" " " " "
12 Sept	4C	80	100 *	4.525"	9.9°	4.61"	" " " " "

* Fuel pre-heated

Average striking velocity 2783 fps (est.)

Large fire - Fire that enveloped the largest portion of the tank section with intensely burning fuel.

Small fire - Fire that burned in small area (less than 12 sq. ft.) and did not spread or increase in intensity.

Figure 6

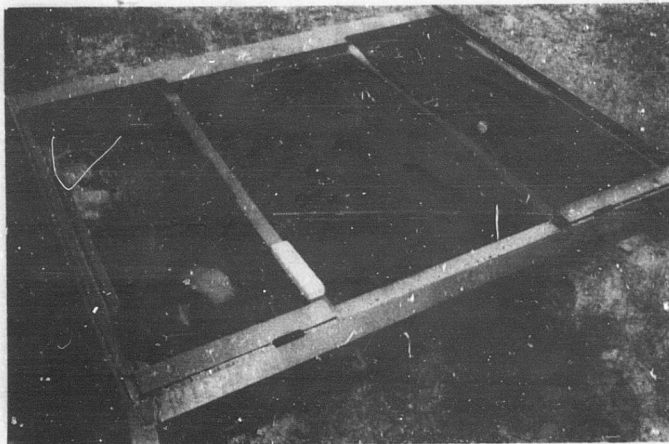


Figure 7 (B19700)

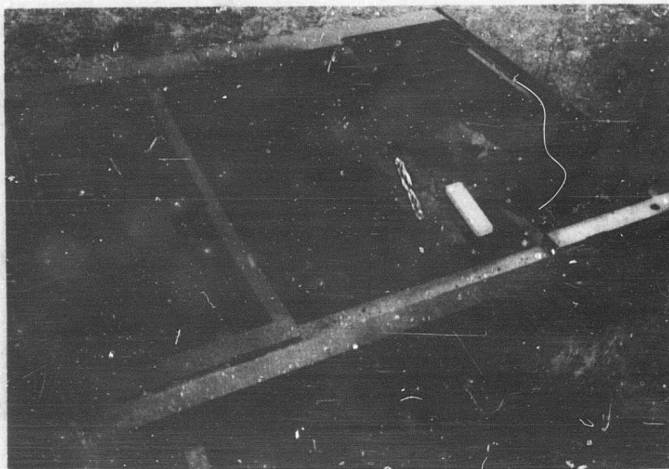


Figure 8 (B19703)

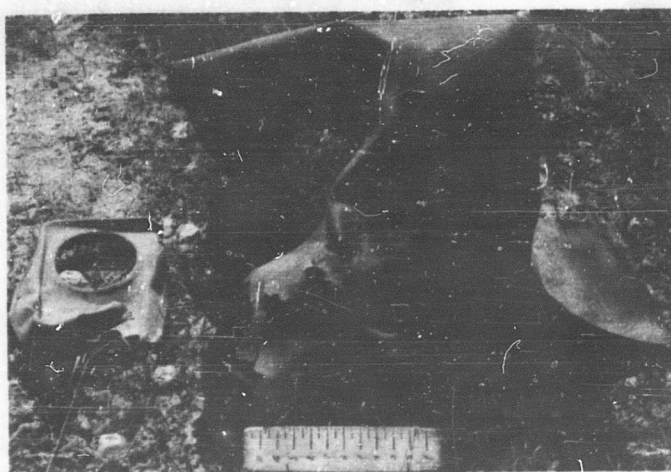


Figure 9 (B20710)

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OBSERVATIONS

1. The damage to the tank hull sections was quite severe as shown by Figures 7 and 8. Welding and repairs were required after firing two rounds at each section.
2. The simulated fuel tanks were severely ruptured on all rounds where the projectile completely penetrated the target armor (see Figure 9).
3. At 2780 fps striking velocity, the maximum plate thickness penetrated (between 4.6 and 5.0 ins.) was lower than expected from previous data.

IV CONCLUSIONS

A. If a 90mm AP projectile has sufficient kinetic energy to penetrate the tank armor protecting the diesel fuel, and the diesel fuel temperature is 90°F or more, a large fire will be produced in areas corresponding to the fuel and engine compartments of the tank.

B. The 90mm AP T33E7 projectile is as effective or more effective than HEAT type projectiles of similar caliber against diesel fuel stowed in the manner and at the temperatures maintained for these tests.

V RECOMMENDATIONS

A. Firings should be continued to determine the ability of the 90mm AP projectile to ignite diesel fuel at lower temperatures, under similar test conditions.

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B. Vulnerability characteristics (including incendiary effectiveness) of kinetic energy and shaped charge type ammunition should be determined, where necessary, and evaluated by comparison against identical targets.

C. The target setup designed and used in these firings should be used in future firings of a similar nature with realistic features such as engine grilles incorporated.

SUBMITTED:

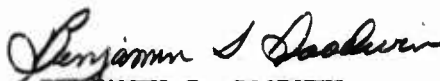

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APPENDIX

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A, CORRESPONDENCE A-1

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OFFICE MEMORANDUM

APPENDIX A
UNITED STATES GOVERNMENT

MrGBeichler/ghm/31240

TO : Director, Development and Proof Services

DATE: 10 May 1956

FROM : Director, Ballistic Research Laboratories

SUBJECT: Vulnerability of Diesel Fuel to the 90mm T33E7 AP Projectile
(Project TB3-1224B)

1. It is requested that Development and Proof Services prepare and submit to the Director, BRL, ATTN: Mr. S. Wise, estimates relative to the time and cost to fire an experimental program to determine the vulnerability of armor protected diesel fuel when attacked by the 90mm T33E7 AP projectile. It is preferred that this information be forwarded on Test Program Form ORDBG-TF-997.

2. a. Test Conditions: Two conditions are to be considered. The first condition will consist of firing rounds against diesel fuel shielded by three inches of armor at 0° obliquity. If no fires occur, a second condition employing 2 inches of armor (0° obliquity) protection will be conducted. However, if fires occur, the armor shielding the diesel fuel is to be increased to 5 inches at 0° obliquity. The fuel temperature will range between 80°F and 100°F. All rounds are to be dynamically fired at a simulated range of 1000 yards.

b. Test Procedure: It is recommended that the prototype boxes presently available at D&PS be reconstructed for a more realistic approach to JA III fuel tanks as per discussion of D&PS and BRL representatives. Fourteen gallons of diesel fuel in a sixteen gallon container (powder can) are to be placed flush on the inside of the armor. The wick material used on previous diesel fuel firings will be used in all phases of this test in the areas that wick material might accumulate in tank hulls. All rounds are to enter the fuel containers below the fuel level.

c. Data to be Collected: Data of primary interest concerns the classification of fires, i.e.:

- (1) No Fire
- (2) Ground Fire
- (3) Small Fire
- (4) Ordinary Fire

d. Scope: Five rounds are to be fired at each test set-up. If no fire or all fires occurs the firings are to stop. If mixed conditions results, five additional rounds are to be fired for a ten round sample.

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SUBJECT: Vulnerability of Diesel Fuel to the 90mm T33E7 AP Projectile
(Project TB3-1224B)

e. Materials: All material required to conduct these tests is to be provided by D&PS.

f. Priority and Classification: The DA priority on this program is 1A and all results pertaining to the tests are to be classified "CONFIDENTIAL."

3. It is anticipated that if costs and time estimates are compatible with resources and plans of the BRL, another memorandum will follow with authority to begin firing.

/s/ H. H. Daubert
H. H. DAUBERT
Lt. Col. Ord Corps
Assistant to Chief
Weapons Systems Laboratory

Army--Aberdeen Proving Ground, Md--D

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