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U.S. ARMY TEST & EVALUATION COMMAND

RESTRUCTURED DEVELOPMENT TEST (DT II) OF HOWITZER, MEDIUM, TOWED 155-MM, XM198 (U)

TEST PLAN

BY

J. S. WHITCRAFT

MAY 1975

NATIONAL SECURITY INFORMATION

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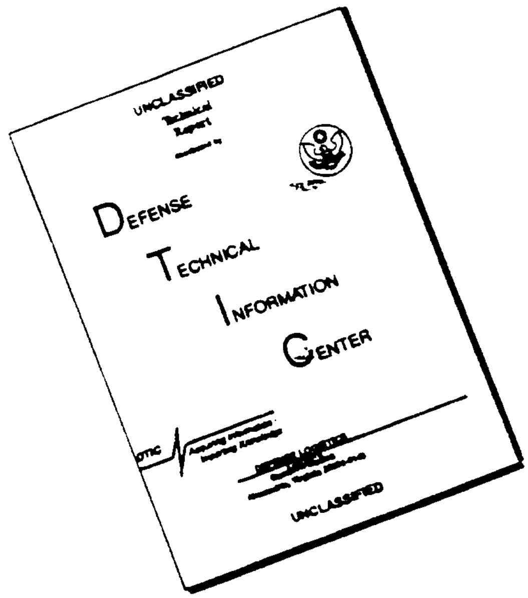

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SECTION 3. DETAILS OF AMMUNITION TESTS

(C) SECTION 1. INTRODUCTION (U)

1.1 (~~C~~) (u) BACKGROUND (U)

1.1.1 (U) The 155-mm howitzer system development program which led to the XM198 towed howitzer (test item), the XM164, XM201, and XM203 propelling charges (test items), and the M549 rocket assisted projectile (test item) began in 1964 when the US Army Combat Developments Command developed requirements for a 30,000 meter range system. Initial efforts were directed toward the XM138, a lightweight, unarmored, self-propelled howitzer with increased range. In mid 1968, the XM138 program was terminated and its remaining resources were applied to a new, armored, self-propelled 155-mm howitzer, the XM179. A requirement for a new airmobile, 155-mm towed system, the XM198, was also stated at that time. Because of high development cost, unacceptable projected production unit cost, and questionable design complexity, the XM179 program was terminated by the Army in December 1969. It was then decided to concentrate development efforts on a simple, lightweight, towed howitzer with an extended range. A primary thrust of the requirements document was achievement of the best reliability, maintainability, and durability characteristics attainable within the state-of-the-art.

1.1.2 (U) In 1968, the US Army Weapons Command has conducted exploratory development work to test the feasibility of utilizing a muzzle brake and extended range ammunition in the XM198 and to obtain data on weapon stability and structural soundness. Design and fabrication of an advanced development prototype was completed in November 1970. Approximately 1,400 rounds were fired in tests of the prototype and information gained in these tests was used to improve the design.

1.1.3 (U) Engineering development began in April 1970. Two engineering development prototypes were manufactured with the improved design and subjected to a firing test program of approximately 10,000 rounds. This development testing resulted in design changes intended to increase durability and operational reliability principally by changing from a slide block breech to an interrupted screw block breech and increasing the weight from 14,600 to 15,000 pounds.

1.1.4 (U) Based upon test results, it was determined that the originally specified reliability requirement, stated in terms of probability for the firing of a 250 round mission throughout the service life, equating to between 4,875 and 8,200 mean-rounds-between-failures (MRBF), could not be met. The reliability requirement was gradually reduced to between 1,950 and 2,600 MRBF based on testing experience. With the publication of Army Regulation (AR) 702-3, interpretation of reliability

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failures were clarified and scoring criteria, failure definitions, and quantification of reliability requirements were standardized. Using the AR 702-3 interpretation of reliability failures, engineering development test results and reliability requirement still could not be met with the XM198 howitzer system.

1.1.5 (U) In a further attempt to improve system reliability, it was decided to conduct additional engineering design testing, using the test-fix concept, on a third engineering development prototype which incorporated the latest design changes. In March 1973, while test firing prototype number 3 with an XM123 propelling charge (predecessor of the XM203), a high pressure (89,500 pounds per square inch (psi)) round ruptured the breech. It was determined that the propelling charge caused this failure and the failure necessitated design of the XM203 propelling charge to its present configuration.

1.1.6 (U) Based on the additional test-fix cycle, the developer has forecast that the XM198 will achieve a reliability of at least 550 MRBF during Development Test II and Operational Test II (DT II/OT II) with a predicted eventual reliability equal to the specified value of 1,100 MRBF. The user, however, maintains that 700 MRBF is the minimum acceptable value for reliability. The US Army Training and Doctrine Command (TRADOC) and US Army Materiel Command (AMC) have agreed to the following with respect to XM198 reliability:

a. That a reliability of 550 MRBF demonstrated at DT/OT II as the lower end of a 70 per cent confidence interval based on a sample of at least 35,000 rounds will be accepted as a valid indicator of sufficient progress toward reaching a minimum acceptable value of 700 MRBF.

b. That efforts will continue to achieve the specified value of 1,100 MRBF at DT/OT III.

c. That acceptable reliability depends on the nature of the failures involved so these goals are to be reexamined after DT/OT II data are available.

d. That these numbers are guidelines with final acceptance or rejection to be based on mutual TRADOC/AMC review of actual test results and predicted growth.

1.1.7 (U) The XM198 howitzer, XM164/XM201/XM203 propelling charge, and M549 rocket-assisted projectile test items, in combination, are designed to meet the 30,000 meter range requirement for the 155-mm howitzer system. The howitzer test item will replace the current M114A1 towed howitzer which has been in the inventory since 1942. The propelling charge test items will eventually replace the current standard M3 (series), M4 (series), and M119 propelling charges. The M549 rocket-assisted projectile was type classified standard in May 1971 for use in the M109, 155-mm self-propelled howitzer.

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5. Letter, Project Manager for 155-MM CSW, AMCPM-CSW, EFC Factors for XM198 Howitzer, 30 September 1971.

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10. FT 155-Q-4, Firing Tables, Howitzer Medium Towed, 155-MM, M114A1 and M114, March 1968.

11. Army Regulation 602-1, Man-Materiel Systems Human Factors Engineering Program, 4 March 1968.

12. Army Regulation 700-52, Licensing and Control of Sources of Ionizing Radiation, 22 May 1968.

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16. MIL-STD-1472A, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, 15 May 1970.

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18. Test Operations Procedures 6-3-524, Maintenance Evaluation, US Army Test and Evaluation, US Army Test and Evaluation Command, 3 March 1971.

19. Army Regulation 70-44, DOD Engineering for Transportability, 9 August 1971.

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21. Test Operations Procedures 1-1-012, Classification of Deficiencies and Shortcomings, US Army Test and Evaluation Command, 28 March 1972.

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23. Department of the Army Approved Materiel Need (Engineering Development) (MN(ED)) for a 155-MM Howitzer, 22 May 1972.

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26. Letter, AMSTE-FA, US Army Test and Evaluation Command, 17 May 1973, Subject: Revised Test Directive for Development Test II (Service Phase) of the 155-MM, XM198 Towed Howitzer, TECOM Project No. 2-WE-200-198-009.

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28. Letter, STEBA-PL, US Army Field Artillery Board, 24 July 1973, Subject: Outline Test Plan (OTP) for the Development Test II (Service Phase) of the XM198, 155-MM, Towed, Howitzer.

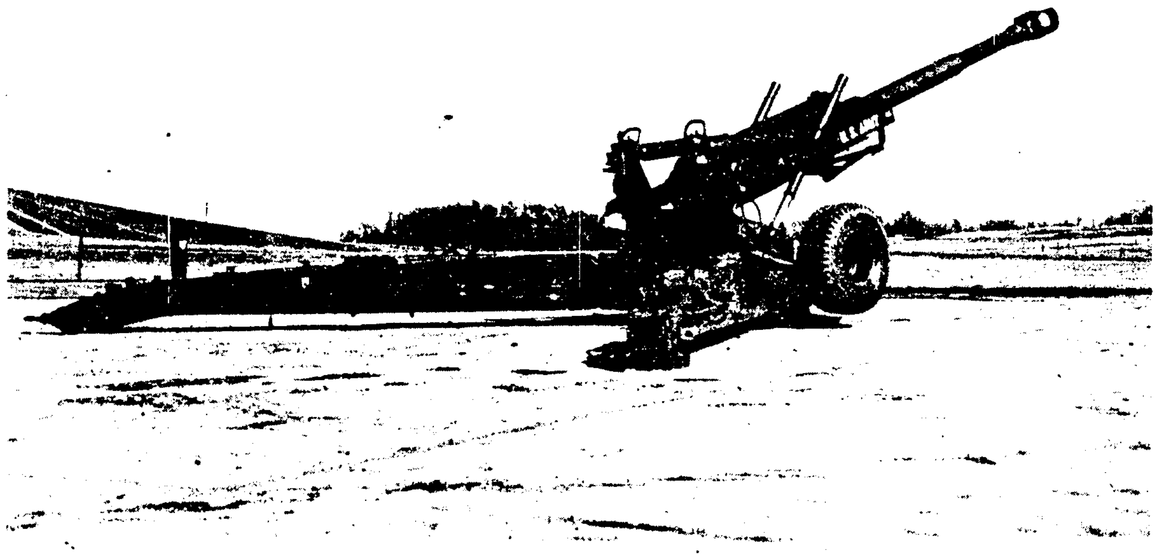
29. Coordinated Test Program (CTP) for Howitzer, Towed, 155-MM, XM198 and Charges, Propelling, 155-MM, XM203/XM201/XM164, 5 October 1973.

1.1.8 (U) The XM198 howitzer is being developed for world-wide employment. It will be airlifted by the CH47C helicopter and is planned for use in airmobile operations. It will provide general support fires, both conventional and nuclear, for the Division/Corps/Army. The XM198 howitzer will be placed in the infantry and airborne divisions and in separate battalions assigned at Corps level. Additionally, the US Marine Corps will use the XM198 howitzer.

1.2 (U) DESCRIPTION OF MATERIEL (U)

1.2.1 (U) Howitzer, XM198

The howitzer test item is a lightweight (15,000 pounds), towed 155-mm howitzer of split-trail design capable of being airlifted by the CH47C helicopter. It employs a high efficiency muzzle brake and, wherever practical, aluminum is used in the structure. To provide stability when firing, the wheels are raised and the weapon lowered onto a firing base hydraulically with hand pumps. The on-carriage traverse is limited to approximately 400 mils right and left of center. A rapid 6400-mil traverse capability is provided by an additional base plate installed behind the firing base. The cannon is designated the XM199 and is similar in design to the M185 cannon used on the M109A1 self-propelled howitzer. The XM45 recoil mechanism is a hydropneumatic variable dependent type which reduces recoil length at high angle fire. The fire control equipment is an improved version of the standard counter-type equipment designed for the bearing method of lay. Self-illumination is provided by means of radioactive materials. Figure 1 shows the advanced development prototype.



PHYSICAL CHARACTERISTICS

Length:	Tow position	39 feet 6 inches
	Stow position	23 feet 6 inches
	Firing position (0 mils quadrant elevation)	36 feet
Width:	Tow position	9 feet 2 inches
Height:	Tow position at muzzle brake	9 feet 6 inches

(U) Figure 1. Howitzer, Medium, Towed: 155-MM XM198 Advanced Development Prototype (U).

1.2.2 (C) Propelling Charges, XM164/XM201/XM203

The propelling charge test items are separate loading, granular, bag-type charges designed to provide indirect fire coverage of ranges between approximately 1,500 to 2,500 meters minimum and 28,500 to 31,000 meters maximum.

a. The XM164 is a base ignited charge consisting of five increments, zones 1 through 5, designed to provide range coverage in indirect fire from approximately 1,500-2,500 meters to 12,600 meters.

b. The XM201 is a base ignited charge consisting of two increments, zones 6 and 7, designed to provide range coverage in indirect fire from approximately 11,200 to 19,300 meters with unassisted projectiles and 17,600 to 24,000 meters with rocket-assisted projectiles.

c. The XM203 (successor to the XM123) is a center core ignited charge consisting of a single increment, zone 8, which is laced for rigidity and is designed to provide range coverage in indirect fire from 2500 to 23,000 meters with unassisted projectiles.

1.2.3 (C) Projectile, Rocket-Assisted High Explosive (HE) M549

The M549 projectile is a 155-mm rocket-assisted projectile weighing approximately 96 pounds. The projectile consists of a composition B filled, high-fragmenting steel warhead and a rocket motor with an ignition delay device. A protective cap on the ignition delay device precludes ignition of the rocket motor, thereby allowing firing of the projectile in the unassisted mode. Removal of the protective cap prior to firing enables the ignition delay device, consisting of two pyrotechnic columns, to be ignited by burning propelling charge gases. The ignition delay device allows the projectile to stabilize for approximately 7 seconds after launch prior to igniting the rocket motor. The rocket motor consists of two segmented, externally inhibited, nitrocellulose rocket propellant grains which burn for approximately 3 seconds, producing an increase in projectile velocity and, hence, range.

1.3 (U) TEST OBJECTIVES

a. The objectives of the DT II are:

1) To determine the technical performance and safety characteristics required by the MN, to obtain data for use in possible further development, and to determine the technical, safety, and maintenance suitability for operational

tests. The US Army Test and Evaluation Command (TECOM) Test Operations Procedure/Material Test Procedures (TOP/MTP's) 3-2-509 and 3-2-510 should be utilized in preparing the armament portion of the test and 2-2-511 in preparing the automotive portion. Specific objectives include, but are not limited to, adequacy and capability of the following:

a) Functioning suitability of all components.

b) Mobility.

c) Safety features.

d) Reliability and maintainability.

e) Laboratory environmental suitability.

f) Human Engineering aspects.

2) To determine the fatigue and wear life of the howitzer tube.

3) To determine that the propelling charges, XM164, XM201, and XM203 are safe to transport, store, handle, and fire from the 155-mm howitzer, XM198.

4) To determine ammunition performance, including range firing. The US Army Ballistic Research Laboratories should be contacted to obtain their requirements for the range firing.

5) To investigate the possibility of projectiles becoming "stuck" in the tube during low-zone fir'ngs, as has been previously experienced with the long-tubed 155-mm M109A1 system.

6) To determine a cook-off temperature for the zone 8 of the XM203 charge and to establish allowable rates of fire to prevent exceeding this critical temperature.

7) To determine to what degree the test items conform to user oriented requirements and performance standards.

8) To perform a maintenance evaluation in accordance with DA Regulation 750-1.

9) To perform a technical assessment based on the performance of the XM198 during testing.

1.4 (U) SCOPE

1.4.1 General

This DT plan will require the use of three complete XM198 weapon systems. One system will be used for the armament - weapon test and one each for range-table and tube-wear firing. Spare cannon and tube are to be used for ammunition-safety tests using some type of facility support. Mobility testing will be conducted at Aberdeen Proving Ground (APG) and on the Western Pennsylvania mountain-brake courses, using the armament-weapon test system.

Soldier-operator-maintainer testing will be integrated into this test during subtests pertaining to safety, human-factors engineering, and the maintenance evaluation. The soldier-operator-maintainer testing will be conducted at Yuma Proving Ground in conjunction with the tube-wear testing. It is anticipated that 2500 rounds will be fired by the military personnel during the tube-wear testing.

Soldier-operator-maintainer testing in this plan is designed to provide an assurance that the development process is reasonably complete and that the requirements and major technological problems associated with the soldier-operator-maintainer have been solved although refinement may yet remain. This assurance is more critical now that OTEA has been established as an independent Army tester, because it brings to each decision point the views of both the development testers and the operational testers. It is most desirable that the test item be evaluated via the medium of soldier-operator-maintainer testing to insure that the system is ready for full field tests prior to its release for operational testing.

The soldier-operator-maintainer tests will provide a basis for understanding problems presented by the operational tester at the decision points. The complex environment of an operational test program will make it difficult, if not impossible, to determine the origin of a problem as soldier-item related or operational-system related. The soldier-operator-maintainer test input will provide a sound base for determining whether the problem is, in fact, one that should be resolved by redesign or is related to doctrine, training, or tactics.

1.4.2 Armament and Mobility Testing

This portion of the test plan includes weapon-system instrumental, functioning, performance and expenditure wear (one tube) test phases.

The testing schedules for each phase of testing, are considered to be statistically adequate to satisfy the specific requirements of the test criteria.

Reliability data will be taken for all firings so that point estimates and confidence limits on reliability may be calculated.

The number of rounds scheduled to be fired during this test is statistically adequate to estimate performance parameters with a high degree of confidence and to detect significant differences in the performance parameters of projectiles fired in the XM198 howitzer and thise fired in the M114A1 howitzer. A possible exception to this statement is subtest 4.2, fatique-life test, which is discussed in the analytical plan.

1.4.3 Ammunition Testing

The ammunition testing at APG will be conducted to evaluate performance with respect to launch and flight safety, the effects of various handling and temperature environments, reliability, precision, and range. Data for provisional firing tables will be obtained in tests to be performed by Yuma Proving Ground in accordance with requirements established by the Ballistics Research Laboratory (References 5 and 6).

Zone 8 firings with M107 projectiles and other projectiles with similar rotating bands are included in the test on the assumption that obturators will be available to prevent loss of rotating bands during firing. The plan will be modified to conduct these firings at a lower zone if it becomes obvious that the obturators or a substitute fix will not be available.

Data for the evaluation of the reliability of the various components at extreme temperature (-60 and +145°F) will be obtained during the safety test only. Failures in most of the firings in that test cannot be attributed solely to a lack of reliability because of the extreme handling and firing conditions involved. Therefore, an additional sample of like size will be fired, with extreme conditions being limited only to temperature, to replace any sample in which a failure occurs that cannot be attributed solely to reliability.

The plan does not provide statistical verification of ammunition safety because of the extremely high reliability requirements. Testing under conditions more severe than those normally encountered and inspections for actual or incipient failure in recovered projectiles is done to increase confidence in the results while maintaining a reasonable sample size. Any single safety malfunction, whether occurring in the safety test or any other subtest, constitutes a failure to meet the safety criteria.

SUBTEST SCHEDULE

CARR. NO.	1ST QTR 75	2ND QTR 75	3RD QTR 75	4TH QTR 75	1ST QTR 76
4	← DURABILITY/YPG → 5500 RDS. XM 119		← OT II/SILL → 4500 RDS.	WEAR/YPG 2500 RDS. XM203	DURABILITY/YPG 9500 RDS. XM119
5	← ARMAMENT/MOBILITY/APG → 1000 RDS.		530 - XM123E2 470 - M3, M4, M119, XM164, XM201		
6		← OT III/SILL → 4500 RDS.			
7		← OT III/SILL → 700 RDS.			
8		← FIRING TABLES/YPG → 6700 RDS.			
Fac. Mt	← CANNON FAT./YPG → 3000 RDS				
Fac. Mt	← AMMO SAFETY & PERFORMANCE/APG → 3000 RDS. 900 - XM208E2				ASARC III

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SECTION 2. DETAILS OF WEAPON-SYSTEM TESTS (U)

2.1 (U) INTRODUCTION

This phase will be conducted on two complete XM198 weapon systems. Testing will consist of firing approximately 22,000 rounds to perform extensive instrumental and weapon performance tests. The XM198 weapon system used in this phase will be used for mobility road tests (Section 5).

Detailed records will be kept of all repairs, using the tools, parts, and test equipment, etc., specified in the maintenance manuals. The maintenance evaluation data which are generated will be reported in the formats (charts) shown in Supplement 1 to AR 750-1. Equipment performance reports will be prepared and submitted in accordance with TECOM Regulation 70-23. Comments on equipment publications will be submitted directly to the proponent agency on DA Forms 2028.

The subtests for this phase are arranged so as to complete short-time high-risk phases first, with longer-time low-risk phases following in descending order.

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2.2 (U) INITIAL INSPECTION AND SERVICING OF WEAPON

2.2.1 Objectives

a. To assure that the weapon system is in good condition mechanically and physically prior to the start of the test program.

b. To examine the maintenance test package for completeness and technical adequacy.

2.2.2 Criteria

a. All subsystems shall be complete, undamaged, and mechanically and physically operational (test agency).

b. The maintenance test package shall be complete, accurate, and adequate (para 34B, AMCR 750-15).

2.2.3 Method

Limited technical inspections are performed, and the serial numbers of major components are recorded. The initial condition of components is noted and other pretest observations are made.

It is ascertained that the brake signal and air braking systems are operational.

Recoil-mechanism inspections are performed to insure proper hydraulic-oil and nitrogen-pressure levels.

Appropriate draft DA equipment publications and lubrication orders will be used to assure good condition and adequate lubrication.

The maintenance test package will be checked against an official listing (to be received at least 2 weeks prior to the receipt of the test item) to verify its completeness.

If elements of the maintenance test package are missing, the items will be reported by teletype equipment performance report (EPR) in accordance with TECOM Regulation 70-23, Equipment Performance Reports, 22 October 1969.

As the test progresses, the package will be evaluated for the adequacy of the spare parts, the effectiveness of the special tools, and the adequacy of the procedural instructions on maintenance and/or repair as stated in the appropriate technical literature.

2.2.4 Data Required and Analytical Plan

The following data will be required:

a. Conditions found throughout inspections.

b. Repairs or maintenance performed.

c. Missing items or completeness of the maintenance test package.

An evaluation of the adequacy of the maintenance package will be made with reference to completeness, technical procedures, excesses, and shortages.

2.3 (U) PREFIRING PREPARATIONS AND STATIC CHECKS. TOP/MTP 3-2-510

2.3.1 Objectives

a. To insure satisfactory condition of the cannon, recoil mechanism, and carriage prior to the firing tests.

b. To determine accuracy, repeatability, and synchronization of the fire-control system with the cannon.

c. To record any structural changes of trails, carriage, cradle, and recoil mechanism through static measurements at critical areas.

d. To determine and record certain basic test data prior to firing.

e. To record essential maintainability and operational data.

f. To install the instrumentation necessary for each functional test phase.

2.3.2 Criteria

2.3.2.1 Cannon. The criteria are that:

a. The cannon shall meet all the requirements of applicable drawings and specifications (test agency).

b. The cannon components (i.e., tube, breech-mechanism assembly, and muzzle brake) shall be free of any cracks or defects (test agency).

c. The manually operated breech mechanism shall be free of interference with the carriage components at all firing elevations and at maintenance operation positions. Potentially hazardous or unsafe operating conditions will be noted and reported (test agency).

d. The sealing device for the cannon chamber shall positively prevent a leakage of propellant gases. It shall not cause undue delays in loading the propelling charge into the chamber (test agency).

e. The firing mechanism shall work smoothly and positively at all firing elevations when actuated by lanyard. All primers shall be ejected when the breech is manually opened (test agency).

2.3.2.2 Recoil Mechanism. The criteria are that:

a. The recoil-mechanism assembly shall meet all the requirements of applicable drawings and specifications (test agency).

b. There shall be no leaks at seals, packings, valves, connections, etc (test agency).

c. There shall be no damage to functional surfaces (i.e., recoil piston rod, and control rod) (test agency).

d. The recoil mechanism shall be free of any deformation, cracks, failure of welds, or loosening of bolts, screws, bearings, etc (test agency).

2.3.2.3 Equilibration System. The criteria are that:

a. The equilibration cylinders shall maintain pressures at seals, packings, valves, etc (test agency).

b. The equilibration system shall maintain reasonably equal elevation handwheel efforts throughout the full elevation and depression range of the weapon (test agency).

c. The top-carriage adjustable sliding connections for the equilibrators shall be free and operable at all times for temperature-change correction (test agency).

2.3.2.4 Elevation and Traverse Systems. The criteria are that:

a. The cannon shall be capable of being depressed between -75 and -100 mils from the horizontal when the carriage is level. Firing at maximum elevation shall not require a recoil pit (MN, para VIk(2)(c)4).

b. The weapon shall be capable of smooth traverse and elevation (MN, para VIk(2)(c)1).

c. The elevation system shall be capable of attaining a maximum elevation of +1275 mils (test agency).

d. Each handwheel shall be capable of obtaining at least 10 mils of movement per one full turn of the handwheel when the carriage is emplaced on level terrain (MN, para VIk(2)(c)2).

e. With the weapon balanced, the average force applied tangentially to the handcranks, at a uniform rate to maintain weapon movement, shall not exceed 15 pounds (test agency).

f. With the tube at zero and carriage cross leveled, the average force applied tangentially to the traverse handwheel to maintain movement shall not exceed 20 pounds (test agency).

g. A traverse and elevation shall be provided the gunner and an elevation handwheel shall be provided the assistant gunner provided (MN, para VIk(2)(c)3).

2.3.2.5 Fire-Control Equipment. The criteria are that:

a. It shall be possible for the weapon crew to boresight the fire-control equipment within 1 to 2 minutes (MN, para VIk(2)(d)1a).

b. Self-illumination of scales, level vials, counters, and reticles shall be provided for all fire-control equipment. Radioactive materials used to provide self-illumination shall comply with the provisions of AR 700-52 and AR 700-64 (MN, para VIk(2)(d)1b).

c. It shall be possible for the weapon commander to check the proper setting of the fire-control instruments without hampering the gunner (MN, para VIk(2)(d)1c).

d. The fire-control equipment shall be able to compensate for a 10 to 12° cant of the weapon (MN, para VIk(2)(d)1d).

e. A selectable ballistic reticle system with a means of changing reticles quickly shall be provided for the direct-fire telescope. A 2-man 2-sight system shall be provided for direct fire (MN, para VIk(2)(d)3a).

f. Both the 1-man 1-sight and 2-man 1-sight systems shall be provided for indirect fire. The equipment shall also allow the weapon to be laid for azimuth and elevation simultaneously, using either system (MN, para VIk(2)(d)2a).

g. A 4-power, 10-degree field of view panoramic telescope shall be provided (MN, para VIk(2)(d)2b).

h. A direct-fire telescope with 8-power magnification and a field of view tailored to meet acceptable size, weight, and cost parameters (but not less than 6 degrees) shall be provided (MN, para VIk(2)(d)3b).

i. A click-stop device for setting in leads of 5-mil increments will be provided (MN, para VIk(2)(d)3c).

j. Storage space for essential equipment such as sighting equipment, etc., will be provided (MN, para VIk(2)(e)).

2.3.2.6 Carriage, Trails, Firing Base, and Spades. The criteria are that:

a. There shall be no failure or deformation of trails, carriage, firing base, travel lock, or spades as a result of road travel or firing operations (test agency).

b. The trails shall be so designed that they do not interfere with the wheeled prime mover (M54 series) when towed in the long tow position.

c. The carriage hydraulic system shall be capable of lifting the carriage rapidly to enable meeting carriage-displacement requirements (test agency).

d. The weight of the weapon will be as light as possible but no greater than 14,600 pounds (MN, para VIk(1)).

2.3.3 Method

Before-fire inspections and tests are performed on the main armament, the carriage, and the on-carriage fire-control components in accordance with TOP/MTP's 3-2-509, 3-2-510, 3-2-600, 3-2-805, and 3-2-709.

Following the preliminary visual and functional inspections, the cannon and mount (recoil mechanism) are removed from the carriage. After a thorough cleaning, the howitzer and mount are disassembled in accordance with the Maintenance Allocation Chart provided in the maintenance test package (MTP) through the general-support level.

2.3.3.1 Howitzer Tube. The results of the star-gage, borescope, magnetic-particle, and ultrasonic inspections, the weights, the wall thickness, and the bore straightness (alignment) will all be recorded. The tube will be photographed both assembled and disassembled.

2.3.3.2 Breech Mechanism. The results of the magnetic-particle inspection of major components, the weights, and photographs, including an exploded view, will be obtained.

2.3.3.3 Muzzle Brake. The results of the magnetic-particle inspection, the weights, and photographs will be obtained.

2.3.3.4 Recoil Mechanism. The results of the magnetic-particles inspection or inspection by the fluorescent penetrant method (Zyglo) of welds, cylinders, recoil, and control rods will be obtained. Measurements of the following (for conformance to applicable drawings) will be taken:

a. Eccentricity of recoil, recuperator, control, and piston rods.

b. Inside diameters of recoil, recuperator, and replenisher (at 2-inch increments).

c. Outside diameters of rods (at 2-inch increments).

d. Outside diameters of pistons (front and rear).

e. Depth and width of oil-seal grooves.

f. Weight of recoiling parts and complete assembly.

g. Photographs showing assembled and disassembled views.

All hydraulic oil drained from the recoil cylinders will be filtered through a 5-micron filter to detect the presence of metallic or abrasive particles.

Complete sets of new seals, provided through supply channels, will be used upon reassembly of the mount.

Upon completion of the before-fire teardown inspections, the cannon and the mount are reassembled and properly serviced. The recoil mechanism is given a static pressure test in accordance with applicable drawings. The complete assembly (i.e., cannon and mount) will be exercised through full recoil to verify normal functioning.

2.3.3.5 Cradle Assembly, Top Carriage, and Trails. An inspection will be made of welds, and critically stressed areas using the fluorescent - penetrant method. Measurements of the tube-cradle bearing (inside diameter) will be recorded and trammel points will be established on each assembly to ascertain possible deformation during the progress of testing.

2.3.3.6 Bottom Carriage, Firing Base, Travel Lock, Road Wheel Arms Assemblies, and Spades. The magnetic-particle or fluorescent - penetrant method of inspection will be used as appropriate. An inspection of the hydraulic lift system, the pump, valves, lines, connections, etc., will be conducted. Periodically, the manual and air-brake systems will be inspected.

2.3.3.7 Elevating Mechanism. This will be inspected for freedom of operation. Operation should be smooth throughout the full elevating range. Disassembly of these items will be made only when a malfunction develops, and at the conclusion of all testing.

2.3.3.8 Equilibrators. These are inspected for freedom of operation, leaks, seals, pressure levels, use of special tools, servicing operations, etc. Disassembly of these items will be made only because of malfunction, at the conclusion of all testing, or for any necessary inspections.

2.3.3.9 Speed-Shift Device. The speed-shift mechanism will be placed in operation with the weapon system positioned on level terrain and on slopes, left and right, up to 10°, to observe its operation and ease of shifting the weapon to a new azimuth position when lifting the trails.

2.3.3.10 Weapon System Static Tests. After reassembly of the complete weapon and after proper servicing, the following functional tests will be conducted:

a. Mount all on-carriage fire-control components and check the ease of mounting, clearances, etc. Check visual satisfactoriness of scales, counter, vials, and reticles.

b. Check the adequacy of the direct- and indirect-fire telescope storage box, retention of the telescope, fasteners, etc.

c. The weapon will be leveled by the three-point suspension method using mechanical jacks, chamber borescope, muzzle cross hairs, and vertical plumb line.

d. Conduct a fire-control performance check on both the direct- and indirect-fire systems to determine backlash, synchronization, alignment of panoramic telescope, horizontal deflection of panoramic telescope, accuracy of elevation counter, boresight adjustment of the direct-fire telescope, boresight retention, ease and simplicity of adjustments, and knob-torque efforts.

e. With the carriage cross leveled, measure handwheel efforts on traverse (clockwise and counterclockwise) at howitzer elevations of 0°, 45°, and 75° with the weapon positioned at center and at maximum right and left traverse. Repeat the above with the carriage at a 5° and 10° cant.

f. Measure manual-handwheel efforts to depress and elevate the howitzer at the following elevation check points: 0, 100, 400, 700, 1000, and 1333 mils.

g. Measure the change in howitzer elevation and traverse for each turn of their respective handwheels.

h. Measure the full elevating range (depression and elevation) of the weapon with the carriage level.

2.3.4 Data Required and Analytical Plan

The following data are recorded.

2.3.4.1 Cannon. The data include:

a. The results of initial, periodic, and final inspections (i.e., star-gage, borescope, pull-over, magnetic-particle, ultrasonic, bore straightness, and wall thickness) of applicable cannon components. Inspection events should be identified by the number of EFC rounds placed on the components (i.e., tube, breechring, muzzle brake, etc.) to permit the acquisition of reliable maintainability and parts service-life data.

b. The following will be recorded:

1) Weight of tube.

2) Weight of breech mechanism (complete).

3) Weight of muzzle brake.

4) Center of gravity of tube only.

5) Center of gravity of cannon (complete).

2.3.4.2 Recoil Mechanism. The data include:

a. Results of initial visual inspection (i.e., evidence of leakage of oil or gas, damage, etc.).

b. Ease of disassembly and assembly. Adequacy of special tools furnished for this purpose.

c. Condition of hydraulic oil from recoil assembly before initial teardown and final after-test teardown.

d. After the initial and final teardown inspection, the following information will be recorded:

1) Inside diameters of recoil, recuperator, and replenisher cylinders.

2) Eccentricity and outside diameters of all rods.

3) Depth and width of all oil-seal grooves.

4) Outside diameters of recoil, recuperator, and replenisher piston.

5) General condition of all cylinder walls, friction surfaces, and oil seals.

6) Inside diameter of cradle-tube bushing.

7) Weight of recoiling parts.

8) Total weight of complete recoil mechanism, assembled and serviced.

9) Hydraulic-oil capacity for proper operation.

10) Recoil piston metal-to-metal distance of recoiling howitzer.

2.3.4.3 Fire Control. The data include:

a. Initial condition and periodic check findings of all on-carriage fire control (i.e., telescopes, mounts, quadrant, vials, counters, illumination, etc.).

b. Adequacy of telescope storage container.

c. The tabulated data on:

1) Alignment of panoramic telescope.

2) Horizontal deflection of panoramic telescope.

3) Accuracy of elevation counters.

4) Backlash of elevation counters.

5) Boresight adjustment of direct-fire telescope.

6) Boresight retention (direct and indirect).

d. Any interferences, malfunctions, failures, etc.

2.3.4.4 Weapon System. The data include:

a. The results of all nondestructive tests for weapon-system components.

b. Handwheel-torque efforts for elevating and depressing.

c. Handwheel-torque efforts for traversing.

d. Equilibrated cylinder pressures at specific elevations of the howitzer.

e. The rates per one turn of the handwheel (elevation and traverse).

2.3.4.5 General. These data include:

a. Note effectiveness of any or all safety devices (during field operation or maintenance).

b. Note other hazards, interferences, use of special tools, etc.

c. During all phases of maintenance, record time required to clean, check, repair or adjust a specific component or a system.

2.4 (U) WEAPON AND PRIME MOVER, CHARACTERISTICS

2.4.1 Objective

The objective is to present tabulated and pictorial characteristics.

2.4.2 Criteria

Not applicable.

2.4.3 Method

The appropriate dimensions, weights, descriptions, payloads, and performance characteristics of each item will be extracted from various technical sources.

Full-coverage characteristic photographs will be taken.

2.4.4 Data Required and Analytical Plan

The following is required:

a. Dimensions, weights, and physical characteristics of the weapon and eligible prime movers.

b. Weapon-performance characteristics.

The data collected will be tabulated to provide a detailed definition of the vehicles and the weapon.

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2.5 (U) FIRING TESTS, RECOIL INSTRUMENTAL, TOP/MTP 3-2-509

2.5.1 Objectives

a. To obtain recoil-system performance data when the weapon is fired under local ambient-temperature conditions.

b. To obtain functional information on the cannon.

c. To determine the design adequacy of the equilibration, elevating, and traversing systems.

d. To determine the degree of weapon displacement, and the vertical trail movements for various soil conditions.

e. To determine the duration and degree of tube whip resulting from firing.

2.5.2 Criteria

The criteria are that:

a. The pressure-versus-time curves for the recoil and recuperator cylinders shall not show excessive rise rates indicative of either improper oil-throttling or design defects (test agency).

b. Recoil-reaction cylinder pressures and individual peaks for rod pull shall not exceed the design limitations (test agency).

c. The equilibration and elevations systems shall allow smooth and positive laying of the weapon at all elevations. Firing shocks shall not produce abnormal changes in elevation (test agency).

d. The traversing system shall allow smooth and positive traversing of the weapon under all specified conditions (test agency).

e. The time-travel-velocity curves for the cannon, developed during the firing cycle, shall meet the requirements of applicable drawings and specifications. They shall not indicate erratic recoil travel or slamming of the howitzer into battery (test agency).

f. The muzzle brake shall not fail during the established round-service life of the tube (test agency).

g. Tube whip shall not degrade the combat effectiveness of the weapon or place undue stresses on the mounting systems (test agency).

h. The firing stability of the weapon system shall be sufficient to permit safe, rapid, or sustained loading, laying, and firing of the howitzer without delays or excessive physical effort by crew (test agency).

i. The design of the cannon and related components shall be such that the cannon will be capable of firing all standard and developmental rocket-assisted and unassisted US/UK/FRG 155-mm projectiles as specified in appropriate ratified standardization agreements (MN, para VIk(3)).

j. The weapon shall be capable of manual loading at all elevations up to the elevations required to achieve maximum ranges for current and developmental munitions (MN, para VIg(3)).

k. The weapon shall be capable of at least 800 mils on-carriage traverse (at least 400 mils left and right). Maximum traverse is desired without increasing the size, weight, or complexity of the weapon. A rapid speed shifting capability for 6400 mils traverse shall also be provided (MN, para VIh).

2.5.3 Method

2.5.3.1 Proof Firing. Prior to conducting any ET firings, the weapon (i.e., cannon and recoil mechanism) will be proof-accepted in accordance with established procedures.

2.5.3.2 Preparations. These include:

a. Instrumental Phase. Instrumental testing of the weapon system will be according to the guide lines presented in TOP/MTP's 3-2-509 and 3-2-510. Preparations, after the cannon and mount have passed all proof-acceptance requirements satisfactorily, are as follows:

1) The breechblock will be modified through adequate design to receive an internal tourmaline pressure transducer (0 to 60,000 psi) to record chamber pressure versus time data.

2) A device for recording velocity travel versus time of the cannon motion relative to the cradle will be designed, fabricated, and mounted to the weapon system.

3) A transducer (CEC gage, 0 to 10,000 psi) will be installed in the recuperator assembly (oil and gas side); one transducer (CEC gage, 0 to 10,000 psi) will be installed in each recoil cylinder (forward end).

4) A rod-pull gage (0 to 50,000 pounds) will be designed, fabricated, and installed on each recoil rod.

5) A linear measuring device will be installed at each elevating mechanism to record relative vertical movement between the cradle and the top carriage.

6) A linear measuring device will be used at each trail end to measure vertical movement relative to the ground.

7) Load-measuring devices (strain gages) will be installed on the elevation mechanisms.

8) Strain gages will be installed on the elevation drive shaft to measure torque strain.

9) Strain gages will be installed on the trails to measure the peak strain due to bending and impact loading.

10) Strain gages will be installed at the muzzle (in line with the end of rifling) and at stations along the surface of the tube to record projectile travel and bore pressures versus time. These strain gages and the chamber-pressure and tourmaline gages should be so instrumented as to provide a common zero time base.

11) The necessary strain gages will be installed at critical attachment areas of the cradle (trunnions, tube bearing, elevating-screw mechanisms, etc.).

12) Brackets will be installed at the bottom carriage and trail ends (spades) to record vertical and rearward hop.

13) On the firing range, utilizing a special Mitchell camera (100 frames per second) tube whip and weapon movement relative to the ground and carriage will be recorded.

14) On the firing range, using high-speed camera coverage, projectile exit from the tube, weapon action, and obscuration will be recorded.

15) Motion-picture cameras (color 16-mm) will be used to obtain general views of over-all action (emplacement of weapon, loading, and firing). Still cameras (color and black and white) will be used to record significant events or items (i.e., failures, new components, etc.).

b. Firing Phase. The minimum number of rounds to be fired are shown in Table 2.5-I.

Table 2.5-I (U). Instrumental Firing Schedule (U)

Projectile: M107 (inert, sand and steel); weight with fuze, 95 pounds.
Projectile: XM549, or modified M107 (inert, sand and steel); weight with fuze, 96 pounds.
Projectile: M101 (inert, sand and steel); weight with fuze, 96 pounds.
Charges: M3A1, M4A1 or M4A2, M119, XM164, and XM203.
Primer: M82.
Fuze: M73 dummy or M78 inert.

Round No.	How. Elevation, degrees	Projectile Model No.	Propelling Charge Model No.	Propelling Charge Zone or % UPL	See Table 2.5-II Recorded Data (rounds)
Weapon Traverse, Over Front					
1 to 5	2	M107	M3A1	1	1 thru 11
6 to 8	2	M107	M3A1	2	1 thru 11
9 to 10	2	M107	M4A2	3	1 thru 11
11 to 12	2	M107	M4A2	5	1 thru 11
13 to 14	2	M107	M4A2	7	1 thru 14
15 to 16	2	XM549	XM164	1	1 thru 11
17 to 18	2	XM549	XM164	2	1 thru 11
19 to 20	2	XM549	XM164	3	1 thru 11
21 to 22	2	XM549	XM164	4	1 thru 11
23 to 24	2	XM549	XM164	5	1 thru 11
25 to 26	2	XM549	XM203	6	1 thru 16
27 to 28	2	XM549	XM203	7	1 thru 16
29 to 30	2	XM549	XM203	8	1 thru 16
31 to 32	2	M101	XM203	(115)	1 thru 16
33 to 34	2	M107	M119	8	1 thru 16
35 to 36	45	M107	M4A2	7	1 thru 5, 8 thru 16
37 to 38	45	M107	M119	8	1 thru 5, 8 thru 16
39 to 40	45	XM549	XM164	1	1 thru 5, 8 thru 11
41 to 42	45	XM549	XM164	3	1 thru 5, 8 thru 11
43 to 44	45	XM549	XM164	5	1 thru 5, 8 thru 11
45 to 46	45	XM549	XM203	6	1 thru 5, 8 thru 11
47 to 48	45	XM549	XM203	7	1 thru 5, 8 thru 15
49 to 50	45	XM549	XM203	8	1 thru 5, 8 thru 16
51 to 52	45	M101	XM203	(115)	1 thru 5, 8 thru 16

Table 2.5-I (Cont'd)

Round No.	How. Elevation, degrees	Projectile Model No.	Propelling Charge Model No.	Propelling Charge Zone or % UPL	See Table 2.5-II Recorded Data (rounds)
53 to 54	70	XM549	XM164	1	1 thru 5, 8 thru 11
55 to 56	70	XM549	XM164	5	1 thru 5, 8 thru 11
57 to 58	70	M107	M4A2	7	1 thru 5, 8 thru 16
59 to 60	70	M107	M119	8	1 thru 5, 8 thru 16
61 to 62	70	XM549	XM203	6	1 thru 5, 8 thru 15
63 to 64	70	XM549	XM203	7	1 thru 5, 8 thru 15
65 to 66	70	XM549	XM203	8	1 thru 5, 8 thru 16
67 to 68	70	M101	XM203	(115)	1 thru 5, 8 thru 16
		Right Traverse			
69 to 70	2	M107	M4A2	7	1 thru 5, 8 thru 16
61 to 72	2	XM549	XM203	7	1 thru 5, 8 thru 11
73 to 74	2	XM549	XM203	8	1 thru 5, 8 thru 16
75 to 76	45	M107	M4A2	7	1 thru 5, 8 thru 16
77 to 78	45	XM549	XM203	7	1 thru 5, 8 thru 11
79 to 80	45	XM549	XM203	8	1 thru 5, 8 thru 16
81 to 82	70	M107	M4A2	7	1 thru 5, 8 thru 16
83 to 84	70	XM549	XM203	7	1 thru 5, 8 thru 11
85 to 86	70	XM549	XM203	8	1 thru 5, 8 thru 16
		Left Traverse			
87 to 88	2	M107	M4A2	7	1 thru 5, 8 thru 16
89 to 90	2	XM549	XM203	7	1 thru 5, 8 thru 11

Table 2.5-I (Cont'd)

Round No.	How. Elevation, degrees	Projectile Model No.	Propelling Charge Model No.	Propelling Charge Zone or % UPL	See Table 2.5-II Recorded Data (rounds)
91 to 92	2	XM549	XM203	8	1 thru 5, 8 thru 16
93 to 94	45	M107	M4A2	7	1 thru 5, 8 thru 16
95 to 96	45	XM549	XM203	7	1 thru 5, 8 thru 11
97 to 98	45	XM549	XM203	8	1 thru 5, 8 thru 16
99 to 100	70	M107	M4A2	7	1 thru 5, 8 thru 16
101 to 102	70	XM549	XM203	7	1 thru 5, 8 thru 11
103 to 104	70	XM549	XM203	8	1 thru 5, 8 thru 16

Note: In addition to the above schedule, fire service round (XM203 zone 8) at increments of elevation (5°) to establish full changeover of recoil length from long to short. Also, fire sufficient rounds to establish the degree of weapon displacement in various soil types without additional support to spades (i.e., sand, gravel, soft soil, and hard soil).

2.5.4 Data Required and Analytical Plan

The following data are recorded:

a. The data to be recorded are shown in Table 2.5-II.

Table 2.5-II (U). Recorded Data (U)

No.	Type of Data	Remarks
1	Muzzle velocity	2° firings, only
2	Peak chamber pressure	T17 or M11 gages
3	Recoil lengths	Mechanical marker
4	Projectile seating	Inches
5	Recoil cycle time	Electric clock
6	Chamber pressure versus time (one channel)	Internal tourmaline gage
7	Tube strain versus time (three channels)	C-1 gage

Table 2.5-II (Cont'd)

No.	Type of Data	Remarks
8	Recoil-cylinder oil pressure versus time (2 channels)	CEC gage
9	Recuperator gas and oil pressure versus time (2 channels)	CEC gage
10	Recoil-rod pull versus time (2 channels)	C-1 gage
11	Weapon recoil travel-velocity versus time (2 channels)	Potentiometer rack and bracket
12	Elevation screw mechanism load versus time (2 channels)	C-1 gage
13	Cradle strain versus time (4 channels)	C-1 gage
14	Trail load versus time (6 to 8 channels)	C-1 gage
15	Carriage and trail (at spade) hop	Mechanical board
16	Tube whip and carriage movement versus time	Mitchell camera

b. The data to be reported are shown in Table 2.5-III.

Table 2.5-III (U). Reported Data (U)

Type of Data	Type of Presentation	No. of Rounds
Corrected muzzle velocities	Tabulated	2° firings only
Peak chamber pressures	Tabulated	All rounds
Recoil lengths	Tabulated	All rounds
Recoil cycle times	Tabulated	All rounds
Projectile seating	Tabulated	Typical rounds
Chamber pressures peak versus time	Tabulated (peaks)	Typical rounds
	Graphical	Typical rounds
Recoil cylinder oil pressure versus time	Tabulated (peaks)	All rounds
	Graphical	Typical rounds
Recuperator cylinder oil pressure versus time	Tabulated (peaks)	All rounds
	Graphical	Typical rounds
Recuperator cylinder gas pressure versus time	Tabulated (peaks)	All rounds
Recoil travel-velocity versus time	Tabulated (peaks)	All rounds
	Graphical	Typical rounds
Elevation mechanism screw strain versus time	Tabulated	All rounds
Cradle strain versus time	Tabulated	All rounds
Trail strain versus time (bending)	Tabulated	Typical rounds

Table 2.5-III (Cont'd)

Type of Data	Type of Presentation	No. of Rounds
Trail strain versus time (impact load)	Tabulated	Typical rounds
Elevation shaft torque loads	Tabulated	All rounds
Tube whip versus time	Graphical	Typical rounds
Vertical movement of trails	Tabulated	Typical rounds

2.6 (U) FIRING TESTS, MUZZLE-BLAST OVERPRESSURES, TOP/MTP 3-2-811

2.6.1 Objective

The objective is to determine the muzzle-blast overpressure, impulse, and noise levels which are developed at critical positions immediate to the crew operation area.

2.6.2 Criterion

The criterion is that blast and noise induced by firing shall not result in the need for special individual protective equipment for field artillery personnel. Overpressure in the crew area shall not be greater than 3 pounds per square inch (psi) (MN, para VIm(1)).

2.6.3 Method

2.6.3.1 Preparation. This includes:

a. All blast gages (electronic recording types), will be calibrated in accordance with TOP/MTP's 4-2-822 and 3-2-811.

b. Gages will be positioned for all tests at a point 5 feet above ground level.

c. Calibration will be by the detonation of bare 1-pound spherical pentolite explosive charges.

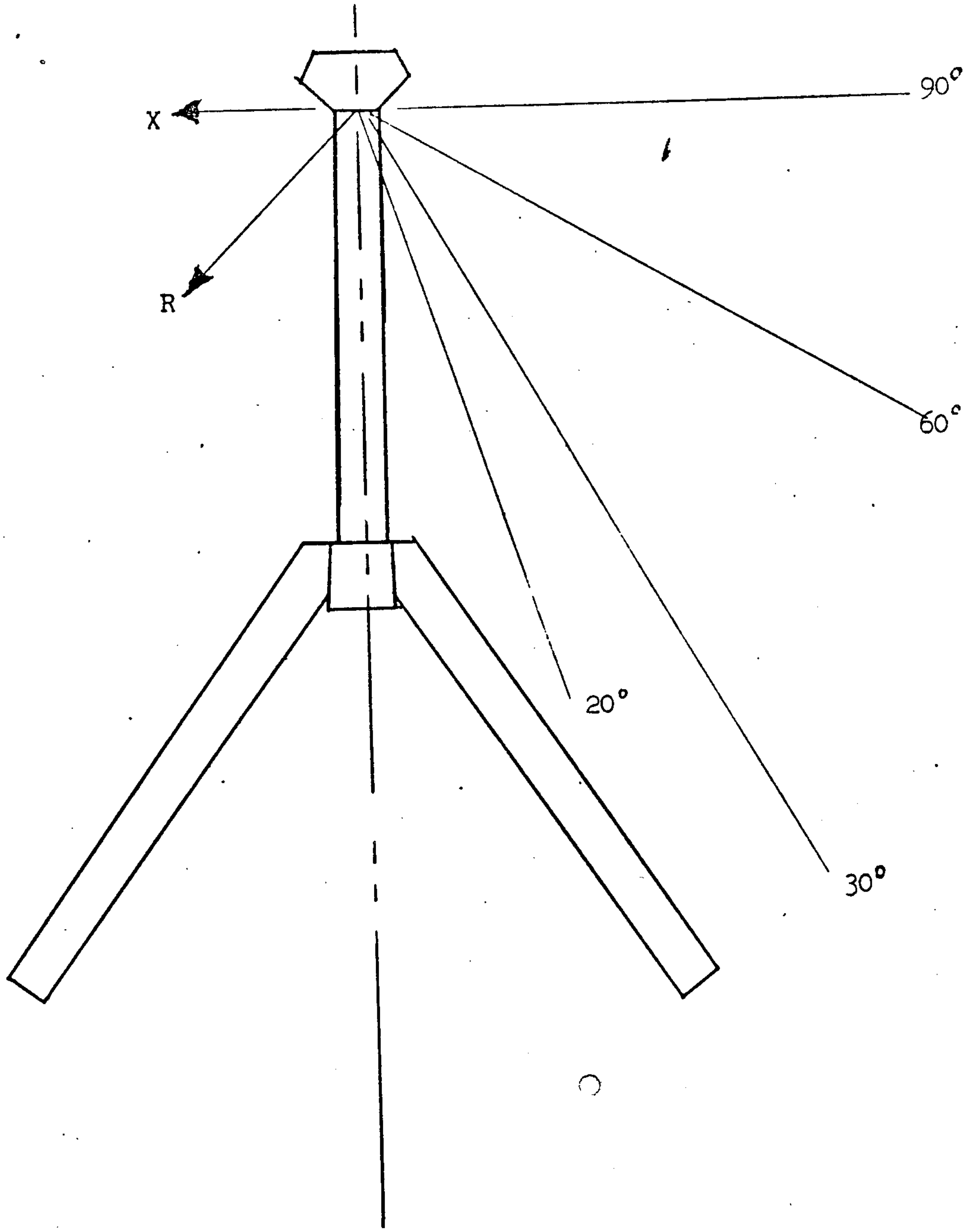
d. Upon each change of howitzer elevation the gages will be re-oriented toward the muzzle.

e. The locations of gages to record muzzle-blast overpressure are as follows:

1) Locate gages in positions 1 through 8 as designated in the tabular listing in Figure 2.6-1.

2) Repeat gage positions 1 and 2 for the assistant gunner's side (right side) of weapon.

3) Position the gages in a fan-scale manner for 180° on either side of the weapon on angles from the muzzle, as designated in Figure 2.6-1. The distances from the muzzle will be from 20 to 50 feet along the projected lines.



Gage No.	1	2	3	4	5	6	7	8
R (ft)	23	21.6	21.6	21.6	24	27	30	39
X (ft)	1.9	3.7	5.4	7.2	7.9	4.7	2.6	6.8

All gages 5.0ft from ground measured at o° quadrant elevation

Figure 2.6-1 (U): Blast-Gage Location Diagram (U).

4) Perform maximum left traverse (22.5°) firing of the weapon with the gages positioned as designated in the tabular listing in Figure 2.6-1. The gages would be relocated to the same relative position to the cannon center line and muzzle (Figure 2.6-1). Distances would be verified. Perform only at zero howitzer elevation.

2.6.3.2 Firing Phase. The schedule of rounds shown in Table 2.6-2 will be fired.

Table 2.6-I (U). Overpressure Firing Schedule (U)

Projectile: M107 (inert, sand and steel); weight with fuze, 95 pounds.
Projectile: XM549, modified, M107 (inert, sand and steel); weight with fuze, 96 pounds.
Charges: M4A1 or M4A2, M119, XM164, and XM203.
Primer: M82.
Fuze: M73 or M78 inert.

Round	How. Elevation, degrees	Projectile Model	Propelling Charge Model	Propelling Charge Zone	Chg Temp, degrees
1 to 3	5	M107	M4A2	7	+ 70
4 to 6	5	M107	M119	8	+ 70
7 to 9	5	XM549	XM164	5	+ 70
10 to 12	5	XM549	XM203	7	+ 70
13 to 15	5	XM549	XM203	8	+ 70
16 to 18	5	XM549	XM203	8	+145
19 to 21	5	XM549	XM203	8	- 65
22 to 24	45	M107	M4A2	7	+ 70
25 to 27	45	XM549	XM203	7	+ 70
28 to 30	45	XM549	XM203	8	+ 70
31 to 33	70	M107	M4A2	7	+ 70
34 to 36	70	XM549	XM203	7	+ 70
37 to 39	70	XM549	XM203	8	+ 70

2.6.4 Data Required and Analytical Plan

The following data will be required:

a. Blast overpressures (psi).

b. Impulse (psi X milliseconds).

c. Duration (ms).

d. Sound-pressure levels (db) based on 0.0002 dynes per square centimeter.

e. Peak chamber pressure.

The following analytical plan will be required:

a. Develop isobaric charts depicting areas of approximately equal blast pressures relative to the muzzle.

b. Convert overpressure (psi) tabular data to db tabular data.

2.7 (U) FIRING TESTS, ACCELERATION

2.7.1 Objective

The objective is to determine the acceleration forces and vibrational characteristics (developed during firing) for the critical mounting surfaces of the fire-control equipment.

2.7.2 Criterion

The criterion is that firing shocks shall not cause damage, deformation, loosening of optics, or malfunctioning of any part of the fire-control system (test agency).

2.7.3 Method

2.7.3.1 Preparations. These include:

a. Calibrate 21 accelerometer gages (CRL Model 302 or similar) through an operating range of 0 to 75 g's (gage capacities of ±10,000 Hz and 0 to ±10,000 g).

b. Design and fabricate gage-mounting blocks (in the vertical, longitudinal, and horizontal directions) for the following areas:

1) Panoramic telescope head.

2) Panoramic telescope eyepiece.

3) Elevation quadrant (panoramic telescope side).

4) Mount, telescope, pivot arm bracket.

5) Direct-fire telescope, M114, front.

6) Quadrant, M14.

7) Direct-fire telescope eyepiece.

2.7.3.2 Firing Phase. The schedule of rounds shown in Table 2.7-I will be fired.

Table 2.7-I (U). Acceleration Firing Schedule (U)

Projectile: M107 (inert, sand and steel); weight with fuze, 95 pounds.
Projectile: XM549 or modified M107 (inert, sand and steel); weight with fuze, 96 pounds.
Charges: M4A1 or M4A2; XM203.
Fuzes: M73 dummy.
Primer: M82.

Rounds	Elevation, degrees	Projectile Model	Propelling Charge Model	Propelling Charge Zone	Traverse
1 to 2	5	M107	M4A1	7	Center
3 to 4	5	XM549	XM203	8	Center
5 to 6	45	M107	M4A1	7	Center
7 to 8	45	XM549	XM203	8	Center
9 to 10	70	M107	M4A1	7	Center
11 to 12	70	XM549	XM203	8	Center
13 to 15	5	XM549	XM203	8	Max right
16 to 18	45	XM549	XM203	8	Max right
19 to 21	70	XM549	XM203	8	Max right
22 to 24	5	XM549	XM203	8	Max left
25 to 27	45	XM549	XM203	8	Max left
28 to 30	70	XM549	XM203	8	Max left

2.7.4 Data Required and Analytical Plan

The following data will be required:

a. Peak g values in both longitudinal and vertical planes for each test condition and for each component listed in paragraph 2.7.3.

b. A plot of typical vibration characteristics.

c. A representative oscillograph showing an actual record for the 5000-Hz, 2500-Hz, and 600-Hz spectrums.

The following analytical presentations will be required:

a. An analysis to determine the rms accelerations.

b. Spectral analyses for representative severe conditions will be presented.

2.8 (U) FIRING TESTS, CLIMATIC, TOP/MTP 3-2-509

2.8.1 Objective

The objective is to evaluate the performance of the armament, the recoil mechanism, the on-carriage fire-control equipment, the structural integrity, and the braking system (static tests) under extreme temperature conditions.

2.8.2 Criteria

a. All components of the weapon system shall be safely operable under temperature conditions which vary from +125 to -60°F (AR 70-38).

b. The functional characteristics of the recoil mechanism shall conform to specification MIL-M-45212A(ORD).

2.8.3 Method

2.8.3.1 Shop Preparations. These include:

a. The cannon will be thoroughly cleaned and inspected. All howitzer components will be magnetic-particle inspected prior to the climatic tests.

b. Prior to the conditioning at the extreme cold-temperature phase, the cannon assembly will be winterized as prescribed.

c. Prescribed measures will be taken to winterize the elevating mechanism and the traverse system, if required, prior to emplacing it into the climatic chamber.

d. Mount the potentiometer rack and gear assembly for recording cannon velocity-travel versus time.

e. Install transducers (CEC gages; 0 to 10,000 psi) in the recuperator assembly (oil side and gas side). Install one transducer (CEC gage; 0 to 10,000 psi) in each recoil cylinder (forward end).

f. Install rod-pull gages (0 to 50,000 pounds) on each recoil rod.

g. Install strain gages on the elevation drive shaft to record torque strain; install strain gages on the trails (180° apart) to measure thrust force; install strain gages on the recoil cradle at selected locations for evaluation.

h. Mount a motion-picture camera (125 frames per second) to record over-all dynamic action.

i. Emplace the weapon system in the climatic facility for maximum full traverse, if possible.

2.8.3.2 Firing Phase. The schedule of rounds shown in Table 2.8-I will be fired at howitzer elevations of 5, 45, and 70°.

Table 2.8-I (U). Climatic Firing Schedule (U)

Projectile: M107 (inert, sand and steel); weight with fuze, 96 pounds.
Projectile: M101 or modified M107 (inert, sand and steel); weight with fuze, 96 pounds.
Projectile: XM549 (inert, sand and steel); weight with fuze, 95 pounds.
Charges: M4A1 or M4A2, M119, XM164, and XM203.
Primer: M82.
Fuze: M73 dummy.

Round No.	How. Elevation, degrees	Projectile Model	Propelling Charge Model	Propelling Charge Zone or % UPL
1	5	M107	M4A1	7
2	5	M107	M119	8
3	5	XM549	XM164	5
4 and 5	5	XM549	XM203	8
6	5	M101	XM203	115
7 to 12	45	Repeat order of rounds 1 through 6		
13 to 18	70	Repeat order of rounds 1 through 6		

The 6-round schedule at three different elevations shown in Table 2.8-I will be fired at each of the temperature levels, in the order shown in Table 2.8-II.

Table 2.8-II (U). Temperature Levels (U)

Order No.	Temperature, °F	Soaking Period, hours
1	+ 70	Not less than 12
2	+125	Not less than 36
3	+125	Not less than 24
4	- 40	Not less than 48
5	- 60	Not less than 24

2.8.4 Data Required and Analytical Plan

The following data will be required:

a. Projectile seating distance, inches.

b. Peak chamber pressure (M11 gage).

c. Recoil and recuperator cylinder oil/gas pressure versus time.

d. Cannon travel-velocity versus time.

e. Strain measurements: trails, recoil cradle, elevation shaft, etc.

f. Recoil-cycle time (electric timer).

g. Recoil lengths.

h. Recuperator-oil temperature.

i. Obturator-ring seal performance. (Note condition of ring seals before and after firing each round and adjustment to seal due to temperature effects.)

j. Functioning of breech mechanism.

k. Ease of operation of all fire-control components.

l. Condition of optics (i.e., fogging of lenses).

m. Condition of rubber eyepiece.

n. Functioning of manual brake system.

o. Condition of air-brake hoses, boosters, connections, etc.

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2.9 (U) FIRING TESTS, RAPID AND SUSTAINED FIRE

2.9.1 Objectives

a. To determine the operational capability of the weapon system in performing rapid and sustained fire rates.

b. To measure the maximum tube-chamber and breechblock temperatures developed during the rapid- and sustained-fire phases (allowable temperature will be determined by cook-off test).

2.9.2 Criteria

a. The firing stability of the weapon system shall be sufficient to permit safe rapid or sustained loading, laying, and firing of the howitzer without delays or excessive physical effort by the gun crew (test agency).

b. The weapon shall be capable of firing the new ballistically matched family of projectiles at a rate of four to six rounds per minute for 3 minutes, at all howitzer elevations up to the elevations required to achieve maximum ranges of current and developmental munitions. A burst rate of fire for this weapon is not required (MN, para VIg(1)).

c. The sustained rate of fire shall be between one and two rounds per minute for 30 minutes and one round per minute thereafter (MN, para VIg(2)).

d. During rapid- and sustained-fire rates the surface temperature of the chamber 30 inches forward of the seal rings shall not exceed maximum allowable temperatures established by cook-off tests (test agency).

2.9.3 Method

2.9.3.1 Preparations. These include:

a. This test phase will be performed after the instrumental performance data of the weapon system have been evaluated as to the safe operation of the crew immediate to the weapon.

b. Prior to performing the test, the weapon will be checked for adequate operation of all systems, and the cannon will be subjected to nondestructive inspections (i.e., star-gage, magnetic-particles inspections, fire-control checks, boresighting, trammel-point checks, etc.).

c. Thermocouples will be placed on the exterior surface of the tube as follows:

1) Just forward of the breech ring.

2) At mid chamber.

3) Five inches behind origin of rifling.

4) At origin of rifling.

5) Six inches forward of origin of rifling.

6) Forward of recording surface.

7) Just behind muzzle brake.

The surface temperatures of the tube will be recorded during the rapid and sustained fire phase and will be correlated with those measured in the chamber surface.

When the prime mover and towed weapon are delivered to the range and emplaced, at least three trial emplacements will be used to determine the average time to safely emplace the weapon, load the cannon, and lay it for the first round. A trained and experienced driver and crew are required for this operation.

2.9.3.2 Firing Phase. The minimum number of rounds to be fired is shown in Table 2.9-I.

Table 2.9-I (U). Rapid and Sustained Fire Schedule (U)

Projectile: XM549 or modified M107 (inert, sand and steel); weight with fuze, 96 pounds.
Projectile: M107 (inert, sand and steel); weight with fuze, 95 pounds.
Charge: M4A2
Primer: M82.
Fuze: M73 dummy.

Round No.	Elevation, degrees	Projectile Model	Prop. Chg Model	Prop. Chg Zone	Time
1 to 6	30	M107	M4A2	7	First 50 seconds
7 to 12	30	M107	M4A2	7	Next 65 seconds
13 to 18	30	M107	M4A2	7	Next 65 seconds
19 to 78	30	M107	M4A2	7	Next 30 minutes
79 to 100	30	M107	M4A2	7	Next 22 minutes
101 to 106	45	XM549	XM203	8	First 50 seconds
107 to 112	45	XM549	XM203	8	Next 65 seconds
113 to 118	45	XM549	XM203	8	Next 65 seconds
119 to 178	45	XM549	XM203	8	Next 30 minutes
179 to 200	45	XM549	XM203	8	Next 22 minutes

See note on following page.

Table 2.9-I (Cont'd)

Note: This schedule of rounds is designed to establish the maximum rapid-fire and sustained-fire rates desired. For reasons of safety, excessive physical efforts, and the imperative requirement for chamber-temperature data during firings, only the minimum rapid and sustained rates of fire may be attained. Gun crews used to perform this phase of test should be oriented on the operation of the weapon and propelling charge.

2.9.4 Data Required and Analytical Plan

The following data will be required:

a. Tube-surface temperatures, by thermocouple.

b. Tube-chamber surface (30 inches forward of RFT) temperature.

c. Breechblock temperature at center of ring-seal area.

d. Time to emplace and fire the first round direct-fire.

e. Maximum number of rounds which can be fired in the first 3 minutes.

f. Maximum number of rounds which can be fired in 30 minutes of sustained fire.

g. Rate of rapid and sustained fire at 30 and 45° howitzer elevations.

2.10 (U) FIRING TESTS, INDIRECT FIRE-CONTROL ACCURACY

2.10.1 Objectives

a. To determine the degree of accuracy to which the fire-control equipment can correctly lay the weapon when in a level or canted (up to 10°) position.

b. To determine the effects of firing shock on fire-control accuracy of lay with the weapon in a canted position.

c. To observe the adequacy of the elevation and traverse system during canted positions of operations.

2.10.2 Criterion

The criterion is that the fire-control equipment shall be able to compensate for a 10 to 12° cant, either right or left, of the weapon (MN, para VIk(2)(d)1d).

2.10.3 Method

2.10.3.1 Preparations. These include:

a. A cross-leveling device will be designed and fabricated to accommodate the rise of a calibrated gunner's quadrant. This device will be attached at a locating point on the top carriage, and, it will be accessible at all howitzer elevations and cants.

b. Scribe lines will be located on the tube and on the breech-ring surface to aid in aligning the tube in the correct azimuth, by utilizing the surveyor's transit.

c. Because of the rotation of the scribe lines on the tube, the taper of the tube, and the cant of the weapon, a transit azimuth reading error develops. Therefore, a graphical transit azimuth correction curve (2 to 12°; 2° increments) will be required. Positive locations of the scribe marks are required prior to developing the correction curves.

d. Prior to the range, cant-accuracy, and shock-firing tests, a complete shop check of the fire-control systems will be performed (i.e., elevation synchronization readings of both the fire-control equipment and elevation/traverse mechanisms, and a check of trammel points, etc.).

e. Clinometer measurements will be made at howitzer elevations of 0, 30, 45, and 70°.

2.10.3.2 Firing Phase. This includes:

a. To check the cant-accuracy and shock-firing tests, the weapon will be emplaced on level terrain (within ±1°) and on slopes of 5 and 10°.

b. The APG 2-transit method will be used to both lay the tube for firing, and to conduct field checks of the cant accuracy of the fire control.

c. A static accuracy check of the tube lay will be made before and after the firing of a 5-round group. The schedule of elevations and cants is shown in Table 2.10-I.

Table 2.10-I (U). Cant-Accuracy Checks (U)

Projectile: M101 (inert, with fuze, sand and steel); weight, 96 pounds.
Charge: XM203.
Primer: M82.
Fuze: M78 inert.

Group No.	Howitzer Elevation, degrees	Right and Left Cant, degrees			Rounds (Each Cant)
1 to 3	0	0	5	10 to 12	5 each
4 to 6	30	0	5	10 to 12	5 each
7 to 9	45	0	5	10 to 12	5 each
10 to 12	60	0	5	10 to 12	5 each
13 to 15	70	0	5	10 to 12	5 each

2.10.4 Data Required and Analytical Plan

The following data will be required:

a. Azimuth reading, transit No. 1 to transit No. 2.

b. Azimuth reading for tube lay before and after each five rounds.

c. Cant reading before and after each five rounds.

d. Elevation and azimuth reading (to transit No. 1) before and after each 5-round group.

e. Elevation and azimuth reading after firing each round.

f. Elevation and traverse system handwheel efforts before or after each 5-round group.

The following analytical plan will be required:

a. The tube azimuth-lay readings will be placed in a tabular form as to howitzer elevation and weapon-system cant for each before- and after-firing group check.

b. The correction for tube-twist, cant, and taper will be applied to each tube-azimuth reading to attain the true tube azimuth.

c. An analysis will be made from these data, relative to the capability of the fire-control equipment to compensate for cant of the weapon system. Unexplainable errors will be noted.

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2.11 (C) FIRING TESTS, VERTICAL TARGET ACCURACY, TOP/MTP 3-2-601

2.11.1 (U) Objectives

a. To determine the round-by-round dispersion on a vertical target (16 by 16 feet) located 2000 meters downrange.

b. To determine the repeatability of the on-carriage 2-man sighting systems.

c. To determine the boresight-retention error of the direct-fire and indirect-fire control items.

d. To determine obscuration effects from flash or smoke on a downrange target.

2.11.2 (C) Criteria

a. (C) The maximum horizontal and vertical probable error shall be between 0.2 and 0.3 mil at all ranges from 2000 meters or less (MN, para VId(2).

b. (U) It shall be possible for the weapon crew to boresight the fire-control equipment within 1 to 2 minutes (MN, para VIk(2)(d)1a).

c. (U) The means of changing ballistic reticles will be accurate and easily performed for the direct-fire telescope (MN, para VIk (2)(d)3a).

d. (U) Boresight retention shall be within 0.3 mil for direct fire and 1.0 mil for indirect fire as measured before and after fire (test agency).

e. (U) For direct fire during daylight hours with the weapon emplaced and laid, ammunition prepared the first round is to be fired in 10 to 20 seconds from receipt of initial fire command (MN, para VIi(2)(b)1).

f. (U) For direct fire during daylight hours, with the weapon not emplaced, the first round is to be fired in 1 to 2 minutes from time the weapon stops at the firing position (MN, para VIi(2)(b)2).

2.11.3 (U) Method

2.11.3.1 Preparations. These include:

a. A check of the boresight of the direct- and indirect-fire equipment will be performed.

b. The muzzle velocities of projectiles will be recorded by the use of sky screens.

c. Peak chamber pressures (M11 gage) will be recorded.

d. Propelling charges are to be conditioned at +70°F for 24 hours prior to their use.

e. AT least two warmer rounds will be fired prior to each 10-round group.

f. The XM198 155-mm towed weapon system will be emplaced on a range to fire at specified targets.

g. The 2-man lay method of the weapon will be employed.

h. The weapon will be boresighted on the target to measure line-of-sight elevation to the target.

i. The deflection and elevation weapon lay before fire, and immediately after fire, will be recorded for each round.

j. The displacement of the weapon will be measured through the use of aiming stakes or other acceptable means.

k. Recoil length will be measured for all rounds.

l. Cycle time will be measured for all rounds (to 1/100 second).

m. Measure projectile-seating distance.

n. Obscuration effects against the target will be photographed from the direct-fire sight position of the weapon.

o. Measure droop or change in the tube, using a muzzle scope, before and after each direct-fire group.

2.11.3.2 Firing Phase. The schedule of rounds shown in Table 2.11-I will be fired.

Table 2.11-I (U). Direct-Fire Schedule (U)

Projectile: M107 (inert, solid-fill); weight with fuze, 95 pounds.
Projectile: XM549 (inert, solid-fill); weight with fuze, 96 pounds.
Charges: M4A1 or M4A2, M119, and XM203.
Primer: M82.
Fuze: M73 dummy.
Target: Cloth, 16 by 16 feet.

Group Round No.[a]	Range, meters	Projectile Model	Chg Model	Weapon Traverse	Purpose
1 and 2	2000	M107	M4A2	Center	Warmer
3 to 12	2000	M107	M4A2	Center	Accuracy
13 to 22	2000	M107	M119	Center	Accuracy
23 to 32	2000	XM549	XM203	Center	Accuracy
33 to 42	2000	XM549	XM203	Left	Accuracy
43 to 52	2000	XM549	XM203	Right	Accuracy
53 to 62	1000	M107	M4A2	Center	Accuracy
63 to 72	1000	M107	M119	Center	Accuracy
73 to 82	1000	XM549	XM203	Center	Accuracy

[a]Represents the minimum number required.

Notes: Order of firing by group may be changed.
The peak chamber pressures (M11 gage, two per round), muzzle velocity, shell weight, projectile-seating distance, and deflection and elevation changes are recorded after the firing of each round.

2.11.4 (U) Data Required and Analytical Plan

The following data will be required:

a. Muzzle velocities, all rounds.

b. Weight of projectile to nearest 0.01 pound, all rounds.

c. Peak powder-chamber pressures, all rounds. The average of the two M11 gages will be produced.

d. Target-boresight elevation.

e. Boresight-retention change.

f. Superelevation required for each projectile/propellant charge type and range.

g. Round-to-round impacts on the target.

h. Projectile-seating distance (from rear face of breech to base of shell).

i. Ground meteorological data.

j. Target-obscuration time due to smoke or flash.

k. Record droop or change for the tube.

The following analytical plan will be required:

a. The probable error in both range and deflection will be computed.

b. Graphical plots of round impacts will be presented.

c. The standard deviation for pressure and velocity will be computed.

d. The ability to sense round impacts on the target will be evaluated in regard to time of obscuration of target.

The point estimate and the upper 90% confidence limit on the probable error will be calculated for both the horizontal and vertical impacts for each 10-round group and for combined groups as deemed appropriate. It is assumed that the horizontal and vertical impacts are independent, normally distributed, random variables.

2.12 (U) FIRING TESTS, JUMP, TOP/MTP 3-2-817

2.12.1 Objective

The objective is to determine the ballistic launch point of the projectile relative to the boresight centerline.

2.12.2 Criteria

Not applicable.

2.12.3 Method

2.12.3.1 Preparations. These include:

a. Emplace the weapon in a level area for firing.

b. The weapon will be fired using several rounds to firmly seat the spades against solid ground.

c. Establish a plywood target 500 to 600 feet (measured to 1/100 inch) from the cannon muzzle.

d. Select a desired firing elevation (5 to 10 mils) to the center of the target.

e. After loading, lay the tube on the jump-target reference point by means of a muzzle scope. (Caution should be used in this operation.)

f. Sky screens will be used to measure muzzle velocity.

2.12.3.2 Firing Phase. The schedule of rounds shown in Table 2.12-I will be fired.

Table 2.12-I (U). Jump-Fire Schedule (U)

Group Round No.[a]	Proj Model	Prop. Chg	Purpose
1 to 3	M107	M4A2	Seating
4 to 8	M107	M4A2	Jump data
9 to 13	XM459	XM203	Jump data

[a]Represents the minimum number required.

Notes: Repeat this jump schedule on three occasions.
The peak chamber pressures (M11 gage, two per round), muzzle velocity, shell weight, projectile-seating distance, and quadrant elevation will be recorded for each round.

2.12.4 Data Required and Analytical Plan

The following data will be required:

a. Muzzle velocities, all rounds.

b. Weight of projectile to nearest 0.01 pound, all rounds.

c. Projectile-seating distance.

d. Peak powder-chamber pressures, all rounds (average of two M11 gages).

e. Distance from muzzle to jump target, to nearest 0.01 inch.

f. Dispersion of impacts from line-of-sight reference.

g. Howitzer elevation, each round.

The following analytical plan will be required:

a. The center of impact will be determined.

b. The jump, in mils, will be determined for range and deflection.

2.13 (U) FIRING TESTS, DIRECT-FIRE RETICLE VERIFICATION, TOP/MTP 3-2-700

2.13.1 Objective

The objective is to evaluate the direct-fire sight-reticle accuracy to the projectile exterior ballistic profile.

2.13.2 Criterion

The criterion is that the difference between the theoretically determined center of impact (the summation of all the effects) and the observed center of impact should be zero if the reticle accuracy reflects projectile performance and all effects can be considered (test agency).

2.13.3 Method

2.13.3.1 Preparations. These include:

a. The bore alignment of the interior of the tube will be recorded prior to this test phase.

b. The indirect- and direct-fire equipment will be boresighted prior to test.

c. Sky screens will be located to measure muzzle velocity.

d. A series of sky screens will be located at 500, 1000, 1500, and 2000 meters, and at maximum reticle range to measure remaining velocities at each location.

e. The range from the cannon muzzle to the vertical target will be measured to the nearest 1/100 inch.

f. Measure projectile seating from the base of the projectile to the rear surface of the breech ring.

g. Peak chamber pressures, M11 gage, will be recorded.

h. Propelling charges are to be conditioned at +70°F for a minimum of 16 hours prior to their use.

i. After the target-impact elevation is determined, the final lay of the cannon for each round will be by transit and reference marks on the tube muzzle (side).

j. The deflection (to a reference point) and elevation (quadrant reading) will be measured and recorded for each final lay.

k. The exterior ballistics or projectile profile will be measured by the HAWK velocimeter for ranges of 1000 meters and beyond.

l. With a muzzle borescope, measure the tube droop, or change, before and after each direct-fire group.

m. Reticle imput data for the design of range-line tolerances will be supplied by Frankford Arsenal.

2.13.3.2 Firing Phase. The schedule of rounds shown in Table 2.13-I will be fired at several ranges.

Table 2.13-I (U). Reticle-Evaluation Schedule (U)

Projectile: M107 (inert, solid-fill); weight with fuze, 95 pounds.
Projectile: XM549 (inert, solid-fill); weight with fuze, 96 pounds.
Charges: M4A2 and XM203.
Primer: M82.
Fuze: M73, dummy.
Target: Cloth, 20 by 20 feet.
Range: 2000 meters.
Traverse: Center.

Group Round No.	Prop. Chg	Projectile Model	Purpose
1 and 2	M4A2	M107	Warmer
3 to 12	M4A2	M107	Accuracy
13 and 14	XM203	XM549	Warmer
15 to 24	XM203	XM549	Accuracy

Note: This schedule of rounds will be fired to a vertical target positioned at distances of 1000, 1500, and 2000 meters and also at maximum reticle range.

2.13.4 Data Required and Analytical Plan

The following data will be required:

a. Muzzle velocities for all rounds; also, remaining velocities at all downrange positions.

b. The weight of the projectile to the nearest 0.01 pound for all rounds.

c. Peak powder-chamber pressures for all rounds. The average of two gages will be recorded.

d. Boresight elevation.

e. Boresight-retention error.

f. Superelevation required for 2000 meters.

g. Projectile-seating distance.

h. Sight parallax from lay of system.

i. The HAWK velocimeter projectile velocity versus time.

The following analytical plan will be required:

a. The probable error in range and deflection will be computed.

b. The standard deviation of pressure and velocity will be computed.

c. A graphical plot of target impacts will be presented.

d. The reticle evaluation data will be tabulated and, the effects due to known factors (i.e., nonstandard materiel, projectile, and meteorological conditions, jump, etc.).

e. Exterior ballistic data for the different ranges will be evaluated against the reticle design as computed by Frankford Arsenal.

2.14 (U) DURABILITY

2.14.1 Objective

To determine whether the howitzer test item meets the durability requirements specified in the MN and the coordinated test program.

2.14.2 Criteria

2.14.2.1 The howitzer test item shall withstand the normal hazards in loading and unloading, handling during surface transport and storage, occupying and evacuating firing positions, and in executing fire missions (MN, para VIk(4)(a)).

2.14.2.2 The subsystems of the howitzer test item shall endure without replacement or overhaul the following:

a. Tube - 2,500 to 5,000 EFC rounds.

b. Recoil mechanism - 10,000 to 15,000 EFC rounds.

c. Breech - 7,500 to 15,000 EFC rounds.

d. Carriage - 15,000 EFC rounds.

2.14.3 Method

2.14.3.1 The howitzer test item (different than that used in previous testing) will be inspected and pre-operational checks and maintenance services performed to insure that the howitzer test item is in suitable condition for testing during the arrival inspection (subtest 2.2). Periodic service and inspections will be conducted throughout the test in accordance with equipment publications provided with the test item.

2.14.3.2 The howitzer test item will fire a total of approximately 22,045 rounds (approximately 15,086 EFC rounds) and travel at least 2,000 miles during conduct of the DT II. Approximately 4500 of these rounds will be fired by OTEA.

2.14.3.3 Firing and towing will be conducted as nearly in accordance with the operational profile as practicable considering the ammunition available for conduct of the test.

2.14.3.4 Malfunctions that preclude further operations of a subassembly under consideration and are of such consequence that general support maintenance cannot restore the subassembly to operational readiness (requiring that the subassembly must be replaced or rebuilt), will be considered as durability failures.

2.14.4 Data Required

2.14.4.1 A daily record of the number of miles each howitzer test item is towed indicating the type of road or terrain and weather conditions.

2.14.4.2 A daily record of the number of rounds fired from each howitzer test item, by propelling charge and zone.

2.14.4.3 A list of malfunctions, repairs, parts replaced, and services for each howitzer test item by cumulative miles towed and rounds fired.

2.14.5 Analytical Plan

2.14.5.1 Significant raw data and analyzed data will be presented in narrative format supplemented by tables showing malfunctions, repairs, and parts replacement by cumulative miles and rounds fired for the howitzer test item or component.

2.14.5.2 Raw data on the malfunctions or the replacement of each subassembly under consideration will be subjectively analyzed in accordance with the condemnation criteria provided to the engineering test agency and equipment publications to determine whether the specific malfunction or replacement is a chargeable durability failure.

2.15 (U) RELIABILITY

2.15.1 Objective

To determine whether the test items meet the reliability requirements specified in the coordinated test program and QMR.

2.15.2 Criteria

2.15.2.1 The reliability performance of the howitzer test item in MRBF when operated in accordance with the operational mode summary shall be as follows (Item 69, Appendix B) (DTP Annex B, para I.A).

a. Minimum acceptable value - 700 MRBF.

b. Specified value - 1100 MRBF.

2.15.2.2 The reliability of functioning for the propelling charge test item shall be at least 0.999 (the requirement of record) (QMR, para 9b).

2.15.3 Method

2.15.3.1 The howitzer test item will fire approximately 22,045 rounds throughout testing as follows (Table 2.15-I):

Table 2.15-I. Reliability Rounds

	Rounds	Estimated EFC
Wear test by YPG	2500	2586
Expenditure, YPG	14945	10000
Firings conducted by OTEA in OT II	4500	2500
Total	22045	15086

In addition to towing accumulated during other testing, the howitzer test item will be towed approximately 2000 miles.

2.15.3.2 All incidents and malfunctions will be recorded and classified as chargeable or nonchargeable failures in accordance with the artillery failure definition and scoring criteria formulated by AMC and TRADOC as shown in Appendix VII.

2.15.3.3 In the absence of a mutually agreed upon failure definition for the purpose of assessing propelling charge test item functioning reliability the following incidents will be considered functioning reliability failures:

a. Primer ignites - propellant fails to ignite.

b. Primer ignites - delayed propellant ignition.

c. Erratic rounds caused by incomplete or erratic propellant burning.

2.15.4 Data Required and Analytical Plan

The data to be recorded are as follows:

a. Parts failure data; hours, rounds, miles, cycles, as applicable.

b. System malfunctions, hours, rounds, miles, cycles, as applicable.

From the data obtained from all testing, if compatible with the durability testing data, point estimates and confidence limits on reliability parameters will be calculated. It is assumed that time (hours, rounds, miles, etc.) between failures is an exponentially distributed random variable (constant failure rate).

2.16 (U) HUMAN ENGINEERING ASPECTS, TOP/MTP 2-2-803

2.16.1 Objective

The objective was to determine the suitability of the arrangements of controls and visual devices, the physical effects of operation, and the sufficiency of the area of work.

2.16.2 Criteria

a. The weapon system shall be free of major human-engineering problems, such as, excessive physical efforts being required to operate controls, load weapons, etc., hazards due to continuous operation, and human-effects criteria (test agency). The system design shall meet or exceed the HFE requirements as specified in Military Standard 1472A (Human Engineering Design Criteria for Military Systems, Equipment and Facilities).

b. Environmental factors induced by dynamic blast and overpressures during firing shall not be greater than 3 pounds per square inch (psi) within crew area, nor shall they create any unacceptable level of crew discomfort during sustained firing or degrade position area equipment and operation (MN, para VIk(5)).

c. Human-factors aspects of maintenance operations. System design will adhere to the essential principles of human factors engineering and the man - item relationship must be adequate for effective maintenance operations (AR 702-3, para 2-5c(6)).

2.16.3 Method

2.16.3.1 Civilian Testing. A human-factors review of the weapon will be made under both static and dynamic conditions. This review will be integrated as much as possible with planned testing. The specific items to be considered with regard to human safety, ease of operation, and efficiency in operation, include the following:

a. Operator's manual.

b. Maintenance manual - cross-reference (analyzed in para 2.18.2.3).

c. The space available for ease of operation.

d. Control-display relationship.

e. Safety in operation and maintenance.

f. Readability of such items as the bubbles counter, etc.

g. Noise levels and muzzle brake effects.

h. Safety in all operations when connecting the weapon to a primer mover.

2.16.3.2 Soldier-Operator-Maintainer Testing. The man - machine interface will be assessed throughout all operations scheduled with the operator and maintainer in regard to operability. Evaluation will be functional requirements for operation and use of weapon system, as follows:

a. Evaluate operating manuals and instructions for simplicity, clarity, and completeness commensurate with the skills of the operator/crew.

b. Personnel fatigue.

c. Any awkward movements or error-likely situations imposed by location, design, or unnatural direction of movement of controls.

d. Suitability of the ratio of movement of a control to the movement of the controlled component.

e. Ease of identification of controls and control positions by sight and touch.

f. Capability of effective use by both right and left handed soldier-operator-maintainers and those wearing eyeglasses.

g. Capability of effective use by soldier-operator-maintainers wearing combat clothing and appropriate seasonal clothing such as gloves or raincoats.

h. Discomforts and hazards from blast, noise, and recoil of weapon.

i. Interference caused by ejection of primer cases or secondary missiles.

j. Discomfort or inefficiency of operation caused by excessive heating of the weapon from firing or heat absorption from exposure to the sun.

k. Difficulties encountered in emplacing, preparing the howitzer test item for firing, march order, handling, and preparation of the propelling-charge test items for firing.

l. Effects of blast, noise, and fumes on crew operations with any requirements for protective equipment.

2.16.3.3 Soldier-Operator-Maintainer and/or Civilian Testing. Additional areas to be considered in assessment by either soldier-operator-maintainer or civilian testers are technical and system performance, publications, error-likely situation analysis and maintenance aspects. These areas are further detailed as follows:

a. The system performance (man - material) will be assessed in terms of system variables, such as reaction times, rates of fire, precision, and other standards expressed as criteria of system effectiveness throughout the test. When any criterion appears not to have been met or difficulties are encountered in meeting criteria, all test data relative to the criterion or difficulty will be evaluated for contributory human factors aspects.

b. Equipment publications provided for the test items will be examined for understandability and readability with respect to the intelligence levels and aptitudes of representative test soldier-operator-maintainers. Recommended changes will be reported on DA Form 2028.

c. An error-likely analysis will be performed to determine those operational tasks or subtasks during which human errors are most likely to occur. Based on this analysis, observations will be made of those selected tasks and all operator errors will be recorded on an error report (Figure VI-17, Appendix VI). The conditions under which the errors occur and the consequences of each error will be described in detail. The cause of the error will be determined and, if possible, defined in terms of inadequate equipment design, inadequate training, deficient operator or maintenance manuals, task overload, or other related causes.

d. Difficulties reported by test personnel and qualified observers will be investigated. Relevant measurements and photographs or motion pictures will be taken to document and findings.

e. Human-factors data will be extracted from subtest 2.18, Maintenance Evaluation, and reported in this subtest.

2.16.4 Data Required

The following data will be required for civilian testing:

a. Noise/blast levels measurements will be taken at the operator locations. These levels will be compared to acceptable levels specified in MIL Standard 1474 (Noise Limits for Army Materiel, 1 March 1973).

b. Notes compiled by test personnel and evaluators continuously observing operations concerning the human factors engineering of the test items.

c. Comments of observers and test personnel relative to the active man - machine relationship.

d. Data concerning the understandability and readability of equipment publications as reported on DA Form 2028.

e. The findings resulting from investigation of difficulties reported by test personnel and observers.

f. A summary of the human-factors aspects contributing to difficulties encountered during determination of system performance throughout the test.

The following data will be required for soldier testing:

a. Summarization of comments and findings of operators, evaluators, and mainteners concerning human-factors engineering characteristics in all operational areas including ease of handling, ease of preparation of the howitzer and ammunition for firing, requirements for special individual protective equipment, effects of muzzle-blast overpressure on personnel and effects of other equipment, noise, and fumes on crew efficiency.

b. Notes on human factors affecting maintenance characteristics of the howitzer test item and its components.

The following analytical plan will be required:

a. Significant test results will be presented in narrative form showing detailed test results.

b. Comments of crewmen, test evaluators, and observers concerning the human-factors engineering characteristics of the system will be compiled and subjectively evaluated, based on military experience and judgment and presented in narrative form to determine whether criteria are met.

c. Each equipment performance report will be reviewed for reclassification and inclusion of data in the test report.

2.17 (U) SAFETY EVALUATION

2.17.1 Objectives

a. To determine the suitability of the XM198 weapon system for both towing and firing tests.

b. To determine operational safety.

c. To determine the safeguards required to prevent accidents.

d. To effect a recommendation for a safety release early in the test.

e. To provide a more complete safety evaluation at completion of testing.

2.17.2 Criteria

a. The criterion is that the XM198 weapon system shall be designed for safe operation by personnel while hooking up or disconnecting the weapon from the prime mover, towing, or during firing or maintenance (test agency).

b. Blast and noise induced by firing the howitzer test item shall not result in the need for special individual protective equipment for field artillery personnel. Overpressures in the crew area shall not be greater than 3 pounds per square inch (MN, subpara VIk(5)). (Dynamic overpressure measurements will be obtained from the engineering test agency.) (The howitzer crew will use the standard issue ear plugs for ear protection when firing the howitzer test item.)

c. Final design of the propelling charge test items shall be based on achievement of essential safety requirements and shall minimize the susceptibility of the propellant to pre-ignition or cook-off during successive periods of maximum-rate firing (subpara 10b(1)(2)).

d. Chamber pressures for the minimum test item propelling charge (zone 1) shall be compatible with fuze design parameters required for reliable arming, battery activation, and safety considerations (QMR, subpara 10d(3)). (Chamber pressures will be determined by the engineering test agency.)

e. Forces developed by the propelling charge test items shall not exceed design safety limits of the howitzer test item or munition items with which they are designed to be used (QMR, subpara 10d(1)). (Forces developed by the propelling charge will be determined by the engineering test agency.)

f. Residue left in the chamber after firing the propelling charge test items shall not require swabbing to prevent preignition of the propellant for successive rounds at the established required rate of fire (QMR, subpara 10d(2)).

g. Fumes from firing the propelling charge test items shall not endanger the health of personnel under field use conditions (QMR, para 12a).

2.17.3 Method

2.17.3.1 Civilian Testing. The safety evaluation will be conducted in two parts: an early evaluation based on preliminary instrumental data and high-risk phases of testing and over-all evaluation based on complete DT II. The following tests will be considered in the safety evaluation:

a. Braking.

b. Turning.

c. Longitudinal and side slopes.

d. Noise levels and muzzle-blast effects.

e. Proof firing.

f. Stability (towing and firing).

g. Instrumental recoil data.

h. Fire-control accuracy.

i. Maintenance operations.

j. Adequacy of safety instructions, cautions, etc.

2.17.3.2 Soldier-Operator-Maintainer Testing:

a. All operations, maintenance, handling, and firings throughout the soldier tests will be closely observed, analyzed, and commented upon by qualified test personnel to determine the existance of safety hazards or potential safety hazards. If any unsafe or potentially unsafe condition is observed during the test, the test will be suspended until the condition is resolved.

b. Observations will be made throughout the test period on malfunctions of munition components; e.g., cook-offs, stickers.

c. A visual inspection of the powder chamber for burning residue will be made after each round is fired. However, the chamber will be swabbed after firing every round.

d. Safety procedures outlined in the manuals will be evaluated for adequacy as indicated in subtest 2.18.

2.17.4 Data Required and Analytical Plan

The following data are required for civilian testing:

a. Limitations on operating or performance of the weapon system which are imposed due to safety considerations.

b. Braking results.

c. Slope performance.

d. Turning results.

e. Proof firing and materiel testing data.

f. Nondestructive examination results.

g. Instrumental dynamic-recoil data.

The safety problems noted will be analyzed for cause and recommended corrective action.

The following data are required for soldier-operator-maintainer testing:

a. Records of adequacy of safety features for operations explored.

b. Notes on warning plates and instruction plates concerning their placement, clarity, and adequacy.

c. Notes on need for any additional safety devices or warning plates.

d. Notes on safety constructions in manuals that are used during maintenance operations.

The following evaluations will be presented:

a. Significant test results will be presented in the report in narrative format.

b. A subjective analysis, based on experience and judgment of military evaluators, will be performed to determine criterion met and not met. The impact on suitability will be discussed when the criterion is not met or only marginally met.

c. Test results will be analyzed and classified as deficiencies and shortcomings, where applicable.

d. Each equipment performance report will be reviewed for reclassification and inclusion of data in the report.

e. Criteria met and not met, as determined by analysis, will be specified.

f. The safety aspects found during over-all maintenance performed will be extracted from evaluation of maintenance and discussed in this safety evaluation.

2.18 (U) MAINTENANCE EVALUATION (TOP/MTP 6-3-524)

2.18.1 Maintainability Indices

2.18.1.1 Objective. To determine whether the howitzer test item maintenance characteristics meet the requirements specified by the MN and to record statistical maintenance and failure data throughout testing for use in assessing its RAM-D.

2.18.1.2 Criteria

a. The mean time (clock hours) to repair (MTTR) shall not exceed 30 minutes at organizational level and 2 hours at direct support level (MN, para VI1(1)).

b. The maintenance ratio (MR) (man-hours of maintenance per operating hour) during the service life of the weapon shall not exceed 0.06. (Man-hours of maintenance includes scheduled and unscheduled maintenance but does not include daily crew services and checks) (MN, para VI1(3).)

c. Scheduled maintenance shall not be performed more frequently than intervals of 6 months, 3200 km or 3000 EFC rounds, item system (MN, para VI1(4)).

d. The weapon design shall permit ease of accessibility to often-checked items (lubrication points) and replacement items. Also, incorporated in the design will be features which will minimize malfunctions or damage to linkage due to mine explosions, freezing, and dirt accumulation (MN, para VII(5)).

e. Design for maintainability. Systems will be designed to eliminate deficiencies prejudicial to the ease of maintenance. System design will be directed toward minimizing maintenance by using the most reliable components, modular construction, built-in simple fault isolation test indicators, and other technological advances in components and methods to the maximum extent practicable. Means to achieve ease of maintenance include:

   1) The location of high mortality parts to provide ready access when maintenance is required.

   2) The use of readily accessible test points to reduce diagnostic time.

   3) The reduction in the number of types and sizes of common fasteners (i.e., bolts, nuts, and screws) and the use of quick disconnects, wing nuts, and other features which will minimize requirements for special or additional tools (AR 702-3, para 2-5c(4)).

2.18.1.3 Method

a. Civilian Testing:

1) Maintain a continuous record of all scheduled and unscheduled maintenance actions and maintenance times for actions performed throughout the test (subpara 6.2.3, TOP 6-3-524).

2) Maintain a continuous record of data to evaluate reliability and maintainability as stated in subtests 2.14 and 2.15.

3) All RAM data input shall be collected for XM198 system serial No. 4 (durability system) and serial No. 6 (firing-tables system).

4) In the event of a requirement for a major component repair or replacement during soldier-operator-maintainer testing, a shop facility may be made available for a more expeditious repair, as conditions warrant, by the military or civilian mechanics. The system could then be made available later when convenient for a soldier-operator-maintainer simulated field exercise for maintenance evaluation.

b. Soldier-Operator-Maintainer Testing:

1) Test personnel will perform every maintenance operation allocated to the organizational category on the maintenance allocation chart (MAC). These operations will be performed either in support of the test (unscheduled maintenance), during scheduled maintenance services, or a malfunction will be simulated and the maintenance operation accomplished to insure that each operation can be performed using the authorized tools and test equipment in accordance with the procedures prescribed in the maintenance literature provided with the howitzer test item.

2) Test personnel will perform maintenance operations allocated to direct and general support maintenance categories on the MAC as required to support the test item during the test, or by sampling. Enough functions, based on the experience and professional judgment of the evaluators, will be performed to determine the adequacy of the test item to include accessory equipment and the maintenance test package.

3) Personnel of appropriate military occupational specialty (MOS) will be used in the performance of these maintenance operations.

4) The time required for individual maintenance operations will be recorded.

5) A record of all scheduled and unscheduled maintenance actions and maintenance time will be maintained throughout the test (subpara 6.2.3, TOP 6-3-524). The number of rounds fired and test miles of travel accumulated will be recorded for each maintenance action.

6) Data required to evaluate reliability and durability will be maintained and classified as stated in subtests 2.14 and 2.15.

2.18.1.4 Data Required. The following data will be recorded for each maintenance action at the time the action is accomplished and entered on STE Form 1303-1, for use in team-up computer routine.

a. Number of maintenance tasks performed.

b. Task maintenance time (clock-hours, man-hours).

c. Delay time (clock-hours).

d. Maintenance downtime in clock-hours to the nearest 0.1 hour for each maintenance action.

e. Nature of the malfunction (scheduled, unscheduled, or simulated).

f. Identity of the failed component or assembly and a record of the accumulated test item miles traveled and rounds fired.

g. Julian date of incident.

h. Maintenance level.

i. Brief description of malfunction and related maintenance operations plus any other remarks deemed appropriate.

2.18.1.5 Analytical Plan

a. Significant raw data and analyzed test data will be presented in narrative format supplemented by maintenance analysis charts. The analysis will also address such areas as malfunction trends, possibility of corrections through design changes or modifications and their impact on maintenance effort, and a subjective comment on significance if a maintainability index is not met (reference TECOM Supplement 1 to AR 750-1).

b. The maintenance data compiled will be used to quantify the maintenance characteristics using the following formula:

1) $$A_a = \frac{\text{Operating Test Time}}{\text{Operating Test Time + Preventive and Corrective Maintenance Time}}$$

Note: Preventive and corrective maintenance excludes operator before and after operation checks, supply and administrative waiting times.

2) The test item MTTR will be computed using the following formula:

$$MTTR = \frac{\text{Total Corrective Maintenance Time}}{\text{Total Number of Malfunctions which Require Corrective Maintenance}}$$

3) The over-all MR and the MR for each maintenance category will be computed to the nearest 0.01 hour using the following formula:

$$MR = \frac{\text{Total Corrective Maintenance Man-Hours + Total Preventive Maintenance Man-Hours}}{\text{Total Operating Test Time}}$$

4) Maximum corrective maintenance downtime ($M_{max_{ct}}$) = that time below which 95% of all corrective maintenance tasks are completed by each category of maintenance.

5) Duration of scheduled maintenance actions (DSMA) will be computed using the following formula for each type scheduled maintenance.

$$DSMA = \frac{\text{Total Preventive Maintenance Time}}{\text{Total Number Preventive Maintenance Actions}}$$

The MTTR and MR will be compared to the criteria to determine if the criteria were met. The A_a, $M_{max_{ct}}$, and DSMA will be reported.

2.18.2 Equipment Publications

2.18.2.1 Objective. The objective is to review maintenance test package literature for accuracy, completeness, and simplicity of instructions.

2.18.2.2 Criterion, Equipment Publications. The equipment publications contained in the maintenance test package will be complete, accurate, easy-to-read, consistent in nomenclature, simple to follow, and adequate to permit completion of both scheduled and unscheduled maintenance operations and parts acquisition at all field levels of maintenance. Draft

Army equipment publications will conform in content and format to that specified in AR 310-3, MIL-M-38784, and MIL-M-63000(TM) series of military specifications as applicable (AR 702-3, para 2-5c(2)).

2.18.2.3 Method. Throughout the test the equipment publications will be reviewed to:

a. Analyze maintenance instructions for simplicity, clarity, and completeness.

b. Observe closely the maintenance operations actually performed to determine whether the instructions and sequence of operations are adequate and practical.

c. Analyze lubrication charts and orders for clarity and completeness.

d. Analyze adequacy of safety instructions for personnel and equipment, including environmental protection during operation and maintenance.

2.18.2.4 Data Required and Analytical Plan. The maintenance package literature chart will be completed. An analysis of the adequacy of instructions for the level of training and skill possessed by maintenance personnel will be performed.

2.18.3 Repair Parts

2.18.3.1 Objective. The objective is to determine that repair parts are adequate with respect to function and quantity.

2.18.3.2 Criterion. Repair parts. Repair parts will be authorized in adequate quantities and diversity at the appropriate maintenance levels, consistent with the maintenance allocation chart, Repair Parts Special Tool Lists (RPSTL) and skills required to install and align the parts. Repair parts which are used to maintain the system must be interchangeable with like parts being replaced.

2.18.3.3 Method

a. In every case, the repair parts which are used to maintain the test item will be compared with the parts being replaced for the purpose of determining interchangeability.

b. Repair parts should be designed to permit easy installation, alignment, and checkout.

c. Standard parts should be used when possible. Peculiar parts will be examined to determine if they can be replaced with standard items already in the logistics system.

d. Repair parts must be examined with respect to the prescribed maintenance category authorized to stock and/or spare parts furnished. For example, it is useless to authorize a repair part at one maintenance category if the tools to install the part are authorized at a different category.

e. Repair parts will be examined to insure modular design has been considered.

f. Repair parts used on the test item will be compared with the repair manual to insure data in the manual are adequate.

2.18.3.4 Data Required and Analytical Plan

a. Sufficient data will be collected during the test to permit preparation of parts analysis chart.

b. Parts analysis chart will be completed in accordance with TECOM Supplement 1 to AR 750-1 and the above methods. The data obtained thereby will be used to judge whether the criterion has been met.

2.18.4 Maintainability and Safety of Maintenance Operations

2.18.4.1 Objective. To determine the adequacy of the design of maintainability and the safety aspects of maintenance operation.

2.18.4.2 Criteria

Deleted.

b. Safety aspects of maintenance operations. System design will embody features to protect personnel from electrical and mechanical hazards and other dangers that might arise from fire, elevated operating temperatures, toxic fumes or dangerous environment. System design will, in general, adhere to essential safety principles and standards (AR 702-3, para 2-5c(5)).

2.18.4.3 Method

a. Determine and record whether the test item adheres to good maintainability design principles and characteristics.

b. Design to minimize maintenance and supply requirements through attainment of optimum durability and service life of materiel.

c. Design for ease of maintenance by insuring accessibility to facilitate inspection, repair, and replacement.

d. Detection of conditions which will adversely affect the conduct of maintenance operations and supply requirements.

e. Design to enable removal of major components as individual units and when feasible, use standardizer components which are compatible with similar equipment already in military system.

f. Testing and maintenance personnel will monitor safety aspects of the maintenance function throughout the conduct of the test.

g. Inspect test item to determine for any necessary safety problems and procedures.

2.18.4.4 Data Required and Analytical Plan

a. The data derived from the above methods will be analyzed and used to judge whether the criterion was met.

b. These elements of the maintenance evaluation may be included in the safety subtest when appropriate.

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2.19 (U) TRANSPORTABILITY

2.19.1 Objective

To determine whether the howitzer test item and the propelling charge test items with their shipping containers meet the transportability requirements specified in the MN and QMR.

2.19.2 Criteria

2.19.2.1 Facilities to provide for tiedown of the howitzer test item on board ship, aircraft, and surface transporters shall be provided. All towing, lifting, and tiedown facilities shall be of a standard NATO size and agree with STANAG 4062 and 4101 (MN, para VIK(2)(b)2 and 3).

2.19.2.2 The howitzer test item shall be transportable on roads using standard type vehicles or trailers, on rail by observing the Berne International Agreement, and on ocean-going transport ships in accordance with AR 70-44 (MN, para VIf(1)).

2.19.2.3 The howitzer test item shall be capable of being transported by C-130 or larger aircraft (MN, para f(2)).

2.19.2.4 The howitzer test item shall be equipped with lifting eyes to facilitate helicopter airlift and shipboard loading. Positioning of the lifting eyes shall be such that mounted fire control equipment shall not be damaged in transit (MN, para VIk(2)(b)1).

2.19.2.5 The howitzer test item shall be capable of being airlifted by the CH47C helicopter and/or the tactical aircraft system (rotary wing) of the time frame (MN, para VIc(1)).

2.19.3 Method

2.19.3.1 The towing, lifting, and tiedown facilities of the howitzer test item will be measured to the nearest millimeter for conformance with the dimensional requirements of STANAG 4062 or 4101 as shown in MIL-STD-209.

2.19.3.2 The data on configuration, weight, and dimensions of the howitzer test item collected in subtest 2.4 will be used to evaluate air and surface transportability in accordance with AR 70-39, AR 70-44, and the dimensional requirements of the Berne International Agreement.

2.19.3.3 The howitzer test item will be sling rigged and transported as an external load by the CH47C helicopter as closely in accordance with the operational mode summary as practical dependent upon aircraft and fuel availability. During flight, aerodynamic stability of the slung load will be observed, photographed, and notes made of trailing attitude, rotation, oscillation, and clearance of slings against rubbing or chafing actions.

2.19.4 Data Required

2.19.4.1 Measurements of howitzer test item towing, lifting, and tie-down attachments, including number and location.

2.19.4.2 A list of materials used, sling lengths and types, and method of rigging the howitzer test item for transport as an external load. Photographs and comments of qualified observers on inflight stability.

SECTION 3. (C) DETAILS OF AMMUNITION TESTS (U)

3.1 (U) INTRODUCTION

Observations are made throughout all ammunitions tests for problems related to safety and reliability. The cannon are inspected periodically for indications of adverse effect of firing.

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3.2 (U) INITIAL INSPECTION AND MEASUREMENTS

3.2.1 Objective

The objective is to determine the condition of, and to obtain baseline data relating to, the test materiel prior to testing.

3.2.2 Criteria

None.

3.2.3 Method

The method is shown in four portions.

3.2.3.1 Projectiles. All projectiles are numbered for future reference, weighed, and inspected for damage, deterioration, and obvious manufacturing defects. The numbering system is keyed to any inspection records furnished by the loading plant.

All live projectiles to be used in phases 29 through 55 of the safety test (para 3.3; are inspected and X-rayed as described in TOP/MTP 4-2-504 unless the required data is furnished by the loading plant. The projectiles that are to be subjected to the environmental phases of the safety test are then repackaged as near as possible to their original condition.

The diameter, width, and hardness of the rotating band and the diameter of the bourrelet are measured on each of the projectiles to be used in phase 56 and 57 of the safety test.

The center of gravity and the axial and transverse moments of enertia are measured on 80 of the fuzed M549 projectiles to be used in the provisional firing tables test and on 10 each of each projectile - fuze combination to be used in each of the tabulated firings in the provisional firing tables test. The measurements are repeated on five of the M549 projectiles after consumption of the rocket propellant through static ignition. The measurements required by TOP/MTP 3-1-004 are made on all of these projectiles.

3.2.3.2. Fuzes. All fuzes are inspected, weighed, and numbered for future reference. All of the fuzes required for phases 29 through 55 of the safety test are X-rayed. The fuzes that are to be subjected to the environmental phases of the safety test are repackaged as near as possible to their original condition.

3.2.3.3 Propelling Charges. All propelling charges are numbered, inspected, and weighed, and the length and diameter (a minimum of two places) are measured. The weights and measurements are compared to the drawing requirement.

The packaging and individual containers for the XM164, XM201, and XM203 charges are inspected for damage; the markings and shipping documents are inspected for clarity and completeness. Each charge and container is inspected for damage, visible manufacturing defects, and deterioration. Charge markings are inspected for clarity and completeness.

Three containers for each of the charges are weighed and measured. The XM164, XM201, and XM203 charges required for phases 8 through 25 of the safety test are repackaged as near as possible to their original condition.

Characteristics photographs are prepared for the XM164, XM201, and XM203 charges and containers.

3.2.3.4 Cannon. All tubes are visually examined, star-gaged, and borescoped in accordance with the guidance furnished in TOP/MTPs 3-2-801 and 3-2-804. The cannon are inspected for general condition with particular emphasis on areas of highest risk of damage from firing forces. Critical parts which show signs of wear are replaced.

3.2.4 Data Required and Analytical Plan

The data required include:

a. The general condition of ammunition components with a description and photograph of any damaged, defective, or deteriorated XM164, XM201, or XM203.

b. The weight of each component.

c. Inspection and X-ray records of the projectiles and fuzes to be used in phases 29 through 55 of the safety test.

d. The lengths and diameters of all propelling charges.

e. The weight and dimensions of XM164, XM201, and XM203 containers.

f. Measurements required for projectiles used in the provisional firing tables test.

g. The width, diameter, and hardness of the rotating band and the diameter of the bourrelet for the projectiles to be used in phases 56 and 57 of the safety test.

h. Inspection, borescope, and star-gage records for the tubes.

i. Inspection records for the cannon, to include the general condition of critical parts.

Measurements are used to determine compliance with drawing requirement. Analyses are generally subjective and relate to the condition of the individual items and their suitability for use in the various tests. The data obtained are used in analyses of other test results as applicable.

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3.3 (U) SAFETY TEST

3.3.1 Objectives

a. To evaluate the launch and flight safety of 155-mm ammunition in relation to its use with the XM198 howitzer.

b. To evaluate the transportation, storage, handling, and firing safety of the XM164, XM201, and XM203 propelling charges.

c. To determine the effects of a worn tube on ammunition safety.

d. To investigate the possibility of a projectile sticking in the tube during low-zone firings.

e. To determine the maximum rate of fire and the total number of rounds that can be used in the XM198 howitzer without reaching the temperature required to produce cook-off of the XM203 charge.

f. To obtain data for use in a safety recommendation to TECOM.

3.3.2 Criteria

The XM164, XM201, and XM203 charges shall not create a handling or disposal hazard as a result of transportation vibration and rough handling (test directive).

All 155-mm ammunition, including the XM164, XM201, and XM203 charges, shall be safe to fire in the XM198 howitzer at temperature extremes of -60 to +145°F (test directive and AR 70-38).

3.3.3 Method

Testing is performed in accordance with Table 3.3-I, using the guidance provided in TOP/MTP 4-2-504. The inspections of the materiel required in paragraph 3.2 are performed prior to firing; all applicable performance measurements recommended in TOP/MTP 4-2-504 are made during the test. Descriptions of the individual phases listed in Table 3.3-I follows:

a. Phases 1 through 6. Inert projectiles are fired as a preliminary check of the XM164, XM201, and XM203 charges. Time - pressure traces are examined for indications of serious irregularities prior to continuing with the testing.

Table 3.3-I (U). Safety-Test Conditions (U)

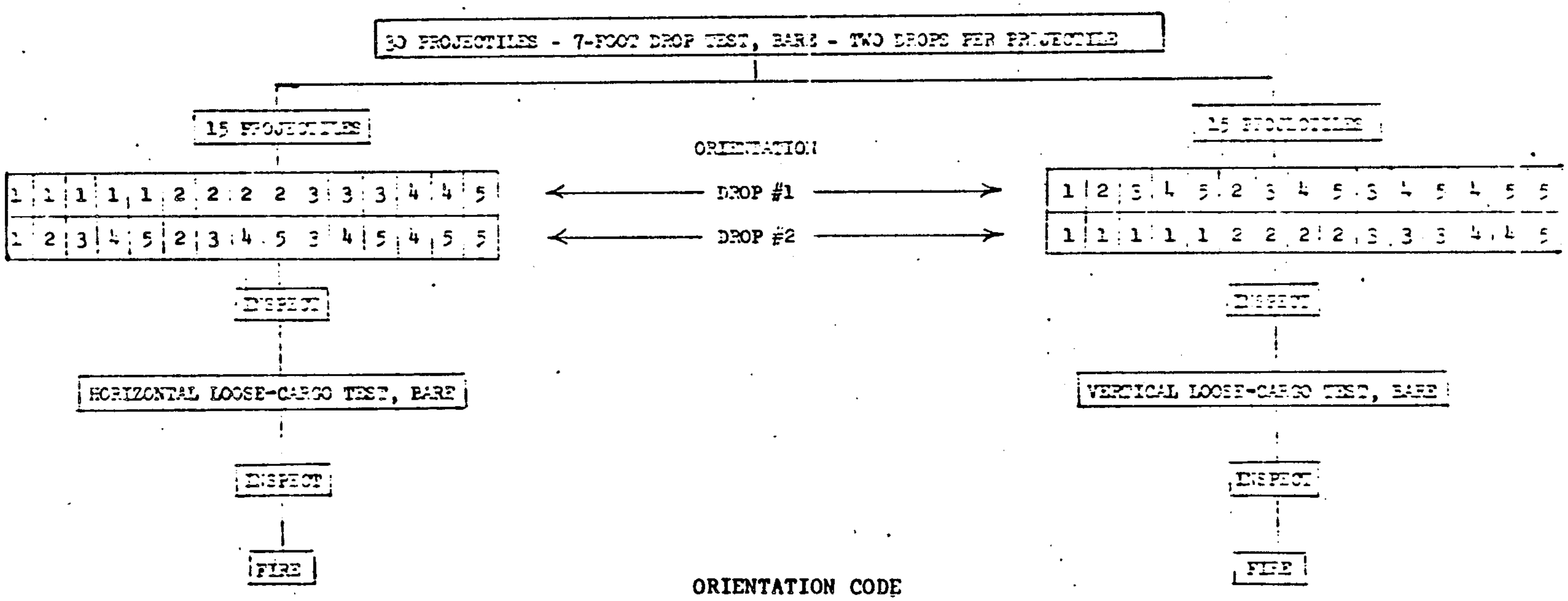
Phase	No. of Rd	Components: Proj	Components: Fuze	Components: Charge	Prefiring Test[a]: Proj	Prefiring Test[a]: Fuze	Prefiring Test[a]: Charge	Prefire Test Temp, °F	Firing Temp of Components, °F	Expected Chamber Press., psi/100	Remarks
1	10	[b]M549	M73	XM203	None	None	None	-	[c] - 60	Resultant	Fired to determine time - pressure relationship. (phases 1–6)
2	10	[b]M107	M73	XM201	None	None	None	-	[c] - 60	Resultant	
3	10	[b]M107	M73	XM164	None	None	None	-	[c] - 60	Resultant	
4	10	[b]M549	M73	XM203	None	None	None	-	[c] +145	Resultant	
5	10	[b]M107	M73	XM201	None	None	None	-	[c] +145	Resultant	
6	10	[b]M107	M73	XM164	None	None	None	-	[c] +145	Resultant	
7	10	[b]M549	M73	Proof	None	None	None	-	[c]+70 to +145	575	Fired to determine temperature required to produce expected pressures.
8	48	[b]M549	M73	XM203	None	None	T-V	+145	[c] +145	Resultant	Fired to establish charge safety. (phases 8–13)
9	48	[b]M549	M73	XM203	None	None	Hot cycle	+93 to +155	[c] +145	Resultant	
10	28	[b]M549	M73	XM203	None	None	T-V	- 60	[c] - 60	Resultant	
11	28	[b]M549	M73	XM203	None	None	Cold soak	- 60	[c] - 60	Resultant	
12	35	[b]M549	M73	XM203	None	None	Rough handling	+145	[c] +145	Resultant	
13	35	[b]M549	M73	XM203	None	None	Rough handling	- 60	[c] - 60	Resultant	
14 to 19	222	[b]M107	M73	XM201	None	None	Various	Various	Various	Resultant	Various conditions identical to phases 8 through 13 except that the XM201 charge is used.
20 to 25	222	[b]M107	M73	XM164	None	None	Various	Various	Various	Resultant	Various conditions identical to phases 8 through 13 except that the XM164 charge is used.
26	10	[b]M549	[b]M557	Proof	None	None	None	-	[d]+70 to +145	575	Fired for base impact and recovery. (phases 26–28)
27	10	[b]M549	[b]M728	Proof	None	None	None	-	[d]+70 to +145	575	
28	10	[b]M483	[b]M577	Proof	None	None	None	-	[d]+70 to +145	575	
29	48	M549	M557	Proof	T-V	T-V	None	+145	[e] +145	575	
30	48	M549	M557	Proof	Hot cycle	Hot cycle	None	+93 to +155	[e] +145	575	

[a]All components are measured and inspected prior to testing in accordance with paragraph 3.2 and TOP/MTP 4-2-504.
[b]Inert loaded.
[c]Propellant temperature. Remaining components fired at ambient temperature.
[d]Propellant temperature as established in phase 7. Remaining components fired at ambient temperature.
[e]Projectile and fuze temperature. Propellant temperature as established in phase 7.

Table 3.3-I (Cont'd)

Phase	No. of Rd	Components Proj	Components Fuze	Components Charge	Prefiring Test[a] Proj	Prefiring Test[a] Fuze	Prefiring Test[a] Charge	Prefire Test Temp, °F	Firing Temp of Components, °F	Expected Chamber Press., psi/100	Remarks
31	28	M549	M557	XM123E2(I)	T-V	T-V	None	- 60	- 60	Resultant	
32	28	M549	M557	XM123E2(I)	Cold soak	Cold soak	None	- 60	- 60	Resultant	
33	[f] 48	M549	M557	Proof	Rough handling	Rough handling	None	+145	[e] +145	575	
34	[f] 48	M549	M557	XM123E2(I)	Rough handling	Rough handling	None	- 60	- 60	Resultant	
35 to 40	[f] 248	M549	M728	Various	None	Various	None	Various	Various	Various	Various conditions identical to phases 29 through 34 except that the M728 fuze is used.
41 to 46	[f] 248	M483	M577	Various	Various	Various	None	Various	Various	Various	Various conditions identical to phases 29 through 34 except that the M483 projectile and M577 fuze are used.
47	100	M549	M557	Proof	None	None	None	-	[e] +145	Resultant	
48	100	M549	M728	Proof	None	None	None	-	[e] +145	Resultant	
49	100	M483	M577	Proof	None	None	None	-	[e] +145	Resultant	
50	100	M107	M514A1	XM201	None	None	None	-	+145	Resultant	
51	100	M110	M564	XM201	None	None	None	-	+145	Resultant	Fired from barrel having maximum of 25% wear life remaining.
52	100	M116	M501A1	XM201	None	None	None	-	+145	Resultant	
53	100	M121	M508	XM201	None	None	None	-	+145	Resultant	
54	100	M449A1	M565	XM201	None	None	None	-	+145	Resultant	
55	100	M485A2	M548	XM201	None	None	None	-	+145	Resultant	
56	75	[b] M107	M73	XM164	None	None	None	-	[c] - 60	Resultant	Fired to determine whether zone 1 will expel the projectile from the barrel.
57	75	[b] M549	M73	XM164	None	None	None	-	[c] - 60	Resultant	
58	300	[b] M549	M73	XM203	None	None	None	-	[c] +145	Resultant	Used to establish maximum rate of fire that will not produce cook-off temperature with zone 8.
59	5	None	None	XM203	None	None	None	-	-	-	
60	5	None	None	XM164	None	None	None	-	-	-	40-foot drop test.
61	5	None	None	XM201	None	None	None	-	-	-	

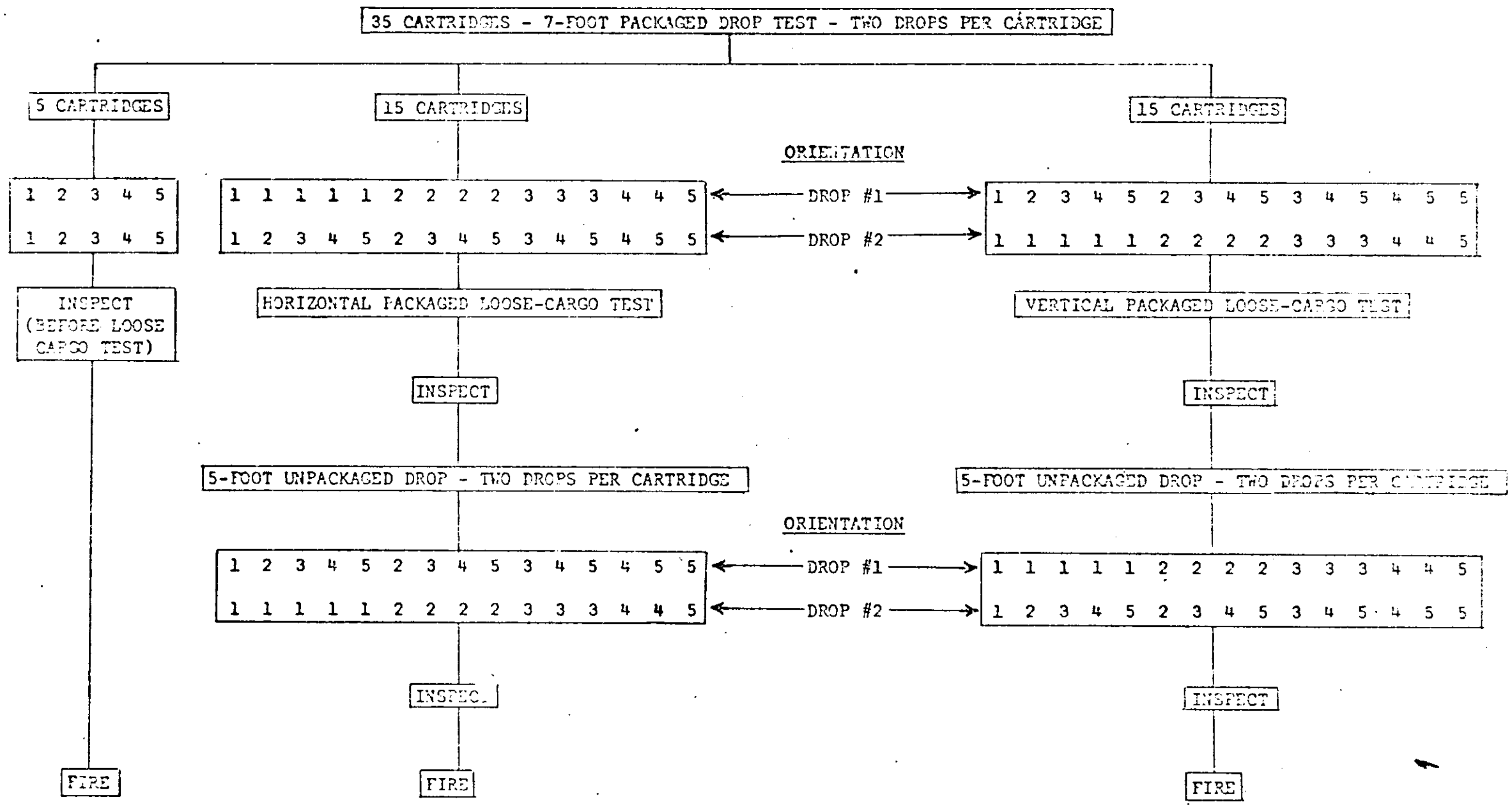
[a] All components are measured and inspected prior to testing in accordance with paragraph 3.2 and TOP/MTP 4-2-504.
[b] Inert loaded.
[c] Propellant temperature. Remaining components fired at ambient temperature.
[e] Projectile and fuze temperature. Propellant temperature as established in phase 7.
[f] Maximum quantity; sample size for fuze rough handling is 48 whereas sample size for projectile rough handling is 35. Depending upon number of serviceable items after rough handling, non-rough-handled projeciles (or fuzes) may be required to permit firing of all serviceable items.



ORIENTATION CODE
1 - SIDE
2 - BASE DOWN
3 - NOSE DOWN
4 - BASE DOWN AT 45°
5 - NOSE DOWN AT 45°

Note: This test is normally conducted at each of two temperature extremes, thus requiring 60 samples.

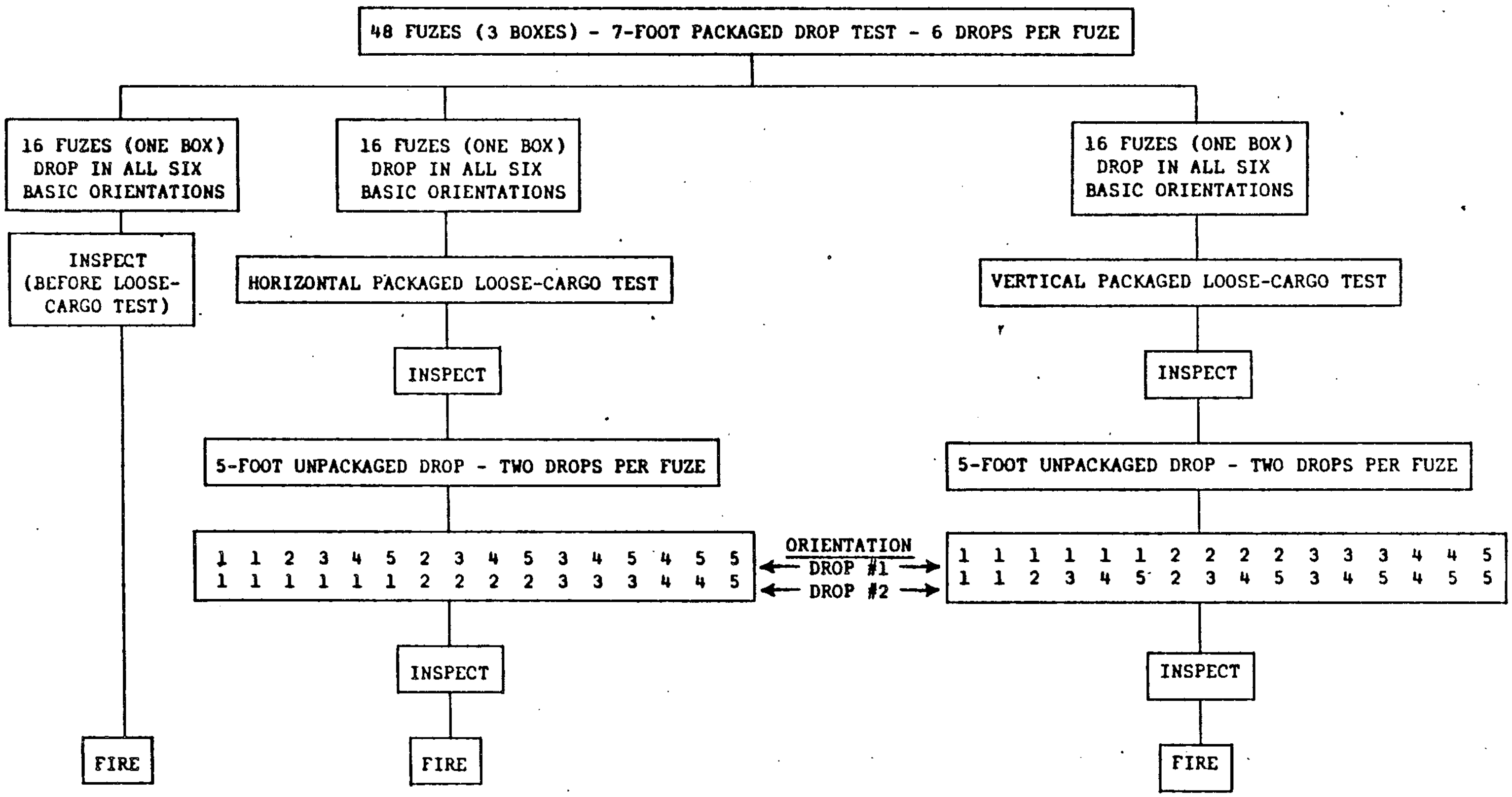
Figure 3.3-1 (U): Sequential Rough-Handling Test for Artillery, Mortar, and Recoilless-Rifle Ammunition - Large-Caliber, Separate-Loading Projectiles, Usually Shipped on Pallets (U).



ORIENTATION CODE
1 - SIDE (BOTTOM WHEN BOXED)
2 - BASE
3 - NOSE
4 - BASE AT 45° (BOTTOM-END EDGE WHEN BOXED)
5 - NOSE AT 45° (BOTTOM-END EDGE WHEN BOXED)

Note: **This test is normally conducted at each of two temperature extremes, thus requiring 70 samples.**

Figure 3.3-2 (U): Sequential Rough-Handling Test for Artillery Mortar and Recoilless-Rifle Ammunition - Cartridges and Propelling Charges Normally Shipped Individually Packaged (U).



ORIENTATION CODE

1 SIDE
2 BASE
3 NOSE
4 BASE AT 45°
5 NOSE AT 45°

Notes: Orientations for packaged drop are bottom, top, side, end, bottom-end edge (opposite from previous end) at 45° and top-side edge (opposite from previous side) at 45°.
This test is normally conducted at each of two temperature extremes, thus requiring 96 samples.

Figure 3.3-3 (U): Sequential Rough-Handling Test for Artillery, Mortar, and Recoilless-Rifle Ammunition Fuzes - Usually Shipped 16 per Package (U).

b. Phase 7. The temperature required to produce a pressure of 57,500 psi with the proof charge is estimated. Ten rounds are fired to check the pressure level.

c. Phases 8 through 25. The XM164, XM201, and XM203 charges are subjected to simulated transport, handling, and storage environments. All components are inspected for damage or deterioration resulting from the test environments. The usable components are assembled, conditioned to the indicated temperature (Table 3.3-I), and fired from a tube having a minimum of 75% of life remaining. Descriptions of the various envionments follow:

1) The transportation - vibration test is performed in accordance with the guidance provided in TOP/MTP 4-2-804, with the major axis vertical and is repeated with the major axis horizontal.

2) The hot-cycle test is performed with the guidance provided in TOP/MTP 4-2-820. The ammunition is subjected to a 7-day high temperature - low humidity schedule simulating storage under desert conditions.

3) The cold-soak test is performed with the guidance provided in TOP/MTP 4-2-504. The ammunition is conditioned at -60°F for 3 days, simulating storage under arctic conditions.

4) The rough-handling test is performed in accordance with Figures 3.3-1, 3.3-2, and 3.3-3 with the guidance provided in TOP/MTP 4-2-602. The test will simulate off-loading from tactical cargo-carrying vehicles, transport over 150 miles of Belgian block as loosely stowed cargo in the bed of a tactical cargo-carrying vehicle, and drops that might occur between vehicle off-loading and firing. The entire test is performed at each of two temperatures, -60 and +145°F.

d. Phases 26 through 28. M549 and M483 projectiles (with appropriate fuzes) are fired for recovery using the proof charge. All combinations are fired for base-first recovery. The recovered projectiles and fuzes are inspected for proper function and are checked dimensionally and for indications of actual or incipient material or metallurgical failure.

e. Phases 29 through 55. Various combinations of the M549 and M483 projectiles plus the M557, M728, and M577 fuzes are subjected to simulated transport, handling and storage environments. Other details are as described in paragraph c above.

f. Phases 47 through 55. Firings are performed from a worn tube with the various combinations of projectiles and fuzes used in previous phases. The firings are performed after tube life is established in the weapon tests (section 2). Ammunition performance is compared to that observed in the firings from the newer barrels.

g. Phases 56 and 57. Firings are performed with inert M107 and M549 projectiles using the lowest charge available for each type. A tube having a minimum of 95% of remaining life is used and firing is performed at maximum elevation. Prior to firing, the tube is measured in accordance with paragraph 3.2. Particular attention is given to the type and extent of deposits in the tube bore. Obvious changes in the characteristics of the deposits which take place during the test are recorded. All detailed inspections and measurements are repeated if any projectile sticks in the tube.

h. Phase 55. This phase is conducted with a new tube, modified to accept thermocouples. The XM203 charges are conditioned at +145°F and fired with inert M107 projectiles from the modified barrel at a rate of two rounds per minute. Firing is terminated when the temperature at any one of the thermocouples reaches the maximum safe temperature of +350°F or when it becomes obvious that the temperature will not be reached. The data obtained in phase 55 are analyzed at this point to determine the schedule to be used in additional trials. Testing is discontinued when the maximum safe firing schedule is defined.

i. Phases 59 through 61. A 40-foot drop test is performed with packaged XM164, XM201, and XM203 charges, in accordance with TOP/MTP 4-2-601. One package of each type of charge is dropped nose down, one base down, one with the major axis horizontal, one with the major axis 45° from the vertical with the nose down, and one with the major axis 45° from the vertical with the base down. The packaging and the charges are inspected for condition and are then destroyed.

All firings performed with live projectiles and fuzes are done at the elevation required to produce maximum range. Approximately one fifth of the PD fuzes fired under each combination of conditions are set to function delay and the remainder are set for SQ. Approximately one quarter of the MT and VT fuzes fired under each combination of conditions, that have dual mode capabilities, are set to function on ground impact and the remaining for air burst. Air bursts will be set to occur at any convenient distance; however, the XM728 fuze on the M549 projectile will not be set to function before the expected rocket-burnout point. All M549 projectiles will be fired with rocket assist.

3.3.4 Data Required and Analytical Plan

The data required include:

a. Data required for all rounds:

1) All of the normal round-by-round data required by TOP/MTP 4-2-504.

2) Peak chamber pressure.

3) Time - pressure traces.

4) Muzzle velocity.

5) A description of smoke, flash, blast, and any residue deposited in or near the weapon based on visual and aural observations with photographs and measurements of significant excesses in any of these characteristics.

6) High-speed photographs of the projectiles in flight near the muzzle.

7) Periodic pull-over gage measurements of the tube.

8) A description of any adverse effects of firing (on the weapon).

9) A detailed description of any actual or potential safety problem.

10) All data pertinent to the reliability test.

b. Additional data for phases 1 through 7 to include typical time - chamber pressure curve with a description of any significant deviation from the typical.

c. Additional data for phases 26 through 28, to include:

1) Dimensions of each round.

2) General description of each projectile and fuze including photographs, X-rays, or results of any other inspection that revealed failure.

d. Additional data required for phases 8 through 25 and 29 through 55 description of each component after being subjected to the individual environments with photographs of significant damage or deterioration.

e. Additional data required for phases 29 through 55 to include:

1) Time of flight to impact or air burst of each round.

2) Approximate range to each impact.

3) A description of projectile function.

4) A description of any malfunction, to include type, cause, and reason.

5) Stop-watch time to rocket-motor ignition and burnout for the M549 projectiles.

f. Additional data required for phases 56 and 57 to include:

1) Travel time in bore.

2) Time - pressure traces.

3) Tube measurements and inspection records made prior to and during firing.

g. Additional data required for phase 58 include:

1) Ambient air temperature.

2) Tube temperature at each thermocouple:

a) At start of firing.

b) At the time firing is discontinued.

3) Time - temperature traces, with the times that each round is loaded and fired being superimposed on record.

4) The number of rounds in each schedule required to reach critical or stabilized temperature.

h. The data required for phases 59 through 61 include the condition of the packaging and the charges after dropping.

There is no statistical plan relating to the over-all safety requirements of individual components. The sample sizes necessary to demonstrate that safety requirements have been met are prohibitively large. Any single safety malfunction that occurs with the ammunition in any of the tests in this plan shall signify a failure to meet the criteria.

The point estimate and upper confidence limit on sticker rate will be calculated using statistical procedures for binomially distributed random variables. This data will be compared to sticker data from previous firings, if possible.

The data from phase 58 are analyzed after each firing to determine the set of conditions to be used in the following firing. All data are used to construct a set of curves using the number of rounds to reach maximum safe temperature and the temperature-rise rates for each firing schedule. The maximum safe rate of fire and the maximum number of rounds that can be safely fired with a given rate are determined from these curves.

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3.4 (U) FUNCTIONING CHARACTERISTICS TEST

3.4.1 Objective

The objective is to determine the functioning characteristics of standard ammunition in the XM198 howitzer.

3.4.2 Criterion

None.

3.4.3 Method

No firing is done in this phase. Applicable data obtained in all other tests are compiled and analyzed in relation to the criteria.

3.4.4 Data Required and Analytical Plan

The data required (from the other test) for an analysis of reliability include:

a. Time to air bursts.

b. Times to ignition and burnout of M549 rocket motor.

c. Horizontal range..

d. A description of the terminal performance of each projectile, based on visual observations.

e. A description of all projectile and weapon malfunctions.

Data from other subtests are combined as appropriate. Point estimates and confidence limits on functioning reliability are calculated for each combination of fuze, projectile, charge, fuze setting, etc. as considered proper after examination of the data. The results are compared to previous firing results, as available, using suitable statistical procedures for comparing binomially distributed random variables.

3.5 (U) VELOCITY AND PRESSURE TEST

3.5.1 Objective

The objective is to establish velocity and pressure levels for standard and developmental charges in the XM198 howitzer.

3.5.2 Criteria

None.

3.5.3 Method

No firing is done in this test. Data obtained in the safety and provisional firing tables tests are used to calculate velocity and pressure levels.

3.5.4 Data Required and Analytical Plan

The data required include the velocities and pressures of all rounds fired in the provisional firing tables test and those phases of the safety test that are fired with unmodified charges.

Point estimates of the mean and standard deviation of the velocity and pressure measurements are calculated.

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3.6 (C) PRECISION AND RANGE TEST (U)

3.6.1 (U) Objective

The objective is to determine the precision and maximum and minimum ranges of standard and developmental ammunition in the XM198 howitzer.

3.6.2 (C) Criteria (U)

a. (C) The distribution of the range probable error for developmental full-caliber matched rocket-assisted and nonrocket-assisted projectiles in low-angle indirect fire shall range from 0.12 to 0.30% of range fired, with a 90% probability that no range probable error shall exceed 0.30% of the range fired. The deflection probable error shall not exceed 1 mil (para VId (1)(a), MN).

b. (U) The range and deflection probable errors listed in appropriate firing tables for the M114A1 towed howitzers shall be used as criteria for the testing of complete rounds of standard ammunition. Exterior ballistic performance of standard ammunition fired in the new weapon shall equal or exceed the criteria deemed to be compatible for unrestricted use (para VId(1)(b),MN).

c. (C) Developmental full-caliber matched rocket-assisted projectiles shall have a maximum range between 28.5 and 31 kilometers when firing with the rocket on (para VIe(1)(a),MN).

d. (C) Maximum range shall be between 22 and 25 kilometers when firing from a new cannon (i.e., with at least 95% of remaining life), the developmental nonrocket-assisted high-capacity projectiles; and, rocket-assisted projectiles with the rocket off (para VIe(1)(b),MN).

e. (U) The maximum range for current standard projectiles shall be equal to or greater than that achieved by the M114A1 towed howitzer. The data listed in the appropriate firing tables for the M114A1 howitzer shall be used as criteria for the testing of complete rounds of standard ammunition (para VIe(1)(c), MN).

f. (U) The minimum range with the new developmental ammunition shall be between 1.5 and 2.5 kilometers in low-angle indirect fire with a minimum quadrant elevation of 200 mils and not more than 2.5 kilometers in high-angle indirect fire (para VIe(2)(b)MN).

g. (U) The minimum range with current standard projectiles shall be equal to or slightly greater than that achieved by standard complete rounds when fired from the M114A1 howitzer (para VIe(2)(c),MN).

3.6.3 (U) Method

The data obtained in the provisional firing tables test are used to satisfy the requirements of this test.

3.6.4 (U) Data Required and Analytical Plan

The data required include all range data obtained in the provisional firing tables test.

The data will be used to determine the precision and range performance of the various projectile - charge combinations. The velocities and pressures will be corrected to the standard projectile weight. Individual ranges will be corrected to remove the effects of velocity and projectile weight variations. In addition, ranges and deflection will be corrected to the standard ICAO meteorological conditions. For each group of rounds means and dispersions (standard deviation or probable error as appropriate) shall be calculated for velocity, pressure, range, and deflection using observed and corrected data. Tabulations of results will be prepared, supplemented by appropriate plots of range, elevation, velocity, and temperature relationships.

For the firings of the M549 RAP where the HAWK velocimeter is used for tracking, the reduction of data will include a determination of the drag coefficient K_D and the projectile form factor. For typical projectiles, plots of velocity - time and drag curves will be provided.

The results from firings of developmental full-caliber matched rocket-assisted and nonrocket-assisted projectiles in low-angle indirect fire will be used to calculate point estimates and upper confidence limits on relative range probable error and on deflection probable error. (The Chi-square distribution will be used.) The number of relative range probable errors exceeding 0.30% will be counted and from this the probability that no relative range probable error exceeds 0.30% will be calculated. (The binomial distribution will be used here.)

Range and deflection probable errors calculated from the test of complete rounds of standard ammunition will be compared to firing-table values for the M114A1 towed howitzer, as appropriate. (The Chi-square distribution will be used.) Exterior ballistic performance parameters of the standard ammunition fired in the new weapon will be compared to criteria deemed to be compatible for unrestricted use. (Standard statistical procedures for normally distributed random variables will be used.)

The point estimate and the 90% confidence interval on average maximum range will be calculated for the M549 projectile when fired with the rocket on. This interval may be compared to the criterion interval. It will be assumed that range is a normally distributed random variable.

The point estimate and the 90% confidence interval on average maximum range will be calculated for developmental, nonrocket-assisted high-capacity projectiles and rocket-assisted projectiles with rocket off when fired from a new cannon (95% remaining life).

The maximum range calculated from the test of complete rounds will be compared to the firing-table values for the M114A1 towed howitzer, as appropriate.

The point estimate and the 90% confidence interval on average minimum range will be calculated for new developmental ammunition for low-angle indirect fire and for high-angle indirect fire. These intervals may be compared to the criteria values.

The minimum range calculated from current standard projectile firings will be compared to that achieved by standard complete rounds fired from the M114A1 howitzer.

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3.7 (U) PROVISIONAL FIRING-TABLES TEST

3.7.1 Objective

The objective is to provide data for the preparation of provisional firing tables.

3.7.2 Criteria

Not applicable.

3.7.3 Method

Tables 3.7-I through 3.7-XI contain the firings that are to be done. New tubes (95% of remaining life minimum) are used for all firings. The inspections and measurements of the test materiel that are outlined in paragraph 3.2 are performed prior to firing.

Table 3.7-I (U). Provisional Firing-Table Test Conditions for the M107, HE Projectile with the M557 Fuze (U)

		Charge Model and Zone										
	Elev,	M3A1					M4A2					M119
Barrel	mils	1	2	3	4	5	3	4	5	6	7	8
1	200	X	X	X	X	X	X	X	X	X	X	X
1	500	X	X	X	X	X	X	X	X	X	X	X
1	800	X	X	X	X	X	X	X	X	X	X	X
1	1000	X	X	X	X	X	X	X	X	X	X	X
1	1250	X	X	X	X	X	X	X	X	X	X	X
2	200	X	X	X	X	X	X	X	X	X	X	X
2	500	X	X	X	X	X	X	X	X	X	X	X
2	800	X	X	X	X	X	X	X	X	X	X	X
2	1000	X	X	X	X	X	X	X	X	X	X	X
2	1250	X	X	X	X	X	X	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Table 3.7-II (U). Provisional Firing-Table Test Conditions for the M107 Projectile with the M557 Fuze (U)

Barrel	Ammo Temp, °F	Elev, mils	Charge Model and Zone: XM164 1	XM164 2	XM164 3	XM164 4	XM164 5	XM201 6	XM201 7
1	- 40	200	X	X	X	X	X	X	X
1	+ 70	200	X	X	X	X	X	X	X
1	+ 70	500	X	X	X	X	X	X	X
1	+125	500	X	X	X	X	X	X	X
1	+ 70	800	X	X	X	X	X	X	X
1	+ 70	1000	X	X	X	X	X	X	X
1	+ 70	1250	X	X	X	X	X	X	X
2	- 40	200	X	X	X	X	X	X	X
2	+ 70	200	X	X	X	X	X	X	X
2	+ 70	500	X	X	X	X	X	X	X
2	+125	500	X	X	X	X	X	X	X
2	+ 70	800	X	X	X	X	X	X	X
2	+ 70	1000	X	X	X	X	X	X	X
2	+ 70	1250	X	X	X	X	X	X	X

Notes: Five rounds are fired under each set of conditions on each of two days.
The rounds conditioned at -40 and +125°F are fired alternately with the rounds conditioned at +70°F under the same conditions.
One lot of projectiles are used for all firings. Two lots of each type of charge are used. One lot is used for the first firing under each set of conditions and another for the second.

Table 3.7-III (U). Provisional Firing-Table Test Conditions for the M449A1 Projectile with the M564 with SR Element and the M107 Projectile with the M557 Fuze (U)

Barrel	Elev, mils	Charge Model and Zone: M3A1 1	M3A1 3	M3A1 5	M4A2 3	M4A2 5	M4A2 7	M119 8
1	200	X	X	X	X	X	X	X
1	600	X	X	X	X	X	X	X
1	1150	X	X	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Ten M449A1 projectiles are fired alternately with ten M107 projectiles for each set of conditions.
One lot of each projectile and propelling charge is used for the firing.

Table 3.7-IV (U). Provisional Firing-Table Test Conditions for the M449A1 Projectile and M564 Fuze with SK Element and the M107 Projectile with the M557 Fuze (U)

Barrel	Elev, mils	Charge Model and Zone XM164 1	XM164 3	XM164 5	XM201 6	XM201 7
1	200	X	X	X	X	X
1	600	X	X	X	X	X
1	1150	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Ten M449A1 projectiles are fired alternately with ten M107 projectiles for each set of conditions.
One lot of each projectile and propelling charge is used for the firing.

Table 3.7-V (U). Provisional Firing-Table Test Conditions for the M483 Projectile with the M577 Fuze (U)

Barrel	Elev, mils	Charge Model and Zone M3A1 1	M3A1 2	M3A1 3	M3A1 4	M3A1 5	M4A2 3	M4A2 4	M4A2 5	M4A2 6	M4A2 7	M119 8
1	200	X	X	X	X	X	X	X	X	X	X	X
1	500	X	X	X	X	X	X	X	X	X	X	X
1	800	X	X	x	x	X	X	X	X	X	X	X
1	1000	X	X	X	X	X	X	X	X	X	X	X
1	1250	X	X	X	X	X	X	X	X	X	X	X
2	200	X	X	X	X	X	X	X	X	X	X	X
2	500	X	X	X	X	X	X	X	X	X	X	X
2	800	X	X	X	X	X	X	X	X	X	X	X
2	1000	X	X	X	X	X	X	X	X	X	X	X
2	1250	X	X	X	X	X	X	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Table 3.7-VI (U). Provisional Firing-Table Test Conditions for the M483 Projectile with the M577 Fuze (U)

		Charge Model and Zone						
	Elev,	XM164					XM201	XM203
Barrel	mils	1	2	3	4	5	6	8
1	200	X	X	X	X	X	X	X
1	500	X	X	X	X	X	X	X
1	800	X	X	X	X	X	X	X
1	1000	X	X	X	X	X	X	X
1	1250	X	X	X	X	X	X	X
2	200	X	X	X	X	X	X	X
2	500	X	X	X	X	X	X	X
2	800	X	X	X	X	X	X	X
2	1000	X	X	X	X	X	X	X
2	1250	X	X	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Table 3.7-VII (U). Provisional Firing Tables Test Conditions for the M485A2 Projectile with the M548 Fuze and the M107 Projectile with the M557 Fuze (U)

		Chg Model and Zone				
	Elev,	M3A1		M4A2		M119
Barrel	mils	1	5	3	7	8
1	200	X	X	X	X	X
1	600	X	X	X	X	X
1	1150	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Ten M485A2 projectiles are fired alternately with ten M107 projectiles for each set of conditions.
One lot of each projectile and propelling charge is used for the firings.

Table 3.7-VIII (U). Provisional Firing Table Test Conditions for the M485A2 Projectile with the M548 Fuze and the M107 Projectile with the M557 Fuze (U)

Barrel	Elev, mils	Chg Model and Zone XM164 1	XM164 5	XM201 6	XM201 7
1	200	X	X	X	X
1	600	X	X	X	X
1	1150	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Ten M485A2 projectiles are fired alternately with ten M107 projectiles for each set of conditions.
One lot of each projectile and propelling charge is used for the firings.

Table 3.7-IX (U). Provisional Firing-Table Test Conditions for the M549 Projectile (Rocket Off) with the M557 Fuze (U)

		Charge Model and Zone								
	Elev,	M3A1				M4A2				M119
Barrel	mils	1	2	3	5	3	5	6	7	8
1	250	X	X	X	X	X	X	X	X	X
1	500	X	X	X	X	X	X	X	X	X
1	750	X	X	X	X	X	X	X	X	X
1	950	X	X	X	X	X	X	X	X	X
1	1200	X	X	X	X	X	X	X	X	X

Notes: The temperature of the ammunition is +70°F.
Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Table 3.7-X (U). Provisional Firing-Table Test Conditions for the M549 Projectile (Rocket Off) with the M557 Fuze (U)

	Ammo		Charge Model and Zone							
	Temp,	Elev,	XM164					XM201		XM203
Barrel	°F	mils	1	2	3	4	5	6	7	8
1	+ 70	250	X	X	X	X	X	X	X	X
1	+ 70	500	X	X	X	X	X	X	X	X
1	- 40	750					X			
1	+ 70	750	X	X	X	X	X	X	X	X
1	+130	750	X							
1	- 40	950	X							
1	+ 70	950	X	X	X	X	X	X	X	X
1	+130	950					X			
1	+ 70	1200	X	X	X	X	X	X	X	X

Notes: Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Table 3.7-XI (U). Provisional Firing-Table Test Conditions for the M549 Projectile (Rocket On) with the M557 Fuze (U)

	Ammo		Charge and Zone			
	Temp,	Elev,	M4A2	M119	XM201	XM203
Barrel	°F	mils	7	8	7	8
1	+ 70	300	X	X	X	X
1	- 40	500	X		X	
1	+ 70	500	X	X	X	X
1	+130	500		X		X
1	+ 20	700	X	X	X	X
1	+ 70	700	X	X	X	X
1	- 40	900		X		X
1	+ 70	900	X	X	X	X
1	+130	900	X		X	
1	+ 70	1150	X	X	X	X
2	+ 70	300	X	X	X	X
2	- 40	500	X		X	
2	+ 70	500	X	X	X	X
2	+130	500		X		X
2	+ 20	700	X	X	X	X
2	+ 70	700	X	X	X	X
2	- 40	900		X		X
2	+ 70	900	X	X	X	X
2	+130	900	X		X	
2	+ 70	1150	X	X	X	X

Notes on page 113.

Table 3.7-XI (Cont'd)

Notes: Five rounds are fired under each set of conditions on each of two days.
One lot of projectiles is used for all firings.
Two lots of each type of charge are used, one lot for the first firing under each set of conditions and another for the second.

Velocities and chamber pressures are measured on all rounds. All rounds are fired for ground impact. One-fifth of the M557 fuzes fired under each set of conditions is set for delay functioning and four-fifths are set for SQ. Observations relative to safety and reliability are made during all firings.

The HAWK velocimeter is used to track each M549 round (Table 3.7-XI) fired with the rocket on. The details of the data to be recorded are to be established through direct contact with personnel of Ballistic Research Laboratories (BRL). A requirement to track 10% of all M549 rounds with an AN/MPS-25 radar may be added if the results of the tests to be performed at Yuma Proving Ground are favorable. Rocket-motor ignition-delay times are recorded by four observers using stop watches. One of the observers uses the telescope on the HAWK velocimeter.

Two M107 projectiles are fired to warm the weapon at the start of each days testing, or at any time that the firing has been interrupted for more than one hour; or, at any time that firing conditions dictate a change of more than two zones, and when nonstandard (+70°F) temperatures are used. The warmer rounds will be at the same zone and temperature as the test rounds to be fired. The XM728, M564, and XM582E1 fuzes set for air burst are used on the warming round. The three fuzes are distributed equally among the various zones of the propelling charges to the extent permitted by test requirements. Reliability data are obtained on all rounds.

Personnel of BRL are notified in advance of firing dates in order for them to observe and coordinate minor changes to the firings as necessary.

3.7.4 Data Required and Analytical Plan

The data required by BRL include:

a. All data required by paragraphs 2 and 3 of TOP/MTP 3-1-004.

b. Peak chamber pressure (crusher gages) and velocities (coils) for all rounds fired.

c. Centers of gravity and moments of inertia of ten fuzed projectiles of each type used in the firings in each of Tables 3.7-I through 3.7-VIII. (This requires measurement of 60, M107 projectiles, since they are used in the firings outlined in six of the tables.)

d. Centers of gravity and moments of inertia of a 5% sample of the fuzed M549 projectiles (Tables 3.7-IX through 3.7-XI).

e. The centers of gravity and moments of inertia of five fuzed M549 projectiles before and after static ignition and consumption of the rocket propellant.

f. Magnetic tape records of the HAWK valocimeter data.

g. Stop watch times to rocket ignition, for the M549 projectiles.

Other data required include:

a. All data required for the functioning - reliability safety, velocity and pressure, and precision and range tests.

b. Tube measurements and inspection records.

c. A description of any ammunition or weapon malfunction.

d. A description of any adverse effects on the weapon due to firing.

All raw data required by paragraph 3.7.4 are forwarded to the Firing Tables Branch, Exterior Ballistic Laboratory, BRL for analysis and preparation of provisional firing tables. In addition, all pertinent data are used for the evaluation of safety, functioning, reliability, precision, range, velocity, and pressure.

3.8 (U) FLASH-CHARACTERISTICS TEST

3.8.1 Objectives

a. To compare the flashes produced in the XM198 and M114 howitzers by standard charges.

b. To compare the flashes produced by standard and developmental charges in the XM198 howitzer.

3.8.2 Criteria

None.

3.8.3 Method

The howitzers are located in a clear field as free of artificial light as possible. Still cameras are located at the front and side of the howitzer at the minimum distances required to cover the entire length, width, and height of the flash. A color motion-picture camera (128 frames per second) is located at three-quarters front at the minimum distance for over-all coverage of the flash.

All firing is done at night under, as near as possible, the same light conditions. All settings for the cameras are the same for all rounds with exposure times being long enough to include the entire duration of the flash.

Three inert projectiles are fired at each zone of the M3A1 and M4A2 charges from the M114 and XM198 howitzers and each zone of the M119, XM164, XM201 and XM203 charges from the XM198 howitzer. All firing is done with the howitzers at 35° of elevation.

3.8.4 Data Required and Analytical Plan

The data required include:

a. Normal round-by-round data.

b. The length, width, and height of each flash, measured on the still photographs.

c. A description of each flash, based on both visual observations and a review of the color motion-picture films.

There are no quantitative standards, requirements, or standardized methods for obtaining reproducible quantitative data for the evaluation of flash characteristics. Analyses are therefore subjective, based on the sizes determined from the still photographs and the impressions of the observers, developed during firings and after reviewing the motion pictures.

SECTION 4. DETAILS OF TUBE-LIFE TESTS (U)

4.1 (U) INTRODUCTION

The proposal consists of a 2-part test of four howitzer tubes in which the first two tubes will be fired using ammunition that will represent the "worst service condition", i.e., the top zone propelling charge heated to +145°F (or to the upper temperature limit, if such a restriction has been established). The firing of each tube will not be terminated until the mean test ammunition pressure falls to that level of pressure previously established for the system at the end of accuracy life with +70°F service ammunition or to a maximum of rounds which is one-half the nominal mean design fatigue life (nominal mean design fatigue for XM199 series tube is 7500 EFC). Laboratory cycling will then be performed on the test items. An interim safety release for operational testing will be developed on these results.

It is anticipated that a substitute projectile for the M549 round will have been qualified in terms of interior-tube stress levels for fatigue tests. This substitution would reduce the costs of ammunition components.

The second phase is the basis for establishing normal bore-wear rates for conventional rounds (+70°F) fired from two tubes. The rounds fired will not exceed the one-third of the total determined by the least number of rounds of the fatigue test tube used in phase one.

One tube will be fired for determining tube-wear life. The results of a previous wear-life tube, conducted at APG during the firing of the durability firing of prototype No. 1, will be substituted for the second tube.

Two breech mechanisms will be used for both phase (fatigue and wear) tests, to enable establishment of the EFC life of this components.

Fatigue and wear-life tests will be conducted on one complete XM198 weapon system or facility mounts of some type.

(Following Page Blank)

4.2 (U) FATIGUE-LIFE TEST

4.2.1 Objective

The objective is to determine an interim safe fatigue life for the XM199 cannon in terms of EFC round numbers, which are based upon the XM123 propelling charge and the M549 or similar projectile under the worst expected field conditions (+145°F), not to exceed three pressure standard deviations below gun design or PIMP pressure.

4.2.2 Criteria

The criteria are that:

a. Failures will be defined as follows (test agency):

1) Loss of firing accuracy through unstable projectile launch, velocity or pressure loss, or malfunction of ammunition with standard propelling charges conditioned to +70°F.

2) Rupture or material failure of tube and breech mechanism components through fatigue.

b. The tube and ammunition shall be designed so that the tube life will be between 2500 and 5000 equivalent full charge (EFC) rounds (MN, para VI K(4)(b)). (The interim safe-life recommendation will be based on the results determined in para 4.2.3.)

c. The breech ring and recoil mechanism must have a 50% probability of enduring 10,000 and 15,000 EFC rounds, without a need for replacement or overhaul, and shall not be over sensitive to sudden temperature changes (MN, para VI K(4)(c)).

d. The carriage, to include the top carriage, bottom carriage, and triails, shall have a 50% probability of enduring at least 15,000 EFC rounds without need for replacement or overhaul (MN, para VI K(4)(d)).

4.2.3 Method

4.2.3.1 Preparation. Two 155-mm, XM199 howitzer tubes are subjected to a complete inspection before and after proof-firing one round. Inspections are performed as follows:

a. Magnetic-particle inspection.

b. Star-gage and pull-over measurements.

c. Borescope inspection and bore photographs.

d. Bore impressions and photographs.

e. Ultrasonic (electronic) inspections of chamber and origin-of-rifling areas.

f. Magnetic recording borescope inspection of bore and chamber.

4.2.3.2 Procedure for Tube Interim Safe-Life:

a. In establishing a test methodology utilizing firing and laboratory cycling for a TECOM fatigue safe life, the following assumptions are made:

1) That the proponent agency will furnish the design parameters of "nominal mean design fatigue life" in terms of full EFC rounds. (For the XM199 cannon this value is 7500 EFC rounds.)

2) The ammunition used will represent the "worst service condition", i.e., the top zone propelling charge or highest pressure cartridge heated to +145°F (or to the upper temperature limit if such a restriction has been priorly established).

3) For weapons that are expected to become unserviceable due to bore erosion and accuracy loss prior to end of fatigue life, fatigue firing will be terminated when the mean test-ammunition pressure falls to that level of pressure previously established (or estimated if no data exist) for the system at the end of accuracy life with +70°F service ammunition.

b. Each (of two) cannon will be fired to at least half the number of EFCs stated in paragraph 1) above, using the ammunition described in paragraph 2). Concurrently with this firing each tube will be subjected to intermittent, laboratory, pressure cycling until tube failure occurs as a result of the combination fire/cycle routine. Each interval of firing and cycling will provisionally be 10% of the total nominal mean design fatigue life, beginning with the firing phase. The laboratory cycling pressure used throughout shall be equal to the measured firing-pressure mean of the first 30 rounds fired, i.e., "new gun pressure".

c. In determining the safety recommendation, a K factor of 0.85 will be used. The life of each tube will be estimated as the number of rounds fired plus 0.85 times the number of laboratory cycled. Those values for the two tubes will be averaged and a safety recommendation of one-third of this result will then be given.

d. In these instances where the wear/accuracy firing life is proven to be less than half the nominal mean design fatigue life, the firing portion will be terminated as stated in paragraph 3) above and the tubes will be cycles to failure.

e. While the above method of testing will not provide data for determining K, it is anticipated that crack-propagation rates will be monitored throughout such tests where time and resources permit. In time an improved value for K may emerge, for each system tested, as fall-out data, provided a method of analyzing crack-growth data can be developed.

4.2.3.3 Life Testing (2 Each, XM199 Cannon). Fire two 155-mm, XM199 howitzer tubes and breech mechanisms, using the schedule of rounds shown in Table 4.2-I.

Table 4.2-I (U). Life-Test Schedule (U)

Projectiles: M549 (HE); weight with fuze, 96 pounds.
M549 or authorized substitute rounds (inert-loaded, solid-fill preferred); weight, 96 pounds.

Charge: XM203E2, zone 8.

Fuzes: Inert, M78 or M73 dummy.
M572 PD or M557 (if safety-certified).

Primer: M82.

	No. of Rounds				
				Record Each Day	
Test Rd No.	Inspection and Measurements[a]	Accuracy Firing[b]	Expenditure[c]	MV	Chamber Pressure
1	[d]BF and AF	Proof Firing		1	1
2 to 13	AF 1-rd	12	-	12	12
[b] 14 to 20	-	Recovery		-	7
21 to 400	400	-	380	10	10
401 to 412	-	12	-	12	12
413 to 700	[d] 700	-	288	10	10

[a]Perform star-gage and pull-over measurements as indicated. Pull-over measurements will be taken at the origin of rifling at the beginning of each day, without cleaning. Perform borescope inspection and record impressions and photographs as indicated; however, impressions and photographs may be omitted at the discretion of the Project Officer when there is no noticeable change from previous inspection. Perform magnetic-particle inspection as indicated. Record pattern indications and photographs of all defects.

[b]Propelling charges for the range and recovery phases are conditioned at +70°F for a minimum of 16 hours before they are used.

[c]All expenditure-round charges are conditioned at an elevated temperature (up to +145°F) to achieve the target pressure.

[d]Special electronic (ultrasonic) and MRB inspections will be used as indicated.

Table 4.2-I (Cont'd)

Test Rd No.	No. of Rounds: Inspection and Measurements[a]	Accuracy Firing[b]	Expenditure[c]	Record Each Day: MV	Record Each Day: Chamber Pressure
701 to 712	-	12	-	12	12
713 to 1100	1100	-	388	10	10
1101 to 1112	-	12	-	12	12
[b]1113 to 1120	-	Recovery		-	8
1121 to 1500	[d] 1500	-	380	10	10
1501 to 1512	-	12	-	12	12
1513 to 1515	[e] 1515	Cold test	3	-	3
1516 to 1900	1900	-	385	10	10
1901 to 1912	-	12	-	12	12
[b]1913 to 1920	-	Recovery		-	8
1921 to 2300	[d] 2300	-	380	10	10
2301 to 2312	-	12	-	12	12
2313 to 3000	3000	-	688	10	10
3001 to 3012	-	12	-	12	12
3013 to 3750	[d] 3750	-	737	10	10
3751 to 3762	-	12	-	12	12

[a]Perform star-gage and pull-over measurements as indicated. Pull-over measurements will be taken at the origin of rifling at the beginning of each day, without cleaning. Perform borescope inspection and record impressions and photographs as indicated; however, impressions and photographs may be omitted at the discretion of the Project Officer when there is no noticeable change from previous inspection. Perform magnetic-particle inspection as indicated. Record pattern indications and photographs of all defects.
[b]Propelling charges for the range and recovery phases are conditioned at +70°F for a minimum of 16 hours before they are used.
[c]All expenditure-round charges are conditioned at an elevated temperature (up to +145°F) to achieve the target pressure.
[d]Special electronic (ultrasonic) and MRB inspections will be used as indicated.
[e]Cold test; condition to -65°F for 24 hours.

Full precautionary measures will be taken when the results of the magnetic-particle, ultrasonic, and MRB inspections indicate the tubes to be hazardous. At this time, all safety measures are observed to prevent injury to equipment and personnel in case of tube fracture.

4.2.4 Data Required and Analytical Plan

The following data will be required:

a. Proof-firing data:

1) Muzzle velocity.

2) Propelling-charge model, zone, and total charge weight.

3) Peak chamber pressure.

4) Projectile weight.

b. Inspection data:

1) Magnetic-particle (photographs).

2) Electronic inspections.

c. Tube measurements:

1) Star-gage.

2) Pull-over.

3) Muzzle wear.

d. Borescope data:

1) Photographs.

2) Impressions.

3) Visual description.

e. Accurate round-by-round data:

1) Range rounds.

2) Expenditure rounds.

3) Muzzle velocities.

4) Peak chamber pressures.

f. Range data:

   1) Meteorological information.

   2) Range dispersion.

   3) Deflection dispersion.

   4) Muzzle velocities.

   5) Peak chamber pressure.

   6) Propelling-charge lot weights.

g. Cannon component failures and the round life of each component.

h. Weapon-component failures and the round life of each component.

i. Photographs of each component failure.

The following analytical plan will be required:

a. Graphical plots of vertical land wear (origin of rifling and muzzle) versus rounds fired.

b. Graphs of pressure and velocity levels versus round fired.

c. Range and deflection standard deviations versus tube wear.

d. For the breech ring, to demonstrate (at a stated confidence of at least 90%) a 50% probability of enduring 10,000 EFC rounds without need for replacement or overhaul would require a minimum sample of 40,000 EFC rounds and no replacement or overhaul failures would be allowed on the test. (This is based on four binomial trials of 10,000 EFC rounds each.) (Testing to a durability requirement is usually very difficult, if not impossible, with respect to time and cost. Often an exponential probability density of time between replacement or overhaul is assumed. It is not believed that this is a good assumption, in general. Other distributions can be assumed but unless a substantial sample of items are tested to failure, estimation of durability is weak.)

   Based on 18,030 (2 x 9015) EFC rounds programmed to be fired in this test, if no replacement or overhaul failures occur, it may be stated with 50% confidence that the 50% probability is demonstrated (one 10,000 EFC round trial; if 20,000 rounds could be tested, the confidence level would be 75%).

c. For the recoil mechanism and carriage, to demonstrate (at a stated confidence of at least 90%) a 50% probability of enduring 15,000 EFC rounds without need for replacement or overhaul would require a minimum sample of 60,000 EFC rounds and no replacement or overhaul failures would be allowed on the test. (This is based on four binomial trials of 10,000 EFC rounds each.)

Based on 18,030 (2 x 9015) EFC rounds programmed to be fired in this test, if no replacement or overhaul failures occur, it may be stated with 50% confidence that the 50% probability is demonstrated (one 10,000 EFC round trial; if 30,000 rounds could be tested, the confidence level would be 75%).

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4.3 (U) BORE-WEAR LIFE CONFIRMATION TEST

4.3.1 Objectives

a. To establish rates of wear for the XM199 tube for various standard and developmental ammunition types.

b. To establish a tube limit of precision life by either range firing, excessive muzzle-velocity loss, rotating-band shear, excessive projectile yaw, round malfunction, etc.

4.3.2 Criteria

a. The tube precision life condemnation limit will be evidenced by the gun/ammunition failure as described below (test agency):

1) Stripped or sheared rotating bands as evidenced by statistically significant outliers observed in accuracy groups. This latter to be verified by high-speed photography and/or examination of recovered projectiles.

2) The observation of mechanical failure of the fuze or the observation of fuze performance significantly different from established requirements such as Material Needs (MN's), specifications, or other requirement documents.

3) Unusual bore-wear/damage conditions observed which correlate to an ammunition malfunction or significant loss of accuracy.

b. The tube and ammunition shall be designed so that the tube life will be between 2500 and 5000 equivalent full charge (EFC) rounds (MN, para VIK(4)(b)).

4.3.3 Method

4.3.3.1 Preparation. Two 155-mm, XM199 howitzer tubes are subjected to complete inspections before and after proof-firing one round. The inspections performed are as follows:

a. Magnetic-particle inspection.

b. Star-gage and pull-over measurements.

c. Borescope inspection and bore photographs.

d. Bore impressions and photographs.

e. Ultrasonic inspections of the chamber and the origin-of-rifling areas.

f. Magnetic recording borescope inspection of bore and chamber.

4.3.3.2 Wear Testing. Fire two 155-mm, XM199 howitzer tubes and breech mechanisms using the schedule of rounds shown in Table 4.3-I.

Table 4.3-I (U). Bore-Wear Test Schedule (U)

Projectiles: M549 (HE); weight with fuze, 96 pounds.
M549 (inert, solid-fill); weight with fuze, 96 pounds.
Charge: XM203E2, zone 8.
Fuzes: Inert, M78 or M73 dummy.
PD, M572 or PD M557 (if safety certified).
Primer: M82.

	No. of Rounds				
				Record Each Day	
Test Rd No.	Inspection and Measurements[a]	Accuracy Firing[b]	Expenditure[b]	MV	Chamber Press.
1	BF and AF	Proof Firing		1	1
2 to 13	AF 1 rd[c]	12	-	12	12
14 to 250	250	-	237	10	10
251 to 262	-	12	-	12	12
263 to 500	500	-	238	10	10
501 to 512	-	12	-	12	12
513 to 750	750	-	238	10	10
751 to 762	-	12	-	12	12
763 to 1000	1000	-	238	10	10
1001 to 1012	-	12	-	12	12
1013 to 1022	-	Recovery		-	10
1023 to 1250	1250	-	227	10	10
1251 to 1262	-	12	-	12	12
1263 to 1500	1500	-	238	10	10
1501 to 1512	-	12	-	12	12
1513 to 1750	1750	-	238	10	10
1751 to 1762	-	12	-	12	12
1763 to 2000	2000	-	238	10	10
2001 to 2012	-	12	-	12	12
2013 to 2022	-	Recovery		-	10
2023 to 2250	2250	-	227	10	10
2251 to 2262	-	12	-	12	12
2263 to 2500	2500	-	238	10	10
2501 to 2512	-	12	-	12	12
2513 to 2750	2750	-	238	10	10
2751 to 2762	-	12	-	12	12
2763 to 3000	3000	-	238	10	10
3001 to 3012	-	12	-	12	12
3013 to 3023	-	Recovery		-	10

See footnotes on following page.

Table 4.3-I (Cont'd)

[a]Perform star-gage and pull-over measurements each 500 rounds. Perform borescope inspection; record bore impressions and bore photographs each 500 rounds; however, impressions and photographs may be omitted at the discretion of the Project Officer when there is no noticeable charge from previous inspection. Perform magnetic-particle inspections each 500 rounds. Record pattern indications and take photographs of all defects.

[b]Propelling charges will all be conditioned for firing at +70°F. Range firing is conducted at that howitzer elevation necessary to attain 80% of the maximum range, with the XM203E2 propelling charge and the XM549 projectile (rocket motor off).

[c]Special electronic (ultrasonic and MRB) tube inspections are conducted each 1000 rounds.

The conduct of this test through 3000 EFC rounds (expected service life) should not present any safety hazard. The complete periodic inspections of the cannon should serve as an added precautionary safety measure.

At the discretion of the Project Engineer the firing, at specified tube-life intervals, of other fuze types to evaluate their performance is authorized.

4.3.4 Data Required and Analytical Plan

The data required are as follows:

a. Proof-firing data:

1) Muzzle velocity.

2) Propelling-charge model, zone, and total weight.

3) Peak chamber pressure.

4) Projectile weight.

b. Inspection data:

1) Magnetic-particle.

2) Ultrasonic.

3) Magnetic recording borescope.

4) Photographs and records.

c. Tube measurements:

1) Star-gage.

2) Pull-over.

3) Muzzle area.

d. Borescope data:

1) Photographs.

2) Impressions.

3) Visual inspections (i.e., coppering, etc.).

e. Accurate round-by-round data:

1) Range rounds.

2) Expenditure rounds (warmer).

3) Muzzle velocities.

4) Peak chamber pressures.

5) Projectile weights (lot number).

6) Fuze type.

f. Range data:

1) Meteorological information.

2) Range and deflection dispersion.

3) Firing azimuth.

4) Muzzle velocity.

5) Propelling-charge lots.

g. Cannon component failures and round life of each component.

h. Weapon (i.e., mount and carriage) component failures and round life of each component.

i. Photographs of each component failure.

The following analytical plan will be required:

a. Graphic presentation of vertical land wear (38.50 inches from the RFT) versus rounds fired.

b. Range and deflection standard deviation versus tube wear.

c. The results of the firing showing tube wear, velocity, pressure, range, and deflection will be shown in tabular and graphic form.

d. For each group of rounds fired for accuracy, the point estimate and two-sided 90% confidence interval on mean range and deflection will be calculated, also, the point estimates and upper 95% confidence limit on range and deflection probable error. This will be done for each tube and the results will be pooled if appropriate. The results of this subtest may be compared to firing-table subtest results of comparable conditions. It is assumed that range and deflection are independently distributed normal random variables.

SECTION 5 (U). DETAILS OF MOBILITY ROAD TESTS

5.1 INTRODUCTION

These road-testing phases generate the requirements for towing operations with the XM198 weapon for 2000 miles. Towing operations are to be performed with both a wheeled (XM813 cargo truck) and a tracked (M548 cargo carrier) vehicle. They will be conducted for a sufficient period, with each prime mover, during each phase of testing (except the mountain-highway test), to determine the total performances of the combinations.

A series of tests is scheduled for a distance of 1500 miles over a mountain highway, with towing operations being performed on a downhill roadway (grades of 9 to 11%) for distances of 2 miles. The location of this test is in Western Pennsylvania over a specific public highway. To efficiently conduct the mountain-roadway brake towing test, it is imperative that at least two complete sets of brake-assembly components be furnished to the testing agency prior to test operations.

The subtests for this mobility engineering test are arranged so as to complete the short-time high-risk phases first, with the longer-time low-risk phases following in descending order.

5.2 BRAKING TESTS, TOP/MTP 2-2-608

5.2.1 Objectives

a. To conduct various tests on the brake systems for safety evaluation, brake performance, and over-all endurance under various operating conditions.

b. To determine whether the towed-weapon brake systems are compatible with those of the prime movers.

5.2.2 Criteria

Performance will be as that cited under criteria in TOP/MTP 2-2-608:

a. Standard military automotive taillight and blackout light kits will be provided (MN, para VIK(2)f).

b. Tires which are standard to the Army inventory during this time frame shall be used (MN, para VIK(2)(c)).

5.2.3 Method

5.2.3.1 Preparation of Test Weapon, Prime Mover, and Instrumentation. This includes:

a. The braking and electrical systems of the towed weapon and the prime mover are prepared for optimum operation.

b. Proper lubrication and tire inflation will be assured.

c. For the mountain-highway brake tests all standard approved warning signboards and signals will be affixed to the towed weapon and the prime mover as required.

5.2.3.2 Brake Burnish. Friction-material burnishing will be accomplished by either the burnish procedure of SAE J286 or the procedure outlined in Appendix B of TOP/MTP 2-2-608.

5.2.3.3 Brake-Holding Ability. The towed weapon will be located on dry, paved, longitudinal slopes up to and including 60% in both ascending and descending attitudes by use of a prime mover. The service- and parking-brake systems will be engaged individually to assure each system's capability to hold the weapon stationary.

5.2.3.4 Brake-Stopping Ability. Brake-stopping distances are obtained from speeds of 20 and 40 mph over level, hard-surfaced roads, using the rated payload for the prime mover.

5.2.3.5 Brake Recovery after Immersion in Water. The wheeled brake system will be completely submerged in water for a period of 15 to 30 minutes. After immersion, brake recovery is determined by making brake applications at road speeds of 20 mph, at preselected input pressure applied at 1-minute intervals.

5.2.3.6 Trailer Breakaway Holding Ability. The towed weapon will be located on ascending and descending paved longitudinal slopes up to and including 60%, when attached to the prime mover. The brake lines will be disconnected to simulate a weapon breakaway. The necessary safety cables will be attached to the towed weapon and the prime mover, as required.

5.2.3.7 Brake-Actuation and Release Time. The time lapse between brake application, actuation, and release will be determined by means of a recording device triggered by switches installed at the application mechanism and at the point where the friction material of the brake contacts the rotating member. This test will be conducted both with and without the towed weapon being attached to the prime mover.

5.2.3.8 Pedal Effort versus Input Pressure. Pedal effort and input pressure will be recorded under static conditions over the complete input-pressure range (actuation supply system). Data will be measured by suitable pedal-effort and input-pressure gages. The test will be conducted both with and without the towed-weapon air-brake lines being connected to the prime mover.

5.2.3.9 Low-Temperature Effects. Static tests for conditioning in extreme temperatures (+125 to -70°F) will be conducted with the towed weapon by placing the system in a climatic facility in order to examine the operation of the parking-brake system under adverse conditions. These tests will be conducted during the climatic testing of the armament system (para 2.8).

5.2.3.10 Brake-Fade Test. The towed weapon, with a wheeled prime mover, will be operated over a downhill roadway (approximately 9 to 11% grade) over a distance of approximately 2 miles during repeated braking operations, with a 40-mph full stop at the bottom of the grade. The temperatures of the brake drums of the prime mover and disk of the towed weapon will be measured.

5.2.3.11 High-Temperature Endurance Test. A high-temperature highway test will be conducted for the evaluation of the performance, fade, wear, and endurance characteristics of the towed-weapon (wheeled) braking system under conditions where elevated brake-system temperatures and the brake torques are a factor. The specific procedure for this test is outlined in Appendix A of TOP/MTP 2-2-608.

5.2.3.12 Brake Endurance Test (Off-Highway). Various components of the vehicle braking systems are subject to failure while travelling over off-highway courses, due to contamination by foreign abrasives and lubricants. The towed weapon will be operated over water and muddy cross-country courses for a distance of 100 to 200 miles. Distance may be a factor of the severity of the course conditions.

5.2.4 Data Required and Analytical Plan

The following data are recorded:

a. Description and diagrams of instrumentation.

b. Area of friction-material burnishing.

c. Slopes at which the test items successfully performed during the brake-holding ability test phases. Also, where failures resulted.

d. Brake-stopping ability results.

e. Depth of water for brake immersion.

f. Time duration for water immersion.

g. Time and brake actuation until recovery of the brake from water immersion.

h. Pedal efforts for braking.

i. Brake-actuation and release time.

j. Brake-fade periods.

k. Temperatures of brake drum prime mover and disk (weapon system).

l. Failures, damaged parts, and interference of brake components will be reported by EPR.

m. Brake-wear measurements.

The following analytical plan will be required:

a. Graphs will be presented showing the following:

1) Brake-pedal effort versus input pressure.

2) Brake-fade versus number of applications.

3) Brake-recovery versus number of applications.

b. Tabulations will be presented showing the following:

1) Brake-temperature data.

2) Brake-component wear.

Comparison analyses data showing the braking performance of the weapon and the prime mover, with and without the weapon being connected, will be presented.

5.3 ENDURANCE TESTING OF TOWED WEAPON, TOP/MTP 2-2-511, 22 DECEMBER 1965 AND TOP/MTP 2-2-506, 18 MAY 1966

5.3.1 Objective

The objective is to determine weapon endurance through road operations on various test courses.

5.3.2 Criteria

a. The weapon shall require only organizational maintenance (1st and 2nd echelon) during 2200 miles of normal operation (test agency).

b. The weapon shall be capable of operation over unimproved roads; cross-country in sand, snow, mud, or ice; and under climatic categories 1 through 8 as specified in AR 70-38. The weapon shall have a cross-country mobility greater than, or, as a minimum, equal to that of the current towed medium field artillery weapon (the M114A1, 155-mm) (MN, para VIc(2)(a)).

c. The weapon will be compatible for towing by the truck, cargo, 5-ton, 6X6, M54 (series), the carrier, cargo, full-tracked, M548; the armored logistics vehicle, general-purpose; or the follow-on vehicle of the time frame (MN, para VIK(2)(J)).

5.3.3 Method

The prime mover will be loaded with the (simulated) high-density payload, which it is intended to carry.

The weapon system will be towed with a prime mover at reasonable and practical speeds on the various test courses specified in Table 5.3-I. The limiting speed on APG test courses is 35 mph, except for the brake-performance tests, at which time the test item will be operated at 40 mph. If the results of the brake tests conducted at speeds of 40 mph are satisfactory, the mobile transfer of the weapon to the Jennerstown area (Pennsylvania) at highway speeds for 40 mph (when permitted) may be conducted.

Table 5.3-I (U). Road-Test Mileage (U)

Location	Course	Vehicle Miles Wheeled	Vehicle Miles Tracked
APG	Perryman hard-surfaced	50	50
APG	Gravel	-	100
APG	Gravel and Belgian block (60 to 40%)	200	-

Table 5.3-I (Cont'd)

Location	Course	Vehicle Miles	
		Wheeled	Tracked
APG[a]	Carriage courses	10 laps	-
APG	Perryman unimproved gravel	-	100
APG[b]	Perryman cross-country No. 4	-	100
APG	Churchville cross-country	100	100
Jennerstown[c]	Mountain roadway (US Route 30)	(up to 1400)	-

[a]Includes 6-inch washboard, 3-inch washboard, space bump, and radial washboard.
[b]Requirement: Reference paragraph 5.2.3.12.
[c]Requirement: Reference paragraphs 5.2.3.10 and 5.2.3.11.

If in the development process a multipurpose prime-mover usage is specified for the weapon system, the mileage and road tests presented in Table 5.3-I, to be conducted at APG, will be divided between wheeled and tracked vehicles at the discretion of the test director, unless otherwise specified.

Periodic lubrication and maintenance services are accomplished in accordance with applicable lubrication orders and technical manuals. Repairs will be made whenever necessary, to prevent damage to the weapon or the vehicle and to correct any adverse performance of the towed weapon and the prime mover.

5.3.4 Data Required and Analytical Plan

The following data are required:

a. Quantity and intervals at which fuels and lubricants are added to the prime mover.

b. Parts mortality for the weapon and the prime mover.

c. Maintenance time.

d. Mileage per prime mover, courses traversed, and adverse performance of the towed weapon and the prime mover.

e. An intensive periodic inspection will be required of the towed weapon during traverse over the carriage courses. Checks will be made of travel-lock, bracket, the travel-lock pin, the pintle, the fire-control carrying case, etc.

5.4 FIRING TESTS, DEEP-WATER IMMERSION, TOP/MTP 2-2-612, JUNE 1967

5.4.1 Objective

The objective is to determine the capability of the XM198 weapon system to perform adequately in the mobility and firing modes following a complete immersion test.

5.4.2 Criterion

The weapon shall be capable of complete immersion or, alternatively, have a flotation capability (MN, para VIc(2)(b)).

5.4.3 Method

5.4.3.1 Preparation and Immersion. The fire-control equipment will be stored in delegated boxes on the trail.

No application of any special covers, kits, or precautionary operations will be required to prepare the weapon system for immersion or deep-water fording.

The complete immersion of the weapon system will be performed by cable controls, in water to a depth of 20 feet.

The immersion of the system will be for a minimum period of 30 minutes.

5.4.3.2 Post-Test Immersion Operation. A check will be made for the presence of water in the recoil cylinders, the cannon barrel, the bottom carriage, the trails, etc.

The condition of the fire-control equipment will be determined.

The conditions of the weapon travel light and the air-brake systems will be determined.

5.4.3.3 Firing Phase. One hour after the immersion test, the weapon will be emplaced on the range and the schedule of rounds tabulated in Table 5.4-I will be fired.

Table 5.4-I (U). Immersion-Test Firing Schedule (U)

Firing Elev, deg	Proj Model	Prop. Model	Chg Zone
30	M107	M4A2	5
30	M107	M4A2	7
30	M101	XM203E2	8

Table 5.4-I (Cont'd)

Firing Elev, deg	Proj Model	Prop. Model	Chg Zone
60	M101	XM203E2	8
5	M107	M4A2	7
5	M101	XM203E2	8

Note: If, upon inspection of the system after immersion, some condition develops or is observed which would prevent a safe firing operation, further firings will be delayed until the unfavorable situation is corrected.

5.4.4 Data Required and Analytical Plan

The following data will be required:

a. The condition of the system components following the immersion test.

b. Photographic coverage of the immersion operation.

c. Depth of water.

d. Recoil time of cycle.

e. Recoil length.

The XM198 weapon system will be evaluated to determine its capability of completing a firing mission following deep-water fording operations.

5.5 TURNING TESTS, TOP/MTP 2-2-609

5.5.1 Objective

The objective is to determine the minimum turning capability of the M813 and M548 prime movers with a towed weapon connected.

5.5.2 Criteria

a. The prime mover shall make a continuous full 360° minimum turn, right and left, without damage to either the prime mover or the towed weapon (test agency).

b. The turning radius of the wheeled prime mover shall not be degraded adversely when towing the XM198 weapon (test agency).

5.5.3 Method

The tires will be inflated to proper pressures.

The prime mover will be loaded to actual or simulated cargo-designed weight.

On a paved, level surface the minimum turning operation will be performed with the towed weapon attached.

The curb-to-curb and wall-to-wall circumferences for each type of mover, in left and right minimum turns, will be measured.

5.5.4 Data Required and Analytical Plan

The following data will be required:

a. Circumferences for left and right minimum turns.

b. Points of contacts or interferences.

c. Difficulties observed in turning operations.

d. Prime-mover loads and distribution.

An analytical plan is not required.

5.6 INSTRUMENTED TOWING TESTS

5.6.1 Objective

The objective is to determine the acceleration and vibration inputs at specified locations of the weapon system when it is being towed over the carriage courses at APG.

5.6.2 Criterion

The criterion is that the peak acceleration and vibration values recorded on the fire-control equipment, the bottom carriage, and the road-wheel arms shall be approximately equal to those values (Reference 7) measured on the advanced development model (October 1971); and in no case shall they exceed design limits (design limit, 6 g's) (test agency).

5.6.3 Method

The direct and indirect fire-control equipment will be boresighted before and after the instrumented road test, with the centerline of the tube being projected to either an infinity target or a distance aiming point.

The towed weapon will be instrumented with accelerator gages at various locations considered to be critical during road testing. The locations selected to record vibration and acceleration data are presented in Table 5.6-I.

Table 5.6-I (U). Instrumentation (U)

Item	Location	Gage Direction		
		Longitudinal	Vertical	Traverse
Panoramic tele-	Head	X	X	X
scope	Elbow	X	X	X
Panoramic mount	Quadrant (counter)	X	X	X
Quadrant, fire-	Quadrant (counter)	X	X	
control	DF scope (front)	X	X	
Bottom carriage	Left side		X	
	Right side		X	
Road-wheel	Left side	X	X	X
arms	Right side	X	X	X
Left trail	Sight box	X	X	X

The carriage courses traversed to record vibration and acceleration data are presented in Table 5.6-II.

Table 5.6-II (U). Carriage Courses (U)

Course	Speeds, mph	Prime Mover
Six-inch washboard	2 to 2-1/2	a
Two-inch washboard	3	a
Space bump (3-inch)	10	a
Radial bump	5	a
Belgian block	10 to 15	a,b
Carriage No. 1 (Perryman)	-	a,b
Carriage No. 3 (Perryman)	-	a,b

[a]XM813 truck cargo (wheeled).
[b]M548 cargo carrier (track).

5.6.4 Data Required and Analytical Plan

The following data are required:

a. Courses traversed.

b. Prime-mover speeds over each course.

c. Peak acceleration values.

d. Dominant frequency ranges of vibration.

The following analytical plan is required:

a. Amplitude distribution (rms acceleration, g's) (g values versus Hz).

b. Spectral analysis (g values versus Hz) of fire-control equipment.

c. Oscillogram records of carriage and fire-control equipment.

5.7 SLOPE PERFORMANCE TESTS, TOP/MTP 2-2-610

5.7.1 Objective

The objective is to determine the gradeability and side-slope performance of the towed weapon system when attached to its prime mover.

5.7.2 Criteria

a. The towed weapon shall ascend and descend longitudinal slopes up to and including 60% (test agency).

b. On the approach to the inclined slopes there shall be no interference between the prime mover and the weapon (test agency).

c. The towed weapon shall have adequate clearance of trails and cannon, on paved surfaces, and on both ascending and descending approaches (test agency).

d. The towed weapon shall traverse side slopes successfully (up to and including 30%) when towed by its prime mover (test agency).

5.7.3 Method

The towed weapon shall be towed by a prime mover over longitudinal and side slopes in the Munson test area.

On the traverse of the severe slopes, the necessary cables will be attached to the prime mover or the weapon in order to meet the safety requirements.

5.7.4 Data Required and Analytical Plan

The following data are required:

a. Slopes successfully (or unsuccessfully) traversed.

b. Interferences between the weapon and the prime mover or between the weapon and paved-road surfaces.

An analytical plan is not applicable.

SECTION 6. APPENDICES (U)

APPENDIX I - TEST DIRECTIVE (U)

DEPARTMENT OF THE ARMY Mr.Byrne/cg/870-4807
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S-29 Feb 72

AMSTE-FA 26 OCT 1971

SUBJECT: Test Directive for Engineering and Expanded Service Tests of the 155MM, XM198 Towed Howitzer and Propelling Charges XM123 and XM164, TECOM Project Nos. 2-WE-200-198-008/009/010 (U)

Commanding Officer, Aberdeen Proving Ground, Aberdeen Proving Ground, Md. 21005
Commanding Officer, Yuma Proving Ground, Yuma, Arizona 85364
President, US Army Field Artillery Board, Fort Sill, Oklahoma 73503

1. (U) REFERENCES.

a. RDTE Project No. 1X563608D37921.

b. Draft Proposed Materiel Need (DPMN) for a 155MM Towed Howitzer, December 1970.

c. Coordinated Test Program (CTP) for Howitzer, Towed, 155MM, XM198; Projectile, Rocket Assisted, 155MM, XM549; Charges, Propelling, 155MM, XM123/XM164, January 1970, with update dated March 1970.

d. Letter, AMSTE-TO-O, TECOM, 2 December 1970, Subject: Continuous Assessment of Risk/Suitability During Test Conduct.

e. Letter, AMSTE-PA-S, TECOM, 25 May 1971, Subject: Use of PERT for Suitability Testing.

2. (~~C~~ U) BACKGROUND.

a. (~~C~~ U) The current 155MM Howitzer program commenced in 1964 when USACDC was developing the requirements for a 30,000 meter range system. The early requirements called for both an armored and unarmored, self-propelled howitzer. The armored version was the XM179 and the unarmored version was the XM138. Both systems have now been terminated. In the Qualitative Materiel Requirement for these systems, USACDC noted that a towed version may be required.

b. (~~C~~ U) Concept studies were made, and in June 1966, a study was published for a lightweight 155MM towed howitzer. This weapon would

CLASSIFIED BY AMCTC 8608.
SUBJECT TO GENERAL DECLASSIFICATION
SCHEDULE OF EXECUTIVE ORDER 11652.
DECLASSIFY ON 31 December 1981.

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have had a range equivalent to the present standard weapon, be able to fire the RAP round, and weigh about 9,300 pounds. Since the user wanted 30,000 meters range, a concept study was published in January 1968, which depicted the present concept for the weapon. Exploratory development work was conducted in 1968 to test the feasibility of utilizing a muzzle brake and to obtain data on weapon stability under various firing conditions. A firing fixture was produced and tested and the results showed a muzzle brake was feasible to meet the Draft Proposed Qualitative Materiel Requirement (DPQMR).

c. (U) The USACDC "Divisional Artillery Study," 14 June 1968, recommended that the 155MM Towed Howitzer (XM2), now designated the XM198, be developed and fielded for use as the General Support Artillery Weapon for the Light Division during the 1975-1980 time frame.

d. (U) The DPQMR, dated 3 July 1969, was converted to a Draft Proposed Materiel Need (DPMN), dated December 1970 (reference 1.b.).

3. (U) DESCRIPTION OF MATERIEL.

a. (U) Howitzer, XM198. The XM198 is a medium, lightweight, towed, 155MM howitzer. The weight is limited by the lifting capacity of the CH-47C Helicopter to 14,700 pounds. The carriage is a split trail design with only manual controls for elevating and traversing. The traversing is limited to 400 mils right and left of center, with a 6,400 mil rapid traverse by extending the speed-shift platform, lifting the trails, and swinging them around the platform. The cannon has a manually operated breech with a horizontal slide block. Obturation is obtained by a metallic ring seal rather than the conventional rubber obturator pads. The recoil mechanism and fire control are similar to other standard artillery weapons now in the field. The howitzer utilizes a single baffle, low efficiency, muzzle brake.

b. (U) Projectile, Rocket Assisted, M549. The M549 RAP was type classified Standard A in May 1971 for use in the 155MM Self-Propelled Howitzer, M109. Its maximum range is approximately 19,000 meters in the M109 weapon. An Engineering Test/Expanded Service Test (ET/EST) is being planned for firing the M549 RAP with the M119 Propelling Charge from the M109A1 weapon with an expected maximum range of 24,000 meters. The expected ranges when firing the M549 RAP from the XM198 Howitzer are 24,000 meters with rocket off and 30,000 meters with rocket on.

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c. (U) Propelling Charges, XM123/XM164. These charges are designed to provide indirect fire coverage of ranges between 2,500 meters and 30,000 meters. The charges are separate loading, bag type and consist of 8 zones. Zones 1 through 5 are designated XM164, and Zones 6, 7, and 8 are designated XM123. Without the rocket assist of the M549, the XM164 Charge covers ranges (indirect fire) from 2,500 meters minimum to 12,700 meters maximum, and the XM123 Charge covers ranges from 11,400 meters minimum to 24,000 meters maximum. With the rocket assist, a maximum range of 30,000 meters is attained with Zone 8. The XM123 Charge will have a wear additive incorporated.

4. (U) TEST OBJECTIVES.

a. The objectives of the ET are:

(1) To determine technical performance and safety characteristics required by the DPMN; to obtain data for use in possible further development; and to determine the technical, safety and maintenance suitability for service tests. TECOM Materiel Test Procedures 3-2-509 and 3-2-510 should be utilized in preparing the armament portion of the test and 2-2-511 in preparing the automotive portion. Specific objectives include but are not limited to adequacy and capability of the following:

(a) Functioning suitability of all components.

(b) Mobility.

(c) Safety features.

(d) Reliability and maintainability.

(e) Laboratory environmental suitability.

(f) Human engineering aspects.

(2) To determine the fatigue and wear life of the howitzer tube.

(3) To determine that the Propelling Charges, XM164 and XM123 are safe to transport, store, handle, and fire from the 155MM Howitzer, XM198.

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(4) To determine ammunition performance, including range firing. The US Army Ballistic Research Laboratories should be contacted to obtain their requirements for the range firing.

(5) To investigate the possibility of projectiles becoming "stuck" in the tube during low zone firings, as has been previously experienced with the long tubed 155MM M109A1 system.

(6) To determine cook-off temperature for the Zone 8 of the XM123 Charge and establish allowable rates of fire to prevent exceeding this critical temperature.

b. The objectives of the EST are:

(1) To confirm the safety of the XM198 weapon and the XM164 and XM123 Propelling Charges when firing the M549 RAP.

(2) To determine system reaction time including procedures and time for emplacement and march order.

(3) To determine the human factors associated with the system including crew size and MOS's required.

(4) To determine the degree with which the system performs its intended mission as described in the DPMN and the suitability of the system for Army use.

(5) To perform a maintenance evaluation in accordance with AR's 750-6 and 70-10.

(6) To assess the adequacy of the training package developed for the system.

(7) To determine the durability and operational capability of the system when tested in accordance with the mission profile specified in the DPMN.

5. (U) RESPONSIBILITIES.

a. Aberdeen Proving Ground (APG) will prepare the test plan, conduct all phases of the ET except the fatigue life test and range table firing, and write the report for the ET. They will also prepare an appropriate PERT network and make a continuous assessment of the risk as discussed in references 1.d. and 1.e.

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b. Yuma Proving Ground (YPG) will conduct the tube fatigue life test and the range table firing and submit the results of these tests to APG for inclusion in the final ET report.

c. The US Army Field Artillery Board (USAFABD) will prepare the test plan, conduct the test and write the report for the EST. They will also prepare an appropriate PERT network and make a continuous assessment of the risk as discussed in references 1.d. and 1.e.

6. (U) SPECIAL INSTRUCTIONS.

a. (U) TECOM Project No. 2-WE-200-198-008 is assigned to YPG. TRMS forms are attached.

b. (U) TECOM Project No. 2-WE-200-198-009 is assigned to the USAFABD. TRMS forms are attached.

c. (U) TECOM Project No. 2-WE-200-198-010 is assigned to APG. TRMS forms are attached.

d. (U) Reference 1.b. (DPMN) lists the specific criteria including reliability and confidence levels to be used in the evaluation of the test data. The present schedule, dated 14 April 1971, lists four systems for ET, with the first scheduled to arrive May 1973 and then one for each of the next three succeeding months from Rock Island Arsenal. Three systems are scheduled for USAFABD in July 1973. Ammunition delivery is scheduled to start to arrive for ET in May 1973, and at USAFABD in July 1973.

e. (U) Since this is an entirely new artillery weapon system, a complete maintenance test package will be tested.

f. (U) Direct coordination with AMCPM-CSW and MUCOM in the planning and preparation of the plans is authorized. Copies of any correspondence will be provided to this headquarters, ATTN: AMSTE-FA.

g. (U) Time and cost estimates will be prepared and forwarded to this headquarters in accordance with the procedures stated in TECOM Regulation 70-33.

h. (U) The EST plan and test will include a field exercise with a small tactical unit as specified in AR 70-10, dated 15 September 1971.

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7. (U) SAFETY.

Safety evaluations will be included in the tests. A safety statement will be provided to APG by this headquarters prior to the start of ET. APG will furnish this headquarters, as early as possible, sufficient information on which to base a safety release for service board tests. This headquarters will execute a safety release, based on data collected during early phases of ET, to the service board before personnel are exposed to undue hazards. Safety confirmation will be an essential feature of the final expanded service test report.

8. (U) TEST PLANS AND REPORTS.

a. Test plans and reports will be prepared in accordance with TECOM Regulation 70-24. The plans are required in this headquarters by 30 April 1972. Equipment Performance Reports (EPR's) will be submitted in accordance with TECOM Regulation 70-23. Final formal reports will be submitted to reach this headquarters no later than the dates shown in the appropriate TRMS forms.

b. Distribution of test plans and reports will be in accordance with the Distribution List attached as Inclosure 1 to this directive.

c. This headquarters should be advised of any documents listed in the reference paragraph which are not available at your agencies.

9. (U) COORDINATION.

a. All coordination accomplished prior to approval of the test plan by this headquarters will be referred to as informal coordination. All coordination accomplished after approval of the test plan by this headquarters will be referred to as coordination.

b. The ET plan will be informally coordinated with the following:

USACDC Maintenance Agency
AMC Project Manager for 155MM Close Support Artillery Weapons System
US Army Munitions Command
US Army Field Artillery Board
Yuma Proving Ground

c. The EST plan will be informally coordinated with the following:

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USACDC Field Artillery Agency
USACDC Maintenance Agency
US Army Field Artillery School
AMC Project Manager for 155MM Close Support Artillery Weapons System
US Army Munitions Command
Yuma Proving Ground
US Army Field Artillery Center Commander

d. Test agencies will exchange draft and approved copies of test plans for review and comment.

10. (U) SECURITY.

Security guidance for this program is contained in AMCTC Item 8608, Security Classification Guide, Read for Record, dated 23 June 1971.

FOR THE COMMANDER:

JOSEPH V. SPITLER, JR.
Colonel, GS
Dir, FA Materiel Testing

4 Incl w/d
1. Distribution List
2. TRMS Forms - Task 008 (YPG only)
3. TRMS Forms - Task 009 (USAFABD only)
4. TRMS Forms - Task 010 (APG only)

CF: (w/o incl)
CG, USACDC, ATTN: USACDC LnO, TECOM (3 cys)
CG, USCONARC, ATTN: ATIT-RD-MD
CG, USAFAC
AMC PM for 155MM Close Support Arty Wpns Sys, ATTN: AMCPM-CSW
CG, AMC, ATTN: AMCRD-W
CG, MUCOM, ATTN: AMSMU-RE
CO, USALDSRA, ATTN: LDSRA-ME
CO, USACDCFAA
CO, USACDCMA
USMC LnO, TECOM
Comdt, USAFAS

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APPENDIX II - TEST CRITERIA (U)

Item	Source	Criteria	Applicable Subtest	Remarks
1	MN, para Ia	(U) The following shall apply for the 155-mm towed howitzer.	-	
2	MN, para VIc (2)(a)	(U) The weapon shall be capable of operation over unimproved roads, cross-country in sand, snow, mud, or ice, and under climatic categories 1 through 8 as specified in AR 70-38.	5.3.2	
3	MN, para VIc (2)(b)	(U) The weapon shall be capable of complete immersion or, alternately have a flotation capability.	5.4.2	
4	MN, para VId(2)	(C) For direct fire the maximum horizontal or vertical probable error shall be between 0.2 and 0.3 mil at all ranges of 2000 meters or less.	2.11	
5	MN, para VIg (1)	(U) The maximum rate of fire, when firing the new ballistically matched family of projectiles, shall be between four and six rounds per minute for a duration of 3 minutes at all elevations up to the elevations required to achieve maximum ranges of current and developmental munitions. A burst rate	2.9.2	

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Item	Source	Criteria	Applicable Subtest	Remarks
		of fire for this weapon is not required.		
6	MN, para VIg (2)	(U) The sustained rate of fire shall be between one and two rounds per minute for 30 minutes and one round per minute thereafter.	2.9.2	
7	MN, para VIg (3)	(U) The weapon shall be capable of manual loading at all elevations up to the elevations required to achieve maximum ranges for current and developmental munitions.	2.5.2	
8	MN, para VIh	(U) The weapon shall be capable of at least 800 mils on-carriage traverse (at least 400 mils left and right). Maximum traverse is desired without increasing the size, weight, or complexity of the weapon. A rapid speed shifting apability for 6400 mils traverse shall also be provided.	2.5.2	
9	MN, para VIi (2)(b)1	(U) For direct fire during daylight hours with the weapon emplaced and laid, ammunition prepared the first round is to be fired in 10 to 20 seconds from receipt of initial fire command.	2.11.2	

Item	Source	Criteria	Applicable Subtest	Remarks
10	MN, para VIi (2)(b)2	(U) For direct fire during daylight hours, with the weapon not emplaced, the first round is to be fired in 1 to 2 minutes from time the weapon stops at the firing position.	2.11.2	
11	MN, para VIk (1)	(U) The weight of the weapon will be as light as possible but no greater than 15,000 pounds.	2.3.2.6	
12	MN, para VIk (2)(c)1	(U) The weapon shall be capable of smooth traverse and elevation.	2.3.2.4	
13	MN, para VIk (2)(c)2	(U) Each handwheel shall be capable of obtaining at least 10 mils of movement per each turn of the handwheel when the carriage is emplaced on level terrain.	2.3.2.4	
14	MN, para VIk(2) (c)3	(U) A traverse and elevation handwheel shall be provided the gunner and an elevation handwheel shall be provided the assistant gunner.	2.3.2.4	
15	MN, para VIk (2)(c)4	(U) When the carriage is level, the howitzer shall be capable of depressing to an elevation of between -75 and -100 mils. Firing maximum elevation shall not	2.3.2.4	

Item	Source	Criteria	Applicable Subtest	Remarks
		require a recoil pit. Use of a variable recoil system is acceptable.		
16	MN, para VIk (2)(d)<u>1a</u>	(U) It shall be possible for the weapon crew to boresight the fire-control equipment within 1 to 2 minutes.	2.11.2	
17	MN, para VIk (2)(d)<u>1b</u>	(U) Self-illumination of scales, level vials, counters and reticles shall be provided for all fire-control equipment. If radioactive materials are used to provide self-illumination, their use shall comply with the [illegible] of AR 700-52 and [illegible].	2.3.2.5	
18	MN, para VIk (2)(d)<u>1c</u>	(U) It shall be possible for the weapon commander to check the proper setting of the fire control instruments without hampering the gunner.	2.3.2.5	
19	MN, para VIk (2)(d)<u>1d</u>	(U) The fire-control equipment shall be able to compensate for 10 to 12 degrees cant of the weapon.	2.10.2	
20	MN, para VIk (2)(d)<u>2a</u>	(U) Both the 1-man, 1-sight, and 2-man, 1-sight systems shall be provided for indirect fire. The	2.3.2.5	

Item	Source	Criteria	Applicable Subtest	Remarks
		equipment shall also allow the weapon to be laid for azimuth and elevation simultaneously using either system.		
21	MN, para VIk (2)(d)2b	(U) A 4-power, 10-degree field of view panoramic telescope shall be provided.	2.3.2.5	
22	MN, para VIk (2)(d)3a	(U) A selectable ballistic reticle system with a means of changing reticle quickly shall be provided the direct-fire telescope. A 2-man, 2-sight system shall be provided for direct fire.	2.11.2	
23	MN, para VIk (2)(d)3b	(U) A direct-fire telescope with 6-power magnification and a field of view tailored to meet acceptable size, weight, and cost parameters (but not less than 6 degrees) shall be provided.	2.3.2.5	
24	MN, para VIk (2)(d)3c	(U) A click-stop device for setting in leads of 5-mil increments will be provided.	2.3.2.5	
25	MN, para VIk (2)(e)	(U) Storage space for essential equipment such as sighting equipment, etc., will be provided.	2.3.2.5	

Item	Source	Criteria	Applicable Subtest	Remarks
26	MN, para VIk (2)(f)	(U) Standard military automotive taillight and blackout light kits will be provided.	5.2.2	
27	MN, para VIk (2)(c)	(U) Tires which are standard to the Army inventory during this time frame shall be used.	5.2.2	
28	MN, para VIk (2)(j)	(U) The weapon will be compatible for towing by the truck, cargo, 5-ton, 6X6, M54 (series), the carrier, cargo, full-tracked, M548; the armored logistics vehicle, general-purpose; or the follow-on vehicle of the time frame.	5.3.2	
29	MN, para VIk(3)	(U) The design of the cannon and related components shall be such that the cannon will be capable of firing all standard and developmental rocket-assisted and unassisted US/UK/FRG 155-mm projectiles as specified in appropriate ratified standardization agreements.	2.5.2(c)	
30	MN, para VIk (4)(b)	(U) The tube and ammunition shall be designed so that the tube life will be between 2500 and 5000 equivalent full charge (EFC) rounds.	4.2.2	

Item	Source	Criteria	Applicable Subtest	Remarks
31	MN, para VIk (4)(c)	(U) The breech-ring and recoil mechanism shall have a 50% probability of enduring between 10,000 and 15,000 EFC rounds, without need for replacement or overhaul; and must not be overly sensitive to sudden temperature changes.	4.2.2(c)	
32	MN, para VIk (4)(d)	(U) The carriage, to include the top carriage, bottom carriage, and trails, shall have a 50% probability of enduring at least 15,000 EFC rounds without need for replacement or overhaul.	4.2.2	
33	MN, para VIk(5)	(U) Safety environmental factors by dynamic-blast overpressures during firing shall not be greater than 3 pounds per square inch (psi) within the crew area, nor shall they create an unacceptable level of crew discomfort during sustained firing or degrade position area equipment and operation.	2.6.2 and 2.17.2	
34	MN, para VII(1)	(U) The operational availability of this weapon shall be between 95.0 and 97.0%.	2.18	

Item	Source	Criteria	Applicable Subtest	Remarks
35	MN, para VII (3)	(U) The maintenance ratio (man-hours of maintenance per operating hour) during the service life of the weapon shall be between 0.04 and 0.06.	2.18.1.2	
36	MN, Para VII (5)	(U) The weapon design shall permit ease of accessibility to often-checked items (lubrication points) and replacement items. Also, incorporated in the design will be features which will minimize malfunctions or damage to linkage due to mine explosions, freezing, and dirt accumulation.	2.18.1.2	
37	Test Agency	(U) All subsystems shall be complete, undamaged, and mechanically and physically operational.	2.2.2	
38	AMCR 750-15, para 34b	(U) The maintenance test package shall be complete, accurate, and adequate.	2.2.2	
39	Test Agency	(U) The cannon shall meet all the requirements of applicable drawings and specifications.	2.3.2.1	

Item	Source	Criteria	Applicable Subtest	Remarks
40	Test Agency	(U) The cannon components (i.e., tube, breech-mechanism assembly, and muzzle brake) shall be free of any cracks or defects.	2.3.2.1	
41	Test Agency	(U) The manually operated breech mechanism shall be free of interference with the carriage components at all firing elevations and at maintenance operation positions. Potentially hazardous or unsafe operating conditions will be noted and reported.	2.3.2.1	
42	Test Agency	(U) The sealing device for the cannon chamber shall positively prevent a leakage of propellant gases. It shall not cause undue delays in loading the propelling charge into the chamber.	2.3.2.1	
43	Test Agency	(U) The firing mechanism shall work smoothly and positively at all firing elevations when actuated by lanyard. All primers shall be ejected when the breech is manually opened.	2.3.2.1	
44	Test Agency	(U) The recoil-mechanism assembly shall meet all the requirements of applicable drawings and specifications.	2.3.2.2	

Item	Source	Criteria	Applicable Subtest	Remarks
45	Test Agency	(U) There shall be no leaks at seals, packings, valves, connections, etc.	2.3.2.2	
46	Test Agency	(U) There shall be no damage to functional surfaces (i.e., recoil piston rod, and control rod).	2.3.2.2	
47	Test Agency	(U) The recoil mechanism shall be free of any deformation, cracks, failure of welds, or loosening of bolts, screws, bearings, etc.	2.3.2.2	
48	Test Agency	(U) The equilibration cylinders shall maintain pressures at seals, packings, valves, etc.	2.3.2.3	
49	Test Agency	(U) The equilibration system shall maintain reasonably equal elevation handwheel efforts throughout the full elevation and depression range of the weapon.	2.3.2.3	
50	Test Agency	(U) The top-carriage adjustable sliding connections for the equilibrators shall be free and operable at all times for temperature-change correction.	2.3.2.3	
51	Test Agency	(U) The elevation system shall be capable of attaining a maximum elevation of +1275 mils.	2.3.2.4	

Item	Source	Criteria	Applicable Subtest	Remarks
52	Test Agency	(U) With the weapon balanced, the average force applied tangentially to the handcranks, at a uniform rate to maintain weapon movement, shall not exceed 15 pounds.	2.3.2.4	
53	Test Agency	(U) With the weapon in a crossway position and leveled (to within 2°), the average force applied tangentially to the traverse handwheel to maintain movement shall not exceed 20 pounds.	2.3.2.4	
54	Test Agency	(U) There shall be no failure or deformation of trails, carriage, firing base, travel lock, or spades as a result of road travel or firing operations.	2.3.2.6	
55	Test Agency	(U) The trails shall be so designed that they do not interfere with the wheeled prime mover (M54 series) when towed in long tow position.	2.3.2.6	
56	Test Agency	(U) The carriage hydraulic system shall be capable of lifting the carriage rapidly to enable meeting carriage-displacement requirements.	2.3.2.6	

Item	Source	Criteria	Applicable Subtest	Remarks
57	Test Agency	(U) The pressure-versus-time curves for the recoil and recuperator cylinders shall not show excessive rise rates indicative of either improper oil-throttling or design defects.	2.5.2	
58	Test Agency	(U) Recoil-reaction cylinder pressures and individual peaks for rod pull shall not exceed the design limitations.	2.5.2	
59	Test Agency	(U) The equilibration and elevations systems shall allow smooth and positive laying of the weapon at all elevations. Firing shocks shall not produce abnormal changes in elevation.	2.5.2	
60	Test Agency	(U) The traversing system shall allow smooth and positive traversing of the weapon under all specified conditions.	2.5.2	
61	Test Agency	(U) The time-travel-velocity curves for the cannon, developed during the firing cycle, shall meet the requirements of applicable drawings and specifications. They shall not indicate erratic recoil travel or slamming of the howitzer into battery.	2.5.2	

Item	Source	Criteria	Applicable Subtest	Remarks
62	Test Agency	(U) The muzzle brake shall not fail during the established round-service life of the tube.	2.5.2	
63	Test Agency	(U) Tube whip shall not degrade the combat effectiveness of the weapon or place undue stresses on the mounting systems.	2.5.2	
64	Test Agency	(U) The firing stability of the weapon system shall be sufficient to permit safe, rapid, or sustained loading, laying, and firing of the howitzer without delays or excessive physical effort by crew.	2.5.2	
65	Test Agency	(U) The criterion is that firing shocks shall not cause damage, deformation, loosening of optics, or malfunctioning of any part of the fire-control system.	2.7.2	
66	AR 70-38	(U) All components of the weapon system shall be safely operable under temperature conditions which vary from +145 to -70°F.	2.8.2	
67	AR 70-38	(U) The functional characteristics of the recoil mechanism shall conform to specification MIL-M-45212A(ORD).	2.8.2	

Item	Source	Criteria	Applicable Subtest	Remarks
68	Test Agency	(U) The firing stability of the weapon system shall be sufficient to permit safe rapid or sustained loading, laying, and firing of the howitzer without delays or excessive physical effort by the gun crew.	2.9.2	
69	Test Agency	(U) During rapid- and sustaining-fire rates the surface temperature of the chamber, 30 inches forward of the seal rings, will not exceed the maximum allowable temperatures established by cook-off tests.	2.9.2	
70	Test Agency	(U) Boresight retention shall be within 0.3 mil for direct fire and 1.0 mil for indirect fire as measured before and after fire.	2.11.2	
71	Test Agency	(U) The criterion is that the difference between the theoretically determined center of impact (the summation of all effects) and the observed center of impact should be zero if the reticle accuracy reflects projectile performance and all effects can be considered.	2.13.2	

Item	Source	Criteria	Applicable Subtest	Remarks
72	Test Agency	(U) The criterion is that the XM198 weapon system shall be designed for safe operation by personnel while hooking up or disconnecting the weapon from the prime mover, towing, or during firing.	2.17.2	
73	Test Agency	(U) The weapon shall require only organizational maintenance (1st and 2nd echelon) during 2200 miles of normal operation.	5.3.2	
74	Test Agency	(U) The prime mover shall make a continuous full 360° minimum turn, right and left, without damage to either the prime mover or the towed weapon.	5.5.2	
75	Test Agency	(U) The turning radius of the wheeled prime mover shall not be degraded adversely when towing the XM198 weapon.	5.5.2	

Item	Source	Criteria	Applicable Subtest	Remarks
76	Test Agency	(U) The criterion is that the peak acceleration and vibration values recorded on the fire-control equipment, the bottom carriage, and the road-wheel arms shall be approximately equal to those values (Reference 7) measured on the advanced development model (October 1971); and in no case shall they exceed design limits (design limit, 6 g's).	5.6.2	
77	Test Agency	(U) The towed weapon shall ascend and descend longitudinal slopes up to and including 60%.	5.7.2	
78	Test Agency	(U) On the approach to the inclined slopes there shall be no interference between the prime mover and the weapon.	5.7.2	
79	Test Agency	(U) The towed weapon shall have adequate clearance of trails and cannon, on paved surfaces, and on both ascending and descending approaches.	5.7.2	
80	Test Agency	(U) The towed weapon shall traverse side slopes successfully (up to and including 30%) when towed by its prime mover.	5.7.2	

Item	Source	Criteria	Applicable Subtest	Remarks
81	Test Agency	(U) Failures will be defined as follows: a. Loss of firing accuracy through unstable projectile launch, velocity or pressure loss, or malfunction of ammunition. b. Rupture, deep crack defects, or material failure of tube and breech mechanism components through fatigue.	4.2.2	
82	Test Directive and AR 70-38	(U) The XM123 and XM164 charges shall not create a handling or disposal hazard as a result of transportation - vibration and rough handling.	3.3	
83	Test Directive and AR 70-38	(U) All 155-mm ammunition, including the XM123 and XM164 charges, shall be safe to fire in the XM198 howitzer at temperature extremes of -65 to +145°F.	3.3	

Item	Source	Criteria	Applicable Subtest	Remarks
84	MN, para VId (1)(a)	(C) Distribution of range probable error for developmental full-caliber matched rocket-assisted and nonrocket-assisted projectiles in low-angle indirect fire shall range from 0.12% to 0.30% of range fired with 90% probability that no range probable error shall exceed 0.30% of the range fired. Deflection probable error shall not exceed 1 mil.	3.6	
85	MN, para VId (1)(b)	(U) Range and deflection probable errors listed in appropriate firing tables for the M114A1 towed howitzers shall be used as criteria for test of complete rounds of standard ammunition. Exterior ballistic performance of standard ammunition fired in the new weapon must equal or exceed these criteria deemed compatible for unrestricted use.	3.7	

Item	Source	Criteria	Applicable Subtest	Remarks
86	MN, para VIe (1)(a)	(C) Developmental, full-caliber, matched rocket-assisted projectiles shall have a maximum range between 28.5 and 31 kilometers when firing with the rocket on.	3.6	
87	MN, para VIe (1)(a)	(C) Maximum range shall be between 22 and 25 kilometers when firing from a new cannon (95% remaining life), the developmental nonrocket-assisted high-capacity projectiles and rocket-assisted projectiles with rocket off.	3.6	
88	MN, para VIe (1)(c)	(U) Maximum range for current standard projectiles should be equal to or greater than that achieved by the M114A1 towed howitzer. Data listed in appropriate firing tables for the M114A1 howitzer shall be used as criteria for test of complete rounds of standard ammunition.	3.6	

Item	Source	Criteria	Applicable Subtest	Remarks
89	MN, para VIe (2)(b)	(U) Minimum range with new developmental ammunition shall be between 1.5 and 2.5 kilometers in low-angle indirect fire with a minimum quadrant elevation of 200 mils and not more than 2.5 kilometers in high-angle indirect fire.	3.6	
90	MN, para VIe (2)(c)	(U) Minimum range with current standard projectiles should be equal to or slightly greater than that achieved by standard complete rounds when fired from the M114A1 howitzer.	3.6	
91	MN, subpara VIk(2)(d)1	(U) The fire control equipment shall be simple, durable, and compatible with the howitzer test item to achieve the required precision, rate of fire, reaction time, reliability, durability, and human factors engineering and safety characteristics. As a minimum the fire control equipment shall conform to the current standard counter type fire control equipment characteristics except the bearing system of lay will be used.	2.5	

Item	Source	Criteria	Applicable Subtest	Remarks
92	MN subpara VIk(2)(b)2 and 3	(U) Facilities to provide for tiedown of the howitzer test item on board ship, aircraft, or surface transporters shall be provided. All towing, lifting and tiedown facilities shall be of a standard NATO size and agree with STANAG 4062 and 4101.	2.19	
93	MN subpara VIf(1)	(U) The howitzer test item shall be transportable on roads using standard type vehicles or trailers, on rail by observing the Berne International Agreement and on ocean-going transport ships in accordance with AR 70-44.	2.19.2	
94	MN subpara VIf(2)	(U) The howitzer test item shall be capable of being transported by C-130 or larger aircraft.	2.19.2	
95	MN subpara VIk(2)(b)1	(U) The howitzer test item shall be equipped with lifting eyes to facilitate helicopter airlift and shipboard loading. Positioning of the lifting eyes shall be such that mounted fire control equipment shall not be damaged in transit.	2.19.2	

Item	Source	Criteria	Applicable Subtest	Remarks
96	MN, subpara VIc(1)	(U) The howitzer test item shall be capable of being airlifted by the CH47C helicopter and/or tactical aircraft system (rotary wing) of the time frame.	2.19.2	
97	CTP Annex B, subpara I.A	(U) The reliability performance of the howitzer test item in mean rounds between failure (MRBF) when operated in accordance with the operational profile shall be as follows: Minimum acceptable value-700 MRBF. Specified Value-1,100 MRBF.	2.15	AMC/TRADOC have agreed that a reliability of 550 MRBF demonstrated at DT/OT II will be accepted as an indicator of adequate progress toward meeting the reliability criterion. See subparagraph 1.1.6, section 1.
98	QMR, subpara 9b	(U) The reliability of functioning for the propelling charge test items shall be at least 0.999.	2.15	The requirement of record.
99	MN, subpara VIk(4)(a)	(U) The howitzer test item shall withstand the normal hazards in loading and unloading; handling during surface transport and storage, occupying and evacuating firing positions and in executing fire missions.	2.14	

Item	Source	Criteria	Applicable Subtest	Remarks
100	CTP Appendix B, subpara I.D	(U) The subsystems of the howitzer test item shall endure without replacement or overhaul the following: a. Tube: 2,500-5,000 equivalent full charge rounds. b. Recoil Mechanism: 10,000-15,000 equivalent full charge rounds. c. Breech: 7,500-15,000 equivalent full charge rounds. d. Carriage: 15,000 equivalent full charge rounds.	2.14	
101	QMR, para VIk (5)	(U) Blast and noise induced by firing the howitzer test item shall not result in the need for special individual protective equipment for field artillery personnel. Overpressures in the crew area shall not be greater than 3 pounds per square inch. (Dynamic overpressure measurements will be obtained from the engineering test agency.) (The howitzer crew will use the standard issue ear plugs for ear protection when firing the howitzer test item.)	2.17.2	

Item	Source	Criteria	Applicable Subtest	Remarks
102	QMR, para 10b (1)(2)	(U) Final design of the propelling charge test items shall be based on achievement of essential safety requirements and shall minimize the susceptibility of the propellant to preignition or cook-off during successive periods of maximum-rate firing.	2.17.2	
103	AMR, para 10d (3)	(U) Chamber pressures for the minimum test item propelling charge (zone 1) shall be compatible with fuze design parameters required for reliable arming, battery activation, and safety considerations. (Chamber pressures will be determined by the engineering test agency.)	2.17.2	
104	AMR, para 10d (1)	(C) (Essential) Forces developed by the propelling charge test items shall not exceed design safety limits of the howitzer test item or munition items with which they are designed to be used. (Forces developed by the propelling charge will be determined by the engineering test agency.)	2.17.2	

Item	Source	Criteria	Applicable Subtest	Remarks
105	QMR, para 10d	(C) (Essential) Residue left in the chamber after firing the propelling charge test items shall not require swabbing to prevent preignition of the propellant for successive rounds at the established required rate of fire.	2.17.2	
106	QMR, para 12a	(U) Fumes from firing the propelling charge test items shall not endanger the health of personnel under field use conditions.	2.17.2	
107	AR 703-2 para 2-5c(6)	(U) Human-factors aspects of maintenance operations. System design will adhere to the essential principles of human factors engineering and the man-item relationship must be adequate for effective maintenance operations.	2.16.2	
108	MN, subpara VIk(5)	(U) Environmental factors induced by dynamic blast and overpressures during firing shall not be greater than three pounds per square inch (psi) within crew area, nor shall they create any unacceptable level of crew discomfort during sustained firing or degrade position area equipment and operation.	2.16 and 2.8	

Item	Source	Criteria	Applicable Subtest	Remarks
109	AR 702-3, para 2-5c(4)	(U) Design for maintainability. Systems will be designed to eliminate deficiencies prejudicial to the ease of maintenance. System design will be directed toward minimizing maintenance by using the most reliable components, modular construction, built-in simple fault isolation test indicators, and other technological advances in components and methods to the maximum extent practicable. Means to achieve ease of maintenance include: a. The location of high mortality parts to provide ready access when maintenance is required. b. The use of readily accessible test points to reduce diagnostic time. c. The reduction in the number of types and sizes of common fasteners (i.e., bolts, nuts, and screws) and the use of quick disconnects, wing nuts, and other features which will minimize requirements for special or additional tools.	2.18.1.2 and 2.18.4.2	

Item	Source	Criteria	Applicable Subtest	Remarks
110	AR 702-3, para 2-5c(4)	(U) Equipment publications. The equipment publications contained in the maintenance test package will be complete, accurate, easy-to-read, consistent in nomenclature, simple to follow, and adequate to permit completion of both scheduled and unscheduled maintenance operations and parts acquisition at all field levels of maintenance. Draft Army equipment publications will conform in content and formal to these specified in AR 310-3, MIL-M-38784, and MIL-M-63000(TM) series of military specifications as applicable.	2.18.2.2	
111	AR 702-3, para 2-5c(3)	(U) Repair parts. Repair parts will be authorized in adequate quantities and diversity at the appropriate maintenance levels, consistent with the maintenance allocation chart, Repair Parts Special tool lists (RPSTLs) and skills required to install and align the parts. Repair parts which are used to maintain the system must be interchangeable with like parts being replaced.	2.18.3.2	

Item	Source	Criteria	Applicable Subtest	Remarks
112	AR 702-3, para 2-5c(5)	(U) Safety aspects of maintenance operations. System design will embody features to protect personnel from electrical and mechanical hazards and other dangers that might arise from fire, elevated operating temperatures, toxic fumes or dangerous environment. System design will, in general, adhere to essential safety principles and standards.	2.18.4.2	

APPENDIX III - (U) SUPPORT REQUIREMENTS

Ammunition

Armament Testing

Propelling charges, M3A1	20 each
Propelling charges, M4A2	230 each
Propelling charges, M119	60 each
Propelling charges, XM164	60 each
Propelling charges, XM203	530 each
Projectiles, M107, HE (inert, solid-fill)	75 each
Projectiles, M107, HE (inert, sand and steel)	220 each
Projectiles, M101, HE (inert, sand and steel)	25 each
Projectiles, XM549, HE (inert, solid-fill)	60 each
Projectiles, XM549, HE or modified M107 (inert, sand and steel)	480 each
Fuze, M73, dummy	125 each
Fuze, M78, inert	775 each
Primer, M82	900 each

Tube Fatigue and Bore Wear

Tube Fatigue Test	
Propelling charge, XM203	7500 each
Projectiles, XM549 or authorized substitute shell (inert)	7300 each
Projectiles, XM549, HE, Comp B	200 each
Fuzes, M572, PD	200 each
Fuzes, M78, inert	7300 each
Primer, M82	7500 each
Bore-Wear Test	
Propelling charge, XM203	3023 each
Projectile, XM549, HE, Comp-B	100 each
Projectile, XM549, HE (inert, solid-fill)	2923 each
Fuze, PD, M572	100 each
Fuze, M78, inert	2923 each
Primer, M82	3023 each
Durability Firing Test	
Propelling charge, M119	14945 each
Projectile, M107	14945 each
Fuzes, M78	14945 each
Primer, M82	14945 each

Ammunition Functioning and Firing-Table Phases

Ammunition Item	APG Requirements[a] Live	APG Requirements[a] Inert	YPG Requirements[b]
Projectiles			
M107 HE	100	622	3800
M110 WP	100	0	0
M116 smoke	100	0	0
M121 chemical with live burster and gas simulant	100	0	0
M449A1 HE	100	0	360
M483 HE	348	10	1800
M485E2 illuminating	100	0	270
M549	696	671	1535
Fuzes			
M73 dummy	0	1186	0
M508 PD	100	0	0
M728 VT	348	10	0
M548 MTSQ	100	0	270
M557 PD	348	10	5235
M564 MTSQ	100	0	0
M564 MTSQ with SR element	0	0	360
M565 MT	100	0	0
M577 MTSQ	348	10	1800
M514A1VT	100	0	0
M501A1	100	0	0
Propelling charges			
M3A1	30	0	1500
M4A2	30	0	1660
M119	3	0	500
XM123E2(I)	312	0	0
XM203	550	0	310
XM164	412	0	1790
XM201	853	0	880
Proof	772	0	0
Primer			
M82	3000	0	6670

[a]One copy of inspection records for all projectiles except 300 inert M107.

[b]Notes on YPG requirements: No requirements for inert components. All projectiles and fuzes of each type are to be from the same lots. Charges are to be equally divided among two different lots.

Test Items

System, Howitzer, 155-MM, Towed, XM198 (Complete)	
Weapon-system testing (APG)	1 each
Range-table firing tests (YPG)	1 each
Durability tests (YPG)	1 each
Cannon, Howitzer, 155-MM, XM199 (Complete)	
Ammunition safety tests (APG)	2 each
Special: modified to accept (APG) replaceable thermocouples as outlined in paragraph 3.3	1 each
Tube, Howitzer, 155-MM, XM199	
Tube bore-wear life tests (YPG)	2 each
Range-table firing tests (YPG), based on the EFC factors cited in Reference 4	20 each
Ammunition safety tests (APG)	3 each
Special: "Stub-tube" fabricated to accept replaceable thermocouples as outlined in paragraph 3.3	1 each
Muzzle Brakes, Cannon, XM199	
For spare use (APG)	1 each
For spare use (YPG)	2 each
Split rings and obturator pads, sets	
For replacements (APG)	5 each
For replacements (YPG)	10 each
Wheel-Brake Assemblies	
For mountain-brake test (APG)	1 each

Facility Vehicles

Truck, cargo, M54 series (one for soldier test)	2 each
Carrier, cargo, track, M548	1 each

Instrument Requirements

Trailer, ballistic-type, 12 channels (magnetic tape), with necessary power supply, etc.	2 each
Timer, electric (1/100-second graduation) with necessary microswitch and wiring	1 each
Dual potentiometer, rack-gear assembly (7.54-inch pitch diameter gear)	1 each
Rod pull-gages (0 to 50,000 pounds)	2 each
Pressure transducer (0 to 10,000 psi)	3 each
Internal tourmaline (0 to 65,000 psi)	1 each
Strain gage, C-1	Various
Accelerometer gages, CRL Model 302 (0 to ±10,000 g's and 10,000 Hz) for firing	12 each
Accelerometer gages, Model A69TC (0 to ±25 g's and 550 Hz) for road tests	24 each
Theodolite	2 each

Test Facilities

Targets, cloth, 16- by 16-feet	4 each
Chronograph (muzzle velocities, assemblies and components, sky screens and magnetic coils)	Various
Climatic facility (APG cold room No. 3)	1 each
Road surfaces, slopes, grades, and weights for automotive testing	Various
Shallow- and deep-water fording or immersion areas	1 each
Aiming circle, M1 (soldier test)	2 each

MOS Personnel (Soldier-Operator-Maintainer Test)

The following types and numbers of personnel are recommended for operation and maintenance of the system:

MOS	Title	No.
	Field Artillery Basic	
13A10	Ammunition handler	4
13A10	Cannoneer loader	3
13A10	Prime mover driver	1
	Field Artillery Crewman	
13B40	Section chief	1
13B40	Gunner	1
13B20	Assistant gunner	1
	Organizational Maintenance	
13B30	Artillery mechanic	2
	DS/GS	
45L20	Artillery repairman	2
	Evaluators	
WO	Warrant officer	1
Captain	Excutive or test officer	1

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APPENDIX IV - (U) TEST SCHEDULE

1. Schedule of Events

Preliminary planning completed	February 1972
Coordination completed	May 1975
Final test plan submission	May 1975
Support equipment delivery	March 1975
Test items delivery	March 1975
Test completion target	February 1976
Partial report	December 1975
Final report	May 1976

2. Detailed Test Schedule

X = Hardware receipt.

Name of Subtest	Time Increment, months X+3	X+6	X+9	X+12	X+15	X+18
Weapon system testing						
Pretest preparations						
Instrumental firings						
Performance firing						
Durability						
Human engineering						
Safety evaluation						
Transportability						
Maintenance evaluation						
Reliability						
Ammunition tests						
Initial inspection and measurements						
Safety test						
Functioning reliability test						
Velocity and pressure test						
Precision and range test						
Provisional firing tables test						
Flash characteristics test						
Tube-life tests						
Fatigue firing						
Bore-wear firing						
Mobility road tests						
Braking tests						
Endurance testing						
Immersion firing						
Turning tests						
Instrumented towing						
Slope performance						
Final report preparation						
Test completion						

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APPENDIX V - (U) INFORMAL COORDINATION

Not used.

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(U) APPENDIX VI -DATA COLLECTION AND PRESENTATION FORMS

(U) FIGURE VI-1. PHYSICAL CHARACTERISTICS DATA COLLECTION FORM

CHARACTERISTIC	STATED REQUIREMENTS	ACTUAL	PASS/FAIL
WEIGHT Without section equipment With section equipment			
LENGTH In firing position In traveling position			
HEIGHT In firing position In traveling position			
MINIMUM GROUND CLEARANCE In traveling position			
REDUCIBILITY FOR AIR TRANSPORTABILITY Length Width Height Weight			
TRAVERSE AND ELEVATING HANDWHEELS			
ON-CARRIAGE STOWAGE SPACE			
TAIL AND BLACKOUT LIGHTS			
COMMUNICATIONS FACILITIES			
TIRES AND WHEELS			

REMARKS: ______________________________

(U) FIGURE VI-2 REACTION TIME DATA COLLECTION FORM

CREW NO:		DATE:		
	INDIRECT FIRE		DIRECT FIRE	
OPERATIONS TIMED	CRITERIA TIME	CLOCK TIME	CRITERIA TIME	CLOCK TIME
FROM RECEIPT OF FIRING DATA TO FIRING				
FROM WEAPON STOP IN POSITION TO FIRING				
FROM RECEIPT OF MARCH ORDER TO MOVEMENT				
WEATHER CONDITIONS				
LIGHT CONDITIONS				
TYPE OF TERRAIN				
DIFFICULTIES				
CREW PROFICIENCY				
REMARKS				

(U) FIGURE VI-3 CONTAINER OPENING TIME DATA COLLECTION FORM

DATE____________________ LOCATION____________________

PROPELLING CHARGE________________ AMMUNITION HANDLER________________

WEATHER CONDITIONS____

____

REPETITION NUMBER	TIME TO OPEN CONTAINER (NEAREST 0.1 SECOND)	SPECIAL TOOLS REQUIRED

REMARKS____

____

OBSERVER____

(U) FIGURE VI-4. RATE OF FIRE DATA COLLECTION FORM

DATE__________________ LOCATION__________________

PROPELLING CHARGE____________________________

WEATHER CONDITIONS____________________________

REPETITION NUMBER	CLOCK TIME REQUIRED TO FIRE ROUNDS	DIFFICULTIES ENCOUNTERED
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

REMARKS____________________________________

____

OBSERVER___________________________________

(U) FIGURE VI-5. DIRECT FIRE PRECISION DATA COLLECTION FORM

TARGET NUMBER	RANGE (METERS)	PROJECTILE	TELESCOPE RANGE LINE GRADUATION USED	ROUND NUMBER	MISS DISTANCE IN CENTIMETERS	
					VERTICAL	HORIZONTAL

Group No ____________________

(U) FIGURE VI-6. FIRING RESULTS DATA PRESENTATION FORM

Part 1

Weapon and Tube Number	Date Fired	Group Number	Achieved Data									Specified Requirements						Remarks
			Mean Measured MV (m/sec)	Range to Mean Point Of Impact (m)	Probable Error				Az to Mean Point of Impact	Probable Error in Deflection		Probable Error						
					Range (m)	% of Range (%)	Time (sec)	Height of Burst (m)		(m)	(m)	Range		Deflection		Time (sec)	Height Of Burst (m)	
												(m)	(%)	(m)	(%)			

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Part 2

Weapon and Round Data					Firing Table Data						Computed Data							
Weapon and Tube Number	Date Fired	Rounds Fired and Group Number	Type Projectile	Propelling Charge and Zone	Fuze		Quadrant Elevation (ø)	Range (m)	% of Max Range (m)	FT Muzzle Velocity (m/sec)	Effects on Range		Site (m)	Height of Burst (m)	Range (m)	Azimuth		
					Type	Time (Sec)					MVV (m/sec)	Met Data (m)				Fired (ø)	Effects	
																	Met (ø)	Drift (ø)

(U) FIGURE VI-7 COMPATIBILITY WITH STANDARD MUNITIONS DATA COLLECTION FORM

NOMEN-CLATURE OF COMPONENT	ZONE FIRED	NUMBER OF ROUNDS FIRED	STICKERS	PRE-MATURE IGNITION	PRE-MATURE BURST	DUDS	COMPATIBLE	
							YES	NO
PROJECTILE: FUZE: PROPELLANT:								
PROJECTILE: FUZE: PROPELLANT:								
PROJECTILE: FUZE: PROPELLANT:								

REMARKS: ____

____

____

____

(U) FIGURE VI-8. ON-CARRIAGE FIRE CONTROL EQUIPMENT DATA COLLECTION FORM

QUESTIONNAIRE FOR THE FIRE CONTROL EQUIPMENT OPERATING PERSONNEL

NAME______________________ RANK______________________
YEARS OF SERVICE____________ MOS______________________

1. Approximately how many days did you operate the fire control equipment during this test? ____________days.

2. Did you find the fire control equipment (easier)(harder)(about the same) to install and (easier)(harder)(about the same) to remove as other artillery weapons? (circle correct answers)

3. Were tools required for the installation or removal of fire control equipment? _____NO _____YES. If YES, list tools and purpose for which used______________________________________

____

4. Did you encounter any difficulties in the installation or removal of the fire control equipment? _____NO _____YES. If YES, describe difficulties ______________________________

____

5. Did you find the fire control equipment (harder)(easier)(about the same) to operate and use as like equipment on other artillery weapons? (circle correct answer)

6. Did you find the speed of operation (laying the weapon and applying firing data) for the fire control equipment (faster)(slower)(about the same) as like equipment on other artillery weapons? (circle correct answer)

7. What method did you use to boresight the weapon, (test target)(distant aiming point)(XM65 optical boresight) (other__________)?

8. Did you find the boresighting operation (easier)(harder)(about the same) compared to boresighting operations for other artillery weapons? (circle correct answer)

9. Did you encounter any difficulties in locating or identifying targets or reference points through the optics of the fire control equipment? _____NO _____YES. If YES, describe difficulties (glare, fogging on lenses)______________________________________

____

10. Did you encounter any difficulties in reading the scales, reticles, and counters of the fire control equipment? ____NO ____YES. If YES, describe (numbers too small, graduations not clear)____

____

11. Did the self-illumination of the fire control equipment provide adequate illumination for operation under all conditions encountered? _____NO _____YES. If NO, describe conditions and specific difficulty encountered______________________________

____

12. Did you encounter any difficulties with the bearing method of lay? _____NO _____YES. If YES, describe________________________

____

13. Did you encounter any difficulties in performing basic periodic fire control test? _____NO _____YES. If YES, describe specific difficulties encountered___________________________________

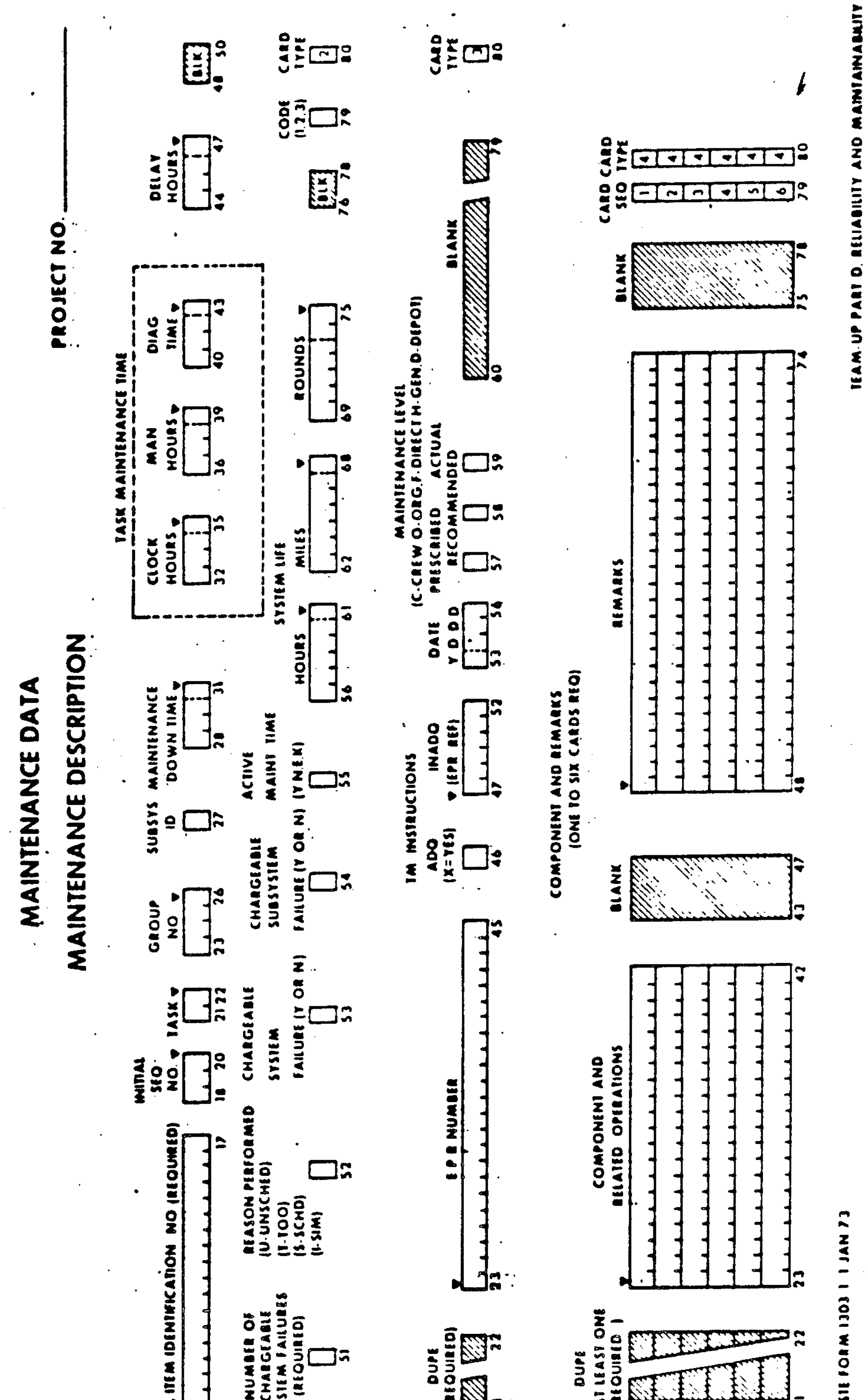
____

Comments on training are solicited.

(U) FIGURE VI-9 FUNCTIONING OF TRANSPORTED AND NONTRANSPORTED TEST ITEMS DATA COLLECTION FORM

GROUP AND NUMBER	WEAPON CALIBER	ZONE	TRANSPORTED TEST ITEMS TYPE FUNCTION (NORMAL OR DESCRIBE MALFUNCTION)	NONTRANSPORTED TEST ITEMS TYPE FUNCTION (NORMAL OR DESCRIBE MALFUNCTION)

(U) FIGURE VI-10. MAINTENANCE DATA



(U) FIGURE VI-11. MAINTENANCE ANALYSIS CHART

MAINTENANCE ANALYSIS CHART		PROJECT NO		NOMENCLATURE						IDENTIFICATION NO
GP NO (SEQ NO)	COMPONENT AND RELATED OPERATIONS	MAINTENANCE LEVEL C-OPERATOR/CREW O-ORG F-DIRECT H-GENERAL		TM INSTRUCTIONS		ACTIVE MAINTENANCE TIME		SYSTEM LIFE H-HOURS M-MILES R-ROUNDS	REASON PERFORMED	REMARKS
		PHESB	RECM	ADQT	INADQT	CLOCK HOURS	MAN-HOURS			
1	2	3	4	5	6	7		8	9	10

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(U) FIGURE VI-12. MAINTENANCE PACKAGE LITERATURE CHART

MAINTENANCE PACKAGE LITERATURE CHART		PROJECT NO	NOMENCLATURE					
MANUSCRIPT			DATE RECEIVED		EVALUATION		FORM 2028	REMARKS
NUMBER	QTY	TITLE	LIT	MATERIEL	ADQT	INADQT	DATE FORWARDED	
1	2	3	4	5	6	7	8	9

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(U) FIGURE VI-13. PARTS ANALYSIS CHART

PARTS ANALYSIS CHART		PROJECT NO	NOMENCLATURE					IDENTIFICATION NO
GP NO (SEQ NO)	FEDERAL STOCK NUMBER	NOUN NOMENCLATURE		MAINTENANCE LEVEL C--OPERATOR/CREW O--ORG F--DIRECT H--GENERAL		PART LIFE H-HOURS M-MILES R-ROUNDS	REASON USED	REMARKS
				PRESB	RECM			
1	2	3		4	5	6	7	8

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(U) FIGURE VI-14. TOOLS AND TMDE CHART

TOOLS AND TMDE CHART	PROJECT NO			NOMENCLATURE					
NOMENCLATURE OR DESCRIPTION	FSN OR PART NO	MAINT LEVEL C-OP/CREW O-ORG F-DIRECT H-GENERAL		DATE RECEIVED	EVALUATION		ROR YES OR NO	TECHNICAL MANUAL IN WHICH LISTED	REMARKS
		PRESB	RECM		ADQT	INADQT			
1	2	3	4	5	6	7	8	9	10

(U) FIGURE VI-15. HUMAN FACTORS ASPECTS OF MAINTENANCE AFTER MAINTENANCE INTERVIEW CHECKLIST

INSTRUCTIONS: Upon completion of maintenance actions, evaluators will interview personnel performing the maintenance action. This interview checklist will be used to insure that all human factors aspects of maintenance are considered.

NAME OF INDIVIDUAL PERFORMING MAINTENANCE ACTION: ________________

MAINTENANCE ACTION PERFORMED ________________

____

	YES	NO	COMMENT
1. Did you encounter any difficulty in determining the nature of the malfunction or service to be performed?	___	___	________
2. Are troubleshooting guides provided to facilitate rapid and positive fault detection and isolation of defective parts for this malfunction?	___	___	________
3. Did you have any difficulty with assembly or disassembly of components or parts?	___	___	________
4. Were any parts mounted so that they prevented convenient access to other parts?	___	___	________
5. Is the configuration of the system designed to preclude incorrect mating of parts?	___	___	________
6. Did your personal or special purpose clothing create any constraints?	___	___	________
7. Were there any procedures that required excessive physical effort such as lifting without adequate handles and grasp areas?	___	___	________

	YES	NO	COMMENT
8. Were hoist and lift points provided and clearly labeled on components requiring mechanical or power lifting?			
9. Did you experience any restriction of body movement during the performance of this maintenance action?			
10. Were any fatigue producing body or limb positions imposed during the performance of this maintenance action?			
11. Are the tables or other markings providing for identification of components and parts adequate?			
12. Did you encounter any procedure where space was not sufficient to perform the required action?			
13. Are components placed so that structural members do not prevent access to them?			
14. Are maintenance check points easily accessible without removing other components?			
15. Are adjustment points and check points easily accessible and visible?			
16. Is the space separation between components adequate for free entry and operation of required tools?			
17. Is clearance allowed for wrenches if torque of 50 foot pounds or more is required?			
18. Did the replacement or alignment of a component require extensive realignment of other parts?			

	YES	NO	COMMENT
19. Were components removable along a straight or moderately curved line?	___	___	___
20. Do hand operated components have clearance for use of tools in the event of binding?	___	___	___
21. Are components tightened clockwise and loosened counterclockwise where possible?	___	___	___
22. Are fluid connectors placed so that the item need not be jacked up to drain, fill, or perform other maintenance?	___	___	___
23. Is connection/disconnection of hydraulic fittings possible without spillage on man or equipment?	___	___	___
24. Are standard lubrication fittings used so that no special extension or fittings are required?	___	___	___
25. In your opinion are there any maintenance operations that require unnatural direction of movement or awkward movements imposed by location or design?	___	___	___

(U) FIGURE VI-16. DATA COLLECTION FORM FOR HUMAN FACTORS ENGINEERING INTERVIEW CHECKLIST FOR OPERATING PERSONNEL

NAME OF INDIVIDUAL ______________________________
RANK ________ YEARS OF SERVICE ________________ MOS ____________
TYPE OPERATIONS PERFORMED ______________________________
WEATHER CONDITIONS ______________________________
LIGHT CONDITIONS ______________________________
RIGHT HANDED ________ LEFT HANDED ______ WEAR EYEGLASSES ____________

1. Approximately how many days have you served as a crew member during this test? ________days

2. What positions did you fill? (list all)

3. What other field artillery weapons have you served as a crew member on? (circle) M101A1, M102, M114, M109, M107, M110, XM____.

4. Did you find the howitzer test item: (circle one)

   a. (easier)(harder)(about the same) to tow

   b. (easier)(harder)(about the same) to emplace

   c. (easier)(harder)(about the same) to fire

   d. (easier)(harder)(about the same) to march order

as other field artillery weapons?

5. Did you experience any difficulty with the following:

	YES	NO	COMMENTS
a. Restriction of body movements during operation.	___	___	____________
b. Fatigue producing body or limb positions imposed by operations?	___	___	____________
c. Operations requiring excessive physical effort; such as, attaching the howitzer test item to the prime mover?	___	___	____________
d. Visibility and readability of dials, counters, or scales during daylight or blackout operations?	___	___	____________
e. Operation of control wheels, cranks, knobs, or levers?	___	___	____________

	YES	NO	COMMENTS
f. Awkward movements or error-likely situations imposed by location, design, or unnatural direction of control movement?	___	___	___
g. The ratio of movement of a control to the movement of the controlled component?	___	___	___
h. The arrangement of controls and mechanical assemblies with respect to logical order of use?	___	___	___
i. Identifying controls and control position by sight or touch?	___	___	___
6. Did your combat or seasonal clothing; such as, steel helmet, gloves, or rain gear, interfer with your operation of the howitzer test item?	___	___	___
7. Did the blast, noise, or recoil of the howitzer test item cause you any discomfort; such as, bloody nose or ringing ears?	___	___	___
8. In your opinion do the standard issue ear plugs provide adequate ear protection?	___	___	___
9. Did you note any interference with operations caused by ejection of the primer case or secondary missiles?	___	___	___
10. Did you note any degradation of howitzer test item operation or crew efficiency caused by heating of the weapon from firing or exposure to the sun?	___	___	___

	YES	NO	COMMENTS
11. Did you encounter any difficulties in unpackaging, preparing to fire, or firing the propelling charge test items?	___	___	___

12. Do you feel that the radioactive material in the fire control equipment presents a safety hazard to you? ______YES ______NO

13. Do you have any recommendation for simplifying or improving operation of the howitzer or propelling charge item? ______YES ______NO

If YES explain in detail______________________________

14. Did you have any difficulty with the bearing method of lay during laying/firing operations?______YES ______NO If YES, describe

____

INTERVIEWER______________________________DATE________________

Comments on training are solicited.

(U) FIGURE VI-17. DATA COLLECTION FORM FOR HUMAN FACTORS ENGINEERING

ERROR REPORT

Test Title:______________________________ Date:__________

Task or Subtest:____________________ Error Report No:__________

1. Description of Error: (Describe exactly what the person did or failed to do that resulted in the error; describe exactly the equipment, component, or tools involved; explain what was supposed to be done or task required.) ______________________________

2. Factors contributing to error: (time-pressure, weather, hazards, etc.)______________________________

3. Consequences of error: (describe in detail) ______________________________

4. Seriousness of error: (check)

   a. Hazard to personnel or equipment. ☐

   b. Degradation of system performance. ☐

   c. Degradation of subsystem performance. ☐

   d. Degradation of component performance. ☐

   e. No effect on performance. ☐

   f. Other (describe): ______________________________

5. Corrective action taken: ______________________________

6. The chance of this error occurring in a real operational or combat situation is considered to be: (check one)

   less likely ☐ about the same ☐ more likely ☐

   Why (explain): ______________________________

7. Suggestions for eliminating or reducing chance of error: (consider changes in procedures, training, warning labels, design of hardware.)______________________________

Evaluator:____________________
(Name)

(U) APPENDIX VII AMC/TRADOC ARTILLERY FAILURE DEFINITION AND XM198 RELIABILITY SCORING CRITERIA

Part I XM198 RELIABILITY SCORING CRITERIA

Extract of XM198 Reliability Scoring Criteria from Coordinated Test Program for Howitzer, Towed XM198 and Charges, Propelling XM203/XM201/XM164.

PREFACE

This Scoring Criteria is to provide guidelines for assessing the reliability of the XM198 Towed Howitzer. This criteria should provide for consistent classification of failure by user, developer and test agencies. It is planned that user/developer/tester scoring conferences be held during DT/OT II and DT/OT III to review failure categorization according to this procedure.

The basis for this scoring criteria is the AMC/TRADOC artillery failure definition as shown in Section I. This basis was used to develop the Procedures which provide a step-by-step guide and a Decision Table Flow Chart (Section III) to assist failure classification. The Procedures should provide adequate guidance for failure classification in most cases. The flow chart provides a quick diagram of the more detailed instructions. Anticipated test structure for evaluating the reliability of the XM198 Howitzer appears as an Operational Mode Summary in Section II.

In those cases where the guidance of the Procedures are incomplete for clear, consistent failure determination, the guidance of Sections IV, V, and VII may be required. Section IV lists typical failure modes which if occur can be counted as failures. Section V is concerned with Alternative Modes of Operation, and Degraded Modes of Performance are addressed in Section VII. Related to Step 11 of the procedures, an extract of MIL-STD-882 is included at Section VI. Section VIII (when prepared) lists the analysis of AD and ED test data which provides examples of how specific failures are categorized by AMC/TRADOC joint analysis. Section VIII, together

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with DT/OT II and III test data should provide a reliability base line based on standardized failure classification.

PROCEDURES

The following scheme provides the instructions for the use of the XM198 Howitzer Failure Definition (Section I) for testing related to the Operational Mode Summary (See Section II). These instructions assume that an incident or malfunction has occurred during test, and a record has been prepared against this action to the extent where it is necessary to determine the chargeability of the action. Incidents where the identification of a reliability failure is in doubt will be deferred to a user/developer/tester Scoring Conference. The procedural flow for this determination is shown in Section III. The step-by-step instructions for using this Failure Definition are as follows:

Step 1. Record the incident information when malfunction of the system occurs or is detected (rounds and miles on test item and system, description of incident, nature of maintenance action required, maintenance time in hours, maintenance manhours, and so forth). Proceed to the next step answering the question posed and taking action according to the answer given.

Step 2. Is this a scheduled replacement of parts before failure? If yes, do not charge a failure; if no, proceed to Step 3.

Step 3. Is this a malfunction resulting from not following the prescribed operational or maintenance procedures or schedule dictated by the equipment manuals? If yes, do not charge a failure; if no, proceed to Step 4.

Step 4. Is this a malfunction resulting from test item abuse, unrealistic operating conditions or accident? If yes, do not charge a failure; if no, proceed to Step 5.

Step 5. Is this an actual or incipient malfunction detected or corrected during initial technical inspection or an incipient malfunction detected during final technical inspection? If yes, do not charge a failure; if no, proceed to Step 6.

Step 6. Is this an incipient malfunction corrected during scheduled preventive maintenance on the part in question, provided a higher level of maintenance is not necessary? If yes, do not charge a failure; if no, proceed to Step 7.

Step 7. Is this incident related to or caused by another reliability failure? If yes, do not charge a failure; if no, proceed to Step 8.

Step 8. The following statements are addressed collectively. (A) The malfunction did not and would not cause a critical or catastrophic hazard to personnel or equipment as defined by MIL-STD-882 (15 Jul 69) (See Section VI). (B) The system performance is above acceptable levels (See Section VII). (C) The Malfunction did not and would not preclude the ability to commence or the cessation of any mode of operation (for example, emplace howitzer; load and fire at any range, charge, elevation, or direction; prepare howitzer for march; tow, air transport or airlift howitzer; conduct deep fording) (See Section IV)? If all three of the above statements are true, do not charge a reliability failure; if any are not true proceed to Step 9.

Step 9. Is the operator/crew authorized and able to remedy the malfunction by adjustment, repair, or replacement action within five minutes, using the controls, Basic Issue Items (BII), Items Troop Installed or Authorized (ITIA) and parts authorized to the crew? If the answer is yes, do not charge a reliability failure; if no, proceed to Step 10.

Step 10. Is an alternative mode of operation available within five minutes (See Section V)? If yes, do not charge a failure; if no, charge a mission reliability failure.

If the previous 10 steps provide inconclusive evidence as to the chargeability or non-chargeability of a reliability failure, the incident should be checked against the criteria of Sections I through VII and analysis of previous test data (See VIII below). If categorization of the incident remains in doubt, defer classification to a user/developer/tester Scoring Conference.

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SECTION I

AMC/TRADOC ARTILLERY FAILURE DEFINITION

I. General Failure Definition:

For the purpose of assessing reliability, a failure is defined as any malfunction which the operator/crew cannot or is not authorized to remedy by adjustment, repair, or replacement action within five minutes, using the controls, Basic Issue Items (BII), Items Troop Installed or Authorized (ITIA) and parts authorized to the crew, and which causes or would cause; inability to commence or the cessation of any mode of operation; a critical or catastrophic hazard to personnel or equipment as defined by MIL-STD-882 (15 Jul 69). For related malfunctions only the primary malfunction will be counted against reliability.

II. Amplification:

A. The following are not considered as reliability failures:

1. Scheduled replacement of parts before failure.

2. An incipient malfunction corrected during scheduled preventative maintenance on the part in question provided a higher level of maintenance is not necessary.

3. A malfunction resulting from not following the prescribed operational or maintenance procedures or schedule dictated by the equipment manuals.

4. A malfunction resulting from test item abuse, unrealistic operating conditions or accident.

5. Actual or incipient malfunctions detected or corrected during initial technical inspection and incipient malfunction detected during final technical inspection.

B. The following are considered as reliability failures:

1. A failure detected and/or corrected during the correction of another failure provided the failures are totally unrelated.

2. Corrected incipient malfunctions not covered by II.A.2 and II.A.5 above.

3. Failures detected and/or corrected during final technical inspection.

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4. Failures resulting from lack of clarity of instruction or other fault in the maintenance test package.

C. When major subsystems of the end item have separate MRBF or reliability criteria, each subsystem will be treated as if it is an end item in itself, and separate compilations of data will be made for each subsystem.

III. Scoring Criteria:

With the mutual agreement of the developer and user, scoring criteria for mission reliability failures may be developed and appended to the preceding failure definition for specific items or equipment.

SECTION II

XM198 OPERATIONAL MODE SUMMARY

The expected use of the towed 155mm Howitzer in an intensive phase of operations is as follows:

a. During normal operations the weapon will either be firing, prepared to fire, or being moved from one position to another.

b. The weapon can be expected to fire 6-10 rounds per mile traveled. The rounds fired will be approximately 25-30 percent top zone charges with the remainder equally distributed among all other zones.

c. Weapon road movement will be 15 percent hard surfaced roads, 65 percent secondary roads and 20 percent cross-country. Ten percent of each of the above distances will be traveled under blackout conditions.

d. During each 120-hour period, the weapon will perform one deep fording operation and one helicopter lift.

e. The operational mode summary intended to provide a basis against which the test plan can be formulated. All rounds fired during DT/OT II and DT/OT III should be fired in the proportions and under the conditions specified above.

f. The above summary may be used for RAM-D requirement calculations by assigning an annual use rate of 7,500 rounds in 3 months as representative of mid-intensity conflict.

SECTION III

DECISION TABLE FLOW CHART

Step 1 Record Incident Information

Step 2 Scheduled replacement of part? — Yes → Not a mission reliability failure

No ↓

Step 3 Were improper maintenance procedures or schedules followed? — Yes → Not a mission reliability failure

No ↓

Step 4 Did this malfunction occur under abnormal conditions? — Yes → Not a mission reliability failure

No ↓

Step 5 Was this incident detected & corrected during initial inspection or an incipient detected during final inspection? — Yes → Not a mission reliability failure

No ↓

Step 6 Is this incident an incipient malfunction corrected during scheduled PM of this part (No higher level maintenance)? — Yes → Not a mission reliability failure

No ↓

Step 7 Is this incident caused by another reliability failure? — Yes → Not a mission reliability failure

No ↓

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Step 8

A. No critical or catastrophic hazard to crew or equipment

and

B. System performance above acceptable level

and

C. Ability to start or stop in any mode

— Yes → Not a mission reliability failure

↓ No

Step 9 Can incident be corrected in 5 minutes? — Yes → Not a mission reliability failure

↓ No

Step 10 Is alternate mode of operation available within 5 minutes? — Yes → Not a mission reliability failure

↓ No

Mission Reliability Failure

COPY

SECTION IV

FAILURE CRITERIA

The following is a list of typical failure modes for use in assessment of mission reliability failures. If there is reason to suspect that a chargeable mode should not be charged as a mission failure the decision logic table (Section III) should be used.

	Assembly (Part/Drawing Number)	Chargeability*
A.	Recoil Mechanism (XM45 72F500)	
1.	Gun over recoils (metal-to-metal Breech hits level terrain).	C
2.	Gun does not return to battery.	C
3.	Gun returns to battery w/shock so as to disrupt firing or cause reset of fire control.	C
4.	Leakage requiring part replacement.	C
B.	Cannon (XM199 WTV-F22385)	
1.	Breechblock cannot be closed/opened.	C
2.	Gun will not fire.	C
3.	Primer cannot be removed/inserted.	C
C.	Carriage (XM39 72K498)	
1.	Emplacement system is inoperative.	C
2.	Elevation/traversing system is inoperative.	C
3.	Inability to be towed.	C
D.	Fire Control (XM137, XM171, XM17, XM172, XM18, XM138)	
1.	Error, irregular movement, or shifting of mechanical parts (knobs, mounts, lenses).	C
2.	Inability to adjust fire control.	C
3.	Fogging which prevents operation.	C

*Subject to performance degradation of Section VII.

SECTION V

ALTERNATE MODES OF OPERATION

I. If a backup method of operation can be utilized and activated within 5 minutes, no reliability failure should be charged. The backup is now treated as if it were part of the original system. NOTE: If the backup mode also fails, only one system reliability failure is charged.

II. The following alternate modes of operation are available for the XM198:

A. Failure of the XM172 Mount during indirect fire - use XM171 Mount, XM137 Pan Tel and XM17 FC Quad.

B. Failure of the XM18 FC Quad during indirect fire - use XM171 Mount, XM137 Pan Tel and XM17 FC Quad.

C. Failure of the XM17 FC Quad during indirect fire - use XM171 Mount, XM137 Pan Tel, XM172 Mount and XM18 FC Quad.

D. Failure of XM137 Pan Tel during direct fire - use XM172 Mount and XM138 El Tel.

E. Failure of XM171 Mount during direct fire - use XM172 Mount and XM138 El Tel.

F. Hydraulic system is inoperative to emplace weapon - use manual jacks.

III. Operation of the following operational modes will not be required for reliability assessment:

A. Towing in short tow position.

B. Operation under climatic categories 7 and 8 or AR 70-38.

C. All lighting equipment.

D. Speed shift operation.

E. Storage equipment.

IV. For any failed part which is replaced by a redesigned improved part, the number of failures counted will be based on the reliability demonstrated by the improved part during test. This also applies to failures caused by manual problems which are corrected during test.

SECTION VI

EXTRACT OF MIL-STD-882

MIL-STD-882, Requirements for System Safety Program for Systems and Associated Subsystems and Equipment, dated 15 Jul 69, provides uniform requirements and criteria for establishing and implementing system safety programs. Under Section III, Definitions, Hazard level is defined as follows:

A qualitative measure of hazards stated in relative terms. For purposes of this standard the following hazard levels are defined and established: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction:

(a) Category I - Negligible

...will not result in personnel injury or system damage.

(b) Category II - Marginal

...can be counteracted or controlled without injury to personnel or major system damage.

(c) Category III - Critical

...will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival.

(d) Category IV - Catastrophic

...will cause death or severe injury to personnel or system loss.

SECTION VII

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DEGRADED MODES OF OPERATION

A certain amount of performance degradation must take place before a reliability failure can be assumed. Of course, if the system ceases to function, performance becomes unacceptable (that is, non-existent); however, if performance is only degraded, then some threshold must be established to define where reliability failures begin. Allowable degradation thresholds have been established for the various performance parameters. Performance beyond these thresholds constitutes a reliability failure. As long as performance remains above the threshold or is returned above the threshold within a 5-minute maintenance period, no reliability failure is charged.

A.	Rate of Fire - maximum	3 rounds/minute
B.	Rate of Fire - sustained	1 round/1.5 minutes
C.	Reaction Times - daylight	8 minutes
D.	Displacement Time daylight	8 minutes
E.	Boresight Fire Control	4 minutes
F.	Compensation for Cant	8 mils

G. Towing - No interference with normal convoy movement.

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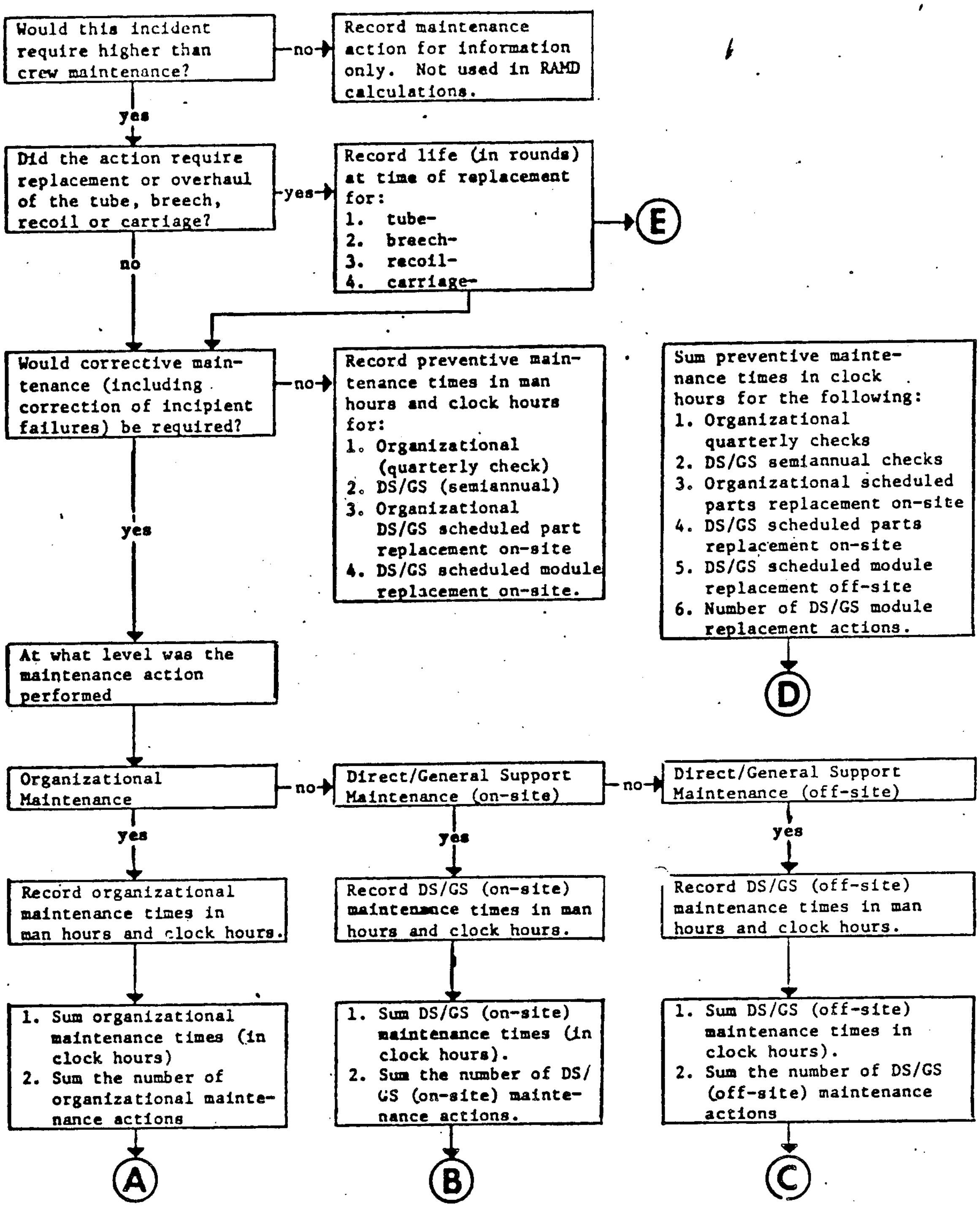
Part II Maintainability, Availability, Durability Scoring Criteria

PREFACE

This scoring criteria is to provide guidelines for assessing the maintainability, availability and durability of the XM198 Towed Howitzer. This criteria should provide for consistent assessment of M, A, D by user, developer and test agencies. It is planned that user/developer scoring conferences be held during DT/OT II and DT/OT III to review assessment according to this procedure. Section V (when prepared) will list analysis of all available test data which should provide a base line based on standardized assessment techniques.

Use of this scoring criteria should begin with evaluating each incident report or EPR according to the decision flow chart of section I. This initial evaluation will categorize and combine the data into manageable groups. Assessment of maintainability, availability, and durability will be conducted according to sections II, III, and IV respective, using the ouput of section I.

SECTION I XM198 M, A, D DECISION FLOW CHART



SECTION II MAINTAINABILITY:

Mean Time to Repair (MTTR) Calculations

Organizational MTTR:

Using the input from (A) divide the total organization maintenance time in clock hours by the total number of organizational maintenance actions.

Direct/General Support MTTR:

Using the input from (B) and (C) add the total of DS/GS on-site maintenance times (in clock hours) (B) to the total DS/GS off-site maintenance times (in clock hours) (C) and divide this sum by the total number of DS/GS on-site and off-site maintenance actions (B) and (C).

SECTION III Availability:

Operational Availability

A_o calculations will utilize values from (A), (B), (C), and (D) and the prescribed administrative logistic down time (ALDT) factors where applicable.

A_o Down Time Calculations:

A. Level of (corrective) Maintenance	Down Time
1. Organizational	
The ALDT factor is 4* hours/event. Multiply the total number of organizational corrective maintenance actions recorded in (A) by 4 and add this number to the sum of the organizational corrective maintenance times (in clock hours) recorded in (A) =	xxxx hours
2. Direct/General Support (on-site)	
The ALDT factor is 15* hours/event. Multiply the total number of Direct/General Support on-site corrective maintenance actions recorded in (B) by 15 and add this number to the sum of Direct/General Support on-site corrective maintenance times (in clock hours) recorded in (B) =	xxxx hours

3. Direct/General Support (off-site)

The ALDT factor is 82* hours/event. Multiply the total number of Direct/General support off-site corrective maintenance actions recorded in (C) by 82 and add this number to the sum of Direct/General support off-site corrective maintenance times (in clock hours) recorded in (C) = xxxx hours

B. Level of (preventive) Maintenance

1. Organizational

The ALDT factors is 0* hours/event.

(a) The Manual requires that an organizational preventive maintenance check be performed quarterly. Record the total organizational preventive maintenance time (in clock hours) from (D) = xxxx hours

(b) Record the total organizational scheduled parts replacement times (in clock hours) from (D) = xxxx hours

2. Direct/General Support (on-site)

The ALDT factor is 0 hours/event.

(a) The Manual requires that a Direct/General support preventive maintenance check be performed semi-annually. Record the total DS/GS preventive maintenance time (in clock hours) listed under semi-annual DS/GS in (D) = xxxx hours

(b) The Manual requires that specific components (such as the tube) will be replaced at scheduled intervals. Record the total DS/GS scheduled parts replacement times (in clock hours) from (D) = xxxx hours

3. Direct/General Support (off-site)

The ALDT factor is 24* hours/event.

The manual states that specific modules will be replaced at scheduled intervals. Multiply the total number of scheduled modular replacement events by 24 and add this number to the sum of scheduled module replacement times (in clock hours) recorded in (D) = xxxx hours

TOTAL DOWNTIME = xxxx hours

*ALDT factors proposed by AMCPM-CAWS. AMC/TRADOC resolution of ALDT is not yet complete.

$$A_o = \frac{\text{uptime}}{\text{uptime and downtime}}$$

Where: uptime = total time - total downtime

And: downtime is the total downtime calculated in III.A and B above.

Total time is calculated to be consistent with the requirement base line of 7,500 rounds per 3 month period (2,190 hours) and will be based upon the number of test rounds actually fired.

Therefore: $\text{Total time} = \frac{\text{(No Rounds)}}{7,500} \times 2,190 \text{ hours}.$

Achieved Availability

A_a calculations, if desired, can be performed utilizing the values from (A), (B), (C), and (D) and by recalculating total downtime above using an ALDT factor of zero in all cases.

$$A_a = \frac{\text{uptime}}{\text{uptime and downtime (w/o ALDT)}}$$

Where:

uptime = total time - downtime (w/o ALDT) and downtime is the total downtime calculated in IIIA and B above using ALDT = 0.

total time = same as for A_o

SECTION IV DURABILITY:

The number of rounds scheduled for system tests may not completely validate attainment of durability requirements. Therefore all system, subsystem, and component testing will be carefully analyzed to determine their adequacy for demonstrating requirements. Block (E)

PART III

XM198 RAM-D REQUIREMENTS

Reliability, MRBF*	700 Minimum Acceptable Value (MAV)
	1,100 Specified Value (S.V.)
	550 w/70 percent confidence by end of DT/OT II
Availability**, Operational	83 percent
Maintainability, MTTR	0.5 hour organizational
	2.0 hours direct support
Durability, EFC Rounds	
Carriage	15,000
Recoil	10,000 - 15,000
Tube	2,500 - 5,000
Breech	7,500 - 10,000

*Mixed charges in accordance with operational profile
**ALDT factors to be used not yet definite.

(U) APPENDIX VIII STATISTICS

1. Introduction

a. This test will use statistical concepts and techniques as tools to determine test item reliability, the mean functioning points of groups of projectiles fired from the weapon system and the probable errors (measures of the dispersion of the functioning points about the mean function points) of the groups of projectiles fired from the weapon system.

b. Testing will be accomplished using standard weapon systems. The projectiles used will be selected from the total population. The sample of projectiles fired will be small with respect to the total population.

2. Reliability

a. The propelling charge reliability will be computed as outlined below.

b. Given a sample of n missions and some variable of interest, X (that is, completion of the mission), whose value is obtained for each mission in the sample resulting in a set of values,

$$X_i = X_1, X_2, X_3, \ldots, X_n ,$$

and which can have either of only two values (for example, 0 or 1, corresponding to completion or noncompletion of the mission), then the mission reliability of the item is

$$R = \frac{1}{n} \sum_{i=1}^{n} X_i$$

This is also the best single or "point" estimate of R.

c. Once R has been computed for the sample of n missions, the desired confidence level on R for the population will be determined, assuming that the population and sample are binomially distributed.

3. Means and Probable Errors

a. Given a sample of n projectiles fired under similar conditions and some variable of interest, x (that is, achieved range, achieved deflection, achieved height of burst, achieved time of flight, chronograph readout velocity), whose value is obtained for each projectile in the sample resulting in a set of values,

$$\{x_i\} = \{x_1, x_2, x_3, \ldots, x_n\},$$

then, the mean value of x for the sample is

$$\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i,$$

and the probable error in x for the sample is

$$PE(x) = .67449 \left[\frac{\sum_{i=1}^{n} x_i - \overline{x}^{\,2}}{n-1} \right]^{1/2}$$

These are also the best single, or "point," estimates of $\overline{x}$ and PE(x) for the population.

b. In the discussion of subparagraph 3a, it was assumed that all projectiles in a sample were fired under similar conditions. It can occur that some conditions (that is, weather) is gradually changing while a sample is being tested. If this is so, then there can be a trend in the set of values, $\{x_i\}$, obtained.

(1) The set of values, $\{x_i\}$, will be tested at the 99 percent confidence level to determine if a trend exists. The test follows:

$$S_d^2 = \frac{1}{2(n-1)} \sum_{i=1}^{n-1} \left(x_{i+1} - x_i\right)^2$$

$$S^2 = \frac{1}{n-1} \sum_{i=1}^{n} \left(x_i - x\right)^2$$

$$T = \frac{S_d^2}{S^2}$$

If T is less than the critical value listed for the appropriate sample size in Table VIII-1, then there is a trend in $\{x_i\}$ at the 99 percent confidence level.

(2) If a trend exists, then the best estimate of the population standard deviation PE(x) is computed by the successive differences method,

$$PE(x) = .67449(S_d).$$

Table VIII-1

Critical values for use in trend tests at the 99 percent confidence level.

Sample Size	Critical Value
8	.3314
9	.3544
10	.3759
11	.3957
12	.4140
13	.4309
14	.4466
15	.4611
16	.4746
17	.4872
18	.4989
19	.5100
20	.5203
21	.5300
22	.5392
23	.5479
24	.5561
25	.5639
26	.4713
27	.5784
28	.5851
29	.5915
30	.5976

c. Prior to making final conclusions concerning the sample mean and probable errors, the outlying observation will be identified.

(1) An outlier is a value, x_j, in a set of n values, $\{ x_i \}$, which should not be there. The following test identifies these outliers at the 99 percent confidence level:

$$K = \frac{S'^2}{S^2}$$

S'^2 is the same quantity as S^2 defined in subparagraph 4b, except that it applies to a set of values, $\{ x_i \}'$, from which the suspected outlier, x_j, has been deleted. If K is less than the critical value listed for the appropriate sample size in table VIII-2, then x_j is an outlier at the 99 percent confidence level. This is a modified F-test.

(2) If there appears to be a trend, then caution must be exercised in determining outliers because one or more outliers may cause the trend test to give erroneous results, and vice versa.

(3) If two suspected outliers are found on the same side of the mean, the ratio S_2^2/S^2 is compared to the values in table VIII-2 for S_2^2/S^2. The test is not applicable if both suspected outliers are not on the same side of the mean.

(4) This test is intended to identify not more than two in a set of values $\{ x_i \}$.

(5) This outlier test identifies outliers at the 99 percent confidence level. It provides no information concerning why the value is an outlier or whether it should be deleted from the set of values, $\{ x_i \}$. Some possible causes of outliers are:

(a) Erroneous data.

(b) Sudden variation in conditions affecting the trajectory.

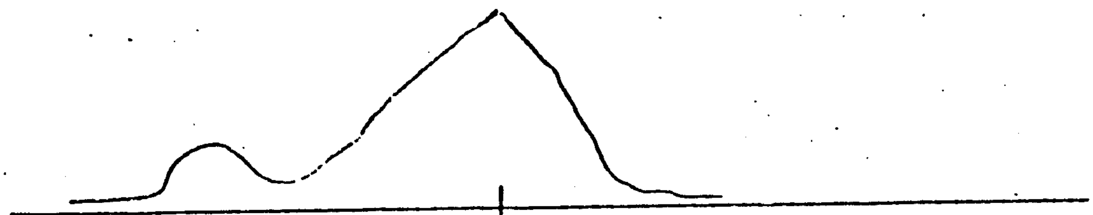
(c) A member of the sample coming from one of the tails of the normally distributed population.

(d) A member of the sample not belonging to the normally distributed population.

(6) Identification of a round as an outlier does not necessarily imply that the round will be deleted from the group. For a round to be deleted, it must be demonstrated that its performance is due to something not inherent in the round itself (that is, muzzle velocity). If this is not the case, there remain two choices:

(a) Consider the round as coming from the tails of the normally distributed population and include it in the probable error.

(b) Consider the round as not coming from the normally distributed population; that is, consider that the population is not normally distributed. An example of such a distribution is



The small peak at point A represents erratic rounds caused by some characteristic of the round itself.

Table VIII-2

Critical values for use in outlier tests at the 99 percent confidence level.

Sample Size	Critical Value (S_1^2/S^2)	Critical Value (S_2^2/S^2)
8	.2273	.1050
9	.2755	.1442
10	.3185	.1833
11	.3568	.2170
12	.3909	.2498
13	.4215	.2800
14	.4490	.3079
15	.4740	.3335
16	.4965	.3574
17	.5171	.3796
18	.5359	.4001
19	.5532	.4191
20	.5693	.4369
21	.5840	.4536
22	.5977	.4692
23	.6104	.4838
24	.6224	.4976
25	.6335	.5105

d. Once $\overline{x}$ and PE(x) have been computed for the sample of n items, the upper and lower bounds (confidence interval) on $\overline{x}$ and PE(x) for the population will be determined at the desired confidence level by means of the student-T distribution which is based on the assumption that the population is normally distributed.

30. Army Regulation 70-10, Test and Evaluation During Development and Acquisition of Materiel, 28 October 1973.

31. Army Program Memorandum XM198, 155-MM Towed Howitzer, November 1973.

32. Letter, AMSTE-FA, US Army Test and Evaluation Command, 25 February 1974, Subject: 155-MM XM198 Howitzer Working Conference.

33. US Army Test and Evaluation Command Supplement to Army Regulation 750-1, 25 March 1974.

34. Letter, AMSTE-FA, US Army Test and Evaluation Command, 10 April 1974, Subject: Test Plan for DT II (SP) of the 155-MM, XM198 Towed Howitzer, TECOM Project No. 2-WE-200-198-009.

35. MIL-M-6300 Technical Manual Series.

36. Letter, AMCPM-CAWS-PA, Project Manager, Cannon Artillery Weapons Systems, AMC, 20 June 1974, Subject: RAM-D Scoring Procedure for XM198 Howitzer.

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APPENDIX X - (U) ABBREVIATIONS

A_a = achieved availability
AD = air density
adqt = adequate
AF = after fire
A_i = inherent availability
AMCTC = Army Materiel Command Technical Committee
A_o = operational availability
bar = barometer
BF = before fire
BTI = burst time indicator
CH = clock-hours
cham = chamber
ctr = center
DPMN = Draft Proposed Materiel Need
DPQMR = Draft Proposed Qualitative Materiel Requirement
EFC = equivalent full charge
EPR = Equipment Performance Report
EST = expanded service test
Fz-Q = fuze quick
Fz-Ti = fuze time
Fz-VT = fuze variable time
ICM = improved conventional munitions
inadqt = inadequate
lit = literature
m = mils
$\overline{M}$ = mean active maintenance downtime
MCI = mean center of impact
MDT = mean downtime
MF = method of fire
MH = man-hours
ML = maximum left
MN = Materiel Need
MR = maintenance ratio
MRB = magnetic recording borescope
MRBF = mean rounds between failures
ms = millisecond
MTBM = mean time between maintenance
MTSQ = mechanical time superquick
MVV = muzzle velocity variation
PD = point-detonating
PE_d = deflection probable error
PE = range probable error
PIMP = permissible individual maximum pressure
PQMR = proposed qualitative materiel requirement
press. = pressure
presb = prescribed
Q = quadrant
RAP = rocket-assisted projectile

RFT	=	rear face of tube
rms	=	root mean square
sched	=	scheduled
SQ/D	=	superquick delay
SR	=	self-registration
temp	=	temperature
TF	=	time of flight
TOP/MTP	=	Test Operations Procedure/Materiel Test Procedure
TRMS	=	Test Resource Management System
unsched	=	unscheduled
UPL	=	upper pressure limit
wgt	=	weight

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HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-FA

14 MAY 1975

SUBJECT: Restructured DT II Test Plan for the 155MM XM198 Towed Howitzer, TECOM Project No. 2-WE-200-198-008/010

SEE DISTRIBUTION

1. Subject test plan has been approved by this headquarters.

2. The plan is provided for information; however, major comments will be accepted within 30 days from the date of this letter.

FOR THE COMMANDER:

1 Incl
Subj Test Plan

THEODORE O. GREGORY
Colonel, GS
Dir, FA Materiel Testing

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