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Development and Proof Services

Report No. DPS/TW-403/5

AUTOMOTIVE DIVISION

REPORT ON

EVALUATION OF ONE T113 AND ONE T117 UNIVERSAL CARRIER HULL AGAINST COMBAT ATTACK (U)

Fifth Report On Ordnance Project TW-403

(D. A. Project No. 545-07-032)
(AD-1271)

W. B. FRYE

JULY 1959

Aberdeen Proving Ground
Maryland

~~CONFIDENTIAL~~

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: ORDMC-REM.1 WBFrye/tsp
PRIORITY : 1A

EVALUATION OF ONE T113 AND ONE T117 UNIVERSAL CARRIER HULL AGAINST COMBAT ATTACK (U)

Fifth Report on Ordnance Project TW-403

Dates of Test: September 1957 to November 1958

ABSTRACT (C)

One T113 hull composed of aluminum armor and one T117 hull fabricated with rolled homogeneous steel armor were subjected to ballistic tests consisting of resistance to penetration by high-explosive shell fragments, ballistic shock tests of the welded joints, resistance to penetration of the virgin armor with small-arms fire, and resistance-to-splash tests from impacting small-arms fire around the various door and hatch openings. Satisfactory comparisons between the T113 and T117 vehicle hulls were obtained for the test conditions outlined above. It is recommended that consideration be given to increasing the armor thickness of the T113 hull within allowable weight limitations in order to provide a level of protection more nearly equal to that afforded by the T117 hull against high-explosive shell fragments and small-arms fire.

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CONTENTS

(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.)

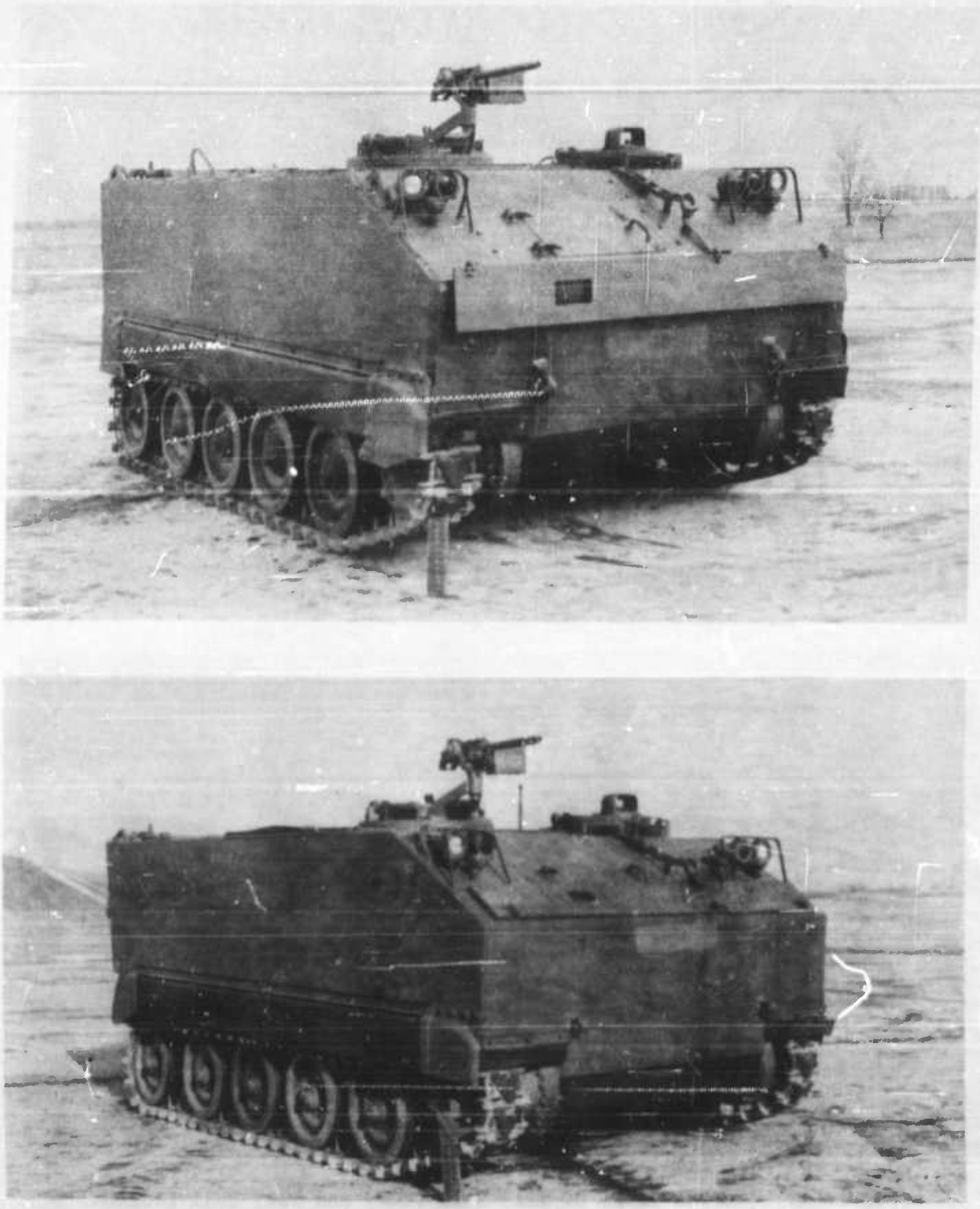

Figure 1: Three-quarter Right Front Views of T113 (TOP) and T117 (BOTTOM) Universal Carriers.

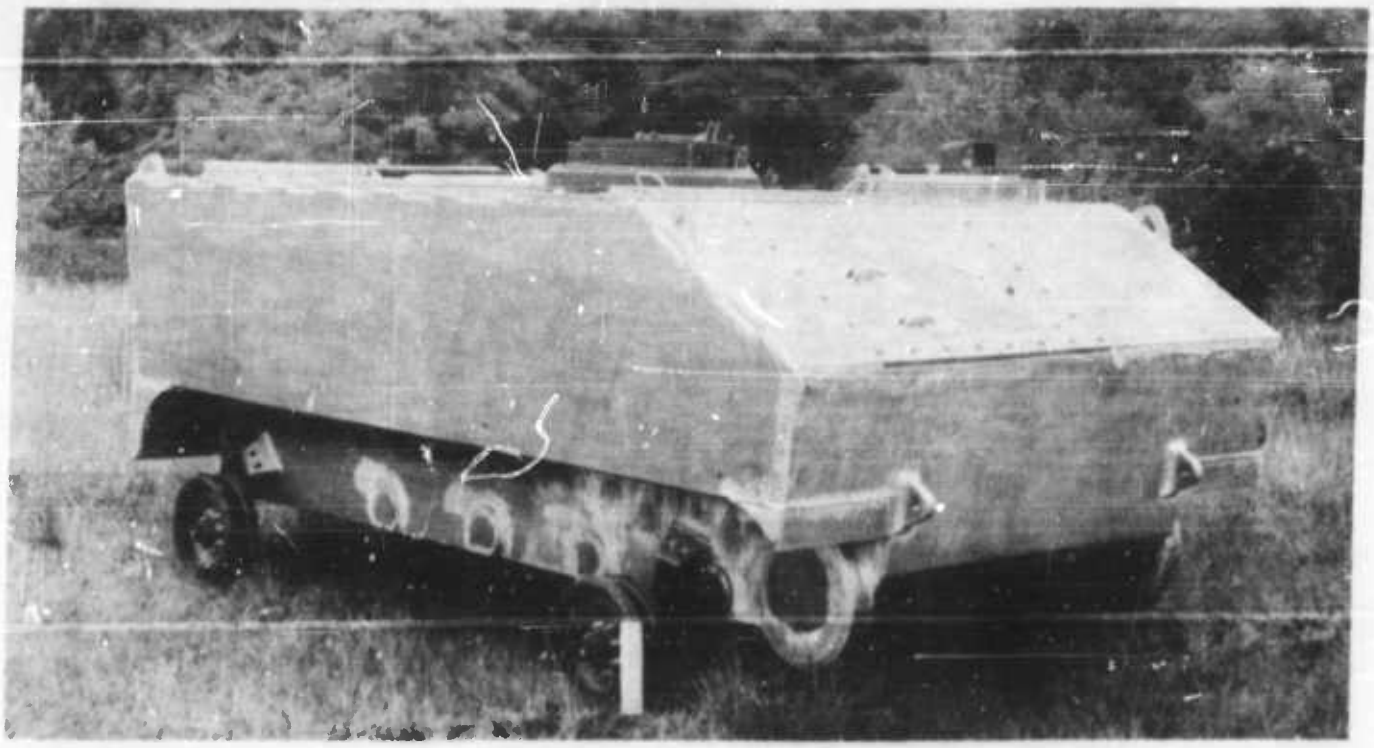

Figure 2: General Views of T113 Hull (TOP) and T117 Hull (BOTTOM) as Submitted for Test.

1. (C) INTRODUCTION

The T113 and T117 universal carriers (Fig. 1) are two of the newest lightly armored, highly mobile, armored infantry vehicles undergoing tests by the Ordnance Corps. The increasing emphasis on air transportability and air drops in modern tactics places a severe weight limitation on any vehicle designed for universal use. In an effort to save weight, the T113 was fabricated from aluminum armor.

The selection of aluminum as a basic armor material for the T113 is the result of development programs in vehicles and materials that have taken place in the past ten years. The very philosophy behind the T113 suggests a new approach in Ordnance development. No longer will it be necessary to develop each vehicle for a specific purpose, but rather the development will be for the "universal chassis" upon which can be placed the appropriate kits for the application required. Consequently, production can be geared to the needs of the field forces without major revisions in design and tooling.

2. (C) DESCRIPTION OF MATERIEL

The one T113 and one T117 hull submitted for test were received with one road wheel installed at each corner of the hull and all interior and exterior mounting brackets welded in place (Fig. 2).

The T113 vehicle was fabricated mainly from 1-1/4 inch thick aluminum and the upper hull side plates, roof plate and sloped upper and lower nose plates were all of this thickness. The vertical nose plate was 1-3/4 inches thick and the main floor plate was 3/8 inch thick. The lower hull side plates were 3/4 inch thick. The aluminum armor alloy 5083 (H115) was used in fabricating the T113 hull by the MIG welding process with 5356 aluminum wire.

The T113 was designed with two different types of welded joints employed between the upper hull side plate and the upper glacis plate and hull roof plate. An interlocking or "dove tail" incomplete-weld-penetration joint was used on the right side of the hull (Fig. 3). In a joint of this type each plate of the joint is alternately recessed or notched to a predetermined distance so that when the two plates are brought together and joined by a continuous weld pass a true interlocking design is achieved.

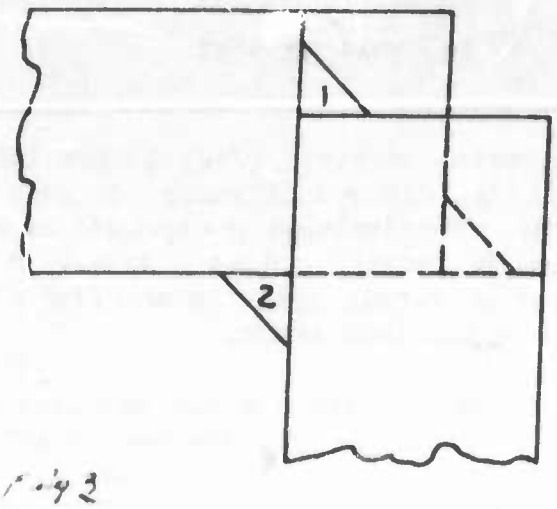

Fig 3

Figure 3: Cross Sectional View of a Typical Interlocking Joint.

On the left side of the hull a rebated-type incomplete-weld-penetration joint was used.

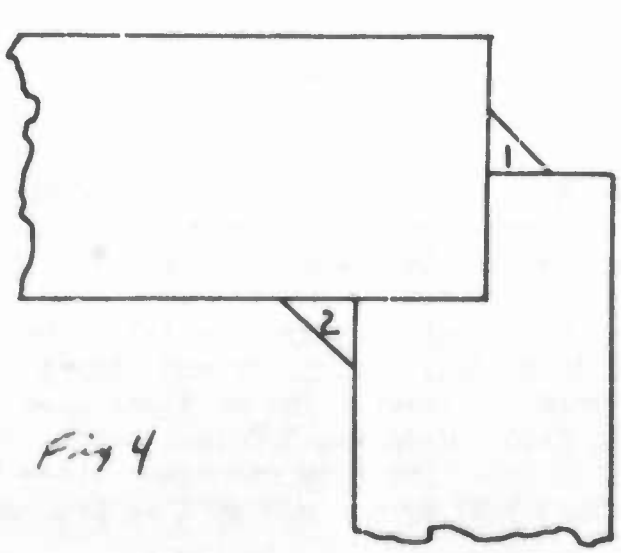

Fig 4

Figure 4: Cross Sectional View of a Typical Rebated Joint.

In the rebated-type welded joint the edge of the vertical plate was recessed to allow the horizontal plate to set down one-half of its thickness on the edge of the vertical plate. The remaining joints of the T113 were fabricated with the standard incomplete-weld-penetration procedure, except for one. This exception was the joint between the main roof plate and the formed upper glacis plate containing the driver's hatch; these plates were joined by a complete-penetration joint.

The T117 vehicle was fabricated from a rolled homogeneous steel armor of a modified hardness. The main armor of this hull was of 1/2-inch thickness except for a 5/8-inch-thick vertical front nose plate, a 3/16-inch-thick main floor plate and a 3/8-inch-thick lower hull side plate. This hull was designed with all conventional incomplete-weld-penetration joints (Fig. 5).

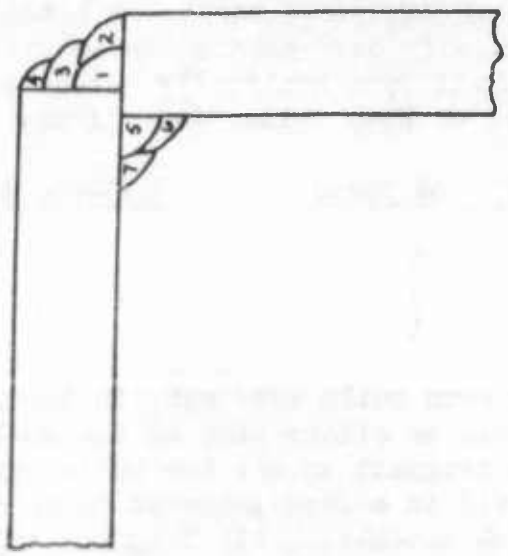

Figure 5: Cross Sectional View of Conventional Incomplete-Weld-Penetration Joint.

3. (C) DETAILS OF TEST

3.1 Procedure

The testing program was divided into four phases, as follows:

Phase I - Resistance to penetration by shell fragments from 105-mm shell, HE, M1 at distances of 90, 50 and 20 feet against roof and side plates.

Phase II - Ballistic shock test of the welded joints using the 37-mm shell, HE, M54 and the 57-mm proof projectile, M1001.

Phase III - Resistance to penetration of the virgin armor with small arms.

Phase IV - Resistance to bullet splash from impacting small-arms fire around doors and hatches.

Before any ballistic testing was accomplished each hull was weighed. A weight of 7,725 lb for the T113 and 9,500 lb for the T117 was recorded.

3.2 Results

3.2.1 Phase I. This phase consisted of a test of resistance to penetration by fragments from high-explosive shell. A total of twelve 105-mm high-explosive shell was statically detonated at three distances from the hull roof plates and twelve shell were statically detonated at three distances from the hull side plates of both hulls, as follows:

No. of Shell	Distance from Shell, feet
8	90
3	50
1	20

In conducting the tests both hulls were set, in turn, at the distances listed above with one hull on either side of the shell to be detonated. In order to catch the main fragment spray, the hulls were positioned 7° back from the nose of the shell in a line measured perpendicular to the side wall of the shell. After each detonation all fragment impacts were counted, marked, and any damage resulting from these impacts was recorded.

As a result of the eight shell detonated at the 90-foot distance from the 1-1/4 inch hull roof plates of the T113, three complete penetrations were obtained. No complete penetrations occurred on the T117 from this attack distance.

From the eight shell detonated in the test of the hull side plates at the 90-foot distance, one complete penetration occurred on the 3/4-inch-thick lower hull side plate of the T113 hull and none occurred for the T117.

From the three shell detonated in the test of the hull roof plates at the 50-foot distance, three complete penetrations occurred on the T113. Two of these complete penetrations occurred on the grilles and one on the 1-1/4-inch thick roof. On the T117, two complete penetrations occurred. One fragment penetrated the engine grille and the other penetrated a steel plate covering the commander's cupola opening. This cover plate was composed of steel armor of the same quality used in the fabrication of the T117 vehicle.

From the three shell detonated in the test of the hull side plate at the 50-foot distance, two complete penetrations occurred on the 3/4-inch-thick lower hull side plate of the T113 hull. Two complete penetrations also occurred on the 3/8-inch-thick lower hull side plate of the T117.

From the one shell detonated at the 20-foot distance against the hull roof plates, three complete penetrations occurred in the 1-1/4-inch-thick roof plate of the T113. None occurred on the T117.

From the one shell detonated at the 20-foot distance against the hull side plates, two complete penetrations occurred on the 1-1/4-inch-thick upper hull side plate of the T113 hull and none occurred on the T117.

The results of the test against shell fragments should be considered only as a general indication of the protection provided. Variables inherent in such a test (which include fragment size, fragment velocity, fragment orientation at impact, and number of fragment impacts) prevent an accurate evaluation unless a much greater number of shell are detonated and the target is of much greater dimensions.

In studying the results it should also be remembered that the 1-1/4 inch aluminum upper side armor of the T113 which weighs approximately 17.3 pounds per square foot while the 1/2-inch steel upper side armor of the T117 vehicle weighs approximately 20.4 pounds per square foot.

The detailed round-by-round data obtained in Phase I are contained in Appendix B.

3.2.2 Phase II. The second phase of testing consisted of a ballistic shock test of the welded joints of both vehicles. The hulls were fabricated with three different types of welded joints. An interlocking or "dove tail" incomplete-weld-penetration joint was used on the right side of the T113 at the joint between the hull roof plate and upper hull side plate and at the joint between the upper glacis plate and upper hull side plate. The corresponding joints on the left side were fabricated with a rebated-type incomplete-weld-penetration procedure. In the rebated-type welded joint, the edge of the vertical plate is recessed to allow the horizontal plate to set down one half of its thickness on the edge of the vertical plate. The remaining joints of the T113 were fabricated with the standard incomplete-weld-penetration procedure, except for one. The exception was the joint between the main roof plate and the formed upper glacis plate containing the driver's hatch. These plates were joined by a complete-penetration weld. The T117 vehicle was fabricated with all conventional incomplete-penetration welds.

A comparison of the three types of welded joints presented for test in these two hulls shows very little difference in performance. The rebated-type joint on the left side of the T113 hull offered the lowest resistance to shock-producing impacts. An average weld-area crack of 11-7/8 inches occurred in the rebated-type weld joint between the upper hull side plate and main roof plate. At the rebated-type joint between the upper hull side plate and upper glacis plate an average weld-area crack of 12 inches occurred. On the right side of the T113 incorporating the interlocking type joints, an average weld area crack of 7-5/8 inches occurred at the junction of the roof plate and upper hull side plate with the interlocks tested in the shear condition. In this same area with the interlocks tested in the compression

condition, no weld-area cracking occurred. At the joint between the upper hull side plate and upper glacis plate an average weld-crack of 7-3/4 inches developed with the interlocks tested in the shear condition. In this same area with the interlocks tested in the compression condition, an average weld area crack of 1-1/2 inches was noted. The fact should be borne in mind that when an interlocking joint develops a weld-area crack in one interlock the nature of this joint design prevents the crack from being propagated by repeated impacts in adjacent areas. In the incomplete-penetration welds on the T117 hull, an average weld-area crack of 1-5/8 inches developed at the joint between the upper hull side plate and roof plate. At the joint between the upper hull side plate and upper glacis plate an average weld-area crack of 8 inches occurred.

Immediately following the shock testing of the welded joints, the virgin armor of the upper hull side plates of both hulls was also subjected to a ballistic-shock test. This test was conducted to determine the critical rupture velocity level of the virgin armor when attacked with the 37-mm, HE, M54 shell.

A rupture of the 1-1/4 inch-thick aluminum armor of the T113 vehicle occurred at a striking velocity of 2498 fps. The plate crack was 4-1/4 inches in length. A large bulge with no cracking occurred at a striking velocity of 2471 fps. On the 1/2-inch-thick steel armor of the T117, a one-inch plate crack was developed at a striking velocity of 2832 fps. However, the tack weld of a small bracket that was displaced by this impact may have somewhat influenced the development of this crack. In order to investigate this possibility, the T117 upper hull side plate was subjected to two impacts at a striking velocity of 2844 fps each, which was the maximum velocity that could be obtained with the weapon and projectile used in this test. No cracks occurred on either impact.

The detailed round-by-round data obtained in Phase II are contained in Appendix C.

3.2.3 Phase III. The third phase of testing the T113 and T117 universal carrier hulls consisted of resistance to penetration by small arms fire using armor-piercing, ball and fragment-simulator projectiles. The results are summarized in Table I.

The upper hull side plates and personnel access door in the ramps of each vehicle along with the vertical nose plate of the T113 hull were subjected to attack by the three types of ammunition from various obliquities. No effort was made to test the vertical nose plate of the T117 hull because the thickness of this plate on the test vehicle was greater than planned for a production T117 hull.

Table I. Summary of Resistance-to-Penetration Tests of T113 and T117 Hulls

Caliber	Condition of Attack	T113 Protection Ballistic Limit, fps	T113 Equivalent Range, yds	T117 Protection Ballistic Limit, fps	T117 Equivalent Range, yds
Upper Hull Side Plate					
.30 AP	0°	2051	310	2205	240
.50 AP	0°	1442	1300	1321	1380
.50 Ball	0°	1506	1190	2486	340
.30 AP	45°	3152	Point Blank	No BL(P) obtained High PP(P) = 3444	Point Blank
.50 AP	45°	2162	575	2805	20
20-mm Frag.Sim.	0°	1919	-Not Tested-		
20-mm Frag.Sim.	45°	2863	-	No BL(P) obtained High PP(P) = 2873	-
Front Nose Plate					
.30 AP	Direct Front	2445	150	Not tested due to incorrect thickness of nose plate on test hull.	
.50 AP	Direct Front	1756	920		
.50 Ball	Direct Front	1823	975		
.50 AP	30° Flank	2109	620		
.50 Ball	30° Flank	2257	475		
.50 AP	60° Flank	No BL(P) obtained High PP(P) = 2846	Point Blank		
Personnel Access Door in Ramp					
.50 Frag.Sim.	0°	No BL(P) obtained High PP(P) = 2891		No BL(P) obtained High PP(P) = 2909	
.50 Frag.Sim.	45°	No BL(P) obtained High PP(P) = 2580		Not tested.	
20-mm Frag.Sim.	45°	2166		2312	

In nearly all conditions of attack where comparisons were possible, the heavier steel armor of the T117 was somewhat superior to the aluminum armor of the T113. In one instance, however, the caliber .50 armor-piercing projectile at 0° obliquity against the upper hull side plate of the T113 gave a ballistic limit of 1442 fps while a ballistic limit of 1321 fps was obtained for the upper hull side plate of the T117 hull.

The detailed round-by-round data obtained in Phase III are contained in Appendix D.

3.2.4 Phase IV. The final phase of testing on the T113 and T117 hulls consisted of a bullet-splash test around various openings on the vehicles. The openings around the cupola, doors and hatches were impacted with caliber .30 and .50 ball projectiles to ascertain if fragments from these impacts could enter the vehicle and cause injury to the crew or vehicle components.

Table II summarizes the results of the bullet-splash test.

A study of Table II shows that under no attack condition tested with either the caliber .30 or .50 ball ammunition was any evidence encountered that bullet splash was entering the vehicle hulls. It will be noted that some complete penetrations were obtained.

The detailed round-by-round data obtained in Phase IV are contained in Appendix E.

Table II. Splash Phase, T113 and T117 Universal Carrier, Hulls, Caliber .30 and Caliber .50 Ball M2 Service Ammunition

Area Tested: T113 Engine Inspection Door

Projectile	No. of Impacts	Condition of Attack	Bullet Splash
Cal .30 Ball M2	4	45° obliquity	None
Cal .50 Ball M2	4	45° obliquity	None
Cal .30 Ball M2	3	0° obliquity	None
Cal .50 Ball M2	2	0° obliquity	Two complete penetrations

Area Tested: T113 Engine Access Door

Cal .30 Ball M2	3	45° obliquity	None
Cal .50 Ball M2	3	45° obliquity	None

Area Tested: T113 Cargo Hatch

Cal .30 Ball M2	5	0° obliquity	Five complete penetrations

Area Tested: T113 Comd'r Cupola

Cal .30 Ball M2	5	15° obliquity		None
Cal .30 Ball M2	4	30° obliquity		None
Cal .30 Ball M2	3	45° obliquity		None
Cal .30 Ball M2	4	0° obliquity	Vel, fps 1970	Four complete penetrations

These four rounds were fired at reduced velocities.

Area Tested: T117 Personnel Access Door

Cal .30 Ball M2	5	Direct Rear	None
Cal .50 Ball M2	2	Direct Rear	Two complete penetrations
Cal .30 Ball M2	4	Flank 45° obliquity	None
Cal .50 Ball M2	4	Flank 45° obliquity	None

4. (C) CONCLUSIONS

Based on the results of this test it is concluded that:

a. The T113 hull provides less protection than the T117 hull against high-explosive shell fragments. Variables such as fragment size, fragment velocity, fragment orientation at impact, and number of fragment impacts greatly influence the results and prevent a quantitative comparison.

b. The resistance to shock of the three types of welded joints used in fabricating the T113 and T117 hull was acceptable.

c. The aluminum armor of the T113 hull ruptured against the impact of the 37-mm, HE, M54 shell at a striking velocity level significantly lower than can be withstood by the steel armor of the T117 hull.

d. The aluminum armor of the T113 hull gave a lower resistance to penetration against all comparable conditions of small-arms fire than did the steel armor of the T117 vehicle, except for the upper side plate against caliber .50 AP at 0° obliquity.

e. The ventilating grilles on the universal carriers were found to have poor structural strength, as indicated by extreme deformation and the breaking of louver bars under high-explosive shell fragment impact.

f. The areas subjected to test for resistance to bullet splash passage gave satisfactory protection against this type of attack.

5. (C) RECOMMENDATIONS

It is recommended that:

a. Consideration be given to increasing the armor thicknesses of the T113 hull within allowable weight limitations in order to provide a level of protection more nearly equal to that afforded by the T117 hull against high-explosive shell fragments and small-arms fire.

b. The three types of welded joints used in fabricating the T113 and T117 hulls be accepted as satisfactory for use in fabricating light-weight combat vehicles of this type.

c. An effort be made to relocate the fuel cells in both vehicles from the rear of the left sponson to a position less vulnerable to small-arms and shell-fragment attack.

d. The ventilating grilles on the universal carrier hulls be redesigned to provide improved structural strength.

SUBMITTED:

Wm. B. Frye

WM. B. FRYE
Test Director

REVIEWED:

W. C. Pless

WM. C. PLESS
Chief, Armor Branch

C. D. Montgomery
for

W. A. GROSS
Chief, Automotive Division

APPROVED:

H. A. Noble

H. A. NOBLE
Assistant Deputy Director
for Engineering Testing
Development and Proof Services

APPENDICES

APPENDIX A

Correspondence

COPY/gl

HEADQUARTERS
ORDNANCE TANK-AUTOMOTIVE COMMAND
DETROIT ARSENAL
28251 VAN DYKE AVENUE
CENTER LINE, MICHIGAN

HSpiro/mm/24-106

In Reply
Refer to ORDMC-RM.1

26 March 1957

SUBJECT: Request for a Cost Estimate for a Ballistic Evaluation of the T113 Universal Carrier Hull

TO: Commanding General
Aberdeen Proving Ground
Maryland

ATTENTION: ORDBG-DP-TE, Mr. William Pless

1. Two Universal Carrier Hulls, one of which is to be fabricated from aluminum alloy and one from rolled homogeneous steel plate, will be shipped to your installation for ballistic evaluation.

2. A tentative test directive is inclosed for your information.

3. It is requested that a cost estimate of each phase be furnished by indorsement covering the test outlined in the inclosed test directive.

FOR THE CHIEF RESEARCH AND DEVELOPMENT DIVISION:

W. D. ENGLAND
Chief, Materials Branch

1 Incl
1. Test Directive
(in dupe)

CC
OCO, ORDTT

TEST DIRECTIVE

OBJECT: Vulnerability Test of the Hull of the Carrier, Personnel, Full Tracked, Airborne, T113

DESCRIPTION OF MATERIAL:

Two T113 Hulls, one of which is to be fabricated mainly from 1-1/4" aluminum armor alloy and one mainly from 1/2" rolled armor plate. Brackets will be welded on the inside of the Hull.

PROCEDURE:

In order to ascertain level of protection afforded by two different Universal Carrier Hulls (one utilizing the rolled armor plate and the other aluminum alloy) the following tests should be conducted on each Hull.

PHASE I

a. Blast Evaluation at Low Temperature:

(1) Shocking of the weldments with 37mm HE projectile to determine the susceptibility of the weldments to cracking.

(2) The shocking of the virgin plate with the 37mm HE projectile.

b. Vulnerability of the vehicles to fragments from 105mm HE round at 90, 50 and 20 ft:

(1) Sides and roof of hull.

(2) Grille openings.

c. Blast evaluation at ambient temperature. (Not required if no cracking is observed at low temperature.)

Shocking of weldments and virgin plates with 37mm HE projectile.

d. Projectile Fragmentation: The ballistic limit of the fragment simulators (.30 Cal., .50 Cal., 20mm and any intermediate size, if available) shall be determined when fired across and into the grilles at various degrees of obliquity (0°, 45°, 60°, and 70°).

e. The ballistic protection afforded by the armor plate and grille to impacts from .30 Cal. and .50 Cal. ball and AP projectiles at various degrees of obliquity (0°, 45°, and 60°).

f. Grenade Testing: Both the fragmentation and offensive grenade shall be used on the grilles.

g. Splash Testing: The capability of bullet splash from .30 Cal. ball, AP rounds, and grenades of entering various openings of the vehicle, such as doors, etc.

The order and method of testing is left to the discretion of Aberdeen Proving Ground. In addition, authorization is granted to conduct any other tests which they deem necessary.

PHASE II

The effect of blast from a light anti-tank mine exploded inboard under the first roadwheel. Under this phase Ordnance Tank-Automotive Command will send roadwheels and roadarms to APG. APG will then be required to attach the roadarms to the vehicle in order to establish mine protection. The floor plates of the vehicles are 3/8" aluminum alloy or 3/16" steel.

PHASE III

Different thicknesses of aluminum alloy will be tested against mines. The mine protection requirement will be specified as soon as CONARC and OCO inform this office. Your office may be required to weld additional plate to the floor and attach roadarms and roadwheels to the hull prior to this evaluation. The plate, roadarms and roadwheels will be furnished by this Command.

Attendance:

This office desires to be notified in advance of scheduled firings to permit attendance by interested personnel.

Reports:

A final report will be required. Distribution shall be in accordance with a distribution list which will be forwarded under separate cover.

APPENDIX B

Detailed Test Data

Phase I

105mm HE M1 - Static Detonation

T113 - Right Side T117 - Left Side

Hull Side - 90 Feet

Hull Type	Round Number	Number Fragment Impacts	Number CP(P)	Remarks
T113	1	4	0	
T117	1	0	0	1 fragment hit left front road wheel
T113	2	2	0	
T117	2	2	0	
T113	3	5	0	
T117	3	0	0	
T113	4	4	0	
T117	4	0	0	
T113	5	3	1	CP(P) 4"x$\frac{3}{4}$" on lower hull side of 3/4" aluminum.
T117	5	3	C	
T113	6	7	0	
T117	6	4	0	
T113	7	1	0	
T117	7	1	0	
T113	8	3	0	
T117	8	1	0	

105mm HE M1 - Static Detonation
Hull Roof Plate - 90 Feet

Hull Type	Round Number	Number Fragment Impacts	Number CP(P)	Remarks
T113	9	3	0	
T117	9	3	0	
T113	10	8	0	
T117	10	3	0	
T113	11	11	1	CP(P) 1-1/2" x 1-1/2" on 1-1/4" thick aluminum
T117	11	1	0	
T113	12	8	1	CP(P) 1-1/2" x 5/8" on 1-1/4" thick aluminum
T117	12	3	0	
T113	13	3	1	CP(P) 1-3/4" x 1" on 1-1/4" thick aluminum and pierced hull bottom
T117	13	7	0	
T113	14	7	0	
T117	14	2	0	
T113	15	3	0	
T117	15	0	0	
T113	16	6	0	
T117	16	10	0	

105mm HE M1 - Static Detonation
Hull Roof Plate - 50 Feet

Hull Type	Round Number	Number Fragment Impacts	Number CP(P)	Remarks
T113	17	15	0	One fragment severed one louvre bar in grille over crew compartment.
T117	17	12	0	One fragment pierced engine grille leaving a 2-3/4" x 13/16" opening.
T113	18	29	2	CP(P) 1-3/4" x 1" on 1-1/4" thick aluminum. CP(P) 1-7/8" x 1" on engine grille.
T117	18	19	0	
T113	19	20	0	
T117	19	11	1	CP(P) 1-1/4" x 7/8" on plate covering commander's hatch opening. Passed through main floor plate.

Hull Side Plate - 50 Feet

	T113 - Left Side			T117 - Right Side
T113	20	14	0	
T117	20	5	1	CP(P) 4-1/4" x 5/8" on lower hull side plate
T113	21	13	2	CP(P) 1-1/4" x 5/8" CP(P) 1-3/4" x 13/16" on 3/4" aluminum lower hull side plate
T117	21	6	1	CP(P) 1-1/8" x 3/4" opening. Fragment did not penetrate plate. Hit on lower hull side plate.
T113	22	7	0	
T117	22	8	0	

105mm HE M1 - Static Detonation
Hull Side Plate - 20 Feet

T113 - Left Side

T117 - Right Side

Hull Type	Round Number	Number Fragment Impacts	Number CP(P)	Remarks
T113	23	75	2	CP(P) 1-1/4" x 3/4" CP(P) 1-3/8" x 3/8" on 1-1/4" thick aluminum side plate. Completely destroyed commander's cupola rear axle mounting bracket.
T117	23	66	0	
		Hull Top - 20 Feet		
T113	24	104	3	CP(P) 1" x 1" CP(P) 1-1/8" x 5/8" CP(P) 1-3/8" x 3/4" all on 1-1/4" thick aluminum.
T117	24	84	0	

APPENDIX C

Detailed Test Data

Phase II

T113 Aluminum Hull - Left Side

Rebated Joints - 37-mm, HE, M54

Joint between upper Hull Side Plate and Vertical Nose Plate

Round No. 1 - Velocity 2553 fps. Hit 2" left of center of weld of vertical nose plate and 2-3/4" below sloped upper front plate. Face 5-1/2" F.Z. cracking. 7/8" plate crack - Rear surface - 3-1/4" F.Z. Plate crack 2". Loosened top weld on forward tubular bracket on upper hull side plate.

Round No. 2 - Velocity 2579 fps. Hit 1-3/8" left of center of weld and 4" above bottom edge of upper hull side plate. Face - 6-1/2" vertical F.Z. cracking and 4" horizontal F.Z. cracking. Rear Surface - 5-1/2" vertical F.Z. cracking - 1-3/16 " transverse weld crack. Displaced tubular bracket loosened by Round No. 1. Tack weld on top mounting bracket of rear tubular container cracked.

Joint between upper Hull side plate and Sponson Floor Plate

Round No. 3 - Velocity 2467 fps. Hit 3/4" above bottom edge of upper hull side plate and 20-1/4" from nose. Face - 4-1/2" F.Z. 1/2" plate crack. Rear surface - 5" F.Z. cracking.

Round No. 4 - Velocity 2564 fps. Hit 3/8" above bottom edge of upper hull side plate and 38-1/2" from nose. Face - 1-7/8" F.Z. cracking. Rear surface - 4-1/8" F.Z. cracking. Secondary F.Z. 2-1/16".

Round No. 5 - Velocity 2586 fps. Hit 1" above bottom edge of upper hull side plate and 57" from nose. Face - 4-7/8" F.Z. cracking. Rear surface 6-1/2" F.Z. cracking - secondary F.Z. cracking 1-1/4".

Joint between upper Hull side Plate and Sponson Floor Plate

Round No. 6 - Velocity 2585 fps. Hit 1-1/2" above center line of weld and 96-5/8" from rear. Face - no weld area cracking - opening on face 3" x 1-1/4" - 1-3/4" plate crack - Rear surface - 3-1/2" F.Z. cracking - opening on back 3-7/8" x 3-1/8" w/65% back spall. Two plate cracks 2" - 1".

Round No. 7 - Velocity 2537 fps. Hit 1-1/4" above center line of weld and 81-1/2" from rear. Face - 1" F.Z. cracking - opening on face 1-1/2" x 1-1/2". Two plate cracks 1-1/4" - 1". Rear surface - 4-1/2" F.Z. cracking - punching started 2-7/8" x 3".

Round No 8 - Velocity 2544 fps. Hit 1½" above center line of weld and 66" from rear. Face - no weld area cracking - opening on face 3½" x 1 7/8" plate crack 1 1/8". Rear surface - 6" F.Z. cracking - opening on back 5" x 2 7/8" w/85% back spall.

Round No 9 - Velocity 2570 fps. Hit 2" above center line of weld and 51" from rear. Face - no weld area cracking - ½ circular crack 1 5/8". Rear surface - 1 3/4" F.Z. cracking - 3½" plate crack.

Round No 10 - Velocity lost. Hit 1½" above center line of weld and 35" from rear. Face - no weld cracking - 6" circular plate crack - Rear surface 1" F.Z. cracking - 6" circular plate crack.

Round No 11 - Velocity lost - Hit 1¼" above center line of weld and 19½" from rear. Face - 2" weld cracking on face - 3½" circular plate crack- Rear surface - 3 3/4" F.Z. crack - 1/2" plate crack.

Joint between upper Hull side Plate and Rear Hull Plate *

Round No 12 - Velocity lost. Hit 2" left of vertical weld and 7" above bottom edge of plate. Face - 2 3/4" F.Z. cracking - Rear surface - 1½" weld cracking and 1" secondary F.Z. cracking.

Conventional Joint - Right Side

Joint between upper Hull side Plate and Rear Plate *

Round No 13 - Velocity 2540 fps. Hit 1" left of vertical seam on rear and 6½" above lower edge of upper hull side plate. Face - no weld cracking. Rear surface - 3½" F.Z. cracking

Joint between upper Hull side Plate and Sponsen Floor Plate

Round No 14 - Velocity 2540 fps. Hit 1½" above center line of weld and 18½" from rear. Face - no weld area cracking - 4½" Plate cracking. Rear sruface - 4½" F.Z. cracking. Two plate cracks 1" and 5/8".

Round No 15 - Velocity 2576 fps. Hit 1½" above center line of weld and 36½" from rear. Face - no weld damage - opening on face 1½" x 1½". Rear surface - Exit diameter 1 3/4" x 1½" w/65% back spall - 2 7/8" x 1 7/8" - 1½" Plate crack. No weld damage.

Round No 16 - Velocity 2548 fps. Hit 1½" above center line of weld and 52¼" from rear. Face - no weld damage - 2" plate crack. Rear surface - 4½" F.Z. cracking - 5/8" Plate crack.

Round No 17 - Velocity 2557 fps. Hit 1½" above center line of weld and 100½" from nose. Face - no weld area cracking - 5½" plate crack. Rear surface 3¼" F.Z cracking. Two plate cracks 1 3/4" - 2".

Round No 18 - Velocity 2520 fps. Hit 1½" above center line of weld and 84½" from nose. Face - no weld area cracking - opening on face 3 3/4" x 2". Rear surface - 4 3/8" F.Z. - opening on back 4" x 2" w/65% back spall 2¼" x 3". Two plate cracks 3/4" - 1½".

Round No 19 - Velocity 2524 fps. Hit 2½" above center line of weld and 68" from nose. Face- no weld area cracking - 5½" plate crack. Rear surface - no weld area cracking - 6 3/4" horizontal plate crack.

Round No 20 - Velocity 2532 fps. Hit 1 5/8" above center line of weld and 51¼" from nose. Face - no weld area cracking - 5" plate crack. Rear surface - 4½" F.Z. Two plate cracks 2" - 2 1/8"

Round No 21 - Velocity 2536 fps. Hit 1 3/8" above center line of weld and 34 3/4" from nose. Face - no weld area cracking - opening on face 1 3/4" x 1 3/4". Two plate cracks 1 5/8" - 1½". Rear surface - 4¼" F.Z. opening on back 2" x 1 3/4". Two plate cracks 1" - 1½".

Round No 22 - Velocity 2524 fps. Hit 1¼" above center line of weld and 15½" from nose. Face - 9¼" weld cracking - 3 3/8" plate crack - transverse weld cracking - 2 7/8" plate crack.

Joint between upper Hull side Plate and Vertical Nose Plate

Round No 23 - Velocity 2516 fps. Hit 1¼" left of center of weld of vertical nose and 5" above bottom edge of upper hull side plate. Face - 3½" weld cracking. Rear surface - 3 3/4" weld cracking.

Interlocking Joints between upper Hull side Plate and upper Sloped Nose Plate

Round No 24 - Velocity 2516 fps. Hit 2½" below center of weld above sloped upper nose plate and 4 3/8" left of center line of weld of vertical nose plate. Joint tested in compression. Face 1½" weld cracking 1 3/4" x 1 3/4" punching started. Rear surface - 1½" HAZ cracking Punching started 2 3/4" x 2 3/8".

Round No 25 - Velocity 2545 fps. Hit 1¼" below center line of weld of sloped upper nose plate and 27½" from vertical nose plate. Joint tested in Shear. Face - 7 3/8" F.Z. cracking. Rear surface 7 3/4" F.Z. cracking.

Inter-locking Joints - Right Side
Joint between upper Hull side Plate and Roof Plate

Round No 26 - Velocity 2510 fps. Hit 1" below center of weld and 109" from rear. Joint tested in shear condition. Face - 4 3/8" F.Z. cracking - 1¼" plate crack. Rear surface - 6½" weld cracking.

Round No 27 - Velocity 2530 fps. Hit on edge of plate 85" from rear. Joint tested in compression condition. Face - no cracking. Rear surface - no cracking.

Round No 28 - Velocity 2494 fps. Hit 5/8" below center of weld and 61½" from rear. Joint tested in shear condition. Face - 7¼" weld cracking. Rear surface - 8 1/8" weld cracking - ½" transverse weld crack.

Round No 29 - Velocity 2502 fps. Disregard.

Round No 30 - Velocity 2510 fps. Hit ½" below center line of weld and 14 3/4" from rear. Joint tested in shear condition. Face - 7¼" weld cracking. Rear surface - 8" weld cracking - 2" plate crack.

Joint between upper Hull side Plate and Rear Hull Plate *

Round No 31 - Velocity 2514 fps. Hit 1" right of center line of weld and 11 7/8" below top edge of plate. Face - no cracks. Rear surface - 1 3/4" weld cracking - secondary weld cracking 1 3/8".

Inter-locking Joints - Left Side

Joint between upper Hull side Plate and Rear Hull Plate *

Round No 32 - Velocity 2514 fps. Hit 2½" left of center line of weld and 10½" below top edge of plate. Face - no weld area damage - opening on face 2½" x 2". Rear surface - no weld area damage. Punching started 3¼" x 3". Displaced lower center retaining strip of fuel cell inspection door.

Joint between Roof Plate and upper Hull side Plate

Round No 33 - Velocity 2510 fps. Hit 5/8" below center line of weld and 15" from rear. Face - no weld cracking - 7½" plate crack. Rear surface - 6½" F.Z. cracking. Displaced top retaining strip of fuel cell inspection door.

Round No 34 - Velocity 2535 fps. Hit 1 3/8" below top edge of plate and 37 5/8" left or rear. Face - no weld area cracking - 11¼" plate crack. Rear surface - 11 ¼" weld cracking - ½" transverse weld cracking - 3 7/8" plate crack. Broke rear tack weld on 'V' shaped hanger on roof of fuel cell compartment.

Round No 35 - Velocity 2551 fps. Hit 1¼" below top edge of plate and 59½" from rear. Face - no weld area cracking - 12 3/8" plate crack. Rear surface - 12½" weld cracking. Fillet weld on outboard side of leading edge of fuel cell compartment split extending from roof plate to sponson floor plate. Also 6 1/8" weld cracking in fillet weld between top of leading edge of fuel cell compartment and hull roof plate - 3 3/16" F.Z. crack in fillet weld joining leading edge of fuel cell compartment with the sponson floor plate. Tack weld on aft 'L' shaped bracket on upper hull side plate cracked.

Round No 36 - Velocity 2547 fps. Hit 1 1/8" below top edge of plate and 82 5/8" from rear. Face - no weld area cracking - 11 ¼" plate crack. Rear surface - 11 ¼" weld area cracking.

Round No 37 - Velocity 2514 fps. Hit 1" below top edge of plate and 110¼" from rear. Face - no weld area cracking - 10" plate crack. Rear surface 9" weld cracking 1" F.Z. cracking.

Round No 38 - Velocity 2529 fps. Hit 1¼" below centerline of weld and 131" from rear. Face - no weld area cracking - 9½" plate crack. Rear surface - 10¼" F.Z. cracking. Full length crack noted in fillet weld attaching diagonally set structural member to upper hull side plate on interior.

Joint between upper Hull side Plate and Sloped upper Nose Plate

Round No 39 - Velocity 2521 fps. Hit 1¼" below center line of weld and 28" from vertical nose plate. Face - no weld area cracking - 11¼" plate crack. Rear surface - 12" F.Z. cracking - 4" plate crack. Displaced rear tubular bracket.

T113 - Rear

Right Side

Joint between Rear Hull Plate and Roof Plate

Round No 40 - Velocity 2501 fps. Hit 2¼" below center line of weld and 7 3/4" from right edge. Face - no weld cracking 1 7/8" x 1 7/8" opening on face. Rear surface - 3¼" F.Z. cracking. Exit diameter 2¼" x 2 3/16" with 50% back spall. Displaced small bracket on rear hull plate.

Joint between upper Hull side Plate and Rear Plate

Round No 41 - Velocity 2545 fps. Hit 1" left of right edge and 12 3/4" above bottom edge. Face - no weld area cracking. Sheared bottom Jerry can retaining strip and right hand can strap bracket. Rear surface - 2" F.Z. cracking.

T113 - Hull Rear

Left Side

Joint between upper Hull side Plate and Hull Rear Plate

Round No 42 - Velocity 2541 fps. Hit 1¼" right of left edge and 14 3/8" above bottom edge. Face - no weld area cracking - 1¼" plate cracking. Rear surface 2" F.Z. cracking.

Joint between Hull Rear Plate and Roof Plate

Round No 43 - Velocity 2549 fps. Hit 1 3/4" below center line of weld and 7¼" right of left edge. Face - no weld area cracking - 7" circular plate crack. Sheared aluminum catch on gasoline filler cap. Rear surface - 1" F.Z. cracking - 3 3/4" plate cracking 2¼" plate cracking.

Joint between Rear Hull Plate and Sponson Floor Plate

Round No 44 - Velocity 2531 fps. Hit 1¼" above center line of weld and 4 3/4" right of left edge. Face - 6¼" weld cracking - plate cracks - 5 5/16" - 1 3/4". Displaced shovel bracket. Rear surface 6 3/8" weld cracking - 4" plate.

Joint between Rear Hull Plate and Sponson Floor Plate

Round No 45 - Velocity 2523 fps. Hit 2" above center line of weld and 10" left of right edge. Face - 4 7/8" weld cracking - 4¼" circular plate crack. Rear surface 5¼" weld crack - Secondary F.Z. 5" tongue crack 3" x 2".

T113 - Front - Left

Joint between upper Sloped Plate and Vertical Nose Plate

Round No 46 - Velocity 2485. Hit 2 3/8" below center line of weld and 27 3/8" from left edge. Face no cracking. Rear surface - no cracking.

Round No 47 - Velocity 2520 fps. Hit 2 3/8" below center line of weld and 27 3/8" from left edge. Face - no cracking. Rear surface - no cracking.

Joint between Vertical Nose Plate and Sponson Floor Plate Left Side

Round No 48 - Velocity 2506 fps. Hit 9" to the left of the center from the bottom of the skirt plate. Face - 5½" x 3½". Diameter of the opening 3" F.Z. cracking 2" F.Z. cracking 3/4" and 1" weld cracking. Rear surface - no cracking.

Vertical Nose Plate

T113 - Right Side

Joint between Vertical Nose Plate and Sloped upper Plate

Round No 49 - Velocity 2523 fps. Hit 7" right of left edge of plate and on weld. Face - no weld cracking. Rear surface - no cracking.

Vertical Nose Plate

Joint between Vertical Nose Plate and Sponson Floor Plate - Right Side

Round No 50 - Velocity 2503 fps. Hit 8¼" left from vertical weld and directly on weld joint. Face - 10¼" weld cracking on scurtiny plate joining to hull 2 3/8", 4", 2½" plate cracks. Rear surface 3" F.Z. cracking.

T113 - Left Side

Rupture of Upper Hull Side Plate

37-MM HE M54

Round No 1R - Velocity lost. Hit 27¼" from rear and 19" below top edge. Face - 7½" circular crack. Rear surface tongue crack 3¼" x 3" - 2" plate crack.

Round No 2R - Velocity 2518 fps. Hit 50½" from rear edge and 18" from top edge. Face - 2 3/8" plate crack. Deformation 2 1/16". Rear surface - large bulge with T shaped crack 2" x 2".

Round No 3R - Velocity 2448 fps. Hit 70" from rear and 17 3/8" below top edge. Face - no cracking deformation 1 3/4". Rear surface large bulge - no cracking.

Round No 4R - Velocity 2498 fps. Hit 88 3/8" from rear and 17½" from top edge. Face deformation 2", 2½" plate crack. Rear surface - large bulge 4¼" horizontal plate crack.

Round No 5R - Velocity 2471 fps. Hit 106½" from rear and 16" from top edge. Face - no cracking deformation 1 3/4". Rear surface large bulge - no cracking.

T117 - Left Side

37-MM HE M54 Projectile

Joint between upper Hull side Plate and Hull Rear Plate

Round No 1 - Velocity 2531 fps. Hit 2" left of center of weld and 10" from top. Face - no weld area cracking. Rear surface - no weld area cracking. Two tack welds broken on outboard edge of sloped plate at top rear of fuel cell compartment. Three tack welds broken on outboard edge of forward bulkhead of fuel cell compartment.

Joint between upper Hull side Plate and Roof Plate

Round No 2 - Velocity 2540 fps. Hit 2" below center line of weld and 27 3/8" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 3 - Velocity 2523 fps. Hit 3/4" below center line of weld and 45 3/4" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 4 - Velocity 2548 fps. Hit 1" below center line of weld and 72 3/4" from rear. Face - 4½" weld cracking. Rear surface 2 3/16" weld cracking - 3 5/8" F.Z. cracking.

Round No 5 - Velocity 2519 fps. Hit 7/8" below center line of weld and 94¼" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 6 - Velocity 2531 fps. Hit 3/4" below center line of weld and 117" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 7 - Velocity 2531 fps. Hit 3/4" below center line of weld and 136½" from rear. Face 2 3/4" weld cracking. Rear surface 1" weld cracking 2 3/8" F.Z. cracking.

Joint between upper Hull side Plate and Sloped upper Nose Plate

Round No 8 - Velocity 2519 fps. Hit 3/4" below center line of weld and 26½" above vertical nose plate. Face - 8 3/8" weld cracking. Rear surface - 9" F.Z. cracking.

Joint between upper Hull side Plate and Sponson Floor Plate

Round No 9 - Velocity 2523 fps. Hit 1" above center line of weld and 3" from nose. Face 4½" weld cracking on horizontal seam and 2½" F.Z. cracking on vertical seam. Rear surface 4 ¼" F.Z. cracking on horizontal seam and 4" F.Z. cracking on Vertical seam.

Round No 10 - Velocity 2519 fps. Hit 5½" above center line of weld and 20¼" from nose. Face - no weld area cracking - 1 5/8" plate crack. Rear surface 3¼" HAZ cracking - dislodged locking clamp on oil can bracket. Sheared off bottom rivet head holding tubular oil can container to mounting bracket.

Round No 11 - Velocity 2564 fps. Hit 1" above center of weld and 37½" from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 12 - Velocity 2528 fps. Hit 1" above center line of weld and 55" from nose. Face - no weld area cracking - Rear surface - no weld area cracking.

Round No 13 - Velocity 2520 fps. Hit 1½" above center of weld and 72½" from nose. Face - no weld area cracking - 6 3/16" plate crack. Rear surface 1½" F.Z. cracking. Two plate cracks 3" and 2½".

Round No 14 - Velocity 2533 fps. Hit 3/4" above center line of weld and 91¼" from nose. Face opening on upper hull side plate 2 1/8" x 1¼". opening on sponson floor plate 1 3/8" x 1 5/8". Plate crack 2". Rear surface 1 3/4" F.Z. cracking - opening on rear 2 3/8" x 2" (Low or detonation).

Round No 15 - Velocity 2523 fps. Hit 1 7/8" above center line of weld and 109" from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No 16 - Velocity 2516 fps. Hit 1¼" above center line of weld and 127½" from nose. Face - no weld area cracking. Rear surface - no weld area cracking. Loosened eight tack welds on outboard edge of forward bulkhead to fuel cell compartment.

Round No 17 - Velocity 2520 fps. Hit 1" above center line of weld and 144" from nose. Face - no weld area cracking. Rear surface - no weld area cracking.

Joint between upper Hull side Plate and Hull Rear Plate

Round No 18 - Velocity 2508 fps. Hit 1" left of center line of weld and 8 3/4" above bottom edge. Face 10 5/8" weld cracking. Rear surface - 9½" F.Z. cracking.

Joint between upper Hull side Plate - Vertical and Sloped upper Nose Plate

Round No 19 - Velocity 2504 fps. Hit 3/4" right of center line of weld and 17" above bottom edge. Face 4 3/4" vertical weld cracking 5¼" weld cracking along diagonal weld seam along sloped nose plate. Rear surface 5" F.Z. cracking along slope and 4" F.Z. cracking on vertical weld.

Joint between upper Hull side Plate and sloped upper Nose Plate

Round No 20 - Velocity 2537 fps. Hit 7/8" below center line of weld and 16½" from nose. Face 13½" weld cracking. Rear surface 1" weld cracking 12" F.Z. cracking.

T117 - Right Side

Joint between upper Hull side Plate and Hull Rear Plate

Round No 21 - Velocity 2557 fps. Hit 1½" right of center line of weld and 8 3/4" above bottom edge. Face 8 7/8" weld cracking. Rear surface - 8¼" F.Z. cracking.

Joint between upper Hull side Plate and Sponson Floor Plate

Round No 22 - Velocity 2533 fps. Hit 1¼" above center line of weld and 18" from rear. Face - no weld area cracking. Rear surface - 2" HAZ cracking.

Round No 23 - Velocity 2504 fps. Hit 1" above center line of weld and 34" from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 24 - Velocity 2528 fps. Hit 7/8" above center line of weld and 51¼" from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 25 - Velocity 2533 fps. Hit 1¼" above center line of weld and 67½" from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No 26 - Velocity 2533 fps. Hit 3/4" above center line of weld and 84" from rear. Face 3 5/8" weld cracking. Rear surface - 4" weld cracking.

Round No 27 - Velocity 2509 fps. Hit 1¼" above center line of weld and 100" from rear. Face - no weld cracking. Rear surface 2¼" F.Z. cracking.

Round No. 28 - Velocity 2517 fps. Hit 1¼" above center line of weld and 116" from rear. Face - no weld cracking. Rear surface - no weld cracking.

Round No. 29 - Velocity 2529 fps. Hit 1" above center line of weld and 134" from rear. Face - no weld cracking. Rear surface - no welding cracking.

Round No. 30 - Velocity 2509 fps. Hit 1" above center line of weld and 20½" from nose. Face - no weld cracking. Rear surface - no welding cracking.

Round No. 31 - Velocity 2538 fps. Hit 1" above center line of weld and 2" from nose. Face 4¼" F.Z. crack on vertical weld - 2½" HAZ on horizontal weld - 2½" plate crack- Rear surface - 4" F.Z. cracking on vertical weld - 2½" HAZ on horizontal weld - 2½" plate crack.

Joint between upper Hull side Plate, Vertical and Sloped Nose Plate

Round No. 32 - Velocity 2505 fps. Hit 2" from center line of vertical weld and 2" below center line of sloped upper nose plate weld. Face - no weld cracking. Rear surface - no weld area cracking.

Joint between upper Hull side Plate and Sloped Nose Plate

Round No. 33 - Velocity 2517 fps. Hit 1" below center line of sloped weld and 16" from nose. Face 6 3/4" F.Z. cracking. Rear surface 7" F.Z. cracking.

Round No. 34 - Velocity 2509 fps. Hit 1" below center line of weld at intersection of upper hull side plate, sloped nose plate and roof plate. Face 3" HAZ crack. Rear surface 3" HAZ crack.

Joint between upper Hull side Plate and Roof Plate

Round No. 35 - Velocity 2505 fps. Hit 1¼" below center line of weld and 67" from rear. Face - no weld area cracking. Rear surface - no weld area cracking.

Round No. 36 - Velocity 2517 fps. Hit 1" below center line of weld and 51" from rear. Face - no weld cracking. Rear surface 1" HAZ cracking. Displaced small bracket.

Round No. 37 - Velocity 2528 fps. Hit 3/4" below center line of weld and 35" from rear. Face - no weld area cracking. Rear surface 2" F.Z. cracking.

Round No. 38 - Velocity 2532 fps. Hit 1¼" below center line of weld and 2" from rear. Face - 1" weld crack. Rear surface 3½" F.Z. cracking - secondary weld crack ¼".

Round No. 39 - Velocity 2540 fps. Hit 1" below center line of weld and 18½" from rear. Face - 3/4" F.Z. crack. Rear surface 3" F.Z. crack.

Hull Rear

Joint between Left Rear and Roof Plate

Round No 40 - Velocity 2512 fps. Hit 1¼" below center line of weld and 12½" from left edge. Face - no weld cracking. Rear surface - 1" F.Z. cracking. Displaced small bracket for outside of vehicle. Fragments of shell entered crew compartment through seal of rear ramp.

Joint between upper Hull side Plate and Hull Rear Plate

Round No 41 - Velocity 2578 fps. Hit 1" from center of weld and 19" below top of vehicle. Face - 3½" weld crack. Rear surface 4" F.Z. crack - cracked 6 tack welds holding main fuel cell bulkhead to rear hull plate.

Joint between Rear Hull Plate and Sponson Floor Plate

Round No 42 - Velocity 2532 fps. Hit 3/4" above center line of weld and 7" from left edge. Face - 3½" weld crack. Rear surface - 4" weld crack.

Rear Hull Plate - Right Side

Joint between Rear Hull Plate and upper Hull side Plate

Round No 43 - Velocity 2287 fps. Hit 1¼" from right edge and 16½" below top edge. Face - no weld area cracking. Rear surface - no weld area cracking 3/4" surface plate crack.

Joint between Rear Hull Plate and Sponson Floor Plate

Round No 44 - Velocity 2540 fps. Hit 5/8" above center of weld and left of right edge. Face - 4¼" weld crack. Two plate cracks 1¼ - 1". Rear surface 5½" weld crack 1" plate crack.

Joint between Rear Hull Plate and Roof Plate

Round No 45 - Velocity 2600 fps. Hit 3/9" below center line of weld and 12½" from edge. Face - no weld area cracking. Rear surface - no weld area cracking. Large upper mounting bracket on right rear of ramp broken loose in one side in HAZ. Blast from shell displaced rubber gasket on right side of ramp.

Joint between Rear Hull Plate and Upper Hull side Plate

Round No 46 - Velocity 2613 fps. Hit ½" from right edge and 8" below top edge. Face 1" weld crack. Rear surface 3" F.Z. crack camer bracket directly behind impact cracked but not displaced.

Frcnt

T117 - Right Side

Joint between Vertical Nose Plate and Sponson Floor Plate

Round No 47 - Velocity 2551 fps. Hit on weld and 11 3/8" from right edge. Face - no weld cracking. Displaced splash plate at front of sponson floor plate. Rear surface - no cracks.

Joint between Vertical Nose Plate and upper Sloped Plate

Round No 48 - Velocity 2509 fps. Hit 8" from right edge and 3/4" below top edge. Face - no cracks. Rear surface - no cracks.

Left Side 57-mm PPM1001

Joint between Vertical Nose Plate and upper Sloped Plate

Round No 49 - Velocity 794 fps. Hit 33½" from left edge and 1 1/8" below top edge. Face no cracking. Rear - no cracking.

Round No 50 - Velocity 807 fps. Hit 20¼" from left edge and 1½" below top edge. Face no cracking. Rear surface - no cracking.

Round No 51 - Velocity 804 fps. Hit 1½" below top edge and 9 3/16" from left edge. Face - no cracking. Rear surface - no cracking.

Joint between Vertical Nose Plate and Sponson Floor Plate

Round No 52 - Velocity 809 fps. Hit 2" above center line of weld and 10" from left edge. Face - no structural weld cracking 13 7/8" weld cracking on skirting plate. Rear surface - no cracking.

Resistance of Main Armor to H.E. Shell Burst

37-mm H.E. M54

T117 Hull - Left upper side Plate

Round No. 1R - Velocity 2541 fps. Hit 24 5/8" from rear and 14 3/4" below top edge. Face - punching out 3¼" x 3 1/8". Four plate cracks 1 3/4" - 1½" - 1½" - 1". Rear surface - punching out 3¼" x 3½". Two plate cracks 2" - 1½". Disregard - low order detonation of fuze.

Round No. 2R - Velocity 2509 fps. Hit 39 3/4" from rear and 15" below top edge. Face - no cracks. Depth of deformation 1½". Rear surface large bulge - no cracks.

Round No. 3R - Velocity 2636 fps. Hit 57" from rear and 16" below top edge. Face - no cracks. Depth of deformation 1 5/8". Rear surface - Large bulge - no cracks.

Round No. 4R - Velocity 2717 fps. Hit 74¼" from rear and 15½" below top edge. Face no cracks. Depth of deformation 1 3/4". Rear surface large bulge - no cracks.

Round No. 5R - Velocity 2832 fps. Hit 92¼" from rear and 15 3/4" from top edge. Face - two plate cracks 1" - 1 5/8", Depth of deformation 1 5/8". Rear surface - large bulge - 1" plate crack - displaced small bracket.

Round No. 6R - Velocity 2844 fps. Hit 108" from rear edge and 15 1/8" below top edge. Face - no plate cracking. Depth of deformation 1 1/8". Rear surface - large bulge - no cracking.

Round No. 7R - Velocity 2844 fps. Hit 124½" from rear and 15" below top edge. Face - no cracking. Depth of deformation - 1 11/16". Rear surface - large bulge - no cracking. Displaced one shock mounting bracket at inner side of upper hull side plate.

APPENDIX D

Detailed Test Data

Phase III

RESISTANCE TO PENETRATION

T113

Upper Hull Side Plate - Right Side

Cal. 50 AP M2 - 0° Obliquity

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	1857	CP(P)	Exit diameter ½" x ½"
2	1351	PP(P)	Slight bulge - No cracking
3	1666	CP(P)	Exit diameter ½" x ½"
4	1496	CP(P)	Large bulge, 5/8" Horizontal crack - Nose through plate.
*5	1458	CP(P)	Large bulge-3/8" vertical crack, ½" horizontal crack
*6	1425	PP(P)	Slight bulge - No cracking

* Protection Ballistic Limit = 1442 fps

Cal. 50 Ball M2 - 0° Obliquity

1	1563	CP(P)	Exit diameter ¼" x ¼" Projectile in plate.
2	1495	PP(P)	Large bulge - Hair cracks
3	1448	PP(P)	Large bulge - ½" Horizontal crack
*4	1504	PP(P)	Large bulge ½" Horzontal crack-¼" Vertical crack
*5	1507	CP(P)	Large bulge ½" Horzontal crack - ½" Vertical crack

* Protection Ballistic Limit = 1506 fps

Cal. 30 AP M2 - 0° Obliquity

Rd. No.	Velocity	CP(P)/PP(F)	Remarks
1	1947	PP(P)	Medium bulge - No cracking
2	2105	CP(P)	Projectile through plate
3	1982	PP(P)	Large bulge - No cracking
*4	2051	CP(P)	Nose through plate $\frac{1}{4}$" - 1/8" plate cracks
5	1975	PP(P)	Large bulge - No cracks
6	1483	PP(P)	No bulge
7	2125		Disregard
*8	2050	PP(P)	Large bulge - No cracks

* Protection Ballistic Limit = 2051 fps

20-mm Fragment Simulator 0° Obliquity

1	1510	PP(P)	Large bulge - No cracks
*2	1941	CP(P)	Exit diameter 1" x 1"
3	1886	PP(P)	Punching started 1" x 1"
*4	1896	PP(P)	Punching started 1" x 1"

* Protection Ballistic Limit = 1919 fps

Cal. 30 AP M2 - 45° Obliquity

1	2531		Disregard
2	2531	PP(P)	No bulge - No cracking
3	Lost		
4	3088	PP(P)	Slight bulge
5	3281	CP(P)	Exit diameter $\frac{1}{4}$" x $\frac{1}{4}$" - 5/16" plate crack
6	3199	CP(P)	Exit diameter 5/16" x 5/16"- 5/16" plate crack
7	3113	PP(P)	Large bulge - Punching started
8	3099	PP(P)	Slight bulge - No cracking
*9	3177	CP(P)	Exit diameter 5/16" x 5/16"
*10	3127	PP(P)	Medium bulge - No cracking

* Protection Ballistic Limit = 3152 fps

Cal. 50 AP M2 - 45° Obliquity

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	2044	PP(P)	Slight bulge - No cracks
*2	2180	CP(P)	Exit diameter 7/16" x 7/16" - 5/8" horizontal crack
*3	2143	PP(P)	No bulge - No cracks

* Protection Ballistic Limit = 2162 fps .

20-mm Fragment Simulator - 45° Obliquity

1	Lost		Disregard
2	2782	$\overline{PP}$(P)	Large bulge - 1" horizontal crack
3	2702	PP(P)	Large bulge - No cracks
4	2798	$\overline{PP}$(P)	Large bulge - 1¼" horizontal crack
*5	2846	PP(P)	Large bulge - Punching started 1 3/4" x 1"
*6	2879	CP(P)	Punching out 1 3/4" x 1 1/8"

* Protection Ballistic Limit - 2863 fps

Front Nose Plate

Cal. 30 AP M2 - Direct Frontal Attack

1	Lost	___	Disregard
2	Lost		Disregard
3	2857	$\overline{CP}$(P)	———
4	2747	CP(P)	———
5	2566	CP(P)	———
6	Lost		Disregard
7	2394	$\overline{PP}$(P)	Cracked interior bracket ¼"
8	2353	PP(P)	Slight bulge
9	Lost		Disregard
*10	2466	$\overline{CP}$(P)	Large bulge -3/8" horizontal crack
*11	2423	PP(P)	Large bulge - No cracking

* Protection Ballistic Limit = 2445 fps

Cal. 50 AP M2 - Direct Frontal Attack

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	2082	CP(P)	Exit diameter 7/16" x 7/16"
2	1594	PP(P)	Slight bulge - No cracking
*3	1733	PP(P)	Large bulge - ½" horizontal crack
4	1809	CP(P)	Large bulge - ¼" x ¼"opening 5/8" horizontal crack - Pip
*5	1779	CP(P)	Large bulge -1/8" x 1/8" opening -½" horizontal crack

* Protection Ballistic Limit = 1756 fps

Cal. 50 Ball M2 - Direct Frontal Attack

1	2201	CP(P)	Exit diameter ½" x ½"
2	1788	PP(P)	Large bulge - ¼" horizontal crack
3	1878	CP(P)	Large bulge 3/4" horizontal crack
*4	1802	PP(P)	Large bulge ½" horizontal crack
*5	1844	CP(P)	Large bulge 5/8" horizontal crack

* Protection Ballistic Limit = 1823 fps .

Cal. 50 AP M2 - 30° Frontal Flank Attack

1	Lost	CP(P)	Large bulge - 5/8" horizontal crack
2	Lost	CP(P)	Exit diameter 7/16" x 7/16" - ½" - ½" horizontal cracks
3	2021	PP(P)	Slight bulge
*4	2093	PP(P)	Slight bulge
5	2243	CP(P)	Exit diameter ½" x ½"
6	2175	CP(P)	Exit diameter ½" x ½"
*7	2124	CP(P)	Large bulge - 3/4"-5/8" horizontal crack

* Protection Ballistic Limit = 2109 fps .

Cal. 50 AP M2 - 30° Frontal Flank Attack

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	2098	PP(P)	No bulge
*2	2247	PP(P)	Large bulge 3/4" horizontal hairline crack
3	2319	CP(P)	Exit diameter ½" x ½" - Two ½" horizontal cracks
*4	2267	CP(P)	Exit diameter ½" x ½" - 3/4" horizontal crack

* Protection Ballistic Limit = 2257 fps

Cal. 50 AP M2 - 60° Frontal Flank Attack

1	2350	PP(P)	No bulge
2	2704	PP(P)	No bulge
3	2783	PP(P)	No bulge
4	2846	PP(P)	No bulge

* No Protection Ballistic Limit Obtained - High Partial Penetration = 2846 fps

Personnel Access Door in Ramp

Cal. 50 Fragment Simulator - 0° Obliquity

1	2703	PP(P)	Large bulge - No cracking
2	2720	PP(P)	Large bulge - Fine hair line crack
3	2835	PP(P)	Large bulge - No cracking
4	2891	PP(P)	Large bulge - No cracking

* No Protection Ballistic Limit Obtained - High Partial Penetration = 2891 fps

Cal. 50 Fragment Simulator - 45° Obliquity

1	2374	PP(P)	Slight bulge - No cracking
2	2472	PP(P)	Slight bulge - No cracking
3	2580	PP(P)	Slight bulge - No cracking

* No Protection Ballistic Limit Obtained - High Partial Penetration = 2580 fps

20-mm Fragment Simulator - 45° Obliquity

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	2068		Disregard
2	2331	CP(P)	Exit diameter 1¼" x 1"
*3	2197	CP(P)	Exit diameter 1" x 1"
4	2085	PP(P)	Large bulge - 1½" crack
5	2051	PP(P)	Medium bulge - No cracks
6	2094	PP(P)	Large bulge - No cracks
*7	2135	PP(P)	Large bulge - ½" crack

* Protection Ballistic Limit = 2166 fps

RESISTANCE TO PENETRATION

T117

Upper Hull Side Plate - Right Side

Cal. 50 AP M2 - 0° Obliquity

1	1413	CP(P)	1/8" x 1/8" opening on rear
2	1297	PP(P)	Large bulge - pin hole light
3	1338		Disregard
4	1296	PP(P)	Large bulge - pin hole light
*5	1298	PP(P)	Large bulge - pin hole light
*6	1344	CP(P)	Large bulge - 1/8" opening

* Protection Ballistic Limit = 1321 fps

Cal. 50 Ball M2 - 0° Obliquity

1	1499	PP(P)	No bulge - no cracking
2	2875	CP(P)	Exit diameter 7/8" x 7/8"
3	2302	PP(P)	Medium bulge - no cracks
4	2633	CP(P)	Exit diameter 3/4" x 3/4"
*5	2504	CP(P)	Exit diameter 5/8" x 5/8"
6	1852	PP(P)	Medium bulge - no cracking
7	2064	PP(P)	Large bulge - no cracking
8	2004	PP(P)	Large bulge - no cracking
9	2173	PP(P)	Large bulge - no cracking
10	2508	CP(P)	Punching out 5/8" x 5/8"
*11	2468	PP(P)	Large bulge - no cracking - Projectile in plate.

* Protection Ballistic Limit = 2486 fps

Cal. 30AP M2 - 0° Obliquity

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	2055	PP(P)	Slight bulge - no cracking
2	2588	CP(P)	Punching out $\frac{1}{4}$" x $\frac{1}{4}$"
3	2319	CP(P)	Large bulge - pin hole opening
4	2276		Disregard
5	2248	CP(P)	Large bulge - pin hole opening
6	2283	CP(P)	Large bulge - projectile nose through plate
7	2279	CP(P)	Large bulge - 1/16" x 1/16" opening
8	2135	PP(P)	Medium bulge - no cracking
9	2266	CP(P)	Large bulge - 1/16" x 1/16" opening
*10	2174	PP(P)	Medium bulge - no cracks
11	2232		Disregard
*12	2235	CP(P)	Large bulge - fine hair cracking

* Protection Ballistic Limit = 2205 fps .

Cal. 30 AP M2 - 45° Obliquity

1	3096	PP(P)	Slight bulge - no cracking
2	3280	PP(P)	Slight bulge - no cracking
3	3444	PP(P)	Slight bulge - no cracking

* No Protection Ballistic Limit Obtained - High Partial Penetration = 3444 f.p.s.

Cal. 30 AP M2 - 45° Obliquity

1	2001	PP(P)	Slight bulge - no cracking
2	2857	CP(P)	Punching out 5/8" x 3/8"
3	2365	PP(P)	Slight bulge - no cracking
4	2639	PP(P)	Large bulge - no cracking
*5	2781	PP(P)	Large bulge - no cracking
*6	2829	CP(P)	Punching out $\frac{1}{2}$" x 3/8"

* Protection Ballistic Limit = 2805 fps

20-mm Fragment Simulator - 45° Obliquity

Rd. No.	Velocity	CP(P)/PP(P)	Remarks
1	1870	PP(P)	Slight bulge - no cracks
2	1969	PP(P)	Slight bulge - no cracks
3	2076	PP(P)	Medium bulge - no cracks
4	2191	PP(P)	Medium bulge - no cracks
5	2334	PP(P)	Medium bulge - no cracks
6	Lost	PP(P)	Large bulge - $\frac{1}{2}$" hair crack
7	2585	PP(P)	Large bulge - no cracks
8	2534	PP(P)	Slight bulge - no cracks
9	2701	PP(P)	Large bulge - 3/4" face crack
10	2869	PP(P)	Large bulge - no cracks
11	2873	PP(P)	Large bulge - no cracks

* No Protection Ballistic Limit Obtained - High Partial Penetration = 2873 fps

Personnel Access Door in Ramp

Cal. 50 Fragment Simulator - 0° Obliquity

1	2785	PP(P)	Slight bulge - no cracking
2	2909	PP(P)	Slight bulge - no cracking
3	2899	PP(P)	Slight bulge - no cracking
4	2933	—	Disregard

* No Protection Ballistic Limit Obtained - High Partial Penetration = 2909 fps

20-mm Fragment Simulator - 45° Obliquity

1	1953	PP(P)	Large bulge - no cracking
2	2005	PP(P)	1" circular crack
3	2234	PP(P)	Large bulge - no cracking
*4	2349	CP(P)	Punching out 7/8" x 7/16"
5	2264	PP(P)	Large bulge - no cracking
*6	2274	PP(P)	Large bulge - hair line crack

* Protection Ballistic Limit = 2312 fps

APPENDIX E

Detailed Test Data

Phase IV

T117 - PERSONNEL ACCESS DOOR

Projectile: Cal. 30 Ball M2 Service

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
1	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	PP	None
2	Direct Rear	Disregarded.	-	-
3	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	PP	None
4	Direct Rear	Disregarded	-	-
5	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	PP	None
6	Direct Rear	Disregarded.	-	-
7	Direct Rear	Disregarded.	-	-
8	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	PP	None
9	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	PP	None
10	45° Rear Flank	Disregarded	-	-
11	45° Rear Flank	Disregarded	-	-
12	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
13	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
14	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
15	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None

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Projectile: Cal. 50 Ball M2 Service

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
16	Direct Rear	Disregarded.	-	-
17	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	CP	None
18	Direct Rear	Hit in the opening between the personnel access door and the rear ramp.	CP	None
19	45° Rear Flank	Disregarded.	-	-
20	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
21	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
22	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None
23	45° Rear Flank	Hit in the opening between the personnel access door and the rear ramp.	PP	None

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THE RESISTANCE TO BULLET SPLASH FROM SMALL ARMS FIRE

ROUND-BY-ROUND-FIRING RESULTS

T113-ENGINE INSPECTION DOOR

Projectile: Cal. 30 Ball M2 Service

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
1	45° Obliquity	Disregarded.	-	-
2	45° Obliquity	Hit in the opening between the engine access door and engine inspection door.	PP	None
3	45° Obliquity	Disregarded.	-	-
4	45° Obliquity	Hit in the opening ir the right side between the engine access door and engine inspection door.	PP	None
5	45° Obliquity	Disregarded.	-	-
6	45° Obliquity	Disregarded.	-	-
7	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
8	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
9	0° Obliquity	Disregarded.	-	-
10	0° Obliquity	Disregarded.	-	-
11	0° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
12	0° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
13	0° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None

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Projectile: Cal. 50 Ball M2 Service

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
14	45° Obliquity	Disregarded.	-	-
15	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
16	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
17	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
18	45° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	PP	None
19	0° Obliquity	Disregarded.	-	-
20	0° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	CP	None
21	0° Obliquity	Hit in the opening between the engine access door and the engine inspection door.	CP	None

T113 -ENGINE ACCESS DOOR

Projectile: Cal. 30 Ball M2 Service

1	45° Obliquity	Hit in the opening between the engine access door and the sloped nose plate.	PP	None
2	45° Obliquity	Hit in the opening between the engine access door and the sloped nose plate.	PP	None
3	45° Obliquity	Hit in the opening between the engine access door and in the sloped nose plate.	PP	None

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Projectile: Cal. 50 Ball M2 Service

Rd No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
4	45° Obliquity	Disregarded.	-	-
5	45° Obliquity	Hit in the crack between the engine access door and the sloped nose plate.	PP	None
6	45° Obliquity	Hit in the crack between the engine access door and the sloped nose plate.	PP	None
7	45° Obliquity	Disregarded	-	-
8	45° Obliquity	Disregarded	-	-
9	45° Obliquity	Hit in the crack between the engine access door and the sloped nose plate.	PP	None

T113-CARGO HATCH

Projectile: Cal. 30 Ball M2 Service

1	0° Obliquity	Disregarded.	-	-
2	0° Obliquity	Hit in the opening between the hatch cover and the hatch ring.	CP	None
3	0° Obliquity	Hit in the opening between the hatch cover and the hatch ring.	CP	None
4	0° Obliquity	Disregarded.	-	-
5	0° Obliquity	Disregarded.	-	-
6	0° Obliquity	Disregarded.	-	-
7	0° Obliquity	Hit in the opening between the hatch cover and the hatch ring.	CP	None
8	0° Obliquity	Hit in the opening between the hatch cover and the hatch ring.	CP	None
9	0° Obliquity	Disregarded.	-	-
10	0° Obliquity	Disregarded.	-	-
11	0° Obliquity	Disregarded.	-	-
12	0° Obliquity	Hit in the opening between the hatch cover and hatch ring.	CP	None

T113-COM'DR CUPOLA

Projectile: Cal. 30 Ball M2

Rd. No.	Striking Vel, fps	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
1	1960	0° Obliquity	Hit in the opening between the hatch cover and hatch ring.	CP	None
2	1958	0° Obliquity	Hit in the opening between the hatch cover and hatch ring.	CP	None
3	1975	0° Obliquity	Hit in the opening between the hatch cover and hatch ring.	CP	None
4	1970	0° Obliquity	Hit in the opening between the hatch cover and hatch ring.	CP	None

Projectile: Cal. 30 Ball M2 Service

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
5	15° Obliquity	Disregarded	-	-
6	15° Obliquity	Disregarded	-	-
7	15° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
8	15° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
9	15° Obliquity	Disregarded	-	-
10	15° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
11	15° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
12	15° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
13	30° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None

Rd. No.	Condition of Attack	Location of Impacts	Penetration (A)	Results Bullet Splash
14	30° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
15	30° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
16	30° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
17	45° Obliquity	Disregarded.	-	-
18	45° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
19	45° Obliquity	Disregarded.	-	-
20	45° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None
21	45° Obliquity	Hit in the opening between the hatch cover and hatch ring.	PP	None

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