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Provides guidance for evaluating the performance of grenade launchers and their attachments, to determine whether they meet criteria specified in requirements documents.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-102
*Test Operations Procedure 3-2-030 13 March 1987
AD No.

GRENADE LAUNCHERS

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1. SCOPE. This TOP provides guidance for evaluating the performance of grenade launchers and their attachments, to determine whether they meet criteria specified in requirements documents. This TOP pertains to launchers that are part of the weapon. With slight changes, it applies to launchers designed as attachment to assemble over or onto the muzzle of a rifle, which usually depend on gases from a grenade cartridge fired from a rifle, and to launchers that are an integral part of a rifle, i.e., flash suppressors or raised rings on the forward end of the barrel that serve as guides for positioning and launching grenades.

*This TOP supersedes TOP 3-2-030, dated 12 May 1972.

Considerable effort is directed toward developing grenade launchers capable of providing the infantry soldier with significantly increased combat effectiveness. The acceptability of a weapon for standardization and issue to troops demands dependable operation under various conditions and the capability of delivering effective fire.

Design of the grenade launcher can vary from hand-held to bipod, tripod, pintle, and vehicle-mounted. Some launchers are single-shot and attach to a rifle or parent weapon. Others are self-contained and fire in the semi-automatic or fully automatic mode, using recoil energy for operation or some means of exterior power such as a hand crank or electric motor.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Camera w/film	35-mm with 80- to 200-mm zoom lens
Targets	Paper screen and/or plywood
Climatic chamber	To condition test item (-50° to 70° C)
Sand/dust chamber	To dispense mixture at 100 g/min/m^2 ± 25
Mud bath	Viscosity of 4,600 centipoises
Salt water solution	5% sodium chloride and 95% water
Ammunition guide tray	Low friction
Antisurge spring	Long enough to permit gradual load application
Rain test facility	To provide water spray of 10 mm/min (0.4 in.)
Ground mounts	Bipods, tripods, gimbals, etc.
Gun solenoid	
Oscillograph	
Test stands	
Control weapon	

2.2 Instrumentation.

DEVICE FOR MEASURING	PERMISSIBLE ERROR OF MEASUREMENT*
Velocity	±0.5 ft/sec
Viscosity (e.g., Brookfield viscometer)	±0.5% full-scale loading
Cyclic rate	
Temperature	±0.6° C (1° F)
Inspecting bore (e.g., star-gauge and borescope)	±0.025 mm

3. REQUIRED TEST CONDITIONS.

For launchers that are not hand-held, proof of weapon/mount compatibility must be provided by the developer or must be established before testing. If not compatible, a suitable mount must be designed and constructed before testing begins. The term "suitable" refers to the specific deflection of the mount in kg/cm (lb/in.). Generally, any grenade

*The permissible error of measurement (instrumentation) is the two-sigma value for normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

launcher too heavy or having too much recoil to be fired hand-held, should be capable of performing under mount conditions ranging from a ground tripod mount through armored vehicle mounts. Ground mounts (bipods, tripods, etc.) or adapters provided with the test weapons but not previously tested are included in the full range of applicable subtests (e.g., climatic, adverse conditions). The term "mount" as used herein is defined as all the supporting structure interposed between the gun and ground, except the actual cradle/adapter used to secure the weapon to the mount. An adequate number of test launchers is required to represent the population from which the sample has been drawn. If the sample is too small to produce adequate or statistically significant results, a decision regarding acceptability cannot be made with confidence. Although economy is also considered when testing, the sample size of each subtest must be sufficient (at least three weapons) to provide reasonable assurance that comparison of test results to requirements will be meaningful.

Although a sample of three launchers may be suitable for a subtest, at least nine new launchers should be provided for a complete development test. When this many are available, they are subjected to testing in accordance with Table 1.

4. TEST PROCEDURES.

4.1 Initial Inspection. Disassemble the test launcher, and carefully examine all parts. Photograph the launcher with and without accessories and in various states of disassembly.

a. Determine and record the physical, operating, and safety characteristics as follows:

(1) Test item nomenclature, serial number(s), and manufacturer's name

(2) Adequacy of packaging and preservatives

(3) Defective parts (ascertain with launcher disassembled; repair or replace; record)

(4) Number and names (established, if necessary) of all parts

(5) Force displacement curve for all springs, within the designed operating range (if specified in the test plan)

(6) Measurement of:

(a) Firing pin protrusion
(b) Firing pin energy (if specified in the test plan)
(c) Force and stroke required to manually operate the trigger
(d) Head space
(e) Charging force
(f) Test launcher length, width, and height
(g) Receiver length

(7) Weight of:

(a) Overall weapon
(b) Individual subassemblies

TABLE 1. WEAPON TEST SCHEDULE

Weapon Numbers	Subtests	No. of Rounds Each Launcher: Single-Shot Design	No. of Rounds Each Launcher: Semi-automatic or Automatic Design
All	Initial Inspection	0	0
1,2,3	Safety Evaluation	100	300
1,2,3	Assembly/Disassembly	0	0
All	Dispersion and Velocity	30	30
Selected	Accuracy and Dispersion	200	200
7,8,9	Rifle Accuracy and Dispersion	120	---
7,8,9	Endurance	[a]2,500	[a]5,000
4,5,6	Attitudes	140	240
5,6	Cookoff[b]	---	[c]4,000
1,2,3	High Temperature	[d]625	[d]1,250
1,2,3	Low Temperature	[e]1,250	[e]2,500
1,2,3	Temperature-Humidity	50	50
1,2,3	Icing	10	10
4,5,6	Mud	20	20
4,5,6	Water Spray	60	120
4,5,6	Sand and Dust	25	70
4,5,6	Salt Water Immersion	25	50
4,5,6	Unlubricated	50	50
1,4	Flash	10	300
4	Smoke	10	300
4	Noise and Blast	25	25
1,4	Belt Pull	---	100
All	Solvents and Lubricants Compatibility	0	0
All	Human Factors	All firings	
All	Reliability	All firings	
All	Logistic Supportability	All firings	

[a]Or in accordance with durability limit when provided.
[b]A cook-off test is not usually required for a grenade launcher. If the test is conducted, however, launchers 5 and 6 should not be used for any other tests, and launchers 1, 2, and 3 are scheduled for the remainder of the tests designated for launchers 4, 5, and 6.
[c]Never greater than durability limit.
[d]One-fourth prescribed durability limit.
[e]One-half prescribed durability limit.

(8) Magazine or ammunition box capacity and weight with and without ammunition

(9) Barrel data:

(a) Length
(b) Rifling:

1 Number of grooves
2 Direction of twist
3 Rate of twist at the muzzle
4 Length of rifling

(c) Diameters across grooves and lands throughout the bore
(d) Method of barrel attachment

(10) Type operation

(11) Gas adjustment

(12) Type of fire and means for control

(13) Type mechanism (open or closed bolt)

(14) Type feed

(15) Type muzzle attachment

Also record test instrumentation nomenclature, serial numbers, accuracy tolerances, and dates of last calibration.

b. Conduct nondestructive test (NDT) inspections of weapon components subjected to high stress during firing (bolt, sear, barrel, gas piston, etc.).

4.2 Safety Evaluation.

a. Information necessary to prepare a safety release recommendation is usually generated from the cumulative results of various subtests. A safety recommendation reflects engineering judgement based on careful study of all safety features, manual and interlock types, such as those intended to prevent firing before the breech is locked, firing without the barrel locked in place, or firing without the breech lock or with it improperly assembled. Report hazardous operation of manually operated assemblies such as feed covers or assemblies, trigger, manual directing handles or grips, etc. Make observations for high pressure gas or particles emanating from the breech area in a direction that could be hazardous to the gunner or crew, case ejection direction that could be hazardous to the gunner or crew, insecure mounting, and failure to sear resulting in a runaway gun condition.

b. If the weapon employs a magazine or belt feed, conduct a safety check to determine the hazard, if any, of double feeding. Examine the types of ammunition (projectile configuration) supplied with the launcher for design safety. Evaluate the variations in feeding angles induced by the different projectile configurations. Determine whether the nose of cartridges being fed will strike the primer of a chambered round. If so, conduct at least 10 trials with each type cartridge striking a chambered primed case (in lieu of a live round) by initiating a normal feeding cycle. NOTE: When testing 40-mm launchers, do not use primed cases with propellant in the high pressure chamber.

c. For muzzle-launched grenades, determine the safety effects of firing a mis-positioned grenade and firing with a grenade using the wrong launching cartridge.

4.3 Assembly/Disassembly. Conduct this test to determine the type and number of tools and time required to accomplish various states of disassembly and assembly. Have three test personnel perform the following operations three times:

a. Completely assemble the weapon.

b. Assemble weapon after completely disassembling.

c. Disassemble weapon to field-strip level.

d. Assemble from field strip.

Any or all of the above exercises may be delayed until testing is completed so that personnel performing the operations will be experienced and trained in handling the weapon. These exercises may also be conducted before, after, or halfway through testing in order to compare untrained personnel with trained.

4.4 Dispersion and Velocity. Conduct this test to determine the inherent dispersion and velocity performance of all test weapons and to select the weapons or weapon/launcher combination for the accuracy-dispersion test.

a. Fire three 10-round groups from each launcher at a vertical target at a 50-m range with inert-type ammunition. If the launcher is capable of more than one mode of fire, repeat the firing in each mode. Fire hand-held launchers from the bench rest position, and non-hand-held weapons from the mounts for which they were designed (tripod, bipod, vehicle mount, etc.). Muzzle-launched grenades that cause excessive recoil should be fired from a test stand that mirrors their operational firing position (i.e., rifle butt to ground, muzzle elevated).

b. Measure vertical and horizontal dispersions on all targets. From these data, select the best, worst, and an average weapon for the accuracy-dispersion test.

c. If practical, record instrumental velocities of the projectiles concurrently with these firings (10 ft) from the muzzle. Otherwise, fire 30 rounds for velocity performance. Condition all rounds fired for velocity at 21° C ± 2° (+70° F ± 3°) for at least 4 hours before firing.

4.5 Accuracy and Dispersion. This test is to determine the inherent accuracy and dispersion characteristics of the launchers and adequacy of the graduations on the sights.

a. Use the three weapons selected from the dispersion and velocity subtest (4.4 above) in this test.

b. This test should be conducted when the weapons are in a "new" condition. Requirements for specific weapons, however, may dictate that certain parts of the test be repeated at the midpoint and end of gun life.

c. Grenade launchers are normally fired for ground impact on a horizontal target to determine the ability of the weapon to meet the accuracy requirements specified. Except when specified otherwise, determine the x and y coordinates of all targets. From the coordinate data, azimuth and range standard deviations, azimuth and range spread, mean radius, and deviation of the center of impact (CI) from the point of aim (when applicable) are provided. The point of aim is determined by means of a boresight reading, test mount sight, or with gun sights (if provided with the weapon); the weapon is relayed on the aiming point after each shot or group, as applicable. Record at least two 20-round groups or four 10-round targets for each range. Obtain mode of fire, types of ammunition, and range (minimum, maximum, and intermediate) from specifications/requirements documents pertaining to the specific weapon being tested.

d. Conduct the firings with hand-held grenade launchers from a bench rest with wind conditions of 16 km/hr and less for ranges to and including 200 m and 8 km/hr (5 mph) and below for ranges greater than 200 m. Conduct accuracy firings with non-hand-held launchers from their respective mounts under the same wind conditions.

4.6 <u>Rifle Accuracy and Dispersion with Grenade Launcher Attached</u>. Attachment of a grenade launcher to a rifle usually causes a shift in group CI with the rifle and may adversely affect its dispersion. This test is therefore performed to determine (a) the effects on the accuracy and dispersion of the parent weapon from the attachment and use of a launcher and (b) any effects on the alignment and security of attachment of the launcher and launcher sights from firing the weapon to which the launcher is attached. Test three launchers and three rifles to which the launchers are to be attached as follows from a bench rest position:

a. Phase 1. Have an expert rifleman zero the rifles at the 100-m range on a vertical target, and record the sight settings for each. Then fire three 10-round groups with each rifle.

b. Phase 2. Attach the launchers and fire three 10-round groups from each rifle using the sight setting established in phase 1.

c. Phase 3. At the 50-m range, zero the launchers on a vertical target, and fire three 10-round groups with each launcher.

d. Phase 4. Fire three additional 10-round groups with the rifles using the sight setting established in phase 1.

4.7 <u>Reliability and Durability</u>.

a. This subtest is called an endurance test unless a specific durability requirement is provided, in which case, sample size and number of firings are determined by referring to TOP 1-2-502.[1*] The objectives of the endurance test are to:

*Superscript numbers correspond to reference numbers in Appendix B.

(1) Determine the nature of incidents, failures, and performance degradation which occur during the firing of a large number of rounds.

(2) Obtain data for application to other subtests such as reliability, logistic support, and human factors.

b. Fire three launchers 2,500 rounds each if single-shot design or 5,000 rounds each if semi-automatic or automatic design. The rounds previously fired for dispersion and velocity are counted as part of the total rounds fired. Because the launchers were cleaned and lubricated before testing, the weapons are fired without additional lubrication or maintenance until required because of degradation in performance. Initially, relubrication alone is applied to correct degradation in performance (rate reduction or malfunction); if this fails to restore satisfactory performance, disassemble, clean, inspect, and lubricate before resuming firing. Apply these lubrication-maintenance intervals throughout the remaining firing in this subtest.

c. After each 1,000 rounds fired or after each maintenance interval, whichever is the most applicable, conduct NDT inspections of weapon components subject to high stress during firing. At the same intervals, record the following suggested measurements and any others required for control:

(1) Firing pin protrusion

(2) Headspace

(3) Firing pin indent

(4) Force and stroke required to manually operate the trigger

(5) Charging force

(6) Force-displacement curves for all springs, within the designed operating range (if specified in the guidance documents)

(7) Barrel bore measurements

d. After each 500 rounds, record degradation in dispersion and velocity performance of the test launchers using the data from paragraph 4.4 for criteria. If the launcher is an attachment for a rifle, also record dispersion and accuracy performance for the rifle. Use the data previously obtained in paragraph 4.6 as criteria.

e. For muzzle-launched grenades, fire the rifles for a total of 1,000 rounds (cartridge/grenade) each. Nondestructive test inspections of key base weapon parts should be performed at 500, 700, 800, 900, and 1,000 rounds. The wear on the launcher/flash suppressor should be checked at the same intervals.

f. If the launcher can be fired both semiautomatically and automatically, fire in 100-round cycles, alternating semi-automatic, short-burst, and fully automatic modes of fire.

g. If the launcher can be fired only single-shot or semiautomatically, fire in 100-round cycles, employing a rate of fire applicable to the weapon design.

h. If the launcher is an attachment to another weapon, fire in 100-round cycles as follows:

(1) At the beginning of the cycle, fire the launcher and weapon to which it is attached 20 rounds alternately. If the parent weapon fires only automatically, fire 60 rounds in 2- to 3-round bursts.

(2) Fire 20 rounds from the launcher, with the parent weapon fully loaded and off "safe," but do not attempt to fire until 20 rounds have been fired from the launcher. Fire the parent weapon 20 rounds.

(3) Fire launcher 60 rounds.

i. Function firings with a launcher on a mount will include extreme left and right deflection and maximum elevation and depression. Firings from a ground mount will include with and without the mount sandbagged, and with the mount on sand, sod, and hard ground.

4.8 <u>Attitudes</u>. This test is designed to determine the functioning performance of the test launchers when fired in various orientations and attitudes.

a. Mounted launcher. If the launcher is fired from a mount and is to be employed in various orientations and attitudes that may adversely affect its performance, conduct an attitudes test with the launcher assembled on a gimbals type mount, using three test weapons. Fire in four stages: (1) launcher topside up, (2) launcher right side up, (3) launcher left side up, and (4) launcher upside down. For each stage, fire 20-round cycles with 10-round belts (or equivalent magazine) in the sequence shown in Table 2. When testing weapons with dual modes of fire, fire the 10-round belts, alternately employing both modes. If the test weapon has capabilities of more than two modes, fire additional 10-round complements using each mode.

TABLE 2 - TEST SEQUENCE FOR ATTITUDES TEST

Elevation	Burst Length	Feed
0°	Semi-automatic	When designed for left- and right-hand feeding, entire sequence is fired at each feed.
0°	Continuous burst	
Max depression (-85° to -90°)	Semi-automatic	
Max depression	Continuous burst	
Max elevation (+85° to +90°)	Semi-automatic	
Max elevation	Continuous burst	

b. Hand-Held Launcher or Muzzle Launcher. If a launcher is of a design whose performance may be adversely affected by firing in various orientations and attitudes, conduct an attitudes test using three test weapons. Fire the launcher 20 rounds under each of the conditions shown in Table 3.

TABLE 3 - TEST CONDITIONS FOR ATTITUDES TEST

Condition	Position of Weapons (hand-held)	
1	Loosely	0° elevation
2	Right side up	
3	Left side up	
4	Normally	80° elevation
5	Loosely	
6	Normally	80° depression
7	Loosely	

4.9 Cookoff.

a. The cook-off test is conducted to determine the maximum number of rounds that can be fired before the chamber of the weapon becomes sufficiently heated to cause a chambered round to cook off. Cookoff is not normally a problem with a grenade launcher in that the rate of fire is usually low, which allows time for the heat to dissipate. If the launcher is an attachment to a weapon that has a high rate of fire, the possibility that sufficient heat will be conducted from the parent weapon to cause a cookoff of a chambered round in the launcher must be investigated. The cartridges for grenade launchers usually contain high explosive or some chemical solution for which deflagration data must be provided, or an investigation must be made to determine whether the components in the projectile cookoff before the propellant or primer.

b. If the launcher can be fired at a continuous rate, so that a possibility for a cookoff exists, a firing exercise must be conducted. This exercise consists of firing a predetermined number of rounds using the most severe firing schedule anticipated to be employed with the weapon. The number of rounds to be fired is based on experience with the test weapon or one that is similar. Fire the predetermined number of rounds, and chamber the last round of the magazine (belt if applicable) by automatic gun action. When weapons of an open-bolt design are fired, the last round is a specially prepared cartridge to permit bolt closure without firing. This can be accomplished by assembling a primer without an anvil or recessing the primer 0.25 cm (0.10 in.) After chambering the final round and closing the bolt, wait 30 minutes. If the round fails to cook off, fire it. In the open-bolt design gun, extract the modified cartridges that fail to cook off, eject into suitable metal containers filled with water, and then destroy. If a cookoff does not occur with the maximum number of rounds estimated, increase the number fired until the point of cookoff is determined. Substantiate the point of cookoff by firing five trials during which cookoffs do not occur. The confirming firing (non-cookoff level) will consist of 10 rounds less than the number that produced a cookoff in continuous firing or one burst less than the number that produced a cookoff during burst firings.

c. If the launcher is an attachment for a weapon from which sufficient heat could be conducted to cause cookoff of a chambered cartridge in the launcher, an exercise must be conducted to determine whether the chamber area in the launcher remains safely below the cook-off temperature of the components of the grenade cartridge. This exercise consists of attaching thermocouples to the components of an inert grenade cartridge chambered in the launcher. Fire the weapon to which the launcher is attached, using the most severe firing schedule which can be employed, and record the heat conducted to the chambered cartridge in the launcher. Conduct firing in a range environment of 21° C ±5° with both weapons shielded to prevent direct exposure to the sun and rapid cooling from air circulation.

4.10 Extreme Temperatures. Test temperatures selected for the extreme temperature subtests are based directly on the stated requirement for the test weapon. Test temperatures based upon AR 70-38[2] are presented in Table 4.

TABLE 4 - TEST TEMPERATURES, EXTREME CONDITIONS

Condition	Temperature °C (°F)
Hot	68 (155)
Cold	-46 (-50)

Beside observations of general weapon performance, report requirements for additional lubrication and cleaning. Therefore, do not clean or relubricate the test weapons unless required for completion of the test. NDT inspections should be performed before and after each test.

a. High Temperature. Condition three test weapons and ammunition to 68° C (in lieu of 52° C [125° F] and exposure to solar radiation) for at least 4 hours before initial firing.

(1) If the weapon is a single-shot design, fire 625 rounds in 50-round cycles.

(2) If the weapon is a semi-automatic or automatic design, fire 1,250 rounds in 100-round cycles alternating, as applicable, among semi-automatic, short-burst, and fully automatic modes of fire for each cycle.

(3) If the grenade is muzzle-launched, fire 250 rounds, alternating base weapons every 50 rounds.

(4) Conduct the high temperature test without a scheduled time interval between firings; however, take precautions against cookoffs.

b. Low Temperature. Condition three test weapons and ammunition to -46° C for at least 6 hours before initial firing.

(1) If the weapon is a single-shot design, fire 1,250 rounds in 50-round cycles.

(2) If the weapon is a semi-automatic for automatic design, fire 2,500 rounds in 100-round cycles alternating, as applicable, among semi-automatic, short-burst, and a fully automatic modes of fire for each cycle.

(3) If the grenade is muzzle-launched, fire 250 rounds, alternating base weapons every 50 rounds.

(4) Allow at least 2 hours between cycles for reconditioning to the test temperature.

(5) Observe conditions peculiar to operation at low temperature, such as increased charging forces, sluggish operation, and maintenance difficulties, including minor adjustments and problems when using cold-weather gear.

4.11 Temperature-Humidity. Subject three test weapons and ammunition to a temperature cycling and humidity test under the "warm-wet" climatic conditions of AR 70-38. Expose the test materiel to the temperatures and humidities indicated in Table 5 for 10 days without cleaning or adding lubricant. Fire 50 rounds: 10 rounds each on the first, third, fifth, eighth, and tenth days.

TABLE 5 - STORAGE SCHEDULE FOR HUMIDITY TEST (24 HOURS)

No. of Hours		Temperature, °C	°F		Relative Humidity, %
2	increase to	41	(105)	decrease to	90
16	maintain at	41	(105)	and	90
2	decrease	41 to 71	(105 to 70)	increase to	95
4	maintain at	21	(70)	and	95

4.12 Icing.

a. Expose three weapons with the muzzles taped shut (and ammunition) to a temperature of -7° C (20° F) for 6 hours, and then subject to a light spray of water until 0.3 to 0.6 cm (1/8 to 1/4 in.) of ice accumulates on the top surface of hand-held grenade launchers and 0.6 to 1.27 cm (1/4 to 1/2 in.) on grenade launchers fired from a mount. Expose each weapon with 10 rounds of ammunition (in a magazine or belted) but with the chamber empty and the bolt closed (breech closed), requiring charging to complete loading. Ready weapons that fire from the open-bolt position by closing the bolt on an empty chamber, requiring only retraction of the bolt to fully load each weapon. When belt-fed weapons are provided with a belt container attached to the weapon, use the container.

b. Remove the tape from muzzles following exposure to icing. Only tools or other equipment normally available to military personnel in the field will be used for removal of ice from the weapons.

c. Attempt to fire with the exposed ammunition. If functioning is unsatisfactory, attempt to fire a belt (or magazine) of ammunition conditioned to the temperature (6 hours) but not subjected to icing.

d. If the weapon cannot be charged to initiate firing because of the ice accumulation on the weapon, repeat the test by fully loading each weapon before exposure to icing. Ready launchers that fire from a closed bolt for icing by closing the bolt on a chambered round; ready weapons that fire from the open-bolt position by leaving the chamber empty and the bolt in the seared position. If the weapon fails to function properly, replace the belt (or magazine) with ammunition conditioned to the temperature (6 hours) but not subjected to icing.

4.13 Mud. This subtest is conducted to determine the functioning performance of the test weapons after being immersed in mud. The test is performed as described in TOP 3-2-045[3] except that 10 rounds of ammunition are used instead of 50. Both phases are included, i.e., "wet" (test No. 1) and dry (test No. 2).

4.14 Water Spray.

a. The water spray subtest is an accelerated test to determine the effects of heavy rainfall on the performance of a weapon. The test consists of a spray of water falling at a rate of approximately 1 cm per minute or 61 $\pm$1 cm (24 $\pm$ 3 in.) per hour. Direct the spray of water over the entire weapon. Measure and record the water and air temperatures. Lubricate the test weapon with the prescribed lubricant before the test but not between the test phases.

b. The basic sequence of operations for the water spray test is contained in Table 6. This procedure is designed for use with semi-automatic and automatic firing weapons that fire from the closed bolt position. If the weapon fires from an open bolt, adjust test conditions a, b, d, and e of Table 6 accordingly. A procedure for testing weapons that fire from an open bolt is outlined in TOP 3-2-045.

c. Part I of the water spray test appraises a weapon's performance under the precipitation requirements of AR 70-38. There is no break, timewise, between the end of part I and the start of part II. Parts I and II taken together (as a continuous sequence of operations) comprise an evaluation of a weapon under the precipitation requirements of MIL-STD-210B.[4]

4.15 Sand and Dust. This subtest is conducted in two stages, static and dynamic, to determine the effects of blowing sand and dust on weapon performance. The procedure is described in TOP 3-2-045, with the adaptations listed below.

a. Conduct the static test first.

b. For single-shot designs, include nine rounds of bandoleer ammunition in the sand and dust box during the static test.

c. In the static test phase, fire 10 rounds from each launcher if single-shot design. If the launcher is semi-automatic or automatic design, fire 20 rounds per launcher in this phase.

d. The test facility for the dynamic phase should have a 6-in. vent opening through which the grenades may pass when the weapon is fired.

e. If the ammunition is packed in bandoleers, keep it in the bandoleers during the dynamic sand and dust treatment.

f. The firing rate during the dynamic test is six rounds per minute for single-shot designs or 20 rounds per minute for automatic or semi-automatic designs. In either case, the total test time is to be 2-1/2 minutes.

g. During the dynamic test phase, if there are no malfunctions that cannot be cleared by immediate action, repeat the test until such a malfunction occurs, or until the test has been conducted three times.

TABLE 6 - SEQUENCE FOR WATER SPRAY TEST

Test Condition[a]	Exposure Time (Minutes)	Cumulative Exp. Time (Minutes)	Rain (Inches)	Cumulative Rain (Inches)
Weapon Horizontal				
a. Bolt open	5	5	2.0	2.0
b. Loaded, bolt closed	5	10	2.0	4.0
c. 20 rounds semi-automatic	4	14	1.6	5.6
d. Bolt open	5	19	2.0	7.6
e. Loaded, bolt closed	5	24	2.0	9.6
f. 20 rounds automatic or short bursts	4	28	1.6	11.2
Weapon Muzzle Up[b]				
a. Bolt open	5	33	2.0	13.2
b. Loaded, bolt closed	5	38	2.0	15.2
c. 20 rounds semi-automatic	4	42	1.6	16.8
d. Bolt open	5	47	2.0	18.8
e. Loaded, bolt closed	5	52	2.0	20.8
f. 20 rounds automatic or short bursts	4	56	1.6	22.4
Weapon Muzzle Down[b]				
a. Bolt open	5	61	2.0	24.4
b. Loaded, bolt closed	5	66	2.0	26.4
c. 20 rounds semi-automatic	4	70	1.6	28.0
d. Bolt open	5[c]	75	2.0[c]	30.0
e. Loaded, bolt closed	5[c]	80	2.0[c]	32.0
f. 20 rounds automatic or short bursts	4[c]	84	1.6[c]	

[a] If the weapon is a single-shot design, test conditions a, b, c, d, e, and f will be as follows:

1. Launcher empty, breech closed.
2. Launcher loaded.
3. 10 rounds.
4. Launcher empty, breech closed.
5. Launcher loaded.
6. 10 rounds.

[b] Before attempting to fire, hold weapon with muzzle down to remove water accumulated in the bore.

[c] Or as required to finish program with at least 32.0 inches cumulative rain total.

4.16 Salt Water Immersion. This test is conducted to determine the deleterious effects of salt water on weapon performance.

a. Use a salt water solution of 20% salt to 80% water by weight. The salt (sodium chloride) will not contain more than 0.1% sodium iodide nor more than 0.2% impurities.

b. Fully load three test launchers and apply the safety. If the launchers are semi-automatic or automatic design, use a 10-round belt (10 rounds in magazine). When belt-fed weapons are provided with a belt container attached to the weapon, use the container. If the launcher is single-shot design, four cartridges in bandoleers or loose will accompany the weapon.

c. Submerge the loaded weapons and prescribed ammunition in the salt solution for 60 seconds. Following removal from the solution, depress the muzzle of each weapon to drain the bore. Fire the previously designated number of rounds from each launcher.

d. Fire additional complements of 10 rounds in semi-automatic and automatic weapons or five rounds in single-shot weapons on the third, fifth, eighth, and tenth days. Between firings, store the weapons (and ammunition not previously immersed in salt water) under the temperature-humidity conditions outlined in Table 5 without cleaning or adding lubricant.

e. If a functioning failure occurs due to parts seizure or rust buildup, terminate the test. The following actions are performed to determine whether the weapon can be returned to serviceable condition in the field: Lubricate the weapon without disassembling; hand-cycle several times, and attempt to fire. If this fails, perform a field stripping operation, apply additional lubricant, and make another attempt to fire.

4.17 Unlubricated. This test is conducted to determine the functioning performance of the test launchers while in the unlubricated condition.

a. Disassemble three weapons; thoroughly clean in drycleaning solvent; reassemble in an unlubricated condition, and fire 50 rounds from each.

b. If unsatisfactory functioning occurs attributable to lack of lubrication, attempt to pinpoint a trouble spot or area. Apply lubricant to that area, and fire 25 rounds to affirm that the addition of lubricant corrected the unsatisfactory condition. If the condition is not corrected, apply lubricant to a second selected area, etc., until satisfactory functioning is restored to the weapon.

4.18 Flash. This test is conducted to determine the signature effects from flash occurring with single-round and burst firing.

a. Photograph the muzzle and breech flash during firing with a still camera under completely darkened conditions. If the launcher is an automatic design, photograph the cumulative flash during a 20-round burst. Fire new and old barrels (see note below) both cold and hot. Before firing a cold barrel (a barrel conditioned at normal ambient temperature), fire one round to remove any oil that may be present in the bore. Immediately fire a 20-round burst for flash. For the hot-barrel phase which pertains only to automatic design launchers, fire 100 rounds in one burst. Immediately fire a 20-round burst for flash. If possible, fire a standard weapon and photograph for comparison.

NOTE: A new barrel is defined as having 90% or more life remaining. An old barrel is defined as have 40% or less life remaining.

b. Place an appropriate camera with lens and film perpendicular to the muzzle of the weapon at a sufficient distance to photograph all the flash but no closer than 1.4 m (4.5 ft). Mount a scale such as shown in Figure 1 under and parallel to the gun barrel near the muzzle, and photograph before firing for record. This photograph is used to permit a grid to be superimposed on the flash photographs when processed. Use a shielded flashlight to lightly illuminate the weapon muzzle before each flash firing. Photographs of cumulative flash should be supplemented by visual observations regarding variation of flash during the firing.

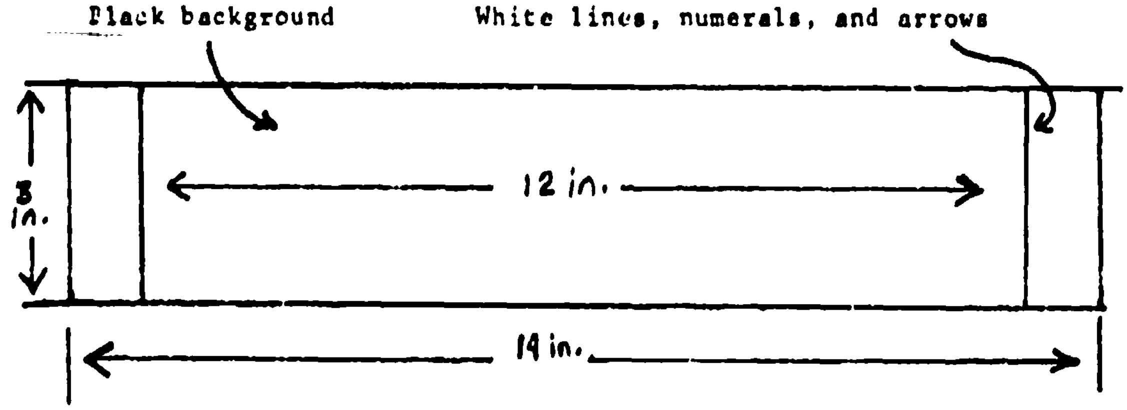

Figure 1. Reference scale dimensions.

4.19 Smoke. This test is conducted to determine the characteristics of the smoke cloud produced by firing. There is not usually a smoke accumulation problem when firing a grenade launcher. If such a problem is present, however, it is evaluated from the standpoints of target obscuration when viewed from directly behind the gun and visibility (or signature) of the cloud from a distance forward of the muzzle. Conduct the firings in a cleared area when visibility is good, permitting a sharply defined photograph under nonfiring conditions. Conduct both test phases when the wind velocity is zero. Record air temperature and humidity. Take photographs 1.0 second after the last round of the burst, or 1.0 second after a single round, using an appropriate camera, lens, and film.

a. Target Obscuration. Fire various numbers of bursts to establish the conditions under which target obscuration will and will not occur. Observe tactical firing schedules when established. Judge the size and density of the smoke cloud and the degree of obscuration by using a checkerboard target, 2.4 by 2.4 m (8 by 8 ft), with 0.3-m (1-ft) black and white squares, placed in line with the gun at a range of 100 m. Elevate the gun to fire slightly above the target. Photograph the target immediately after a burst. Position the camera behind and as near as practical to the weapon, in the position assumed by the gunner.

Compare the photograph to a photograph of the target under nonfiring conditions to determine the degree of target obscuration caused by the firing.

b. Smoke Cloud Signature at the Gun. Photograph the smoke cloud produced by a 10-round burst, one magazine, or a single round, whichever is most applicable, against a black background immediately after the burst, using a camera 100 m forward of the muzzle 6 m and (20 ft) to the right of the line of fire. Use a comparable standard weapon as a basis for evaluating the smoke cloud signature.

4.20 Solvents and Lubricants Compatibility. This test is conducted to determine the chemical compatibility of nonmetallic parts of the test weapons with various compounds used in the combat environment. For test procedures, refer to TOP 3-2-609.[5]

4.21 Human Factors Evaluation.

a. Throughout all test operations, observe and record data related to the effectiveness with which the test system is deployed, operated, and maintained by representative users and the degree to which it is compatible with the capabilities and limitations of individual operators. Restrictions imposed by individual body size and build, clothing and body armor, effects of noise level (see para 4.11), ease of loading and firing in various positions, tendency of the weapon to "ride up", recoil effect, etc., are typical areas of concern. Evaluate the adequacy of human factors engineering of the test system using appropriate data-collection aids (task lists, performance checklists, error reports, interview forms, rating scales, etc.) prepared/selected from the following guides:

(1) TOP 1-2-610[6]
(2) MIL-STD-1472C[7]
(3) MIL-HDBK-759[8]
(4) HEL Standard S-2-64A[9]

b. Determine, report, and evaluate as appropriate:

(1) Configuration and operation of weapon and mount controls (grips, triggers, sights, charging handle, elevating and traversing knobs, locking handles, mounting pins and lugs, etc.)

(2) Time required for:

(a) Conversion from fixed to flexible role
(b) Assembly to and removal from ground mount
(c) Extra operations in weapon assembly/disassembly attributable to addition of components for flexible use

(3) Facility with which the following can be performed:

(a) Traverse
(b) Elevation (at maximum and minimum limits)
(c) Sight adjustment and reading
(d) Battle sight setting under poor visibility

(4) Stability of system during manual charging, with and without sandbags; system stability throughout firing

4.22 Logistic Supportability. Throughout the test, collect data to determine the maintenance characteristics of the test item in accordance with TECOM Suppl 1 to AMC-R 700-15.[10] Use appropriate forms contained in TECOM Suppl 1 (maintenance and parts analysis charts, etc.) to record the performance of all organizational, direct and general support maintenance tasks to determine, if applicable, the adequacy of the following items and to provide data for the preparation of maintainability indices:

a. Tools and test measurement and diagnostic equipment (TMDE)
b. Equipment publications
c. Repair parts
d. Safety aspects of maintenance operations
e. Human factors aspects of maintenance operations
f. Design for maintainability

4.23 Reliability Evaluation. To determine whether an item meets the reliability criteria stated in the requirements documents, use data collected during endurance testing, during those test phases that are not interspersed with extreme severity tests, and during any special maintenance evaluation tests. If additional data are needed for mean rounds between failure, additional firing may be performed with weapons that have not reached their design life. Additional guidance on statistical samples are contained in MTP 3-1-002.[11]

4.24 Noise. Test in accordance with TOP 1-2-608.[12]

4.25 Rough Handling. Test in accordance with TOP 3-2-045.

5. DATA PRESENTATION. Test results are analyzed by suitable statistical procedures for comparing samples, for obtaining point and/or interval estimates of a parameter of interest, and for determining from test results whether specified requirements have been satisfied. MTP 3-1-002 provides guidance on analysis and presentation of test results.

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APPENDIX A

RELIABILITY, AVAILABILITY, MAINTAINABILITY (RAM) DATA

1. Test Data.

a. The purpose of recording data is to establish an accurate, complete historic profile of the items being evaluated. For some tests, the definitions listed in Table A-1 are sufficient to explain what has occurred; in other tests, failure definitions and scoring criteria specified by the customer take precedence whenever these criteria conflict with those in Table A-1.

b. The advent of increased data computerization from input through completed analysis may change the format and content of the information presented here. Therefore, this information is mainly for use as a guide in planning the appropriate data-collection and analysis portion of the test plan.

c. The cycle of operation of most small caliber weapons, either single-shot or autoloading, is broken down into six parameters: feeding, chambering, locking, firing, extracting, and ejecting (in that order). Within these six parameters, malfunctions may occur which can adversely influence one or more segments of RAM. In recent years, the trend has been to include malfunctions under a maintenance category, since a malfunction or a stoppage requires some action in order to correct the problem.

d. Data collection for large, complex development programs is usually controlled by a RAM-D Failure Definition and Scoring Criteria manual published jointly by the materiel and combat developers. The format and content of that manual are established by AR 702-3[13] and the test item's specification or other qualifying publications. Since the RAM-D Failure Definition and Scoring Criteria address analysis of the collected data, rather than specific nomenclature of the stoppages and other malfunctions, the definitions explained in Table A-1 are used as the basis for describing what has occurred. The definitions shown in the RAM-D Failure Definition and Scoring Criteria are then applied.

e. When test programs do not use a RAM-D Failure Definition and Scoring Criteria list, data collection and analysis should be tailored to meet the specific needs of the program. The basic concepts previously discussed should still be used. In this manner, if a scoring conference should be necessary to clarify disputed data, a concise, presentable format will have already been prepared and used.

f. In testing weapons, the primary method of reporting where an incident occurs is by using round counts. Several types are used, including cumulative total rounds on the weapon receiver or frame. Within this end item, major components can require their own round counts (e.g., quick change barrels, multidirectional feed mechanisms, and magazines). Attachments to the end item, as well as parts rendered unserviceable or damaged/worn due to use, may also require separate round tallies.

g. After establishing an appropriate format for recording round counts, provide the other types of data collected and reported on the data sheet. These include identification of the test item, ammunition used, project engineer's I.D., subtest title, test phase and/or firing cycle, mode of fire, number of rounds loaded in the belt, clip, magazine, etc., number of rounds fired from that load complement, and the total cumulative rounds fired to-date from that weapon.

h. Data obtained during performance tests should be used when feasible in the maintenance evaluation of an item, but it is essential that the determination of malfunction cause(s) not be compromised in these tests to concurrently obtain data for the maintenance evaluation.

i. When a malfunction occurs, the mode of fire (if different from that specified in the firing schedule) is noted, along with the type of malfunction (use one of the six in Table A-1). If more information is needed to clarify a "non-standard" type of malfunction, use the narrative form and write it immediately following the basic malfunction assessment. Since RAM data must be obtained concurrently during testing (in most cases), this information is also noted in the firing data log and supplemented by a separate maintenance log when necessary.

2. Definitions.

a. For operational RAM scoring and assessment purposes, the weapon system may consist of the basic weapon magazine, ammunition, operator, maintainer, and any ancillary equipment required for mission success.

b. An operational mission failure is defined as any malfunction that results in any one or a combination of the following:

(1) Cessation of weapon operation requiring corrective action

(2) Inability to begin or cease a mode of operation

(3) A critical catastrophic safety hazard as defined in MIL-STD-882.

c. A malfunction is a faulty action of the ammunition, launcher, or supporting equipment. Malfunctions are subdivided into two categories: those that cause stoppages (unintended interruptions of firing) and those that cause failures. Examples of malfunctions that cause stoppages are weapon failure to feed, extract, or eject. Examples of malfunctions that cause failures are damaged weapon sear or solenoid components that cause uncontrolled fire, loss of weapon flash suppressor, or loosening and shifting of a sight.

d. In performance tests, attempts are made to determine the cause of each malfunction and whether the fault is attributable to the gun, magazine, or ammunition belt (link), ammunition, installation (supporting equipment). Malfunctions attributable to otherwise improper personnel action such as faulty component assembly or improper loading of ammunition are charged to personnel. Consequently, when practical, the magazines or link lot numbers, when more than one type is used, should be assigned an identifying code. The magazine number or link lot should be recorded throughout testing so that malfunctions attributable to bad magazines or a bad lot of links can be scored properly.

e. If no RAM Failure Definition and Scoring Criteria are available for use in determining the classification of malfunctions, develop a time-based classification from available operational performance requirements documents, or use the following definitions:

Class I. Clearable stoppages. A stoppage that can be cleared by the weapon operator within 10 seconds.

Class II. Operator-correctable stoppages/failures. One that cannot be cleared by the operator within 10 seconds but which can be corrected at the operator level using only equipment immediately available to the operator.

Class III. System failures. A failure that is not correctable at the operator level and requires a higher level of maintenance.

f. Repetitive stoppage. A series of clearable stoppages that are attributable to a single malfunction are classified as repetitive stoppages. For reliability scoring purposes, if the repetitive stoppages are positively traceable to that particular malfunction, only the first stoppage in the series is charged as an independent clearable stoppage and operational failure. Subsequent stoppages of that series are separately charged as repetitive stoppages. Only those stoppages that occurred within the last 200 rounds before the detection of a malfunction will be considered for classification as repetitive stoppages attributable to that malfunction. The malfunction/failure that caused the series of stoppages will be charged as a hardware system failure and an operational failure.

g. For maintainability assessment purposes, the following parameters are defined:

(1) Scheduled maintenance action. A maintenance action that is preprogrammed to occur at specific intervals or when pre-determined conditions or measurable criteria are met as prescribed in the operator or maintenance manuals.

(2) Unscheduled maintenance actions. A maintenance action that occurs as the result of a failure or other incident that requires corrective action.

(3) Active maintenance time. The time required to perform a maintenance action (either scheduled or unscheduled).

(4) Classification of the maintenance level at which a specific maintenance action is performed is one of the following:

(a) Operator level

(b) Organizational level

(c) Direct support level

(d) Depot level

h. Generally, parts are not replaced solely because they appear to have wear or have cracks/chipping in noncritical areas, unless there is a possibility of a safety hazard or other catastrophic weapon failure. Once a functional failure occurs that is attributable to such a part or broken part is discovered during scheduled maintenance (clean, inspect, lubricate [CIL]), the part is replaced. Therefore, during each scheduled maintenance period, each test sample may require complete disassembly. The limits of disassembly are guided by the results of the initial inspection at USACSTA and the recommendations of the manufacturer, in that order.

There is generally no scheduled parts replacement during development or technical feasibility tests. After a weapon has been accepted and initial production accomplished, follow-on production tests may have parts replacement schedules to conform with the proven maintenance requirements. Requests for parts replacement with a re-designed part should be approved by TECOM and the test sponsor. Each time a part is replaced in the weapon, a complete history is obtained, including the part name and number, reason for replacement, description of functional failure mode and total number of rounds fired from the part and weapon. The time required to replace the part is also recorded. This time span covers disassembly to area of concern, insertion of part, reassembly and any lubrication or measurements required. It does not include the time to retrieve the replacement part form supply.

i. Durability. The service life of the weapon will be determined based on when the weapon shows signs of imminent failure, cracks, or excessive wear in the frame, high increase in the malfunction rate, safety hazards, or other conditions that preclude further operation. Such conditions must be of such consequence that the weapon must be replaced/rebuilt. Evidence of cracks is usually gained through use of nondestructive test (NDT) methods such as dye penetrant or magnetic particles.

j. The basic stoppages encountered during function tests are as follow. The explanations may require adjustment for a particular weapon type. The list of stoppage types may be expanded as the intricacies of a particular weapon system become known.

(1) Failure to feed (FFD). Feeding is defined as the appropriate action required to properly position each succeeding round in position so that the weapon's bolt can strip the round from the magazine/belt. The feeding portion of the cycle of operation stops once the round leaves control of the magazine and receives control by other weapon components (e.g., bolt or barrel chamber). If a round leaves control of the magazine and a stoppage occurs before the round in controlled by other weapon components, the stoppage is assessed as a feeding failure.

(2) Failure to chamber (FTC). Chambering is defined as the placement of a round of ammunition in the barrel chamber of the weapon. Chambering starts after completion of feeding, and is completed upon full insertion of the round in the chamber. In some weapons, the projectile nose enters the breech end of the chamber before the feeding portion of the cycle has been completed by release of the round from the magazine's feed lips. If a stoppage occurs at that location, the stoppage is charged as an FFD, not an FTC. Other causes that can prevent chambering are: insufficient counterrecoil force; barrel chamber damage; obstructions in the chamber and bore such as dirt, mud, ice, and ruptured cartridge cases; and broken/deformed parts that prevent or restrict forward movement of the breeching components.

(3) Failure to lock (FTL). Locking is defined as the securing of the weapon's breeching components to prevent opening during high pressure generation at the time of firing. For hand-held weapons, locking may be affected by manual closure of the breech. The use of advanced primer ignition as the bolt is moving

forward is not uncommon with automatic weapons operating on the blowback principle. Locking begins with the completion of chambering and terminates upon full engagement of the lock components with their mating surfaces. Some weapons additionally require a small amount of forward free travel [illegible] locked position before firing can occur. This complete return to batter[illegible] [illegible]nus point of counterrecoil. It is sometimes difficult to differen[illegible] an FTL and an FFR (failure to fire) because of this additional move[illegible] [illegible]nents after full locking has occurred. One indicator of the failure [illegible]der this situation is a light or nonexistent firing pin indent in the cartridge primer. If a judgmental call is necessary, provide enough narrative to describe the occurrence so that later analysis can possibly reveal the true classification and cause.

(4) Failure to fire (FFR). Firing is defined as the action created by release of the striker/hammer which causes the striker/firing pin to function the cartridge primer. The primer then ignites the propellant which then builds up enough pressure to propel a projectile through and out the barrel bore. The firing sequence starts upon completion of locking and is terminated upon expulsion of the projectile from the barrel. Failures to fire are caused by two basic problems: defective ammunition or defective weapon. Within each of these two problem areas are several causes. With ammunition, they are: primer defect, propellant defect, or cartridge case defect. With the weapon, they are: defective parts or dimensional mismatches (i.e., bolt bounce to the rear at the time of firing which prevents firing due to being unlocked). Since the symptoms of light/nonexistent firing pin indent of the primer are the same if the gun either fails to lock or is unlocked at the instant of firing pin/striker release, other signs of the cause must be noted. Such things as deformation of the headspacing shoulder (case mouth on straight walled cases), rifling engraving marks on the projectile and case body marks may give additional evidence about the location of breeching components at the time of actual incident. Although there may be some overlapping of causes in the determination of FFRs, the result will not be adversely compromised.

(5) Failure to unlock (FUL). Unlocking is defined as the action taken either manually or automatically by the weapon when fired, to release the breeching components so that extraction can take place. Unlocking begins with the completion of firing (or manual retraction of the bolt/slide form the battery position) and is completed upon rearward movement of the bolt, at the point of separation of the bolt from the barrel (in instances when the barrel and breeching components recoil together in a locked position for a short distance before separation).

(6) Failure to extract (FXT). Extraction is defined as the removal of the fired case or unfired round from the chamber of the weapon. Extraction begins with the completion of unlocking and is terminated when the case or complete round is in a position to be ejected. This ejection position varies with the weapon design (fixed or spring-loaded ejector). Determination of extraction failures is complicated by short recoil of the breeching components. Extraction failures that masquerade as other problems due to short recoil are: soft cartridge case, rough chamber wall, broken parts, and external contamination such as dirt, mud, snow, ice, and corrosion that prevent most of the recoil movement after firing, but allow the breeching components to return to battery. Dimensional problems with the case rim thickness and angle, and chamber pressure also contribute to extraction problems.

(7) Failure to eject (FEJ). Ejection is defined as the complete removal of a fired case or unfired round from contact with the weapon. Ejection starts after extraction and is completed upon expulsion from the weapon. Extraction and ejection are closely related since one follows the other. Failure of the extractor and breech face to control the fired case or complete round until ejection occurs may cause an ejection failure. In order to differentiate between the two stoppages, inspect cartridge cases for signs of ejection marks on the base and extractor marks on the rim. A change in the usual marks may signify that loss of control occurred before ejection. Case sidewall indentation will also help identify ejection failures. If the case or complete round is caught by the bolt in a position other than 0° (in line with the longitudinal bore axis), the stoppage is very likely an ejection failure. Residual gas pressure, acting upon the fired case and breeching components, may be enough to allow case extraction when the weapon has a broken extractor, but not ejection. The correct assessment of the malfunction type will be an FXT, not an FEJ. When short recoil is coupled with fixed ejector design, the fired case may be returned to the chamber. This would first appear to be a failure to unlock or extract. If the fired case can be manually extracted and ejected, the stoppage should be classified as an ejection failure if there are no other indicators of the type of stoppage and its cause. If this condition persists, high speed photography may be necessary to isolate the cause of the problem.

(8) Failure of the bolt to remain rearward (FBR). After the last round is fired from the weapon (or manual retraction with an empty weapon), weapons may be designed so that the bolt is locked back until either manually or automatically released, upon insertion of another loaded magazine/belt. In rare instances, weapons equipped with separate bolt stops may prematurely engage the stop before firing the last round. This type of stoppage will be reported under the heading OTHER and appropriately described in narrative form.

APPENDIX B

REQUIRED REFERENCES

1. TOP 1-2-502, Durability Testing, 14 September 1972.

2. AR 70-38, Test and Evaluation of Materiel for Extreme Climatic Conditions, 1 August 1979; Change 1, 15 September 1979.

3. TOP 3-2-045, Automatic Weapons, Machine Guns, Hand and Shoulder Weapons, 21 December 1983.

4. MIL-STD-210B, "Climatic Extremes for Military Equipment", 15 December 1973.

5. TOP 3-2-609, Chemical Compatibility of Nonmetallic Materials Used in Small Arms Systems,

6. TOP 1-2-610, Human Factors Engineering (Part I - Procedures, Part II - Hedge), 30 November 1983.

7. MIL-STD-1472C, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, 2 May 1981.

8. MIL-HDBK-759, Human Factors Engineering Design for Army Materiel.

9. HEL Standard S-2-64A, Human Factors Engineering Design Standard for Vehicle Fighting Compartments, June 1968.

10. TECOM Suppl 1 to AMC-R 700-15, Integrated Logistics Support, 20 June 1980.

11. MTP 3-1-002, Confidence Intervals and Sample Size, 25 January 1967.

12. TOP 1-2-608, Sound Level Measurements, 17 July 1981.

13. AR 702-3, Army Materiel Systems Reliability, Availability, and Maintainability, 1 June 1982; TECOM Supplement 1, 31 May 1984.

REFERENCES FOR INFORMATION ONLY

a. MIL-STD-810D, Environmental Test Methods, 19 July 1983.