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COMPARISON TEST OF

TANK, COMBAT, FULL-TRACKED, 105-MM GUN, M60A1

FINAL REPORT

BY

EDWARD C. KOTRAS

SEPTEMBER 1972

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U.S. ARMY TANK-AUTOMOTIVE COMMAND,
WARREN, MICHIGAN 48090

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND

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ABSTRACT

A third sample Inspection Comparison M60A1 Tank, US Army Registration No. 09A 18471, produced under contract DAAF03-71-C-0015, was operated for 2018 miles during comparison testing at Aberdeen Proving Ground. In addition to the endurance test, construction, automotive, and turret performance tests were accomplished per specification MIL-T-45379C(MO). Firing programs were also conducted on the 105-mm gun, M68, and the machine gun installations. Test activity was from 25 April to 4 August 1972. During the test, failures of the No. 2 left cylinder fuel injector nozzle tube assembly, and four road wheel hub seals occurred. Test results indicated that the vehicle did not meet all of the requirements of specification MIL-T-45379C(MO), specifically, noise level. In addition to the failures experienced, this vehicle had two shortcomings which have been observed on prior produced M60A1 tanks. First, the shifting control hasp is readily dislodged from the quadrant and the shifting and steering controls can then be inadvertently moved with possible injury to personnel, if the engine is running. Second, both tracks guide against the inner edges of the outer sprockets causing excessive wear on the sprockets and the outer edges of the track shoes.

FOREWORD

The Materiel Testing Directorate was responsible for conducting the test and preparing the test report. This test was sponsored by the M60 Project Manager's Office, AMCPM-M60-Q, Mr. C. Bloch, and was under the administrative direction of USATACOM, AMSTA-QKP, Mr. R. DeMore. The sample vehicle was produced under contract DAAF 03-71-C-0015.

TABLE OF CONTENTS

	<u>PAGE</u>
ABSTRACT	i
FOREWORD	iii

SECTION 1. SUMMARY

1.1	BACKGROUND.	1-1
1.2	DESCRIPTION OF MATERIEL	1-1
1.3	TEST OBJECTIVES	1-2
1.4	SCOPE	1-2
1.5	SUMMARY OF RESULTS	1-2
1.6	CONCLUSION	1-3
1.7	RECOMMENDATION	1-3

SECTION 2. DETAILS OF TEST

2.1	INITIAL INSPECTIONS	2-1
2.2	ENGINEERING PERFORMANCE	2-5
2.3	ENDURANCE TEST	2-9
2.4	TURRET AND FIRE-CONTROL PERFORMANCE TESTS	2-9
2.5	FINAL INSPECTIONS	2-12

SECTION 3. APPENDICES

I	TEST DATA	I-1
II	TEST FINDINGS	II-1
III	DEFICIENCIES AND SHORTCOMINGS	III-1
IV	MAINTENANCE EVALUATION	IV-1
V	REFERENCES	V-1
VI	CORRESPONDENCE	VI-1
VII	ABBREVIATIONS	VII-1
VIII	DISTRIBUTION LIST	VIII-1

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

TECOM PROJECT NO. 1-VC-080-060-026

FINAL REPORT ON COMPARISON TEST OF
TANK, COMBAT, FULL-TRACKED, 105-MM GUN, M60A1

25 APRIL TO 4 AUGUST 1972

SECTION 1. SUMMARY

1.1 BACKGROUND

The M60A1 tank was produced under procurement contract DAAF03-71-C-0015 and was the third sample vehicle to be submitted from production for testing at APG.

1.2 DESCRIPTION OF MATERIEL

The M60A1 tank is a full-tracked combat vehicle, mounting a 105-mm gun, M68, in a 360° fully-traversable turret. The vehicle is equipped with a torsion-bar suspension with six pairs of individually-suspended road wheels on each side. Additional suspension components include volute springs, friction snubbers, and T97E2 rubber chevron tracks.

An AVDS-1790-2A, air-cooled, 12-cylinder, 4-cycle, 90°V, turbocharged, compression-ignition engine, rated at 750 hp, furnishes vehicle power. Power is transmitted to the final-drive gears and track-drive sprockets through a CD-850-6A transmission, which includes the functions of differential, steering, and braking. The two-speed transmission is controlled by means of a T-bar handle, a brake pedal, and shifting controls installed in the driver's compartment and mechanically connected to the transmission linkages, except for the brakes, which are hydraulically-connected.

The hull and the turret are homogeneous-armor castings, and the hull is separated into crew- and power-pack-compartments. The turret mounts a 7.62-mm machine gun, M73, coaxially with the 105-mm gun in an M140 combination gun mount. A caliber .50 machine gun, M85, is in the tank commander's cupola; a crew of four is carried in the vehicle. Additional information concerning the vehicle can be found in TM's 9-2350-215-10 and -20.

1.3 TEST OBJECTIVES

- a. To evaluate the endurance and performance of the vehicle components.
- b. To provide evidence of contractor conformance to contractual requirements and adequacy of quality assurance and manufacturing procedures as outlined in the Procurement/work Directive, 2 June 1971.

1.4 SCOPE

This vehicle was subjected to the construction, automotive, turret, and gun fire-control performance tests, as well as to 2018 miles of endurance testing. Throughout testing, observations were made regarding vehicle performance and reliability.

1.5 SUMMARY OF RESULTS

Initial inspections revealed that the holes in the right fuel tank drain access cover, Ord Part No. 8734773, would not align properly with the tapped holes in the hull. The outboard tapped hole was approximately 3/8 inch too far to the rear of the vehicle to align with its mating hole in the cover. The transmission shifting control hasp, Ord Part No. 10951872, could be readily dislodged from the shifting control quadrant (Appendix III).

During endurance test, the No. 2 left cylinder fuel injector nozzle tube and four road wheel hub seals failed (random failure) (para 2.3).

Engineering performance tests, except noise level test, were satisfactory. Noise levels exceeded acceptable limits for each of the crew positions at one or more octave bands with the turret ventilating blower or the turret power pack hydraulic motor in operation (para 2.2).

Turret and fire control performance test results were satisfactory (para 2.4).

The magnetic particle inspection of the final drive gears and the dye penetrant check of the engine compartment floor plate were waived by AMCPM-M60-PQ, Mr. C. Bloom. New tracks were installed, and the power pack was operated on the test stand to check for proper operation (para 2.5).

1.6 CONCLUSION

It was concluded that except as noted, the vehicle complies with the requirements of MIL-T-45379C(MO) (para 1.5 and Appendix III).

1.7 RECOMMENDATION

Not applicable.

SECTION 2. DETAILS OF TEST

2.1 INITIAL INSPECTIONS

Vehicle construction was evaluated in accordance with the test directive and the applicable paragraphs of specification MIL-T-45379C(MO), 4 August 1964. Table 2.1-I covers construction details.

Table 2.1-I. Construction

<u>Test</u>	<u>QA Requirement of MIL-T-45379C</u>	<u>Results</u>
Sealing	4.5.1.2.1. The sealer used to seal the vehicle shall prevent the entrance of water into the vehicle. Seals shall prevent the entrance of water and foreign matter, except as noted, when fording. All seals except those designed to allow the exit of flushing lubricant, shall prevent the leakage of lubricants from the bearings.	Satisfactory.
Shroud seal	4.5.1.2.2. Space between the upper metal surface of the engine shroud and the sealing surface of the top deck grille shall be from 0.82 to 1.25 inches.	Satisfactory, 1.25 inches.
Hatch seal	4.5.1.3. The driver's, loader's and commander's hatches shall be closed and locked. A spray of water shall be directed on each hatch for 3 minutes without leakage into the crew compartment.	Satisfactory.
Air-cleaner outlet-hose system	4.5.1.4. Air-cleaner outlet-hose system, with a vacuum of 25 to 30 inches of water applied, shall lose not more than 3 inches of vacuum during a 3-minute interval.	Satisfactory.
Fuel-return system	4.5.1.5. The fuel-return selector valve shall divert fuel to the tanks as indicated by the pointer on the valve.	Satisfactory.
Throttle linkage	4.5.1.9. With the throttle linkage attached to the engine and with the throttle pedal depressed to within	Satisfactory.

Table 2.1-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Results
	3/16-inch of the pedal stop, the throttle shall be checked for full rack position.	
Fuel shut-off valve	4.5.1.10. With the engine operating at 800 to 1000 rpm, and the transmission in neutral, the engine shall stop within 5 minutes after the manual shut-off valve is placed in off position.	Satisfactory.
Lights	4.5.1.11. The internal and external lights shall operate as specified under all vehicle-operating conditions.	Satisfactory.
Controls	4.5.1.12. All electrical, mechanical, and hydraulic controls shall operate without malfunction throughout all ranges of operation under all vehicle-operating conditions.	Satisfactory.
Adjustment mechanisms	4.5.1.13. All adjustment mechanisms shall function properly, and shall maintain adjustment settings.	Satisfactory.
Driver's hatch	4.5.1.14. Force required to breakaway and slide hatch cover across opening shall not exceed 30 pounds at handle. Force to lock cover in closed position shall not exceed 75 pounds at end of locking lever.	Satisfactory, 25 pounds to slide, 60 pounds to lock.
Driver's escape hatch	4.5.1.14. Hatch shall seal out water and dirt. Force required to release hatch shall not exceed 30 pounds at a point 1/2-inch from end of operating handle.	Satisfactory, 9 pounds to release.
Battery access door	4.5.1.15. Latch shall be free of paint and shall function properly. Force to open latch shall not exceed 15 pounds.	Satisfactory, 2 pounds.
Driver's seat	4.5.1.16. With the driver seated, force to actuate the fore and aft adjustment lever shall not exceed 12 pounds. With the seat vacated, force	Satisfactory.

Table 2. 1-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Results
	to actuate the vertical adjustment lever shall not exceed 14 pounds. Driver's seat shall move forward, backward, and vertically when the appropriate levers are actuated.	
Gunner's seat	4.5.1.16. Without load, force to pull seat-adjusting pin shall not exceed 15 pounds. The spring shall raise the unloaded seat at least 7 inches.	Satisfactory, force to pull pin, 10 pounds; spring distance, 8 inches.
Commander's seat	4.5.1.16. Without load, the platform seat shall move upward a minimum of 12 inches. Force to lift the pin for seat adjustment shall not exceed 25 pounds. The platform latch shall lock securely in the up position and the backrest shall stay in vertical position when not in use as a platform. Seat shall also stay in vertical position when not in use.	Satisfactory, upward movement, 14 inches; force to lift pin, 6 pounds.
	4.5.1.16. Force to position upper swing-seat pin for seat release shall not exceed 15 pounds. Force to rotate seat shall not exceed 10 pounds.	Satisfactory, 7 pounds to release, 2 pounds to rotate.
Loader's seat	4.5.1.16. When properly installed and not in use, lifting spring shall move and retain seat in a vertical position.	Satisfactory.
Generator voltage	4.5.1.17. Vehicle generator shall deliver between 27.8 and 28.3 volts, under all conditions of vehicle operation.	Satisfactory.
Generator blower motor	4.5.1.18. The generator blower motor shall be capable of maintaining constant flow of air through generator.	Satisfactory.

Table 2. 1-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Result
IR power pack high-voltage supply	4.5.1.19. Output voltage at the connector shall be at least 14,000 volts, using an 80-megohm load, without any evidence of high-voltage arching.	Satisfactory.
Slip ring and external communications circuit	4.5.1.20. The slip ring and external communications circuits shall maintain continuity without evidence of shorts at pins or connectors.	Satisfactory.
Air-cleaner blower motors	4.5.1.21. With the engine idling, air-flow shall be detectable at each blower outlet.	Satisfactory.
Searchlight control circuits	4.5.1.22. Circuits shall be capable of providing power for controlling the searchlight.	Satisfactory.
Main gun firing circuits	4.5.1.23. Each of the firing triggers shall be capable of igniting the main round.	Satisfactory.
Machine gun firing circuits	4.5.1.24. Each of the machine gun firing circuits shall be capable of energizing its respective machine gun solenoid.	Satisfactory.
Engine manifold heater	4.5.1.25. Operation of the push-button switch on the purge-pump handle shall provide 18 volts at pin a at the engine electrical quick-disconnect.	Satisfactory.
Power package and train	4.5.1.26. The vehicle shall be operated throughout all gear- and speed-ranges, without loss of lubricants or damage. Controls shall operate without binding of linkages, grabbing, chattering, or slippage when applied to controls, stop, and hold vehicle.	Satisfactory.

Table 2.1-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Results
Front and rear drain valves	4.5.1.34. Force to operate front drain valve 3/8-inch shall not exceed 17 pounds after lever is unlocked. Operation of rear drain valve 11/16-inch shall require force not over 25 pounds.	Satisfactory.
Inflatable seal and pump	4.5.1.35. Force to operate pump shall not exceed 20 pounds and pump shall inflate seal to 25 psi. Pressure loss shall not exceed 5 psi during 30-minute period.	Satisfactory.

2.2 ENGINEERING PERFORMANCE

The engineering performance tests listed in Table 2.2-I were conducted in accordance with the requirements of specification MIL-T-45379C(MO), 6 August 1964.

Table 2.2-I. Engineering Performance

Test	QA Requirement of MIL-T-45379C(MO)	Results
Level road speed	4.5.1.27. Vehicle shall operate at sustained speeds of 30 mph and 2.5 mph on level ground without damage to power plant and power train. When traveling between 25 and 30 mph, the vehicle drift shall not exceed 3 feet in 100 feet. Vehicle shall be operated at maximum speed for at least 10 minutes and minimum speed for 5 minutes.	Maximum speed 31.5 mph at 2530 rpm; Minimum speed 1.8 mph at 650 rpm; drift negligible.
Grade speeds	4.5.3.7. Vehicle shall operate at a sustained speed of 10 mph while ascending a 10% grade and 20 mph while ascending a 3% grade.	Satisfactory; 10% grade, 11 mph at 2500 rpm; 3% grade, 23.5 mph (computed value based on maximum speeds on level and 5% grade).

Table 2.2-I (Cont'd)

Test	QA Requirement of MIL-T-45379C(MO)	Results
Acceleration	4.5.1.28. Vehicle shall accelerate from a standing start on level ground through a distance of 200 feet in not more than 13 seconds.	Satisfactory; 11.5 seconds.
Engine starting on grades and slopes	4.5.1.29. When standing on a 60% grade for not less than 2 minutes, with engine operating under no load between 700 and 750 rpm, the engine shall be stopped for not less than 2 minutes. The engine shall restart in not more than 1 minute when headed up- and down-grade. Similar engine stopping and starting tests shall be accomplished on 30% right and left side slopes. The engine shall start and oil pressure and temperature shall be maintained when operating on the specified grades and slopes.	Satisfactory.
Stopping	4.5.1.30. Vehicle traveling at 20 mph shall stop within 60 feet from point of brake application; drift not to exceed 4 feet during stopping. Vehicle shall be operated on dry, level, hard-surfaced road without loose materiel, and three consecutive stopping tests shall be averaged to make determination.	Satisfactory, stopping distance 46 feet, drift negligible.
Holding	4.5.1.31. With vehicle combat-loaded standing on a 60% grade with service brakes applied, the vehicle shall be held stationary when headed up- and down-grades. With parking brake engaged and all other holding devices inoperative, the vehicle shall be held stationary when headed up- and down-grade.	Satisfactory.
Turning	4.5.1.32. Vehicle shall turn 360° to the right and left in pivot, in neutral steer, within a circle 35 feet in diameter.	Satisfactory. right, 33.5 feet; left, 34.5 feet.

Table 2.2-I (Cont'd)

Test	QA Requirement of MIL-T-45379C(MO)	Results
Fording	<p>4.5.1.33. Vehicle shall ford a level hard-bottom body of water 48 inches in depth, including wave, without special equipment. With the vehicle standing in water 48 inches in depth for 30 minutes, the accumulation of water shall be not more than 1-1/2 inches on the crew compartment hull floor, measured in the center of the vee.</p>	Satisfactory.
	<p>With the vehicle standing for 30 minutes in water 48 inches in depth with the engine operating at 1000 rpm for 15 minutes, then being stopped for 15 minutes, the engine shall restart in not more than 3 minutes. All accessories shall function satisfactorily during and after fording operation; the water contamination content of the transmission, engine, final drives, and suspension-system lubricants shall be not more than 2% by volume.</p>	Satisfactory.
Fuel system operation	<p>4.5.3.3. During engine operation, the fuel system shall maintain fuel supply to the engine when ascending 60% grades in forward and reverse gear, and when vehicle is being operated on 30% side slopes with each side of vehicle up-slope. The vehicle shall be observed for functional requirements during operation on the grades, cross-country, and hard-surfaced roads.</p>	Satisfactory.
Climbing	<p>4.5.3.8. Vehicle shall ascend longitudinal grades of 60% in forward and reverse gear without stalling or damage to power plant and power train. Vehicle shall operate on right and left side slopes of 30%.</p>	Satisfactory; 60%, 1.2 mph at 1840 rpm (fwd).

Table 2.2-I (Cont'd)

Test	QA Requirement of MIL-T-45379C(MO)	Results
Trench crossing	4.5.3.10. Vehicle shall cross trenches 36 inches in depth and 102 inches in width without stalling or damage to suspension, gun tube, and fenders.	Satisfactory.
Vertical obstacles	4.5.3.11. Vehicle shall cross vertical obstacles 36 inches in height while moving forward without stalling or damage to suspension and hull floor.	Satisfactory.
Electromagnetic compatibility test	4.5.3.12. The vehicle shall conform to the electromagnetic compatibility requirements of MIL-E-55301 for tactical equipment.	Not tested per reference letters: AMCPM-M60-Q, 23 February 1972 and AMSTA-QST, 16 March 1972.
High temperature operation tests	4.5.3.2. and 4.5.3.6. With vehicle operating in ambient temperature of +115°F, in all transmission gear ranges above 0.3 maximum speed range, the engine oil temperature shall not exceed +250°F at the heat exchange outlet, and the transmission oil temperature shall not exceed +300°F at the heat exchanger inlet.	Satisfactory.
Noise level	4.5.3.14. Equipment operation for training or maintenance shall not exceed the maximum acceptable levels in Table V.	Turret ventilating blower and turret power pack hydraulic pump noise excessive in one or more octave bands (see data sheet Appendix I).

2.3 ENDURANCE TEST

Vehicle operations on the various test courses are shown in Table 2.3-I.

Table 2.3-I. Operations Summary

<u>Course</u>	<u>Miles</u>
Gravel	498
Paved	219
Level (Perryman) cross-country	650
Hilly (Churchville) cross-country	651
Total APG Test Mileage	2018

Over-all fuel and engine-oil consumption data are tabulated in Table 2.3-II.

Table 2.3-II. Fuel and Engine-Oil Consumption

<u>Characteristics</u>	<u>Measurements</u>
Engine-oil changes, number	2
Engine-oil added, quarts	47
Miles per quart of oil	42.9
Ratio of fuel to oil, gpg	335.5:1
Fuel, gallons	3918
Miles per gallons of fuel	0.51

Various equipment performance reports concerning vehicle test incidents were forwarded during endurance operation. No major failures occurred during this operation. Replacement of the No. 2 cylinder fuel injector nozzle tank and four road wheel hub seals was necessary, however.

2.4 TURRET AND FIRE-CONTROL PERFORMANCE TESTS

Turret and fire-control performance tests were conducted in accordance with the applicable paragraphs of specification MIL-T-45379C(MO), 6 August 1964, as shown in Table 2.4-I.

Table 2.4-I. Turret and Fire-Control Performance Tests

Test	QA Requirement of MIL-T-45379C	Results
Turret and gun-control systems	4.5.1.36. Gun shall operate throughout depression and elevation; turret shall traverse 360° in both directions with main armament balanced as specified, and turret level within 1° with minimum of 26 volts dc.	Satisfactory.
Main armament balance	4.5.1.36.1. Main armament shall be balanced muzzle-heavy within 56 to 70 foot-pounds with required equipment installed.	Satisfactory.
Nylon ballistic shield	4.5.1.36.2. Gun mount shall elevate to +20° and depress to -10° without binding between the machine gun, sighting system, and nylon ballistic shield.	Satisfactory.
Manual traverse effort	4.5.1.36.3. Mean force measured at four points of 360° traverse to maintain turret movement shall not exceed 17 pounds. No individual reading to exceed 20 pounds.	Satisfactory.
Manual elevation effort	4.5.1.36.4. Mean torque to maintain gun movement, measured at -5°, 0°, and +15°, shall not exceed 46 pound-inches. No individual reading shall exceed 55 pound-inches.	Satisfactory, 30 pound-inches.
Manual elevation and depression response rate	4.5.1.36.5. Gun shall move 10 mils per revolution when hand crank is turned at 10 to 20 rpm.	Satisfactory.
System backlash	4.5.1.36.6. Control-system backlash shall not exceed 1 mil in traverse and elevation with a force of 70 pounds applied and then reversed 20 inches from muzzle end of gun.	Satisfactory, 0.5 mil traverse, 0.5 mil elevation.

Table 2.4-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Results
Power and manual control	4.5.1.36.7. Manual traverse and power elevation or power traverse and manual elevation shall operate simultaneously. No movement of gun or turret when power switches are turned on or off.	Satisfactory.
Override control	4.5.1.36.8. Commander control shall instantaneously take over system control when override switch is actuated. Gunner control shall regain system control instantaneously when commander control is released.	Satisfactory.
Control-system deadspot	4.5.1.36.9. Control-system dead spot at gunner and commander power controls shall not exceed 7° from neutral center in any direction. Dead spot angles must be equal within 2° in elevation and traverse.	Satisfactory, gunner's control. 5° each direction, commander's control 5° each direction.
Gun elevation speeds	4.5.1.36.10. Gun shall be controllable with gunner and commander power controls at all speeds between 0.5 and 7 mils per second. Systems shall remain stable and gun speed shall increase with increased control-handle displacement.	Satisfactory.
Turret traversing speeds	4.5.1.36.11. Turret shall be controllable with gunner and commander power between 0.5 and 400 mils per second. Tracking speed shall range from 0.5 to 65.2 mils per second.	Satisfactory.
Traverse, elevation and depression stability	4.5.1.36.12. Gun shall not move more than 1 mil in traverse, elevation, or depression with vehicle level or canted up to 15° with power switch on or off during a 12-hour period.	Satisfactory.

Table 2.4-I (Cont'd)

Test	QA Requirement of MIL-T-45379C	Results
Elevation and depression limits	4.5.1.36.13. The gun shall be operated in elevation and depression using power and manual controls individually and the angles shall be measured in each of the defined areas to determine conformance to 3.6.13.11.	Satisfactory.
Gun laying on stationary target	4.5.1.36.14. Time to position gunsight reticle within the borders of an 0.25-mil-square target shall be determined for all positions in Table II, para 3.6.13.12.	Satisfactory, data sheets, Appendix I.
Gun laying on moving target and tracking accuracy test	4.5.1.36.15. Gunsight reticle to be positioned within and remain on target for times (%) and length of courses specified in Table III, para 3.6.13.13.	Satisfactory.

Sixty rounds of MDS-T, M392A2 and TP-T, M490 ammunition were fired from the 105-mm gun.

Machine gun firing produced the following results when firing 10-round groups:

- a. The 7.62-mm, 3-1/2 mils azimuth, 2-1/2 mils elevation.
- b. Caliber .50, 7-1/8 mils azimuth, 6-1/4 mils elevation unlocked.

2.5 FINAL INSPECTIONS

The magnetic particle inspection of the final drive gears, and the dye penetrant check of the engine compartment floor plate were waived by ANCPM-M60-PQ. New tracks were installed on the vehicle and the power pack was operated on the test stand to check for satisfactory operation.

SECTION 3. APPENDICES

APPENDIX I - TEST DATA

**SOUND PRESSURE LEVELS IN DB (RE: 0.0002 MICROBAR) OF TANK, COMBAT,
FULL-TRACKED, M60A1, USA REG. NO. 09A18471**

<u>Test Condition</u>	<u>A11 Band Pass</u>	<u>Octave Band (Commercial Frequencies)</u>								
		<u>37.5</u> <u>75</u>	<u>75</u> <u>150</u>	<u>150</u> <u>300</u>	<u>300</u> <u>600</u>	<u>600</u> <u>1200</u>	<u>1200</u> <u>2400</u>	<u>2400</u> <u>4800</u>	<u>4800</u> <u>9600</u>	<u>9600</u> <u>19.2K</u>
<u>Commander's Ear Position</u>										
1	103	93	99	85	83	81	76	72	66	58
2	103	93	99	85	84	81	78	73	67	60
3	109	107	102	89	83	82	79	74	69	63
4	106	98	100	90	92	94	90	79	71	66
5	105	94	100	90	86	91	92	83	72	66
6	113	111	103	92	97	95	93	85	73	68
<u>Gunner's Ear Position</u>										
1	100	91	93	89	83	80	78	74	66	57
2	101	91	93	90	84	82	80	77	70	62
3	108	105	98	90	84	82	80	76	70	61
4	104	94	94	93	89	92	86	79	72	65
5	104	92	95	89	88	95	94	87	79	72
6	110	107	99	95	99	97	95	90	80	74
<u>Loader's Ear Position</u>										
1	100	90	92	86	86	83	80	76	71	61
2	100	90	92	86	86	83	81	76	71	62
3	107	104	97	88	86	83	82	78	71	63
4	102	93	92	90	89	95	89	80	73	67
5	103	92	93	87	86	92	90	85	78	70
6	109	106	99	92	98	95	92	87	78	71
<u>Driver's Ear Position</u>										
1	100	91	87	85	85	81	77	74	67	58
2	100	91	87	86	86	82	79	75	70	64
3	108	106	95	89	87	83	82	79	73	68
4	102	94	87	88	93	88	82	75	69	61
5	102	92	88	87	87	90	92	85	77	71
6	112	110	97	92	96	93	93	87	79	73

MAXIMUM STEADY STATE NOISE LEVEL FOR AMC EQUIPMENT - REF. 1.6, TABLE 5

120 115 109 101 93 89 89 91

Test Conditions:

1. Engine running at idle (750 rpm).
2. Engine running at idle plus gas particulate operating.
3. Engine running at idle plus heater operating.
4. Engine running at idle plus turret blower operating.
5. Engine running at idle plus hydraulic pump motor operating.
6. Engine running at idle plus all equipment in operation mentioned above.

Summary of Gun Laying on Stationary Target

Tank, Combat, Full-Tracked, 105-MM Gun, M60A1
Serial No. 6117, USA No. 09A18471

<u>Layoff, mils</u>		<u>Gunner's Controls</u>		<u>Commander's Control</u>	<u>MIL-T-45379C(MO) Avg Time, sec</u>	
<u>Azimuth</u>	<u>Elevation</u>	<u>Manual</u>	<u>Power</u>	<u>Power</u>	<u>Manual</u>	<u>Power</u>
Vehicle on Level						
-	+10	1.5	1.6	1.9	2	2
-	-10	1.4	1.8	1.5	2	22
25L	+10	3.1	3.1	4.3	5	5
25L	-10	3.1	3.5	4.1	5	5
25R	+10	3.5	3.1	3.8	5	5
25R	-10	3.6	3.3	3.7	5	5
25L		2.1	2.2	2.0	3	3
25R		2.3	2.1	2.5	3	3
100L		3.4	3.4	4.0	4.5	4
100R			3.3	3.6	4.5	4
400L			4.0	5.4	13.5	5
400R			4.6	5.6	13.5	5
800L			5.1	6.3	-	6
800R			5.3	6.5	-	6
1600L			6.9	7.9	-	8
1600R			7.8	7.9	-	8
3200L			11.6	11.7	-	13
3200R			11.5	10.7	-	13

Vehicle Canted 15°

	+10	1.0	1.7		2	2
	-10	1.4	1.9		2	2
25L	+10	2.5	3.3		5	5
25L	-10	2.7	4.1		5	5
25R	+10	3.5	3.4		5	5
25R	-10	2.8	3.9		5	5
25L		1.9	2.5		3	3
25R		1.9	2.9		3	3
100L		3.8	3.7		4.5	4
100R		3.8	3.4		4.5	4
400L		11.9	5.1		13.5	5
400R		12.0	5.1		13.5	5
800L			6.3		-	6
800R			6.1		-	6
1600L			8.1		-	8
1600R			7.8		-	8
3200L			12.0		-	13
3200R			11.8		-	13

^a Reference par. 3.6.3.14 and par. 4.5.1.36.16: Turret and Gun-Control Systems, Operation on Slope. The gun-control system shall be capable of gun laying on a 0.25-mil stationary target as specified in 3.6.13.12, Table II, except time limitation need not be met.

APPENDIX II - TEST FINDINGS

Not Used

APPENDIX III - DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

None

2. Shortcomings

<u>Shortcoming</u>	<u>Suggested Corrective Action</u>	<u>Remarks</u>
2.1 Hasp, shifting control, FSN 2530-135-2387, readily dislodged from quadrant.	Redesign and appropriate modification to all M60A1 vehicles equipped with this hasp.	During maintenance, with engine running, transmission shifting and steering controls can be inadvertently moved because of dislocation of hasp. Injury to personnel can thus result.
2.2 Hub, final drive sprocket, FSN 2530-736-4134, too far inboard for correct alignment with suspension.	Check dimensional tolerances on final drives, sprocket hubs, and output shaft.	Both tracks guide against inner edges of the outer sprockets. This causes excessive wear on these sprockets and outer edges of track shoes.
2.3 Cover, right fuel tank drain access, Ord Part No. 8734773, would not align with holes in hull.	Spot check various production vehicles to insure that covers and holes in hull match.	Outboard tapped hole approximately 3/8 inch too far to rear of vehicle to align with hole in cover.
2.4 Blower assembly, turret ventilator, Ord Part No. 7974293 and turret power pack hydraulic motor generate noise levels in excess of acceptable limits.	Engineering evaluation of turret ventilating blower and power pack hydraulic motor to establish suitable noise reduction procedures for these units.	Noise levels exceed limits for each of the crew positions at one or more octave bands.

3. Corrected Deficiencies and Shortcomings

<u>Deficiency/Shortcoming</u>	<u>Corrective Action</u>	<u>Remarks</u>
3.1 Tube assembly, fuel injection pump to injector nozzle, Ord Part No. 10865408, failed at ferrule near nozzle.		Random failure. Replacement installed.
3.2 Seal assembly, hub, Ord Part No. 7364672, failed after 2001 test miles.		Random failures. Replacements installed.

APPENDIX IV - MAINTENANCE EVALUATION

Not Used

APPENDIX V - REFERENCES

1. Letter, TECOM, AMSTE-BB, Customer Test/Support Directive: TECOM Project No. 1-VC-080-060-024/-025/-026/-027, Comparison Test of Tank, Combat, Full-Track, 105-MM Gun, Contract DAAF-03-71-C-D-015, 10 June 1971.
2. Bishop, Ralph, Final Report on Comparison Test of Tank, Combat, Full-Track, 105-MM Gun, M60A1, Serial No. 6271, USA Reg No. 09A10571. TECOM Project 1-VC-080-060-024, Aberdeen Proving Ground, Report No. APG-MT-3992, December 1971 (Distribution Controlled by US Army Tank-Automotive Command, ATTN: AMSTA-QST. AD 889 999L.)
3. DiDomenico, Donald, Final Report on Comparison Test of Tank, Combat, Full-Track, 105-MM Gun, M60A1, Serial No. 6055, USA Reg No. 09A13271. TECOM Project 1-VC-080-060-025. Aberdeen Proving Ground, Report No. APG-MT-4040, February 1972. (Distribution controlled by US Army Tank-Automotive Command, ATTN: AMSTA-QST. AD 872 409L.)

APPENDIX VI - CORRESPONDENCE



DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48090

Mr. DeMore/
dhm/369-2439

AMSTA-QST

24 MAR 1972

SUBJECT: Test Items for M60A1 Vehicle ICT

Commanding Officer
US Army Aberdeen Proving Ground
ATTN: STEAP-MT-U
Aberdeen, Maryland 21005

1. Reference is made to letter from Project Manager's Office to TECOM, AMSTE-BB, dated 3 March 1972, subject as above.
2. This letter is to advise you that this division is cooperating with the PM Office in the conduct of supplementary testing of two items under TECOM Project No. 1-VC-080-060-026.
3. No EPR's will be issued against the two items (M19 Cupola Ammo Box Last Round Stop Modification Kit and Co-Axial Machine Gun Feed Chute Anti-Roll Back). However, it is requested that a letter type report be made to the PM, Engineering Division (AMCPM-M60-T) upon completion of subject tests.

FOR THE COMMANDER:

WILBERT SIMKOVITZ
Chief, System Performance
Assessment Division
Product Assurance Directorate

CF:
PM, M60 Tk
(AMCPM-M60-Q)



DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48090 Mr. DeMore/san/369-2439

AMSTA-QST

16 MAR 1972

**SUBJECT: Electromagnetic Interference (EMI) Test on M60A1
Tanks**

Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-MT-U
Aberdeen, Maryland 21005

1. The purpose of this letter is to make the Test Directive changes necessary to comply with the instructions issued by the Project Manager's Office regarding subject tests. Details of their directions are contained in a letter to TECOM, AMSTE-BB, dated 23 Feb 72, subject as above.

2. In paragraph 13e (page 7 of 12) of the Test Directive, Electromagnetic Compatibility (Radio Suppression) Tests are required to be performed in accordance with paragraphs 3.9 and 4.5.3.12 of MIL-T-45379C(MO). The requirement for these tests is hereby deleted. However, this is not to be construed as deleting the requirement for the testing of slip ring noise in the communications system as required by paragraph 3.6.15.3 of the specifications and referred to in the EMI requirements (paragraph 4.5.3.12).

FOR THE COMMANDER:

ROBERT C. BEESLEY
Chief, Test Branch
System Performance Assmt Div
Product Assurance Directorate

CF:
CG, TECOM
ATTN: AMSTE-BB, Mr. Resch
PM, M60 Tanks
(AMCPM-M60-Q), Mr. Block



DEPARTMENT OF THE ARMY
PROJECT MANAGER — M60 TANKS
MICHIGAN ARMY MISSILE PLANT
WARREN, MICHIGAN 48090

AMCPM-M60-Q

23 February 1972

SUBJECT: Electromagnetic Interference (EMI) Test on M60A1
Tanks

Commanding General
U.S. Army Test & Evaluation Command
ATTN: AMSTE-BB
Aberdeen Proving Ground, MD 21005

1. It has been determined that the failure of the M60A1 tank to pass the EMI portion of the ICT (MIL-S-10379A) is an inherent design problem, not a quality fault. The vehicle does not have the capability to meet this or any other existing EMI requirement.
2. There is no quick or easy solution to the problem, so rather than continue to test the ICT tanks on TECOM Project Nos. 1-VC-080-060-026 and -027 and 7-VS-050-728-004 to existing requirements, this office directs that the EMI portion of these tests be terminated.
3. Funding has been instituted to cover the cost for TECOM Project No. 1-VC-080-060-029. Said test will establish a baseline for determining the vehicle capability. Steps will then be taken to bring the vehicle capability and the requirements in line.

FOR THE PROJECT MANAGER:

CARL E. NARA
Chief, Product Assurance Division

CF:
AMSTA-Q

AMSTE-BB (23 Feb 72) 1st Ind Mr Resch/mj/5266
SUBJECT: Electromagnetic Interference (EMI) Test on M60A1 Tanks

HQ, U. S. Army Test and Evaluation Command, Aberdeen Proving Ground,
Maryland 21005 6 MAR 1972

TO: Commanding Officer, Aberdeen Proving Ground, ATTN: STEAP-MT-D,
Aberdeen Proving Ground, Maryland 21005

1. Basic letter is forwarded for action as requested on TECOM Projects
No. 1-VC-080-060-026 and -027 and 7-VS-050-728-004.

2. As indicated in the letter, a more thorough EMI test has been
established under TECOM Project No. 1-VC-080-060-029. Funds saved
by deletion of EMI portions of the above IC tests are to be used to
initiate this latter project.

FOR THE COMMANDER:



ABRAM V. RINEARSON III
Colonel, GS
Dir, Arm Mat Test Dir

Copy furnished:
PM-M60 Tanks, ATTN: AMCPM-M60-Q, w/o basic
CG, TACOM, ATTN: AMSTA-QST

APPENDIX VII - ABBREVIATIONS

EMI = electromagnetic interference
GPG = gallons per gallons
IC = inspection comparison

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Materiel Testing Directorate Aberdeen Proving Ground, Maryland 21005	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
6 COMPARISON TEST OF TANK, COMBAT, FULL-TRACKED, 105-MM GUN, M60A1.

4. DESCRIPTIVE NOTES (Type of report and its date)
9 Final Report. 25 April 1972 - 4 August 1972

10 Edward C. Kotras

9. REPORT DATE Sept 1972	7a. TOTAL NO. OF PAGES 12 34 pgs	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. Contract No. DAAE-00-71-C-0015	8b. ORIGINATOR'S REPORT NUMBER(S) 14 APG-MT-4142
16 b. PROJECT NO. TECOM -1-VC-080-060-026 USA	8c. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government Agencies only; Test and Evaluation; September 1972. Other requests for this document must be referred to Project Manager, M60 Tanks, ATTN: ANCPM-M60-PQ.

11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY Project Manager, M60 Tanks
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13. ABSTRACT
A third sample Inspection Comparison M60A1 Tank, US Army Registration No. 09A 18471, produced under contract DAAE03-71-C-0015 was operated for 2018 miles during comparison testing, at Aberdeen Proving Ground. In addition to the endurance test, construction, automotive, and turret performance tests were accomplished, per specification MIL-T-45379C(MO). Firing programs were also conducted on the 105-mm gun, M68, and the machine gun installations. Test activity was from 25 April to 4 August 1972. During the test, failures of the No. 2 left cylinder fuel injector nozzle tube assembly, and four road wheel hub seals occurred. Test results indicated that the vehicle did not meet all of the requirements of specification MIL-T-45379C(MO), specifically, noise level. In addition to the failures experienced, this vehicle had two shortcomings which have been observed on prior produced M60A1 tanks. First, the shifting control hasp is readily dislodged from the quadrant and the shifting and steering controls can then be inadvertently moved with possible injury to personnel, if the engine is running. Second, both tracks guide against the inner edges of the outer sprockets causing excessive wear on the sprockets and the outer edges of the track shoes.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Tank, Combat, Full-Tracke d, 105-MM Gun, M60A1 Endurance Engineering performance Turret performance Gun, M68						