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US Army Aberdeen Test Center
400 Colleran Road
Aberdeen Proving Ground, MD 21005-5059

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14. ABSTRACT
This TOP contains a compilation of procedures for testing hand and shoulder weapons and machine guns, including crew served weapons and light automatic cannons up to 50 millimeters in caliber. The test procedures apply to the basic weapons only; see TOP 04-2-016 for test procedures for small arms ammunition. Also, see TOP 03-2-504 for safety evaluations of hand and shoulder weapons. Grenade launchers are covered in TOP 03-2-030. Many small arms are also used as subsystems in combat vehicles, aircraft, watercraft, etc.; in these cases, consult the TOPs relevant to the specific platforms for possible additional test procedures.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 03-2-045A 24 June 2016
DTIC AD No. AD1011733

SMALL ARMS - HAND AND SHOULDER WEAPONS AND MACHINE GUNS

*This TOP supersedes TOP 03-2-045, Small Arms - Hand and Shoulder Weapons and Machineguns, 17 September 2007.

Approved for public release; distribution unlimited.

1. SCOPE.

a. This Test Operations Procedure (TOP) contains a compilation of procedures for testing hand and shoulder weapons and machine guns, including crew served weapons and light automatic cannons up to 50 millimeter (mm) in caliber. The test procedures apply to the basic weapons only; see TOP 04-2-016[1**] for test procedures for small arms ammunition. Also, see TOP 03-2-504A[2] for safety evaluations of hand and shoulder weapons. Grenade launchers are covered in TOP 03-2-030[3]. Many small arms are also used as subsystems in combat vehicles, aircraft, watercraft, etc.; in these cases, consult TOPs relevant to the specific platforms for possible additional test procedures.

b. The test procedures are meant to help standardize testing and to aid the development of Detailed Test Plans (DTPs), Test and Evaluation Master Plans (TEMPs), and similar planning documents. This TOP does not constitute a requirement to do any of the specific tests nor does it serve to set performance or safety criteria for Army materiel. Actual requirements and criteria must come from requirements documents, contractual obligations, Army Regulations (ARs), etc.

2. FACILITIES AND INSTRUMENTATION.

This section lists specialized items that are used in testing. Additional information is contained in the individual test procedures since requirements for accuracy and precision of a given measurement may vary among the procedures. Standard equipment common to most technical organizations is not listed; however, the test officer must ensure that the specific requirements of each procedure are met by whatever equipment or instrumentation is used.

2.1 Facilities.

Item	Requirement
Firing ranges	Ranges must safely accommodate firing to the required distances; range safety fans must consider the possibility of catastrophic failure of test weapons.
Test stands	Must safely restrain the weapon, allow remote firing, and assure reproducible results.
Ground mounts (bipods, tripods, gimbals, etc.)	Specific to the test weapon.
Control weapon	Similarity to the test weapon to permit checkout of test setups, instrumentation, etc.

** Superscript numbers correspond to Appendix B, References.

Item	Requirement
Targets	Physical or electronic with the capability of recording the X and Y coordinates of each projectile passing through the plane of the target; where required the Z fuze burst distance from muzzle will be recorded; specific accuracy requirements will vary among the various tests, but in all cases the accuracy and precision must be sufficient to address the criteria for the particular test being done. Other targets, such as gel blocks, silhouettes, plates etc. as required.
Climatic chambers	Meet the requirements of Military Standard (MIL-STD)-810G CN1[4]. Chambers must be capable of providing temperatures between -54 and 71 °Celsius (°C) (-65 and 160 °Fahrenheit (°F).
Salt Fog Chamber	Chamber shall be capable of producing a salt fog of up to 3 milliliter (ml) of solution per hour per 80 centimeter^2 (cm)^2 at temperatures up to 35 °C (95 °F).
Sand/dust chamber	To dispense mixture at rate of 100 ± 25 grams per minute per square meter (g/min/m^2).
Dust chamber	To dispense mixture at a rate of 50 ± 10 g/min/m^2 temperature control to ± 2 °C.
Mud bath	Viscosity of 4600 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 ± 1 centimeter per hour (cm/hr) (3.9 ± 0.4 inch per hour (in./hr).

2.2 Instrumentation.

Devices for Measuring	Maximum Permissible Error of Measurement[a]
Brookfield viscometer	± 0.5% full-scale reading.
Cyclic rate recorder	± 1% at rates up to 6,000 shots per minute (spm) and burst lengths of 100 rounds.
Impulse noise measuring system	Peak pressure to ± 1 decibel (dB), A-duration and B-duration to ± 10 percent.
Photometric head	± 1.6% relative uncertainty.
Recoil energy instrumentation	Recoil energy to ± 0.1 foot-pound (ft-lb) (0.14 Joules (J)) as calculated form measured impulse and weapon mass.
Stargage, airgage, and laser bore mapping	± 0.025 mm.
Thermograph/thermocouples	± 0.6 °C (1 °F).
Velocimeter	0.1% or 0.5 meter per second (m/s) (whichever is highest) for bursts to 6,000 spm.

[a] Values can be assumed to represent ± 2 standard deviations; thus, the stated tolerances should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Review the Safety Assessment Report and all instructional material issued with the test item by the developer and manufacturer, as well as reports of previous tests conducted on the same model or closely related item.

b. Review the test item's capability documents (if any) such as the Initial Capability Document (ICD), Capability Development Document (CDD), or Capability Production Document (CPD). For evaluated programs, the System Evaluation Plan (SEP) (or Data Source Matrix (DSM) for programs without SEPs) is the governing document. The SEP will document the methodology and data requirements. For non-acquisition projects, the customers test requirements will be followed to the extent possible, based on information in the Request for Test Services (RFTS) and direct communication with the customer. If available, use the test item's Failure Definition and Scoring Criteria (FDSC). See U.S. Army Test and Evaluation Command (ATEC) Regulation 73-1[5], Chapter 4, for additional information about test planning.

In all cases, the Acquisition System Team (AST) Test Manager and evaluator should be consulted.

c. As needed, assemble information on the physical characteristics of the test item, its method of operation, maintenance requirements, and expected modes and areas of deployment.

d. Based on the above information, plan a comprehensive testing program to verify that the test item satisfies minimum design and construction requirements for safe field deployment. Tests appropriate for forming a test program are described in paragraph 4. For some test programs, these procedures will need to be expanded or special test considerations will be required, while in other cases, not all procedures contained in this TOP will be applicable. The ATEC Test Manager and Evaluator should provide feedback depending on the type of test.

3.1.1 Sample Size.

a. The number of weapons and rounds to fire per weapon must be considered in determining sample size. The number of weapons should adequately represent the population from which the sample has been drawn. If the sample is too small to sufficiently detect small differences in the statistical parameter(s) of interest, a conclusion regarding acceptability cannot be made with confidence. Although test economy must also be considered, the sample size must be sufficient to provide reasonable assurance that comparison of test results against requirements will be meaningful. International Test Operations Procedure (ITOP) 03-1-005[6] provides guidance in selecting samples for desired levels of confidence in test results. Documents such as the SEP or CDD should be reviewed for required sample sizes or for confidence intervals from which sample sizes can be derived. Consideration must be given to the possibility of combining data from separate test procedures to effectively increase sample sizes and confidence in results.

b. A subtest for a hand or shoulder weapon should rarely be considered with less than three weapons. For complete engineering tests, 16 new weapons are considered satisfactory, with more than 4,000 rounds normally being fired from each weapon. To analyze the weapon at or close to its expected serviceable life, 5,500 to 6,000 rounds (or as otherwise specified) should be fired from each weapon.

c. Most subtests for machine guns and automatic weapons should consist of at least three weapons; at least 10 new weapons should be used for a complete engineering test. Three of the weapons are fired a minimum of 25,000 rounds each; they may be fired to a much higher round count to analyze the weapon at or close to expected serviceable life. Additional testing for logistic supportability (maintenance analysis), barrel performance, reliability, etc. may require additional weapons and spare barrels.

d. Whenever a certain minimum number of weapons is specified in this TOP, the number is considered adequate to detect fundamental and consistent weapon deficiencies in a particular environment. When marginal performance or randomly encountered problems are expected and are to be measured with some degree of confidence, more weapons must be used.

e. External drive-type weapons, particularly those with multiple barrels, have much longer lives than self-powered automatic weapons. It may not be economically feasible to fire such weapons to their expected service life. In such cases requirement documents and statistical decisions should be factors in determining the number of test rounds.

3.1.3 Gun Mount Compatibility.

a. Machine guns and automatic weapons must be compatible with the gun mount from which they are fired; this compatibility must be established prior to the conduct of actual testing. This can be done by separate testing, by data from other Government sources, or by contractor-furnished evidence. A suitable adapter and mount base can then be designed and constructed before testing begins. Generally, a light or dual purpose machine gun should be capable of performing whether hand-held or mounted on aircraft or armored vehicles. Any machine gun too heavy or having too much recoil to be fired hand-held should be capable of performing from a ground mount or aircraft and armored vehicle mounts. Ground mounts (bipods, tripods, etc.) or adapters provided with the test weapon(s), but not previously tested, will be included in the full range of applicable subtests as the test weapon itself in addition to any test stand firings.

b. The term "mount base" as used herein is defined as all of the supporting structure of a test stand interposed between the gun and "ground", except the actual cradle or adapter used to secure the weapon to the mount base. The term "suitable" refers to the rigidity of the mount in Newton centimeters (N/cm) (pound inches (lb/in.)) deflection, and lack of interference with the proper operation of the weapon.

3.2 Test Conduct.

3.2.1 Barrel Changes (Machine Guns).

During all subtests involving sustained fire (except barrel performance test), the barrels are changed before reaching the cook off level established by separate firings. The 200-round cycle mentioned in some subtests as the interval for complete cooling or change of barrels is an arbitrary figure and may have to be adjusted in accordance with the results of the cook off tests. **Note:** For those guns that have spare barrels, and the operational concept prescribes barrel interchanges, those instructions should be followed.

3.2.2 Endurance Data versus Parts Replacement.

Replacement intervals prescribed in technical publications should be complied with unless otherwise indicated by requirement documents, the SEP, etc. The arbitrary replacement of critical weapon parts with new parts before each subtest would permit a precise analysis of the influence of the test environment on weapon functioning. This practice however, would negate the accumulation of data on long-term parts durability and weapon life. Therefore, following completion of each subtest, the weapons are cleaned and inspected, and only unserviceable components are replaced before the weapons are used in another subtest. Parts that are determined to be in a condition to adversely affect safety are replaced immediately whenever they are identified. The life history of each part replaced is recorded and the part is retained for possible detailed examination.

3.2.3 Forced Air Cooling of Weapon Barrels.

The use of forced air to accelerate cooling of weapon barrels between firing trials is permitted. A locally fabricated rack can be used for barrels that are detached from the weapon; the air should be directed from the chamber toward the muzzle. When the barrel cannot be removed from the receiver, it can be cooled by forced air by inserting a curved tube (copper suggested) into the receiver from below, forcing air into the chamber toward the muzzle. The supply of compressed air must be free of entrained matter such as water, oil, or particulates.

3.2.4 Weapon Maintenance.

a. Weapons will be maintained in accordance with technical manuals, if available. Weapons will always be cleaned, inspected, and lubricated (CIL) at the end of each test procedure and before the start of another procedure (the CIL at the end of a test procedure may serve as the CIL for the start of a subsequent test procedure based on the judgment of the test officer). At a minimum, the CIL will be conducted at the operator level (often referred to as "field strip and clean"). More detailed maintenance should be completed as needed. All maintenance actions will be recorded.

b. Key weapon components subjected to high stress will undergo inspection by nondestructive test (NDT) methods. Ferrous metallic weapon components will be inspected by the fluorescent magnetic particle wet continuous method. The item will be magnetized using direct current (DC), sprayed with a bath consisting of size 14A fluorescent magnetic particles suspended in a petroleum distillate liquid (kerosene), and inspected under black light for patterns indicative of cracks or other defects. This inspection method will be performed in accordance with American Society for Testing and Materials (ASTM) E1444/E1444M-12[7].

c. Nonferrous metallic weapon components will be inspected using the liquid penetrant method. A type ZL-22 fluorescent penetrant, a type ZE-3 emulsifier solution, a warm water spray wash, and type ZP-9 developer will be used. The test items will be inspected under black light for fluorescent penetrant bleed-out patterns indicative of cracks or other surface defects. This method will be performed in accordance with ASTM E1417/E1417M-13[8].

3.2.5 Ammunition.

a. The operation of small arms is interrelated with ammunition. Care must be taken during testing to assure that the distinction is made between inherent weapon functioning and ammunition induced problems. If the test weapon uses standard ammunition, a single lot of ammunition should be used for the entire series of tests. If a single lot cannot be obtained, every effort must be made to complete each separate test procedure with a single lot. The ammunition used must be fully identified; record the full nomenclature, Department of Defense Identification Code (DODIC), condition code (CC) and lot number. Only CC "A" and CC "B" should be used. The use of lower CCs should not be attempted until after consultation with the Evaluator, Customer, and the ATEC Test Manager.

b. Ammunition should be kept in its original shipping and storage containers until use. A general visual examination of the ammunition should be made after it is removed from its packaging; record any discrepancies such as shipping damage, evidence of improper storage, etc.

3.3 Test Sequence.

To provide an early indication of weapon suitability, conduct safety tests and high-risk tests first. Otherwise, when one weapon must be used in several subtests, plan the test sequence so that the most abusive test will be conducted last. A predetermined sequence for the complete series of subtests cannot be established in advance due to the many variations of weapon designs and due to facility considerations such as the scheduling of ranges and laboratory support. However, general recommendations for test sequences for hand and shoulder weapons and for machine guns are provided in Tables 1 and 2. These recommended sequences must be tailored for each test project and may have to be revised during testing to accommodate emerging results, changes in scope, etc.

TABLE 1. HAND AND SHOULDER WEAPONS
(WEAPON ASSIGNMENT BASED ON A 16-WEAPON SAMPLE)

WEAPON NO. 1	WEAPONS NO. 2,3,4,5,6	WEAPONS NO. 7, 8, 9	WEAPONS NO. 10, 11, 12[a]	WEAPONS NO. 13, 14, 15	WEAPON NO. 16
Weapon Combustion Products/Toxic Fumes[c]	Accuracy and Dispersion	Extreme Temperature	Ammunition Comp	Attitudes	Cook Off[b]
Flash	Reliability and Durability	Icing	Accessory Comp	Rough Handling	
Smoke		Water Spray	Humidity		
Noise		Mud	Human Factors		
Recoil Energy		Sand and Dust			
Solar Radiation		Salt Fog			
Blocked Barrel		Salt Water			

[a] Weapons no. 10, 11, and 12 may also be used for any supplemental tests that may be required.
[b] After the cook off test, weapon no. 16 is available for operator training, demonstrations, and as a replacement for any weapon that fails prematurely in the other test sequences.
[c] Weapon Combustion Products has historically been referred to as Toxic Fumes, and the two terms are used interchangeably throughout this document.

TABLE 2. MACHINE GUNS
(WEAPON ASSIGNMENT BASED ON A 10-WEAPON SAMPLE)

WEAPON NO. 1	WEAPONS NO. 2, 3, 4	WEAPONS NO. 5, 6, 7	WEAPONS NO. 8, 9, 10[a]
Cook Off	Accuracy and Dispersion	Extreme Temperatures	Attitudes
Weapon Combustion Products[b]	Reliability and Durability	Icing	Ammunition Comp
Flash		Water Spray	Belt Pull
Smoke		Humidity	Rough Handling
Noise		Mud	Accessory Comp
Recoil Energy		Sand and Dust	Human Factors
Solar Radiation		Salt Fog	Barrel Performance
Blocked Barrel		Salt Water	

[a] Weapons no. 8, 9, and 10 may also be used for any supplemental tests that may be required.
[b] Weapon Combustion Products has historically been referred to as Toxic Fumes, and the two terms are used interchangeably throughout this document.

4. TEST PROCEDURES.

4.1 Initial Inspection.

4.1.1 Background.

a. Weapons received for test must be inspected for their physical characteristics, safety, and identification. These inspections also often serve as a baseline for subsequent inspections later in the sequence of tests. The following paragraphs list typically required information; a specific test item may require more, fewer, or different inspections. Project documents such as the TEMP, SEP, and DTPs should be reviewed for any required inspections.

b. Marking individual weapons with a simple identification is a good practice often done at the start of the initial inspections. For example, rather than long serial numbers, weapons could be identified as T1, T2, etc. for test weapons and C1, C2, etc. for control weapons.

4.1.2 Method.

a. Disassemble the weapon, and visually examine all major components (e.g., safety and trigger mechanisms, locking arrangement) for conformance with specifications and design drawings. Record any deviations from specifications.

b. Photograph the weapon with and without its accessories and in various stages of disassembly.

c. Conduct NDT on components subjected to stress during firing (e.g., bolt, locking lugs, barrel, muzzle device, etc.).

(1) Ferrous metallic weapon components will be inspected by the fluorescent magnetic particle wet continuous method. The item will be magnetized using DC, sprayed with a bath consisting of size 14A fluorescent magnetic particles suspended in a petroleum distillate liquid (kerosene), and inspected under black light for patterns indicative of cracks or other defects. This inspection method will be performed in accordance with ASTM E1444/E1444M-12.

(2) Nonferrous metallic weapon components will be inspected using the liquid penetrant method. A type ZL-22 fluorescent penetrant, a type ZE-3 emulsifier solution, a warm water spray wash, and type ZP-9 developer will be used. The test items will be inspected under black light for fluorescent penetrant bleed-out patterns indicative of cracks or other surface defects. This method will be performed in accordance with ASTM E1417/E1417M-13.

d. Record the following for the test weapon and its ancillary equipment, as applicable:

(1) Test item nomenclature, serial number(s), manufacturer's name, and the corresponding locally assigned identification.

(2) Type and adequacy of packaging and preservatives.

(3) Defective parts (ascertain with weapon disassembled, repair or replace, record).

(4) Number and names (establish, if necessary) for all parts.

(5) Completeness of logistic support (Maintenance concept, System Support Package, level and source of repair, etc.).

(6) Free length or force-displacement curves for all springs, as appropriate, within the designed operating range (if specified in test plan).

(7) Weapon physical characteristics.

e. Record the weight of the following:

(1) Weapon.

(2) Mount.

(3) Weapon accessories.

(4) Complete system.

(5) Without accessories or magazine.

(6) With loaded magazine.

(7) With loaded magazine and accessories.

(8) Individual subassemblies.

f. Record the dimensions of:

(1) Weapon. Test item length, width, and height, with and without accessories length from butt to trigger/butt to rear sight (if applicable).

(2) Mount, traverse and elevation limits, free and controlled.

g. Record sight characteristics.

(1) Zeroing and adjustment markings.

(2) Maximum range setting.

(3) Increment of adjustment, range, and windage (i.e., range change per "click").

(4) Total adjustment, range, and windage.

(5) Battle sight setting.

(6) Front and rear sight type, dimensions, and means of adjustment.

(7) Sight radius.

(8) Height of sight line above bore line.

(9) Distance of rear sight to line of rear face of stock.

h. Record the following physical characteristics:

(1) Firing pin protrusion.

(2) Firing pin copper crush indent, equated to energy (if specified in test plan).

(3) Trigger pull (force and stroke required to manually operate the trigger). Use appropriate method to include Trigger Scan system, hanging weights, and spring gauge.

(4) Fire control selector, type and method of operation.

(5) Headspace.

(6) Barrel length.

(7) Length of rifled bore.

(8) Direction and twist of rifling.

(9) Number of lands and grooves.

(10) Diameter across lands and grooves.

(11) Chamber dimensions.

(12) Charging force.

(13) Receiver length.

i. Time and tools necessary for the following. **Note:** This test is conducted to determine the type and number of tools and time required to accomplish various stages of assembly and disassembly. The following measurements are taken three times by each of three test personnel:

(1) Complete disassembly of weapon.

(2) Assembly of weapon after complete disassembly.

(3) Dismounting of the operating parts and magazine or feeder (field strip).

(4) Assembly of operating parts and magazine or feeder.

(5) Change of barrels (if designed for operator exchange of barrels).

j. Record the following general characteristics:

(1) Magazine or ammunition box capacity and weight with and without ammunition.

(2) Method of barrel attachment.

(3) Type of operation.

(4) Gas adjustment (if any).

(5) Type of fire (semiautomatic, automatic, etc.) and means of control.

(6) Type of mechanism (open or closed bolt).

(7) Type of feed, extraction, ejection, cocking.

(8) Flash hider.

(9) Muzzle-compensation device.

(10) Bayonet, grenade launcher, or other ancillary equipment.

k. Prepare a characteristics data sheet, suitable for the formal report and other purposes, consisting of a general view photograph of the weapon, along with a listing of all principal physical and performance characteristics.

l. Personnel. Familiarize test personnel with technical and operational characteristics of the test item as described in applicable technical manuals, requirements documents, or manufacturer's literature. Provide New Equipment Training (NET) to personnel directly involved with the operation and maintenance of the weapon. Before conducting test firings, review the inspection results to determine if special warnings, new Standard Operating Procedures (SOPs), or test revisions are needed to assure safe operations.

4.1.3 Data Required.

The data from the inspections should be recorded in tabular or spreadsheet formats where possible; this will facilitate data comparisons in subsequent inspections throughout the overall test. Photographs, X-rays, etc. should be preserved in a digital format to assist data handling and transmission. If identification numbers are assigned to the weapons, a list will be maintained of the assigned number versus the weapon serial number (or other information that uniquely identifies the weapon).

4.2 Cook Off Test.

4.2.1 Background.

This test determines the maximum number of rounds that can be fired semi-automatically or automatically from the weapon before the chamber becomes hot enough to cause the propellant to cook off, i.e., ignite spontaneously, if a cartridge is resting in the chamber. This test should be performed early in the test sequence since it determines safe firing limits for use in other test procedures.

CAUTION: The cook off test described herein is designed to be conducted only with nonexplosive ammunition. If explosive ammunition is included in a hand or shoulder weapon system (and the weapon can also be fired rapidly enough to possibly induce cook off), special test procedures must be instituted that fully control the hazards of such a test (see TOP 04-2-016). Safety precautions for any cook off test must consider that this test increases the likelihood of a catastrophic weapon failure. Note that cook off may occur after the barrel temperature has peaked and is declining.

4.2.2 Method.

a. Disassemble, clean, lubricate with prescribed lubricant, and reassemble one test weapon.

b. Instrument the weapon for continuous temperature data by installing thermocouples at the following locations: on the exterior of the muzzle device or on the exterior of the barrel at the muzzle (if no muzzle devices present), on the exterior of the barrel immediately over the chamber mouth, and on the exterior of the barrel proper at the point of the smallest outside diameter. Use dual thermocouples positioned 180° apart at each location to ensure against loss of data due to breakage of any single thermocouple. Record the temperature data continuously from the initiation of firing until cook off or expiration of the waiting period.

c. When the projectiles are inert or contain nothing more than tracers, the person firing may remain in position at the gun during firing, but must be adequately protected. Be sure that this person uses a face shield, protective vest/clothing, heavy gloves, and ear protection. A physical barrier should also be employed to shield the person firing from as much direct exposure to the test weapon as practical.

d. All cook off tests are conducted at a fixed ambient temperature with a wind speed less than 8 kilometers per hour (km/hr) (5 miles per hour (mph)) with no sunlight on the barrel or receiver.

e. Conduct a firing exercise, using a predetermined number of rounds, based on experience with the test weapon or one similar. Subject the weapon to the most severe firing schedule anticipated for it in service. Fire the weapon, changing belts or magazines as quickly as possible to achieve the predetermined number of rounds. Closed bolt weapons will retain a round in the chamber if firing is stopped in the middle of a belt/magazine. However, when weapons of an open-bolt design are fired, the last round must have a cartridge specially prepared to permit bolt closure without firing. This can be accomplished by assembling a primer without an anvil, or by recessing (crushing) the primer 0.25-cm (0.10-in.).

f. After the final round is chambered and the bolt closed, a 30-minute waiting period is observed (local range SOPs must be followed if they require a different waiting period).

NOTE: Under no circumstances will personnel be exposed after any potential cook off round has been chambered until either (1) the round has cooked off and there are no other rounds in the weapon, (2) the test is terminated by expiration of the 30-minute waiting period without cook off occurring, or (3) the chambered round is fired (remotely by use of a lanyard) and not removed for inspection. The first round will usually cook off within 60 seconds, but delays of many minutes have been observed. Automatic gun action may continue to load and fire subsequent rounds until the weapon temperature falls below the cook off level. From the records on temperature, time, and rounds fired, fewer rounds can be selected in subsequent trials when the purpose is to bracket the cook off level in terms of number of rounds fired.

g. Discontinue the test without determining cook off point if 500 rounds can be fired without cook off occurring, or if the weapon can no longer be fired in a normal manner because of heat. The barrel can be considered cool enough to start a new trial when temperature measurements taken on the barrel are within 2 °C (4 °F) of the ambient temperature.

h. Substantiate the point of cook off by firing three trials during which cook offs do not occur. The confirming firing (non-cook off level) will consist of 15 rounds, or 5 percent, less (whichever is greater) than that producing a cook off.

4.2.2 Data Required.

Record the following information:

a. Continuous time-temperature recording with maximum temperature read from recording.

b. Ambient temperature.

c. Number of belts/magazines and rounds.

d. Rate-of-fire (ROF) when firing, and overall rate of firing, including time to change belts/ magazines.

e. Time to cook off, from last round fired, if it occurs.

f. Malfunctions in accordance with paragraph 5.

4.3 Reliability and Durability.

4.3.1 Background.

a. Reliability and Durability testing is conducted to determine the functional life of the weapon and its component parts. The data from this test helps establish logistical requirements for parts stockage and replacement schedules, aids “repair or discard” decisions, and supports cost benefit analysis.

b. It is not possible to specify exactly how many rounds must be fired for a Reliability and Durability test. Service life expectations vary among weapons. For example, a sniper rifle may have quite different requirements than that of an assault rifle. Some weapons have very long lives, particularly those that are externally powered or employ multi-barrels. In general, handguns and shoulder weapons are fired at least 6,000 rounds and machine guns and automatic weapons at least 25,000 rounds unless otherwise specified in the test plan or requirements documents.

c. All instances of malfunctions and failures are recorded. Parts are replaced only when they become unserviceable or present a safety hazard. When a specific part is being studied, continue the test only long enough to determine its useful life.

d. The nature of this test requires firing an unusually large number of rounds per day. Personnel should be provided with suitable personal protective equipment (PPE) such as heavy gloves, shoulder pads for shoulder fired weapons, and attire for protection from hot gun barrels and expended cartridge cases. The large number of rounds fired may also increase weapon combustion products to levels above those more typically encountered. Since weapon barrels are often fired to, or past, the limits of serviceability, personnel must consider the possibility of erratic bullet flight and deviations from the established line-of-fire (LOF).

4.3.2 Method.

a. Hand and Shoulder Weapons.

(1) Disassemble, thoroughly clean, inspect (including NDT of critical parts), lubricate, and reassemble at least five test weapons. Record headspace and barrel bore measurements for each weapon.

(2) Fire from each test weapon using the procedures given in paragraph 4.4 and record velocity and dispersion. The range distances for targets are usually established in the requirements documents; when they are not specified, refer to test reports on similar items, or use 50 meters (m) for handguns, 100 m for shoulder weapons, and 300 m for sniper weapons. Velocities should be recorded as corrected to muzzle using any appropriate instrumentation; the same instrumentation should be used for the duration of the test.

(3) Fire each test weapon in accordance with the firing procedure (number of rounds, firing cycle, mode of fire, sequence of modes) as specified in the test plan or requirements document. All firing is done with the weapon firmly hand-held or held in an appropriate mount. If a firing procedure is not specified, use the firing cycle shown below. Note that the procedure is based on a typical 30-round magazine and may need to be adjusted to account for specific magazine sizes.

(a) The basic firing cycle is 120 rounds (the first cycle includes the rounds fired for velocity and dispersion). Observe a minimum time of 10 minutes to cool the weapon after firing the 120 rounds.

(b) Every 240 rounds, the weapon must be cooled to the point that the barrel can be held in a bare hand indefinitely (these cycles may have to be modified if they approach or exceed the cook-off temperature, see paragraph 4.2).

(c) Every 600 rounds (five 120-round cycles), wipe and lubricate the weapon without disassembly.

(d) Every 1,200 rounds (ten 120-round cycles), disassemble the weapon and CIL. Fire the 30-round dispersion and velocity as given in paragraph 4.4.2.e(4).

(e) Every 2,400 rounds add NDT to the CIL (NDT may not need to be performed early in the progress of the test if the general weapon characteristics are known from experience with similar weapons).

(f) Continue the above process for a total of 7,200 rounds, or as specified in the test plan or requirements documents.

(4) For weapons capable of only single-shot or semiautomatic operation, fire at a regular cadence of approximately one shot per second for semiautomatic or one shot per five seconds for single-shot weapons. Reloading and magazine changes should be done at a pace that can be comfortably maintained throughout the firings.

(a) For weapons capable of both semiautomatic and full automatic fire, fire the first half of each 120-round cycle (if necessary, adjust round count to the nearest full magazine) in the semiautomatic mode at a rate of approximately one shot per second, and fire the second half in bursts of three to five shots at a rate of approximately 85 spm. Record the cyclic rates of the first and last burst in each 120-round cycle.

(b) Weapons with only full automatic fire capability are fired in three to five round bursts at a rate of approximately 85 spm (this will take about 1 minute and 29 seconds). Record the cyclic rates of the first and last burst in each 120-round cycle.

b. Machine Guns and Automatic Weapons. Fire these weapons 25,000 rounds each in accordance with the procedures below using firing schedules applicable to the weapon. The procedure is as follows:

(1) Disassemble, thoroughly clean, inspect (including NDT of critical parts), lubricate, and reassemble at least three test weapons. Record headspace and barrel bore measurements for each barrel in its assigned receiver.

(2) Use ammunition representative of the standard combat mix unless otherwise specified by the test plan or requirements documents. A typical mix is four ball cartridges to one tracer cartridge. If a mix is used, it is necessary to keep track of the order of the cartridges since the data for any stoppage or malfunction must include the specific type of cartridge involved.

(3) The basic firing cycle is 200 rounds at a given condition, unless otherwise dictated by the test plan or requirements documents. The first 200-round cycle is fired from a stable mount (test stand, sandbagged tripod, etc.). The first 30 rounds are fired for accuracy and velocity measurements (three each 10-round burst targets). If an ammunition mix is used, the order of the cartridge types should be the same for each target so that each X/Y coordinate can be associated with its individual type of cartridge. The range distances for targets are usually established in the requirements documents; when they are not specified, refer to test reports on similar items, or use 100 meters. Cyclic rates are recorded for each of the ten-round burst targets.

Velocities should be recorded as corrected to muzzle using any appropriate instrumentation; the same instrumentation should be used for the duration of the Reliability and Durability test. The remaining 170 rounds of the first 200-round cycle are fired in bursts of five to seven shots at a rate of approximately 85 rounds per minute (rpm).

(4) Following the initial 200-round cycle, subsequent cycles are done by firing the first 100 rounds in bursts of five to seven shots at a rate of approximately 85 spm (this will take about 1 minute and 11 seconds). The remaining 100 rounds are fired in two bursts of 50 rounds with a 15 second period between bursts.

(5) The 200-round cycles are continued until the end of the scheduled maintenance period. This period may be determined in two ways:

(a) As specified in the test plan or requirements documents.

(b) Use a standard schedule of cleaning and re-lubrication, without disassembly (wipe and lubricate), at 2,000 rounds followed by a complete disassembly, inspection, cleaning and lubrication and NDT at 4,000 rounds (NDT may not need to be done early in the progress of the test if the general weapon characteristics are known from experience with similar weapons).

(6) After the weapon is reassembled, record headspace and barrel bore measurements and repeat the 4,000-round cycle including the target firing. Continue this procedure until at least 25,000 rounds are fired unless otherwise specified in the test plan or requirements documents. The final 200-round cycle should be fired as in paragraph 4.3.2.b(3) to record the final weapon performance. A detailed inspection, including a magnetic particle or dye penetrant inspection of components subjected to stress, is performed after all firings are completed.

(7) Many weapons have barrels that are designed to be changed by the operator (often called "quick change" barrels). Usually the Soldier has access to one spare barrel in addition to the barrel in his weapon. In this case, the two barrels are assigned to a specific weapon; the barrels are rotated equally in the firing sequence with each barrel being used to fire a complete 200-round cycle with complete cooling of the barrel between cycles. The initial 200-round cycle must be modified so that each barrel is fired 30 rounds for accuracy and dispersion as detailed in paragraph 4.3.2.b(3); subsequent 200-round cycles following maintenance intervals also require firing all barrels.

(8) Consideration must be given to the way the test weapon is designed to be held or mounted in use. Below are recommended firing conditions for various likely weapon characteristics:

(a) If the weapon is equipped with an attached bipod, but is not designed to be otherwise mounted, all firing should be performed using the bipod (it may be sandbagged or firmly emplaced to assure safe control of the weapon).

(b) Many machine guns are intended to be fired from a variety of mounts such as a bipod, tripod, and pintle type mount. It is preferable to distribute firings among representative mounts; for example, 2,000 rounds from the bipod, 2,000 rounds from a tripod, and 2,000 rounds from a pintle repeated through the entire test. The pintle mount should simulate its likely configuration on the platform (vehicle, watercraft, aircraft) for which it is designed to be used.

(9) Weapon barrels are treated the same as other parts, that is, they are only replaced when they become unserviceable or unsafe. Barrel serviceability limits may be defined by the test plan or requirements documents. If no such information is available, replace barrels when needed by the following three conditions:

(a) If replacement is indicated by a barrel wear gauge designed for the specific weapon/barrel being tested.

(b) When the average bullet velocity of the three 10-round bursts falls more than 6 percent below that recorded initially.

(c) If gross bullet instability is noted, such as yawing, extreme increases in dispersion, etc.

NOTE: Small arms barrels typically demonstrate a very slow drop in velocity and increase in dispersion over a life of thousands of rounds (some barrels may actually gain velocity early in their life before the velocity starts decreasing). Near the end of the barrel life, however, degradation happens very rapidly, often only a few hundred rounds separate a worn but serviceable barrel from one that is grossly unserviceable or even hazardous. Therefore, test personnel must always be alert for indications of imminent barrel failure. These indications may include an increase in muzzle flash, erratic flight of bullets (easily observed if traced ammunition is being fired), an increase in the malfunction rate, and any other significant change in weapon performance.

c. Mounts. The following mounts are used for the following conditions:

(1) Shoulder Fired. Typically used for operational reality.

(2) Tactical Mount. Typically used for operational reality.

(3) Test Stand. Typically used for consistent precision and repeatability.

4.3.3 Data Required.

a. Muzzle velocity.

b. Target accuracy and dispersion, and distance to the target.

c. Cyclic ROF.

d. Ambient temperature.

e. Malfunctions, breakages, and replacement parts in accordance with paragraph 5.

f. All maintenance actions performed.

g. Bore and headspace measurements.

h. NDT results.

4.4 Accuracy and Dispersion.

4.4.1 Background.

a. This test determines the inherent accuracy and dispersion characteristics of the test weapons throughout their tactical ranges when fired hand-held from a supported position or fired from a mechanical mount secured to a rigid base.

b. Accuracy is a measure of the ability of weapon-ammunition system to center projectile impacts on the point of aim (PoA). Dispersion is the extent to which projectile impacts spread about the center of impact (COI) because of shot-to-shot variations. Methods of calculating measurements of accuracy and dispersion are given in ITOP 04-2-829[9]. In tests of weapons, a dispersion test requires that the effect of variations in ammunition be eliminated in so far as possible; therefore, the lot of ammunition used must be one that has a small and consistent dispersion.

c. Results of the Accuracy and Dispersion test are often used as a "baseline" for analysis of subsequent test results. Ideally, accuracy and dispersion data will be generated by each of three separate procedures.

(1) Firing the ammunition from a special test barrel (referred to as a "Mann barrel").

(2) Firings from the weapon/ammunition combination from a test stand.

(3) Manned firing of the weapon/ammunition combination (man-in-the-loop).

d. Conducting all three procedures will allow comparison of data across conditions and will greatly aid the development of an error budget.

4.4.2 Method.

a. Ammunition Selection.

(1) Ammunition can be selected through review of ammunition acceptance test results (available from the manufacturer). The results must be in the form of the actual recorded dispersion; ammunition lots that only marginally meet the acceptance criteria should be avoided.

(2) Candidate ammunition lots can be fired to determine their inherent dispersion. This process requires special test barrels (Mann type barrels) and rigid test mounts. Refer to the acceptance test procedures given in the specification for each specific cartridge for details of the test procedure.

(3) The Accuracy and Dispersion test should be completed with the type(s) of ammunition identified in the requirements documents or test plan. If no other information is available, fire one of each category of cartridge likely to be used in combat (for example, ball, trace, sabot, etc).

b. Targets. Electronic targets that do not physically interfere with the bullet trajectory are preferred. Electronic targets also expedite the test by allowing multiple targets along the LOF so that each shot is recorded at multiple ranges. Care must be taken to establish a reproducible aim point. Physical targets, such as paper, cloth, or plywood may also be used; these require careful manual measurement of each bullet hole. Targets are positioned perpendicular to the LOF.

c. Weapon Mounts.

(1) Hand-Held Firing. Weapons, particularly hand and shoulder weapons, may be fired manually from a supported position. This can be accomplished by seating the person firing the weapon in a comfortable position with the weapon supported by sandbags or a height adjustable rest (this is often referred to as a “bench rest” position). The weapon should be supported such that the firer needs only to adjust the final aim of the weapon. Trained and experienced firers should be used. Care must be taken to not fatigue the person firing the weapon.

(2) Mechanical Mounts. The gun mount must be compatible with the specific weapon being tested. Specific procedures must be designed for assembling the weapon to the mount and adjusting the aiming of the mount/weapon system.

d. Meteorological Conditions.

(1) Ensure that the velocity of the transverse wind is no greater than 8 km/hr (5 mph) or varies by more than 4 km/hr (2.5 mph); wind parallel to the LOF should not exceed 16 km/hr (10 mph) or vary by more than 8 km/hr (5 mph). These are the maximum wind velocity conditions permitted and are not necessarily acceptable for all small arms projectiles at all ranges. Records of previous tests of the same or closely related weapon should be consulted before establishing the maximum permitted wind velocities for the test.

(2) Firings should be performed with the weapon and ammunition at standard ambient conditions (25 ± 10 °C (77 ± 18 °F) and 20- to 80-percent relative humidity (RH)). The ambient air temperature along the trajectory of the bullet may not be within the standard ambient conditions, in these cases consult with the program evaluator, customer, and test manager to determine if conditions are acceptable.

e. Hand Guns and Shoulder Weapons.

(1) Position targets at the ranges indicated by the requirement documents or test plan. Use the target distances below if no other guidance is provided:

(a) Hand guns – 50 m.

(b) Submachine guns – 50 and 100 m.

(c) Shoulder weapons – 100, 300, and 500 m.

(2) Disassemble, clean, lubricate with prescribed lubricant, and reassemble at least five test weapons.

(3) Zero each weapon in accordance with the weapon or sight manual; zero the weapon for 100 m if manuals are not available. Fire any additional rounds needed to assure that the weapon is sighted on target. If sighting rounds are not required, fire three rounds to condition the barrel (these shots are often referred to as “warmer rounds”).

(4) After the sighting rounds, fire at least three (preferably five) targets as follows: Three experience shooters each fire ten rounds semi-automatically from the test weapon at each target from a bench rest or mechanical mount. Ideally, specific shooters are assigned to each specific weapon throughout the accuracy test firings. Sight alignment is checked before each shot is fired. Use a boresight (optical or laser) as necessary to check alignment to the target aiming point if the weapon is not equipped with sights.

(5) For weapons capable of automatic fire, also fire 30 rounds at each target automatically in bursts of three rounds. Note that for hand-held firings it may not be possible to keep all three rounds on the longer-range targets.

(6) The tests may need to be repeated to analyze particular capabilities of the weapon design or to examine specific technical requirements. These include tests to determine the effect of muzzle attachments such as bayonets, sound suppressors, etc.

f. Machine Guns.

(1) Position targets at the ranges indicated by the requirement documents or test plan. It is difficult to suggest target ranges due to the large variety of machine gun calibers and the many ways they are employed. If no other guidance can be obtained, place targets at 100 and 300 m for weapons of less than caliber 7.62-mm, and at 100, 300, 500, and 800 m for calibers of 7.62-mm and larger. If possible, the target ranges should include the maximum desired effective point fire range.

(2) Disassemble, clean, lubricate with prescribed lubricant, and reassemble at least three test weapons.

(3) Assemble the weapon to the mechanical mount in accordance with the procedures for the specific combination. Fire enough rounds to ensure that each test weapon is correctly sighted on target. If sighting rounds are not required, fire three rounds to condition the barrel.

(4) Fire a 10-round burst, fully automatic, from each weapon at each of at least three targets at each range. Other burst lengths may be appropriate as indicated by the test plan, requirement documents, etc. Sight alignment is checked before and after each burst is fired to assure that the weapon has not moved during the burst. Use a boresight (optical or laser) as necessary to check alignment if the weapon is not equipped with sights. If an ammunition mix is used, the order of the cartridges must be known for each target so that each X and Y coordinate can be associated with its individual type of cartridge. For example, for a typical mix of four ball cartridges to one tracer cartridge, order the cartridges so that the fifth and tenth rounds are always the tracer cartridges.

(5) The tests may need to be repeated to analyze particular capabilities of the weapon design or to examine specific technical requirements. For example, weapons with quick-change barrels may have a requirement that the COI of each barrel fall within specified limits.

4.4.3 Data Required.

Measure and record the following:

a. X and Y coordinates of each impact relative to the aim point.

b. Type of cartridge associated with each impact coordinate.

c. Target data reduced in accordance with ITOP 04-2-829.

d. Inherent ammunition dispersion (from lot acceptance or test firings).

e. Target ranges and nature of target.

f. Photographs of test mounts and bench rest firing facility.

g. Procedures used to mount and fire weapons.

h. Malfunctions, breakages, and replacement parts in accordance with paragraph 5.

i. Meteorological conditions.

4.5 Adverse Conditions.

a. Background.

(1) By the very nature of their use, small arms are exposed to, and must reliably operate in, adverse conditions. These adverse conditions consist of both natural environments

(such as extreme temperature and rain) and in induced environments (such as sand and dust caused by vehicular traffic). These adverse conditions vary by the climate of the geographic areas of intended use. The climatic conditions, as well as performance standards for operations, storage, and transit for each system, are specified in applicable requirements documents.

(2) The basic documents describing military environmental extremes are AR 70-38[10] and Military Handbook (MIL-HDBK)-310[11]. MIL-STD-810G CN1 establishes uniform environmental test methods for determining the resistance of equipment to the effects of natural and induced environments peculiar to military operations. General ATEC policy concerning climatic testing is given in ATEC Pamphlet 73-1[12], Test and Evaluation Volume I. Some adverse conditions test procedures, such as for mud, have been developed within test centers since there is no known Army wide procedure.

b. AR 70-38 requires that climatic tests be performed, as a minimum, under the “basic” climate conditions as defined by the AR. If requirement documents require worldwide operation, the system must be able to operate in all four climatic design types. The climatic design types, extracted from AR 70-38 are provided in Table 3. The “Induced Air Temperature” should be used as the high temperature for each climatic design type since small arms are subject to solar radiation in use as well as in storage.

TABLE 3. AR 70-38 CLIMATIC DESIGN TYPES

Climatic Design Type	Daily Cycle	OPERATIONAL CONDITIONS						STORAGE AND TRANSIT		
		Ambient Air Temperature				Solar Radiation BTU/hr, W/m²	Ambient Relative Humidity (RH), %	Induced Air Temperature		Induced RH, %
		Daily Low		Daily High						
		°C	°F	°C	°F			°C	°F	
Hot	Hot Dry (A-1)	32	90	49	120	0 to 355 (0 to 1120)	3 to 8	33 to 71	91 to 160	1 to 7
	Hot Humid (B-3)	31	88	41	105	0 to 343 (0 to 1080)	59 to 88	33 to 71	91 to 160	14 to 80
Basic	Constant High Humidity (B-1)	Nearly Constant 24 °C (75 °F)				Negligible	95 to 100	Nearly Constant 27 °C (80 °F)		95 to 100
	Variable High Humidity (B-2)	26	78	35	95	0 to 307 (0 to 970)	74 to 100	30 to 63	86 to 145	19 to 75
	Basic Hot (A-2)	30	86	43	110	0 to 355 (0 to 1120)	14 to 44	30 to 63	86 to 145	5 to 44
	Temperate (A-3)	28	82	39	102	0 to 335 (0 to 1060)	43 to 78	28 to 58	82 to 136	See note below
	Basic Cold (C-1)	-32	-25	-21	-5	Negligible	Tending toward saturation	-25 to -33	-13 to -28	Tending toward saturation
Cold	Cold (C-2)	-46	-50	-37	-35	Negligible	Tending toward saturation	-37 to -46	-35 to -50	Tending toward saturation
Severe Cold	Severe Cold (C-3)	-51 °C (-60 °F)				Negligible	Tending toward saturation	-51	-60	Tending toward saturation

Note: Humidity for the A-3 storage condition varies too widely between different situations to be represented by a single set of conditions.

c. General Test Conditions. During environmental functioning tests, it may be desirable to condition the weapons fully loaded (safety selector in the Safe position), including leaving a round in the weapon chamber for closed bolt firing designs; however, this is not normally performed due to the safety hazards involved. The decision must be based on a careful review of the conditions for each specific test. For example, it may be acceptable to subject fully loaded weapons to the mud test and to the rain test since the weapon operator maintains a “hands on” control of the weapon at all times. Conversely, weapons subjected to unattended conditions, such as temperature conditioning, are not conditioned loaded as there is no continuous hands on control. Weapons firing from the open-bolt position are prepared by leaving the chamber empty and the bolt in the seared position, these weapons must be subjected to the same safety review as for the closed bolt weapons. For some tests and because of safety precautions, it may be more realistic to condition the weapons "half loaded", i.e., with the bolt in the battery position and the chamber empty, so that a full stroke of the charging handle is required to completely load the weapon.

(1) If test results indicate a high number of first round failures, it may be necessary to manually operate the firing mechanism several times to restore proper operation of the weapon. When this action is performed, it will be so noted.

(2) When testing weapons with multiple cyclic ROF, rotate the firing cycles among the various ROF.

(3) Specified lubricants to be used in each environmental test are determined by reference to appropriate manuals or other authority. In addition to observations of general weapon performance, also report requirements for additional lubrication and cleaning. Do not clean or re-lubricate test weapons unless required for completion of the test.

4.5.1 Extreme Temperatures.

Small arms are exposed to extreme temperatures during operation, transit, and storage. Table 3 provides test temperature guidance based on AR 70-38. If requirements documents or the test plan do not specify the number of weapons and rounds to be fired, use three weapons and the number of rounds per weapon as provided in Table 4.

TABLE 4. RECOMMENDED AMMUNITION REQUIREMENTS (MINIMUM)

TYPE OF WEAPON	NO. OF ROUNDS PER WEAPON[a]	
	Low Temperature	High Temperature
Hand and shoulder	2,880	960
Machine gun	8,000[b]	4,000[c]

[a] Unless otherwise specified.
[b] The number of rounds equal to two cleaning cycles.
[c] The number of rounds equal to one cleaning cycle.

a. High Temperature Test.

(1) Background. This subtest determines the effect of extreme high temperatures on the functioning performance of weapons. Personnel are required to load, fire, and service the weapon in the high temperature environment; local SOPs must be followed to prevent possible heat injuries. Consideration must be given to the possibility of a cook off at fewer rounds than expected due to the higher starting temperatures of the weapon and ammunition.

(2) Method. Clean and lubricate three test weapons, use the lubricant specified for high temperatures. Condition the three test weapons, spare barrels (if applicable), and the ammunition in a climatic chamber for at least 6 hours at the temperature specified in the test plan. If there is no other guidance, use 71 °C (160 °F) in accordance with Table 3.

(a) Test each hand and shoulder weapon within the chamber as follows:

1 Fire 960 rounds (in 240-round cycles divided into two 120-round groups) with 2 hour minimum reconditioning times between cycles using the firing cycles detailed in paragraph 4.3, Reliability and Durability, unless otherwise specified in the test plan, requirements documents, etc. Measure the cyclic ROF for each automatically fired burst or measure on a sampling schedule if specified in the test plan. Do not perform maintenance during the 960-round cycle unless otherwise specified.

2 After 960 rounds have been fired through each weapon, remove the weapons from the conditioning chamber, and disassemble, thoroughly inspect, clean, and lubricate each one. If maintenance is required before the end of the 960-round cycle (as indicated by increased malfunction rate, difficulty in loading or operating the weapon, etc.), remove the weapon from the chamber and perform maintenance as required.

(b) Test each machine gun within the chamber as follows:

1 Fire 4,000 (minimum) rounds (in 200-round cycles) at the designed sustained ROF specified in applicable requirement documents. If no designed sustained rate-of-fire is specified, fire the first 100 rounds of each cycle at a ROF of 85 spm in bursts of five to seven rounds each. Fire the remaining 100 rounds in two bursts of 50 rounds each. Measure the cyclic rate of fire for each 50-round burst or measure on a sampling schedule if specified in the test plan. Maintain a 1 hour minimum reconditioning time between firing cycles, unless otherwise specified in the test plan, requirements documents, etc. If replacement barrels are used, they are also subject to the 6 hour conditioning requirement and a 1 hour minimum reconditioning between firings. Do not perform maintenance during the 4,000-round cycle unless otherwise specified.

2 Perform maintenance at intervals specified in applicable requirements documents. If no scheduled maintenance intervals are specified, perform cleaning and lubrication, without disassembly, at 2,000-round intervals. Do not perform additional maintenance unless weapon operation is degraded as evidenced by loss of cyclic rate, increased frequency of malfunctions, etc. All maintenance is performed after removing the weapons from the temperature chamber. After the 4,000 rounds have been fired through each weapon, remove the weapons from the conditioning

chamber, and disassemble, thoroughly inspect (including NDT, if appropriate), clean, and lubricate each one.

(c) If the weapon is fired remotely using a gun solenoid, the voltage selected for the test should be the maximum operating voltage specified.

(d) Data Required. Record the following:

1 Temperature and exposure times.

2 Cyclic ROF.

3 Malfunctions in accordance with paragraph 5.

4 Any damage noted during inspection.

5 All maintenance actions performed.

6 All difficulties in loading or operating the weapons.

b. Low Temperature Test.

(1) Background. This subtest determines the effect of extreme low temperatures on the functioning performance of weapons. Personnel are required to load, fire, and service the weapon in the low temperature environment; therefore, local SOPs must be followed to prevent possible injuries due to the cold environment. Particular attention must be given to avoid the contact of bare skin with the weapon, ammunition, or any cold surface.

(2) Method. Clean and lubricate three test weapons, use the lubricant specified for low temperatures. Condition the three weapons, spare barrels (if applicable), accessories, and the ammunition in a climatic chamber for at least six hours at the applicable low temperature indicated in the test plan or requirement documents. If no other guidance is available, use -51 °C (-60 °F) in accordance with Table 3. The recommended minimum number of rounds to be fired through each weapon is shown in Table 4.

(a) Test each hand and shoulder weapon as follows:

1 Fire 960 rounds (in 240-round cycles divided into two 120-round groups) with 2 hour minimum reconditioning times between cycles using the firing cycles detailed in paragraph 4.3, Reliability and Durability, unless otherwise specified in the test plan, requirements documents, etc. Measure the cyclic ROF for each automatically fired burst or measure on a sampling schedule if specified in the test plan. Do not perform maintenance during the 960-round cycle unless otherwise specified.

2 After 960 rounds have been fired through each weapon, remove the weapons from the conditioning chamber and disassemble, thoroughly inspect, clean, and lubricate each one. Record any changes noted.

(b) Repeat the test two more times for a total of 2,880 rounds fired from each weapon. Test each machine gun within the chamber as follows:

1 Fire 8,000 rounds per weapon (minimum), or two cleaning cycles in 200-round cycles at the designed sustained rate-of-fire specified in applicable requirement documents. If no designed sustained ROF is specified, fire the first 100 rounds of each cycle at a ROF of 85 spm in bursts of five to seven rounds each. Fire the remaining 100 rounds in two bursts of 50 rounds each. Details of this firing cycle are given in paragraph 4.3, Reliability and Durability. Measure the cyclic ROF for each 50-round burst or measure on a sampling schedule if specified in the test plan. A 2 hour minimum reconditioning time between firing cycles is maintained, unless otherwise specified in the test plan, requirements documents, etc. If replacement barrels are used, they are also subject to the 6 hour conditioning requirement and 2 hour minimum reconditioning between firings. After 4,000 rounds have been fired through each weapon, remove the weapons from the conditioning chamber, and disassemble, thoroughly inspect (including NDT, if appropriate), clean, and lubricate each one.

2 After the 8,000 rounds have been fired through each weapon, remove the weapons from the conditioning chamber, and repeat the 4,000-round maintenance.

(c) Observe conditions peculiar to operation at low temperature such as increased charging forces, increased power requirements, and maintenance difficulties including minor adjustments and problems in field stripping when using cold weather gear.

(d) If the weapon is fired remotely using a gun solenoid, the voltage selected for this test should be the minimum operating voltage specified. If unsatisfactory operation results, determine the increased voltage required for satisfactory operation.

(3) Data Required. Record the following:

1 Temperature and exposure times.

2 Cyclic ROF.

3 Malfunctions in accordance with paragraph 5.

4 Any damage noted during inspection.

5 Evidence of bullet instability.

6 All maintenance actions performed.

7 Any change in solenoid voltage.

8 All difficulties in loading or operating the weapons.

4.5.2 Humidity Test.

a. Background. This subtest determines the effect of high humidity on the functioning performance of weapons. Effects can include surface reactions such as rust and corrosion, material reactions such as swelling and delaminating, and degradation of lubricants.

b. Method.

(1) The humid test environment is detailed in MIL-STD-810G CN1, Method 507.6, Procedure II (see Figure 1). This test consists of a 24-hour conditioning period followed by a series of 24-hour temperature and humidity cycles for a minimum of 10 cycles, or a greater number as otherwise specified in the test plan. Subject the test weapons, spare barrels (if required), and ammunition to the 10-day test environment without cleaning or adding lubricant.

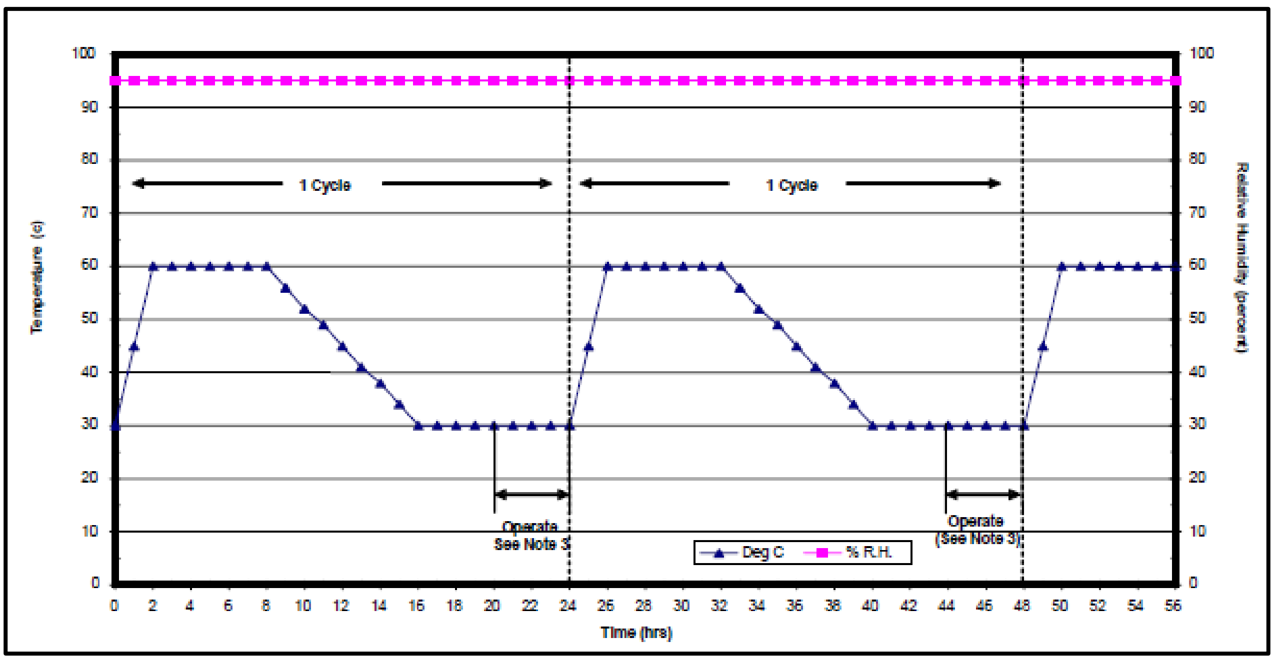


Figure 1. Humidity cycle, MIL-STD-810G CN1, Method 507.6.

NOTES:

1. Maintain the relative humidity at 95 ± 4 percent at all times except that during the descending temperature periods the relative humidity may drop to as low as 85 percent.
2. A cycle is 24 hours.
3. Perform operational checks near the end of the fifth and tenth cycles.

(2) With the test item installed in the test chamber in its required configuration, adjust the temperature to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain for no less than 24 hours.

(3) Adjust the chamber temperature to 30 °C (86 °F) and the RH to 95 percent.

(4) Expose the test item(s) to at least ten 24-hour cycles ranging from 30 to 60 °C (86 to 140 °F) (Figure 1). Conduct a test item operational check (for the minimum time required to verify performance) near the end of the fifth and tenth cycles and document the results.

(5) At the completion of 10 or more successful cycles, adjust the temperature and humidity to 23 ± 2 °C (73 ± 3.6 °F) and 50 ± 5 percent RH, and maintain until the test item has reached temperature stabilization (generally not more than 24-hours).

(6) Perform a thorough visual examination of the test item, and document any conditions resulting from test exposure.

(7) Hand and Shoulder Weapons. Expose at least three test weapons to the temperature and humidity indicated in Figure 1 for 10 days (ten each 24-hour cycles). The 960 rounds of ammunition required for this test are not exposed to the humidity cycle.

(a) Firings (done with the weapon removed from the chamber) will be scheduled to be performed during the test period between the 20 and 24 hours, and the 44 and 48 hours of the test cycle.

(b) On the fifth and tenth days of exposure, fire 240 rounds of ammunition in two each 120-round groups. Observe a time period between the two 120-round groups sufficient to assure that the specific weapon stays below the cook off temperature.

(c) For weapons capable of only single-shot or semiautomatic operation, fire at a regular cadence of approximately one shot per second for semiautomatic or one shot per 5 seconds for single-shot weapons. Reloading and magazine changes should be done at a pace that can be comfortably maintained throughout the firings.

(d) For weapons capable of both semiautomatic and full automatic fire, fire the first half of each 120-round cycle (adjust round count to the nearest full magazine) in the semiautomatic mode at a rate of approximately one shot per second, and fire the second half in bursts of three to five shots at a rate of approximately 85 spm.

(e) Weapons with only full automatic fire capability are fired in three to five round bursts at a rate of approximately 85 spm.

(f) If an unscheduled interruption occurs that causes the exposure conditions to fall below allowable limits, the test must be restarted from the end of the last successfully completed 24-hour cycle.

(g) Weapons are not cleaned or maintained at the conclusion of the 240-round firing cycle; they are placed back into the test chamber and exposed to another 24-hour cycle.

(h) After 960 rounds have been fired through each weapon, remove the weapons from the conditioning chamber and disassemble, thoroughly inspect, clean, and lubricate each one. Record any damage noted. If any weapon's operation was degraded at the end of the procedure, fire one 240-round cycle to determine if the maintenance actions have restored the weapon to proper operation.

(8) Machine Guns. Machine guns are tested in the same manner as hand and shoulder weapons except that the firing cycle consists of 200 rounds (total 800 rounds). The first 100 rounds are fired in five- to seven-round bursts at a rate of approximately 85 spm. The remaining 100 rounds are fired in two bursts of 50 rounds each. Cyclic rates will be recorded for the 50-round bursts.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure chamber operation.

(2) Malfunctions in accordance with paragraph 5.

(3) Any damage noted during inspection.

(4) All maintenance actions performed.

(5) Cyclic ROF for machine gun bursts.

4.5.3 Water Spray (Rain) Test.

a. Background. This subtest determines the effects of a heavy rainfall on weapon performance. It is an appropriate test for all types of small arms that are used or transported in a rain environment. For weapons exposed to extreme wind driven rain, such as those mounted on the exterior of vehicles, watercraft, or aircraft, MIL-STD-810G CN1, Test 506.6, Procedure I, may be appropriate.

b. The rainfall rate of 1.7 mm/min (4.0 in./hr) is consistent with the highest 1-hour rates shown in MIL-HDBK-310, MIL-STD-810G CN1 Procedure I, and North Atlantic Treaty Organization (NATO) Allied Environmental Conditions and Test Publication (AECTP) 300[13]. The 3-hour exposure (30 cm of rain) simulates the maximum total rainfall in a 12-hour period in monsoon conditions (as shown in MIL-HDBK-310).

CAUTION: This test requires that personnel load, fire, and clear weapons while in a heavy rain environment. Visibility will be reduced and surfaces may be slippery. There is a risk of catastrophic weapon failure if the weapon is fired with a water-filled bore (see paragraph 4.11, Blocked Barrel). The shooter must be provided with the proper PPE for firing weapons while in a heavy rain environment.

c. Method.

(1) Disassemble, clean, lubricate, and reassemble three weapons.

(2) Adjust the water supply to provide a spray of water falling at a rate of about 10 ± 1 cm/hr (3.9 ± 0.4 in./hr) from a height great enough to direct the spray over the entire weapon.

(3) Conduct the water spray test for handgun and shoulder weapons according to the basic sequence of operations listed in Table 5. For machine guns and automatic weapons, conduct the test as shown in Table 6. The round counts shown are advisory; they may be tailored to account for magazine sizes, typical Soldier combat loads, and capacity of load bearing equipment, etc. Use the firing cycles established in paragraph 4.3, Reliability and Durability, except that there is no maintenance performed during this test.

TABLE 5. WATER SPRAY TEST FOR HANDGUNS AND SHOULDER WEAPONS

TEST		EXPOSURE TIME, min	CUMULATIVE TIME, min	RAIN, cm	
Orientation	Condition			Per Condition	Cumulative
Weapon Horizontal	Bolt open	12	12	2	2
	Loaded, but closed	12	24	2	4
	120 rounds[c]	6	30	1	5
	Bolt open	12	42	2	7
	Loaded, bolt closed	12	54	2	9
	120 rounds[c]	6	60	1	10
Weapon Muzzle Up[a]	Bolt open	12	72	2	12
	Loaded, bolt closed	12	84	2	14
	120 rounds[c]	6	90	1	15
	Bolt open	12	102	2	17
	Loaded, bolt closed	12	114	2	19
	120 rounds[c]	6	120	1	20
Weapon Muzzle Down	Bolt open	12	132	2	22
	Loaded, bolt closed	12	144	2	24
	120 rounds[c]	6	150	1	25
	Bolt open	12[b]	162	2	27
	Loaded, bolt closed	12[b]	174	2[b]	29
	10 rounds[c]	6[b]	180	1[b]	30

[a] Before attempting to fire, hold the weapon with muzzle down; unlock the bolt slightly, and drain any water accumulated in the bore.
[b] As required to finish the program with 30 cm cumulative rain total.
[c] For weapons with the capability of both semiautomatic and full automatic fire, fire the first 50 rounds semi-automatically and the second 50 rounds in bursts of three to five rounds.

TABLE 6. WATER SPRAY TEST FOR MACHINE GUNS

TEST		EXPOSURE TIME, min	CUMULATIVE TIME, min	RAIN, cm	
Orientation	Condition			Per Condition	Cumulative
Weapon Horizontal	Bolt closed, half loaded	12	12	2	2
	Bolt open, fully loaded	12	24	2	4
	200 rounds[a]	6	30	1	5
	Bolt closed, half loaded	12	42	2	7
	Bolt open, fully loaded	12	54	2	9
	200 rounds[a]	6	60	1	10
Weapon Muzzle Up[b]	Bolt closed, half loaded	12	72	2	12
	Bolt open, fully loaded	12	84	2	14
	200 rounds[a]	6	90	1	15
	Bolt closed, half loaded	12	102	2	17
	Bolt open, fully loaded	12	114	2	19
	200 rounds[a]	6	120	1	20
Weapon Muzzle Down	Bolt closed, half loaded	12	132	2	22
	Bolt open, fully loaded	12	144	2	24
	200 rounds[a]	6	150	1	25
	Bolt closed, half loaded	12[c]	162	2[c]	27
	Bolt open, fully loaded	12[c]	174	2[c]	29
	200 rounds[a]	6[c]	180	1[c]	30

[a] The first 100 rounds are fired in five to seven round bursts at a rate of approximately 85 spm. The second 100 rounds are fired in two bursts of 50 rounds; record cyclic rates for the 50-round bursts.
[b] Before attempting to fire, unlock the bolt to allow water accumulated in bore to drain (closed bolt weapons).
[c] As required to finish the program with 30 cm cumulative rain total.

(4) Ammunition should be removed from sealed containers and be exposed, along with the weapons, in its lowest packing configuration (i.e., bandoliers, clips, loaded magazines, etc.).

(5) The weapons are subjected to the water spray continuously throughout the test. They are not removed for firing. The shooter should be provided with a test fixture, bench, or table to facilitate loading and firing the weapons.

(6) After completion of firing, disassemble, thoroughly inspect, clean, and lubricate each weapon. Record any damage noted. If any weapon's operation was degraded at the end of the procedure, fire one additional cycle to determine if the maintenance actions have restored the weapon to proper operation.

d. Data Required. Record the following:

(1) Rate of rainfall.

(2) Water and ambient air temperatures.

(3) Any evidence of water retained in bore.

(4) Malfunctions in accordance with paragraph 5.

(5) Cyclic ROF.

(6) Results of the post-firing inspections.

(7) All maintenance actions performed.

4.5.4 Sand and Dust.

a. Background.

(1) Sand and dust are part of the natural environment in which small arms must operate. The adverse effects of sand and dust include physical interference with moving parts, packing of recesses necessary for function, and wear and abrasion.

(2) Naturally occurring sand and dust has a great variability of particle size and chemical composition. The variability depends on geographic area, climatic conditions, and mechanical disturbances such as vehicular traffic.

(3) The sand and dust compounds identified in this TOP have been chosen to comply with the information in AR 70-38 and MIL-HDBK-310. There are two related compounds, one to simulate blowing dust and one to simulate a combination of blowing sand and dust.

(4) These test procedures must often be tailored to correspond to requirement documents, operational requirements, and the availability of test and support items. Tailoring considerations may include the following items:

(a) Exposure times and number of cycles.

(b) Degree of protection afforded the test weapon.

(c) Degree of protection afforded ammunition during exposure.

(d) Position and orientation of the test weapon.

(e) Use of ancillary items such as weapon racks, ammunition pouches, etc.

(f) Number of rounds fired.

(g) Firing cycles.

(h) Control of ambient temperature.

(i) Maintenance and lubrication procedures.

CAUTION: The sand and dust compounds used in these procedures are largely composed of silica; this material is considered hazardous under Occupational Safety and Health Administration standards. Local safety specialists should be consulted to determine proper procedures. Obtain the manufacture's Material Safety Data Sheet (MSDS) for additional information.

b. Methods.

(1) Sand and Dust Compounds:

(a) The compound for the blowing dust test is SIL-CO-SIL 125; this compound is 99.5-percent silicon dioxide with the following particle size distribution:

Size, Microns	Less than 45	45 to 53	53 to 75	75 to 106	106 to 150
Percent, by weight	79	6	9	4.4	1.4

(b) The compound for the blowing sand and dust test is a mixture, by weight, of the following three products: 50-percent SIL-CO-SIL 125, 42-percent No. 1 Dry Unground Silica, and 8-percent No. 3 Q-ROK Unground Silica. The resulting mixture is approximately 99.5 percent silicon dioxide and will have the following particle distribution:

Size, Microns	Less than 45	45	53	75	106	150	212	300	425	600	850	1180
Percent, by weight	28.0	10.5	7.5	3.4	2.7	5.5	15.1	17.6	2.1	1.2	6.1	0.3

(2) Test Chambers. There are two types of test chambers, one for dynamic sand and dust testing and one for static tests.

(a) The dynamic chamber is used for testing small weapons. It is designed to allow free access for an operator to fire the test weapon in a blowing dust, or sand and dust, environment. One possible design is a box 0.9 m (3 ft) wide, 1.2 m (4 ft) high, and 1.8 m (6 ft) long, with transparent sides and an interior gun cradle. A volumetric dry feeder and electric blower are attached to the back end of the chamber. The feeder must deliver a constant but adjustable flow of dust mixture to the air delivery duct of the blower. A 7.6 cm (3 in.) vent hole is provided in the front (firing direction) of the box and is aligned with the blower duct in the other end. A pair of flexible gauntlet gloves for the shooter is attached over openings on each side of the box. The gloves provide dust-sealed access to the weapon and permit full control for installing magazines and firing the weapon.

(b) The static chamber is used for larger weapons or when it is not convenient to use the dynamic chamber. The chamber is a box of any size that allows free circulation of the sand and dust laden air around the test weapon. The chamber is provided with the same dust feeder and electric blower as for the dynamic chamber. Vents are provided to relieve any buildup of air pressure and aid air circulation. It may be bottomless so that it can be lowered over the weapon and mount. Access doors, windows, and cable ports are provided as needed but must fit tightly enough to contain the circulating atmosphere. The chamber does not need to accommodate firings, but should be located as closely as possible to a firing position.

(3) Dynamic Test Procedure for Sand and Dust Exposure:

(a) This subtest is conducted to determine the effects of blowing sand and dust on weapon performance using the sand and dust mixture identified in paragraph 4.5.4.b(1). It simulates the conditions found near ground vehicles operating on unpaved terrain and the conditions caused by helicopter rotor downwash.

(b) Use the dynamic chamber and adjust volumetric feeder and electric blower of the facility to dispense the mixture at a rate of 100 ± 25 g/m^2/min over the area of concern (this can be done by placing a flat collection plate of known size in the position to be occupied by the weapon, operating the chamber for one minute, and then weighing the mixture that has been deposited on the plate).

(c) Clean and lubricate three test weapons. Place one weapon and one complement of ammunition into the chamber. The weapon should be in the orientation in which it would normally be fired; multiple tests may be necessary if there are other likely weapon exposure orientations. The ammunition complement will be four magazines for magazine-fed weapons, or 200 rounds for belt-fed infantry weapons; or one full complement of ammunition for weapons using special ammunition containers or feed mechanisms (such as armored vehicles, antiaircraft systems, aircraft weapons, etc.).

(d) Turn on the dust dispenser and, operate for one minute, and then initiate weapon firing. Continue to dispense the dust mixture until firing is complete. The firing schedule for magazine-fed weapons is one magazine every 30 seconds, with the first two magazines fired semi-automatic and the last two fired in short bursts (if the weapon is capable of automatic fire). For belt-fed weapons, fire the 200 rounds in short bursts of five to seven rounds each with a pause of about two seconds between bursts (total time of about two min). Firing schedules may also be based on combat scenarios, weapon specifications, or other available information.

(e) It may be necessary to adopt a stepwise approach due to the restricted visibility and difficulty in loading the weapon. Use the following steps:

1 Load the weapon and operate the dispenser for one minute.

2 Fire the weapon's magazine or belt.

3 Turn off the dispenser and wait for the dust atmosphere to clear.

4 Reload the weapon.

5 Operate the dispenser for one minute and fire.

6 Continue until the test is complete.

(f) If weapon performance is unsatisfactory, clean congested parts as much as possible by blowing sharply or by jarring the weapon. If performance is still unsatisfactory, replace the exposed ammunition with clean ammunition and try to complete the firings.

(g) Record cyclic rates for all automatic bursts. Record a complete time line of the test; this should include the time of each magazine change, malfunction encountered, time to clear the malfunction, and total time that the weapon is exposed to the blowing mixture.

(h) Repeat the test with the other two weapons.

(4) Static Test Procedure for Sand and Dust Exposure:

(a) This test also determines the effects of blowing sand and dust on weapon performance using the sand and dust mixture as identified in paragraph 4.5.4.b(1). Adjust the volumetric feeder and electric blower of the static test chamber to dispense the mixture at a rate of 100 ± 25 g/m^2/min over the area of concern.

(b) Clean and lubricate three test weapons. Place all three weapons and one complement of ammunition for each weapon in the static test chamber. For weapons fired from a closed bolt, chamber a round. Weapons fired from an open bolt will have the bolt open on the empty chamber. Close the dust cover and set the safety on Safe. Assemble a fully loaded magazine in the weapon; for belt fed weapons engage the belt and charge the weapon, leaving the bolt open on an empty chamber if the weapon fires from an open bolt. Use the same ammunition complements and exposure conditions as for the dynamic test. Position the weapons in the chamber in a normal firing position; multiple tests may be necessary if there are other likely weapon exposure orientations.

(c) Turn on the dust dispenser and operate it for five minutes. Turn off the dispenser and allow the dust to settle before entering the chamber (observe local safety regulations for procedures, use of PPE, etc.). Move the weapons and ammunition to the firing position while disturbing any sand and dust deposits as little as possible.

(d) Fire the weapons using the same schedule as for the dynamic test. If weapon performance is unsatisfactory, clean congested parts as much as possible by blowing sharply or by jarring the weapon. If performance is still unsatisfactory, replace the exposed ammunition with clean ammunition and try to complete the firings.

(e) If repeated malfunctions make it impossible to fire all of the ammunition, field strip and clean the weapon in accordance with the applicable operator's manual. Then attempt to fire the remaining ammunition. If repeated malfunctions make it impractical to fire the remaining ammunition, completely disassemble the weapon in accordance with applicable technical manuals (TMs). Attempt to determine the exact source of dust-induced malfunctions. Reassemble the weapon and fire to verify serviceability.

(f) Repeat the test with the remaining weapons.

(5) Static Test Procedure for Dust Exposure:

(a) This test simulates exposure to airborne dust during operations in dusty areas. Use SIL-CO-SIL 125 as the dust simulant and adjust the feeder of the static test chamber to deposit the compound at the rate of 50 ± 10 g/m^2/min over the area of concern. To replicate the hot desert environment the temperature chamber shall be maintained at 105 ± 5 °F.

(b) Clean and lubricate three test weapons. Place all three weapons and one complement of ammunition for each weapon in the facility. For weapons fired from a closed bolt, chamber a round. Weapons fired from an open bolt will have the bolt open on the empty chamber. Close the dust cover and set the safety on "Safe". Assemble a fully loaded magazine in the weapon; for belt fed weapons engage the belt and charge the weapon, leaving the bolt open on an empty chamber if the weapon fires from an open bolt. Use the same ammunition complements and exposure conditions as for the dynamic test. Position the weapons in the chamber in a normal firing position; multiple tests may be necessary if there are other likely weapon exposure orientations.

(c) Turn on the dust dispenser and operate it for 30 minutes. Turn off the dispenser and allow the dust to settle before entering the chamber (observe local safety regulations for procedures, use of PPE, etc.). Move the weapon to the firing position while disturbing any dust deposits as little as possible. Fire the weapons using the same procedures as for the static sand and dust test.

(d) Return the weapons to the test chamber; do not perform any cleaning or maintenance operations. Place one complement of ammunition in the chamber. Repeat the 30 minute exposure and firing four times (total of five exposures and firings).

c. Data Required. Record the following:

(1) The complete time line of the test; including the time of each magazine change, malfunction encountered, time to clear the malfunction, and total time that the weapon is exposed.

(2) Actual sand and dust dispensing rate.

(3) Number of rounds fired.

(4) Cyclic ROF.

(5) Malfunctions in accordance with paragraph 5.

(6) Maintenance actions performed.

(7) Chamber dimensions.

(8) Position of the weapons while in the chamber.

(9) Difficulties encountered in the operation of safety switches, charging the weapon, magazine insertion and removal, etc.

4.5.5 Mud Test.

a. Background. This subtest determines the effects of mud on weapon performance. The test is performed in two stages. Stage one is an immersion of the weapon in liquid mud followed immediately with weapon firing; stage two is identical except that the mud is allowed to dry before firing the weapon.

b. Method. Prepare a mud bath as follows:

(1) Make a mixture of 4.5 kilogram (kg) (10 lb) of bentonite clay, 1 kg (2.2 lb) of SIL-CO-SIL 125 as used in the Sand and Dust test (paragraph 4.5.4), and about 45.5 liters (l) (48 quarts (qt)) of water. The amount of water to be added to the sand and clay mixture will vary with the moisture content of these components. The water content will be limited to the quantity producing a mud viscosity of 4600 ± 200 centipoises as determined with a viscometer. The measurement conditions are as provided:

(a) Room temperature of 23 ± 1.7 °C (73 ± 3 °F).

(b) Spindle No. 3 used at 10 revolutions per minute.

(c) Container diameter greater than 7 cm (2.75 in.).

(d) 1-minute test duration.

CAUTION: For planning purposes, the mud mixture may take up to 1 day to prepare and achieve the proper viscosity.

(2) The bentonite clay is also referred to as the following common names: sodium bentonite, sodium montmorillonite, Wyoming bentonite, and montmorillonite. The pH must be between 8.3 and 9.1. It must have the following ingredient percentages:

Silica	61.4%
Aluminum	18.1%
Iron	3.5%
Sodium	2.3%
Magnesium	1.7%
Calcium	0.04%
Other	12.96%

c. Stage No. 1 Test (Wet Mud) for Hand Guns and Shoulder Weapons.

(1) Clean and lubricate three test weapons and close the muzzles with tape. Load three magazines for each weapon, place the safety switch in the "Safe" position, insert one of the loaded magazines and charge the weapon. Since the weapon is ready to fire, **extreme caution must be taken to assure that the safety switch is not accidentally disengaged and that the weapon is always pointed in a safe direction.**

(2) Fully immerse the first weapon, in a horizontal orientation, in the mud bath for a period of 1 minute. Remove the weapon from the mud bath, wipe it with bare hands to remove excess mud, remove the tape from the muzzle, disengage the safety switch, and fire the rounds in the magazine (fire in the semi-automatic mode, or if possible, fire in short bursts of three to five rounds). Note: The predominant malfunction encountered in this test is that the bolt cannot be retracted or closed by hand or by gun action without considerable effort. In most instances, it will be necessary to strike the bolt-retracting lever a sharp blow with the hand to open the action. If firing is unsatisfactory with the magazine assembled in the weapon, replace the magazine with the second, clean, magazine and continue firing.

(3) If firing with the clean magazine is unsatisfactory, open the weapon's bolt, dust cover, etc. and attempt to wash out the mud by pouring 1 l (approximately 1 qt) of clean water over and into the receiver. Assure that any water has been drained from the weapon bore and attempt to fire the third, clean, magazine.

(4) If firing continues to be unsatisfactory, perform a field stripping operation, with parts hand-wiped with a cloth, to determine whether the weapon can be returned to a serviceable condition in the field.

(5) Repeat the above procedure for the remaining two weapons.

d. Stage No. 1 Test (Wet Mud) for Machine Guns and Automatic Weapons.

(1) Clean and lubricate three test weapons. Tape the muzzle of one weapon shut, fully load the weapon, and place the safety in the "On" position. If the weapon uses linked ammunition, prepare a 50-round belt and assemble it to the weapon in the same configuration as for combat (in the magazine, bandolier, etc. attached to the weapon in accordance with applicable documents). If the weapon utilizes magazines of less than 50-round capacity, use a sufficient number of magazines to total 50 rounds. Since the weapon is ready to fire, **extreme caution must be taken to assure that the safety switch is not accidentally disengaged and**

that the weapon is always pointed in a safe direction. Completely immerse the weapon (and 50-round belt of ammunition or loaded magazine and mount if applicable) in the mud bath in a horizontal position for one minute.

(2) After removing the gun from the mud, remove the tape from the muzzle. Without opening the weapon cover or breech, attempt to clean the weapon and ammunition by wiping with bare hands, blowing on congested areas, and jarring the weapon and ammunition.

(3) Attempt to fire 50 rounds in a continuous burst. If the weapon fails to function satisfactorily, open the cover and perform additional cleaning, by wiping with bare hands, blowing on congested areas, and jarring the weapon and ammunition. If the weapon still fails to function, attempt to fire using a clean belt of ammunition (or magazine when applicable).

(4) If firing with clean ammunition is unsatisfactory, open the weapons feed cover, dust cover, etc., retract the bolt, and attempt to wash out the mud by pouring 1 l (approximately 1 qt) of clean water over and into the receiver. Assure that any water has been drained from the weapon bore and again attempt to fire 50 rounds of clean ammunition.

(5) If firing continues to be unsatisfactory, perform a field stripping operation, with parts hand-wiped with a cloth, to determine whether the weapon can be returned to a serviceable condition in the field.

(6) Repeat the above procedure for the remaining two weapons.

e. Stage No. 2 Mud Test (Dry Mud). Conduct this test in a manner identical to that of the stage No. 1 mud test, except that the weapons and ammunition are permitted to dry, without any wiping or cleaning, for at least 4 hours after being removed from the mud bath.

f. Data Required. Record the following:

(1) Number of rounds fired.

(2) Malfunctions in accordance with paragraph 5.

(3) Number of attempts to overcome each malfunction.

(4) Maintenance actions performed.

(5) Difficulties encountered in the operation of safety switches, charging the weapon, magazine insertion and removal, etc.

4.5.6 Immersion Tests.

a. Fresh Water Immersion Test.

(1) Background. This test determines the effects of fresh-water immersion to a depth of 1 m on weapon performance.

(2) Method. Testing will be performed in accordance with MIL-STD-810G CN1, Test Method 512.6, Procedure 1, and TOP 04-2-016, paragraph 4.6.4 (Waterproofness, Shallow Submersion).

(a) Clean and lubricate three test weapons in accordance with the maintenance manuals. The weapons will not be over lubricated to discourage corrosive buildup. Weapons with adjustable gas systems will be initially set on minimum but will be adjusted to maximum if necessary to sustain weapon functioning.

(b) The test items will be conditioned to 10 °C above the temperature of the fresh water bath, then submerged to a depth of 1 m for 30 minutes.

(c) The test items will be removed and inspected for evidence of adverse effects.

(d) The weapons will be function fired.

b. Salt Water Immersion Test.

(1) Background. This test determines the effects of salt-water immersion on weapon performance. Small arms are exposed to salt-water immersion both for deliberate operations (such as fording) and incidental occasions such as transportation in watercraft. The test consists of a single immersion followed by firings over a period of 10 days; the number of immersions and test duration may be tailored to correspond to requirements documents, test plans, etc.

(2) Method.

(a) Prepare a salt-water solution of 5-percent sodium chloride and 95-percent water by weight. The sodium chloride must not contain more than 0.1-percent sodium iodide and 0.2 percent other impurities. See MIL-STD-810G CN1, Method 512.6, Procedure I for detailed instructions on the preparation of the solution.

(b) Clean and lubricate three test weapons in accordance with the maintenance manuals. The weapons will not be over lubricated to discourage corrosive buildup. Weapons with adjustable gas systems will be initially set on minimum but will be adjusted to maximum if necessary to sustain weapon functioning.

(3) Hand and Shoulder Weapons. Temperature condition the three test weapons and the salt-water solution to within 10 °C of each other. Immerse the weapon in the salt-water solution for 1 minute. The solution must cover the test items completely.

1 Remove the test item, and drain all salt water from the bore by depressing the weapon muzzle and slightly retracting the bolt to allow the salt water to drain from it (salt water is similarly drained from the bore of a weapon that fires from the open-bolt position but without

disturbing the bolt). Immediately store the weapons in a high humidity chamber (at least 90 percent RH) for a period of 10 days.

2 On days 3, 5, 8, and 10, fire 240 rounds per weapon using the firing cycles established in paragraph 4.3, Reliability and Durability, except that there is no maintenance performed during this test. Reloading and magazine changes should be done at a pace that can be comfortably maintained throughout the firings.

3 Weapons are not cleaned or maintained at the end of the 240-round firing cycle; they are placed back into the high humidity chamber until the next scheduled firing. No cleaning, wiping or maintenance of the weapons is permitted until after the test has been completed or until such time as they are rendered inoperable. Should this occur before 10 days, perform the minimum restorative maintenance necessary to return each weapon to operating condition, and continue testing to its normal conclusion. Store the weapons and ammunition in a high humidity environment (at least 90-percent RH) between firings.

4 Record all malfunctions in accordance with paragraph 5. Also, record any difficulties in operating the weapon such as difficult magazine insertion/removal, excessive force required to charge the weapon, inability to operate firing selectors, etc.

(4) Machine Guns. Machine guns are tested in the same manner as hand and shoulder weapons using their firing cycles as established in paragraph 4.3, Reliability and Durability, except that there is no maintenance performed during this test. Fire a 200-round cycle from each weapon on days 3, 5, 8 and 10. Cyclic rate will be recorded for each 50-round burst.

(5) Final Inspection. The test weapons will be disassembled and thoroughly inspected after the final firing (or when they become inoperable). All exterior and interior parts must be inspected for indications of corrosion or deterioration. Record any difficulties encountered in disassembly and any unusual cleaning requirements.

(6) Data Required. Record the following:

(a) Records to substantiate proper exposure.

(b) Malfunctions in accordance with paragraph 5.

(c) Any damage noted during inspection.

(d) All maintenance actions performed.

(e) Difficulties encountered in operating the weapons.

(f) Cyclic ROF for machine gun bursts.

(g) Photographs of corrosion, damage, etc.

c. Deep Water Immersion. Some operations may require that small arms be subjected to deep-water submersion prior to their use. The depth of submersion will be stated in the requirements documents or will be available from the materiel developer.

(1) Using the water depth of 66 ft (Performance Specification for MK20 MOD 0 Sniper Support Rifle (SSR))[14] and the following relevant depth/pressure equation from MIL-STD-810G CN 1, Method 512.6, Paragraph 2.3.2.3.a:

$$P = 9.8d \text{ (fresh water)}$$
$$P = 10.045d \text{ (salt water)}$$

Where:

d = depth of the water in meters
P = pressure in kPa (1 psi = 6.895 kPa)

Therefore:

P = 197 psi (fresh water)
P = 202 psi (salt water)

(2) A natural body of water may also be used by lowering the test item to the required depth. The item should be submerged for 1 hour, recovered, and fired as soon as possible thereafter to evaluate its ability to function properly.

d. Surf Zone.

(1) Background. This test determines the combined effects of fresh water immersion and wave driven near shore debris on the functional performance and safety of the weapons.

(2) Method.

(a) Three test weapons will be cleaned and lubricated and five rounds will be fired on each sample as a function check.

(b) The weapons (full magazine loaded, first round chambered, muzzle capped/taped, and safety in “ON” position) and a sufficient number of spare magazines, will be stored, top down, in standard issued magazine pouches, and will be positioned to a depth of approximately 1 ± 0.1 m (3.3 ± 0.3 ft) near the shore of the wave generation facility or natural shoreline. Test items will be positioned horizontally, with the centerline of the bore approximately 30 cm (11.8 in.) off the bottom, on a wire rack. The wave generator facility will be adjusted to provide approximately 0.6-m (2-ft) waves at a rate of approximately 15 per minute.

(c) The test cycle will be continued for a duration of 2 hours. After conditioning, the weapon will be removed from the water, the muzzle uncapped and angled downward at an angle of 45 ± 5 degrees to allow the water to drain from the bore and all exposed ammunition fired from the magazines.

(d) If firing is unsatisfactory with the magazine assembled in the weapon, an attempt will be made to fire an unexposed magazine.

(3) Data Required. Record the following:

(a) Number of rounds fired.

(b) Malfunctions in accordance with paragraph 5.

(c) All maintenance actions performed.

(d) Difficulties encountered in operating the weapons.

(e) Immersion duration.

(f) Water temperature, surface and depth.

(g) Air temperature.

(h) Wave height and frequency.

4.5.7 Salt Fog.

a. Background. This test determines the effects of a salt fog on weapon performance. Small arms are exposed to high levels of salt in the atmosphere during costal operations, marine transport, and operations near salt lakes and salt deserts. The test consists of 24-hour exposures to the salt fog environment alternated with 24-hour drying periods. The standard procedure uses two 24-hour exposures and two 24-hour drying periods for a total of 48 hours of exposure to the salt-fog and 48 hours of drying; this test duration may be tailored to correspond to requirements documents, test plans, etc. The number of rounds fired may also be tailored for the specific type of weapon under test, or to comply with requirements documents.

b. Method.

(1) Prepare test chamber and salt-water solution in accordance with MIL-STD-810G CN1, Method 509.6.

(2) Clean and lubricate three test weapons in accordance with the maintenance manuals. The weapons will not be over lubricated to discourage corrosive buildup. Weapons with adjustable gas systems will be initially set on minimum but will be adjusted to maximum if necessary to sustain weapon functioning.

(3) Hand and Shoulder Weapons. Temperature condition three test weapons at 35 °C (95 °F) for at least 2 hours. Reserve a minimum of 720 rounds of ammunition (240 rounds per weapon).

(a) Charge the weapons so that the bolt is closed on an empty chamber and place their safeties in the "On" position. Install an empty magazine and close all dust covers. Then place the weapons into the salt fog test chamber.

(b) Operate the chamber for 24-hours as detailed in MIL-STD-810G CN1, Method 509.6.

(c) After the 24-hour exposure, remove the test items, and drain any accumulated liquid from the bores by depressing the weapon muzzle and slightly retracting the bolt to allow the liquid to drain from it (liquid is similarly drained from the bore of a weapon that fires from the open-bolt position but without disturbing the bolt.

(d) Store the weapons and any exposed ammunition for 24 hours at standard ambient conditions (25 ± 10 °C (77 ± 18 °F) and 20- to 80-percent RH). Disturb the items as little as possible and do not make any adjustments during the drying period.

(e) Repeat the 24-hour salt fog exposure and 24-hour drying period.

(f) After the last drying period, fire each weapon using the 240-round cycle established in paragraph 4.3, Reliability and Durability. Cleaning, wiping, or maintenance of the weapons is not permitted until after the test has been completed or until they are rendered inoperable. Should this occur before completion, perform the minimum restorative maintenance necessary to return each weapon to operating condition, and continue testing to its normal conclusion.

(g) Record all malfunctions in accordance with paragraph 5. Also record any difficulties in operating the weapon such as difficult magazine insertion/removal, excessive force required to charge the weapon, inability to operate firing selectors, etc.

(4) Machine Guns. Machine guns are tested in the same manner as hand and shoulder weapons except that each weapon fires 200 rounds (total 600 rounds) using the firing cycle established in paragraph 4.3, Reliability and Durability. Cyclic rates will be recorded for the 50 round bursts.

(5) Final Inspection. The test weapons will be disassembled and thoroughly inspected after the final firing (or when they become inoperable). All exterior and interior parts must be inspected for indications of corrosion or deterioration. Record any difficulties encountered in disassembly and any unusual cleaning requirements.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Malfunctions in accordance with paragraph 5.

(3) Any damage noted during inspection.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Cyclic ROF for machine gun bursts.

(7) Photographs of corrosion, damage, etc.

4.5.8 Icing.

a. Background. This subtest determines the operability of a weapon after exposure to icing produced by freezing rain or freezing drizzle. The test also provides for analyzing the effectiveness of expedient de-icing procedures by the weapon operator. The procedure generates icing for general conditions (see MIL-STD-810G CN1, Method 521.4); it does not reproduce the heavy loading found in marine operations or from long-term exposure to extreme environments.

CAUTION: The conduct of this test requires personnel to work on slippery surfaces in close proximity to loaded weapons, test mounts, and various obstructions; therefore, care must be taken to prevent slips and falls. A small amount of sand sprinkled on slippery floor surfaces has been found to be very useful for the prevention of such accidents.

b. Method.

(1) Disassemble, clean, lubricate the weapons, and reassemble at least three test weapons, and tape the muzzles closed. Outside surfaces of the weapons must be clean of any lubricant, dust, etc. not present during normal operation.

(2) Hand and shoulder weapons will be loaded with one full magazine with the safety in the “On” position and the bolt closed on an empty chamber. Belt-fed weapons will be loaded with a 50-round belt, the safety in the “On” position (if so equipped), with the belt engaged but with the chamber empty and the bolt closed, requiring charging to complete weapon loading. When belt-fed weapons are provided with a belt container attached to the weapon, the container will be used.

(3) The weapons (and ammunition) are placed in the test chamber and conditioned to a temperature of -18 ± 2 °C (0 ± 5 °F) for 6 hours.

(4) Raise the chamber temperature to -7 ± 2 °C (20 ± 5 °F) and subject the test items to a light spray of water until 3 to 6 mm (1/8- to 1/4-in.) of ice accumulates on the top surface of hand and shoulder weapons, including shoulder-fired machine guns, and 6 to 13 mm (1/4- to 1/2-in.) on other machine guns. If possible, use water precooled to near freezing, this will greatly reduce the time need to produce the ice buildup. A mist attachment for a hand-held garden hose is suitable for producing the ice accumulation.

(5) Remove the tape from the muzzles following exposure to icing. Do not immediately attempt to remove ice from the weapon or ammunition. Attempt to charge and fire

the weapon with the exposed ammunition. If functioning is unsatisfactory, attempt to clear the ice from the weapon and ammunition by striking with a gloved hand. If this does not restore operation, attempt to remove the ice with items likely to be readily available to a Soldier in an operational status (weapon cleaning equipment, bayonet, ammunition can lid, etc.). Attempt to fire the weapon with clean ammunition if icing of the ammunition appears to be preventing proper weapon operation.

(6) If the weapon cannot be charged to initiate firing, due to the ice accumulation on the weapon, repeat the test by fully loading each weapon before exposing to icing. Guns firing from a closed bolt are readied for icing by closing the bolt on a chambered round; guns firing from the open-bolt position are readied by leaving the chamber empty and the bolt in the seared position.

c. Data Required. Record the following:

(1) Test temperatures and times.

(2) Glaze accumulation.

(3) Number of rounds fired.

(4) Malfunctions in accordance with paragraph 5.

(5) Cleaning and maintenance performed to attain proper weapon performance.

(6) Photographs of ice accumulations, ice removing procedures, and tools used.

4.5.9 Solar Radiation.

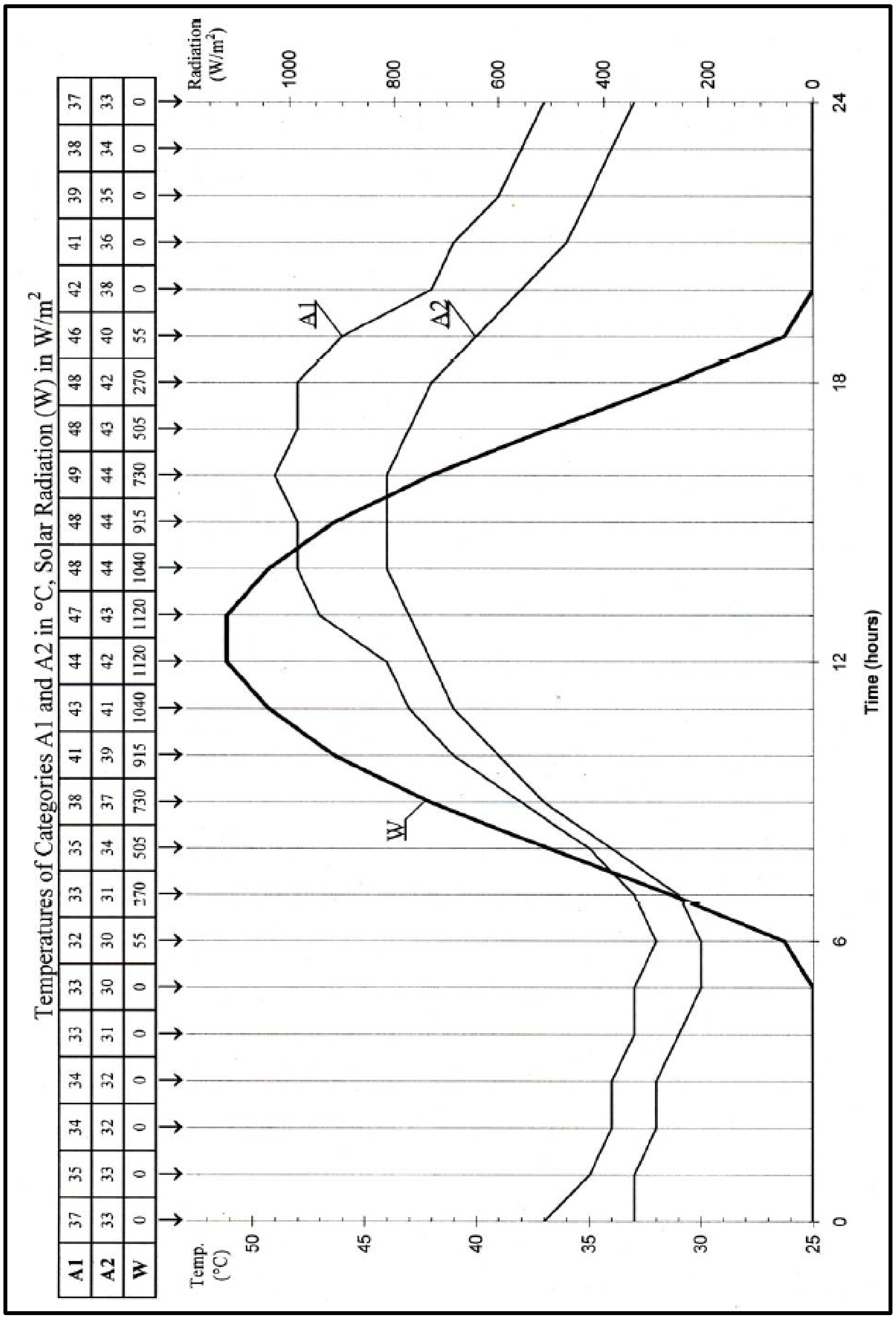
a. Background. Small arms weapons are exposed to solar radiation through all phases of their use. Adverse effects result from both thermal effects and actinic effects. Thermal effects can include differential expansion resulting in binding, or loosening, of moving parts and changes in strength and elasticity. Actinic effects can include deterioration of composites, paints, and surface compounds, and also changes in the characteristics of lubricants. This test is designed to determine the heat produced by solar radiation, and effects of that heat by exposing materiel to continuous 24-hour cycles of simulated solar radiation (or thermal loading) at realistic levels typical throughout the world.

b. Method.

(1) The test procedure is conducted in accordance with MIL-STD-810G CN1 Method 505.6, Procedure 1, Cycle A1.

(2) Subject the test weapons, spare barrels (if required), to the test environment without cleaning or adding lubricant. The test items will be exposed to continuous 24-hour cycles of controlled simulated solar radiation and temperature as indicated in Figure 2 (cycle A1)

or as identified in the requirements documents. A goal of this test is to establish the highest temperature that the test item will reach during repeated cycles. Perform at least three continuous cycles with a peak chamber air temperature of 49 °C (120 °F). If the maximum of the peak response temperature of the previous 24-hour cycle) is not reached (+ 2 °C (+ 3.6 °F)) during three cycles, continue the cycles until repeated peak temperatures are reached, or for seven cycles, whichever comes first.



A1	37	35	34	34	33	33	32	33	35	38	41	43	44	47	48	48	49	48	48	46	42	41	39	38	37
A2	33	33	32	32	31	30	30	31	34	37	39	41	42	43	44	44	44	43	42	40	38	36	35	34	33
W	0	0	0	0	0	0	55	270	505	730	915	1040	1120	1120	1040	915	730	505	270	55	0	0	0	0	0

Figure 2. Procedure I - Cycling Test.

(a) Place a single test weapon into the chamber (ammunition is not needed). The weapon should have temperature-recording sensors at locations likely to cause skin contact, such as the fore stock, carrying handle, buttstock, etc. Also instrument any other part of the weapon that may be sensitive to the solar heating. The weapon should be oriented in a stable position, usually lying on its side. Multiple weapons can be used if it is desirable to do exposures in more than one orientation.

(b) Operate the chamber as required by the specified procedure. Maintain a record of chamber conditions and test item temperatures.

(3) At the end of the solar radiation exposure, remove the weapons from the conditioning chamber and thoroughly inspect each one. Record any changes or damage to the test weapon. Do not perform any cleaning, re-lubrication, or maintenance. Fire a single firing cycle (as for the Reliability and Durability test, paragraph 4.3). If proper weapon performance is not evident, determine what maintenance actions are needed to restore the weapon to proper operation.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure chamber operation.

(2) Malfunctions in accordance with paragraph 5.

(3) Any damage noted during inspection.

(4) All maintenance actions performed.

(5) Cyclic ROF for machine gun bursts.

4.6 Chemical Compatibility.

4.6.1 Background.

Small arms weapons are exposed to a variety of chemical compounds during storage, cleaning and use. Some exposures are deliberate (such as decontamination efforts) and some are inadvertent (such as contact with insect repellent used by Soldiers).

4.6.2 Method.

a. The test procedure is conducted in accordance with TOP 03-2-609[15].

b. Test samples do not need to be complete weapons. Specimens can be cut from a single component; for example, a polymer buttstock can be cut into many samples. Components can also be salvaged from spare parts, damaged weapons, etc. TOP 03-2-609 gives detailed procedures for the selection and preparation of the test specimens.

c. Table 7, extracted from the TOP 03-2-609, lists the chemicals used for this test. Requirement documents, test plans, etc. should be reviewed for additional requirements.

TABLE 7. CONDITIONING CHEMICALS

CHEMICAL	NOMENCLATURE
1. Cleaning compound, solvent	MIL-L-372B Bore cleaner
2. Dry cleaning solvent	P-D-680, type I or equivalent (naphtha solvent)
3. Engine oil	MIL-L-2104
4. Lubricant, semi-fluid, automatic weapons	MIL-L-46000B (LSA)
5. Lubricating oil, general purpose	VV-L-800 (PL-S)
6. Lubricant, cleaner, and preservative	MIL-L-63460A (CLP)
7. Gasoline, commercial, or combat	ASTM D 910
8. Turbine fuel (JP-8)	MIL-T-83133
9. Fuel oil diesel (DL-2)	ASTM D 975 Grade Low Sulfur No. 2
10. Insect repellent	0-I-503E
11. Dexron III	Transmission fluid
12. Antifreeze, ethylene glycol	MIL-A-46153
13. Carbon-removing compound	P-C-111B, type II
14. Water	Water (distilled)
15. Simulated sea water or 5% Sodium chloride	ASTM D1141
16. Decontaminating agent DS2	MIL-D-50030
17. Decontaminating agent STB	MIL-D-12468
18. Lubricating oil, weapons	MIL-L-14107 (LAW)
19. Hydraulic fluid, petroleum base	MIL-H-5606
20. Hydraulic fluid, fire-resistant	MIL-H-46170

4.6.3 Data Required.

Record the following for each sample tested:

a. Type of material tested.

b. Identification of the conditioning chemical.

c. Source of the material (weapon part nomenclature, weapon serial number, etc.).

d. Number of samples tested.

e. Conditioning time.

f. Air temperature and RH.

g. Weight and tensile strength changes, as appropriate.

h. Evidence of loss of gloss, developed texture, decomposition, discoloration, swelling clouding, tackiness, rubberiness, bubbling, cracking, delaminating, solubility, etc.

4.7 Signature Tests.

4.7.1 Flash.

a. Background. Flash is created by firing small arms weapons. The flash at the muzzle is usually the primary concern, but some weapons also emit a visible flash from the breech or from under the feed cover. Flash is undesirable because it can reveal a firing position to the enemy, interfere with the use of night vision devices, and cause the loss of night vision adaptation. The flash test is used to determine the flash characteristics of the weapon. There are two methods of flash testing - qualitative and quantitative.

b. Method. Qualitative.

(1) The qualitative flash test is performed as a comparison-type test in a dark environment. A test weapon is fired in alternate trials with a known standard weapon. The results will determine if the test weapon provides an increase or decrease in flash as compared to the standard weapon.

(2) Disassemble, clean, lubricate with prescribed substance, and reassemble two test weapons. Record the bore and chamber measurements. One weapon should be new and the other used, the latter being a weapon previously fired to approximate its service life. For machine guns with operator replaceable barrels, use a single weapon with two barrels, one new and one near the end of its serviceable life.

(3) Fabricate a reference flash scale and mount the scale parallel to the barrel at the muzzle of the test weapon. The scale can be of any design, such as alternating black and white squares painted on plywood, that will allow the measurement of muzzle flash when illuminated by the flash produced by firing the weapon.

(4) Mount a video camera perpendicular to the muzzle of the test weapon at a distance that will photograph all of the flash and the reference scale. Position a second video camera behind the weapon in line with the weapon sights so as to photograph the flash as would be seen by the firer.

(5) Fire three rounds to condition the barrel, then photograph the weapon flash under completely darkened conditions. For hand and shoulder weapons, photograph both a single shot and a ten-round series fired as rapidly as possible. For machine guns, fire a three-round burst and a 20-round burst. Some experimentation may be necessary to determine camera settings, camera positions, and rounds fired needed to produce a useable video image.

(6) Replace the test weapon with the standard weapon and repeat the firings exactly as was done for the test weapon.

(7) Repeat the firings with different types of ammunition, if required.

(8) Data Required. The following data are required:

(a) Description of test set up.

(b) Identification of the type of cameras, settings, etc.

(c) Chamber and bore measurements of the weapons.

(d) Digital images of the flash produced by the test and standard weapons.

c. Method. Quantitative.

(1) The quantitative flash test is performed to provide light intensity and flash duration.

(2) For this test two single-lens reflex (SLR) cameras and one optometer will be used. One camera will be positioned at the rear of the weapon to capture the flash at the gunner's position. The second camera and the light sensor will be placed perpendicular to the muzzle. The light sensor is not required by the TOP, but is being used in addition to the camera to determine the intensity and duration of the flash. A photograph of a reference scale (checkerboard) will be taken from both positions to allow measurement to be made in real world units. The cameras are triggered by the gunner and when the rounds are fired. The optometer is triggered internally using pre-triggering to capture the flash event.

(3) Each test scenario results in two photographs and a time history of the flash. The photographs are processed using National Instruments Vision Assistant[***] to determine the size (mm^2) and relative intensity (0-255) (peak value from the luminance plane) of each flash. The photographic intensity values can only be compared to photographs from the same camera taken during the same time period, but they do provide a quantitative value for comparison. The peak intensity (lx) and duration (ms) of each flash is taken from the optometer data.

(4) Three rounds will be fired to condition the barrel, and then the flash produced by the ammunition will be imaged under completely darkened conditions.

(5) Data Required. Record the following:

(a) Description of test set up.

(b) Identification of the type of cameras, settings, etc.

*** The use of brand names does not constitute endorsement by the Army or any other agency of the Federal Government, nor does it imply that it is best suited for its intended application.

(c) Identification of the test and standard weapons.

(d) Type of ammunition fired.

(e) Photographs of the flash produced by the test and standard weapon.

(f) Time and peak intensity values from optometer.

4.7.2 Noise.

a. Background. Small arms typically produce a high noise level when fired. The noise level may be hazardous to the shooter and to nearby personnel. The noise is also a factor in position disclosure and communications.

b. Method.

(1) This test is conducted in general accordance with TOP 01-2-608A[16]. Additional information for instrumentation specifications and calibration is given in MIL-STD-1474E[17], this document also details the analysis procedures and noise limit standards for Army materiel. Collected data should be coordinated with the Army Public Health Center (Provisional) (APHC) as part of an overall Health Hazard Assessment.

(2) Mount one test weapon so that the weapon muzzle is 1.6 m (5 ft, 3-in.) above ground level. The test stand should hold the weapon so that all parts of the stand are behind the weapon and no part of the stand is interposed between the muzzle and the microphone positions noted below.

(3) The test stand must be in a level open area with no sound reflecting surfaces within 15 m (49 ft) of the weapon.

(4) Place instrumentation microphones at a height of 1.6 m at the locations specified by the test plan or requirements documents. At a minimum, use four microphones, one at each of the following positions:

(a) Shooter's left ear position (assuming a right-handed shooter).

(b) 5 m (16.4 ft) directly to the rear of the weapon.

(c) 5 m to the left and parallel to the weapon muzzle.

(d) 5 m to the left rear at 45 degrees from the LOF.

(5) Additional microphones may be needed at specific locations such as crewmember locations.

(6) Fire five single shots and record the sound pressure levels versus time at each of the microphones.

c. Data Required. Record the following:

(1) Identification of the specific weapon and ammunition.

(2) Meteorological data (temperature, humidity barometric pressure, wind direction and speed).

(3) Peak pressure levels.

(4) A-Duration (pressure wave duration).

(5) B-Duration (pressure envelope duration).

d. Additional factors for consideration in noise testing for the APHC:

(1) Positions. All three positions are used for each program (as appropriate according to the "Use Scenarios" for the weapon system in question). Heights are: 1.6-m (5.25-ft) standing, 0.8-m (2.62-ft) kneeling, and 0.3-m (0.98-ft) prone.

(2) Temperatures: All three temperatures are used for each program. Combat systems: -51 to 71.1 °C (-60 to 160 °F). Training systems: -31.6 to 51.6 °C (-25 to 125 °F). Ambient temperature is whatever it is that day ("range ambient").

(3) Comparison with Live Round: Not required by APHC.

(4) Burst Firing: No need to fire burst mode if the durations are short enough and the shots are far enough apart in burst mode that each shot can be characterized as a distinct peak during burst firing. APHC will look into being able to predict this using a comparison of the A-duration and the distance between the peaks (determined by the weapon's ROF).

(5) Downrange Microphone: 15 degrees offset is fine. Use this for all training ammunition. This is not required for suppressed systems but this should be used as a measure of suppressor performance.

(6) 15-m Microphone: Ideally, there should be a microphone outside the 140 dB contour and one inside. However, data can be extrapolated from a close microphone out further but not the other direction. 15 m may be better than 5 m except in quiet systems. Use for downrange microphone as well.

(7) A digitized waveform from the transducer at the shooter and any other nearby crewed position should be provided with the other information. Analysis of other metrics, such as A-weighted Equivalent Continuous Sound Level (Leq) may be necessary.

4.8 Rough Handling Tests.

These tests are designed to simulate the rough handling experienced by small arms in use by an individual Soldier. Tactical transportation is represented by a loose cargo test to simulate carrying an unpackaged or unsecured weapon in a vehicle. The test includes a 1.5-m (5 ft) drop to represent accidentally dropping the weapon during combat or during mounting/dismounting operations. Rough handling of materiel used to mount or support the weapon during operations (attached bipods, tripods, etc.) is simulated by a series of drops. These tests are likely to damage the test items; therefore, they should be done near the end of the overall test sequence.

CAUTION: These tests are conducted with a primed but otherwise empty cartridge case. Eye protection must be provided for protection from the possible firing of the primer.

4.8.1 Loose Cargo.

a. Use three serviceable weapons for this test. Load each weapon with a primed but otherwise empty cartridge case to analyze the possibility of accidental firing. Place the safety switch in the “Safe” position.

b. Conduct the loose cargo test in accordance with ITOP 04-2-602[18]. Operate the test machine for 20 minutes at a 25-mm peak circular motion at a frequency of 5 Hertz (Hz). Divide the 20 minutes of exposure equally among the stable positions of the specific weapon under test; typically, this is 10 minutes left hand side down and 10 minutes right hand side down.

c. Inspect the weapons after the loose cargo test. Ascertain the position of the safety switch and check to see if the primed cartridge case has fired. Record all damages and all maintenance required. Conduct a firing test if the serviceability of the weapons is questionable.

4.8.2 1.5 Meter (5 Feet) Drop.

a. Use three serviceable weapons for this test. Load each weapon with a primed but otherwise empty cartridge case to analyze the possibility of accidental firing. Place the safety switch in the “Safe” position.

b. Drop each weapon one time in each of the following orientations:

(1) Major axis horizontal (normal firing orientation).

(2) Major axis vertical, butt down.

(3) Major axis vertical, muzzle down.

(4) Major axis 45 degrees from vertical, butt down.

(5) Major axis 45 degrees from vertical, muzzle down.

c. Drop the weapons onto a clean, level, concrete surface. They may be dropped by a mechanical means or by manually releasing them in the required orientation. Verify the proper impact orientation by video recording (preferred), or by careful visual observation, or photographic records.

d. Inspect the weapons after each drop. Ascertain the position of the safety switch and check to see if the primed cartridge case has fired. Record all damages and all maintenance required. Conduct a firing test if the serviceability of the weapons is questionable.

e. When performing the drop test for a safety release of a test item - follow the above procedures at the beginning of testing, except the weapon is dropped once in one to two of the orientations and a protective pad is placed over the concrete surface to prevent weapon damage.

4.8.3 Mount Test.

a. Use three serviceable weapons for this test. Load each weapon with a primed but otherwise empty cartridge case to analyze the possibility of accidental firing. Place the safety switch in the Safe position. Set and lock all legs on each mount in the open position; attach the weapon to the mount in the same manner as if it were to be immediately employed.

b. Drop each mount, with the weapon attached, straight down from a 0.9-m (3-ft) height to land on firm sod. Do the drops so that the mount impacts equally on all ground-seating points. Repeat the procedure for a total of three drops on each of three test items.

c. Inspect the weapons and mounts after each drop. Ascertain the position of the safety switch and check to see if the primed cartridge case has fired. Record all damages and all maintenance required. Conduct a firing test if the serviceability of the weapons or mounts is questionable.

4.8.4 Data Required.

Record the following:

a. Records of the position of the safety switch and the condition of the primed cartridge case.

b. Records and photographs of damages.

c. Maintenance records.

d. Results of firing tests, if any.

4.9 Attitudes Test.

4.9.1 Background.

Operational conditions often require that small arms weapons be fired in various orientations. In particular, operations in urban terrain may require that a Soldier fire his weapon at extreme elevations and unusual positions. This test is designed to determine the basic functioning and reliability performance of small arms when fired in various likely orientations and attitudes.

CAUTION: The firing site should be equipped to prevent ricochets while firing in depression. A physical barrier must be employed between the shooter and weapon if hand and shoulder weapons are fired in depression while being hand-held. Range safety fans and air space requirements may need to be modified due to the extreme firing elevations.

4.9.2 Method.

a. Clean and lubricate three test weapons.

b. Weapons should be mounted to a mechanical mount that will allow them to be fired in the six orientations shown in Table 8. Hand and shoulder weapons may be fired hand-held, but precautions must be taken to assure the safety of the shooter, particularly for firing in depression. If firing is done hand-held, the shooter must be provided with the means to assure achievement of the proper weapon elevations and orientations. The shooter must consider body posture and grip to maintain weapon control and allow adequate resistance to recoil and to accommodate proper weapon function. A simple platform or brace may be needed to allow better weight management and recoil control.

TABLE 8. TEST SEQUENCES FOR ATTITUDE TESTS

WEAPON ELEVATION	WEAPON ORIENTATION
0°	Normal
0°	Upside down
0°	Right side up
0°	Left side up
Maximum depression[a]	Normal
Maximum elevation[b]	Normal

[a] Maximum depression is -80 to -85°.
[b] Maximum elevation is 80 to 85°.

c. Hand and Shoulder Weapons.

(1) Fire 120 rounds at each of the six orientations.

(2) For weapons capable of only single-shot or semiautomatic operation, fire at a regular cadence of approximately one shot per second for semiautomatic or one shot per 5 seconds for single-shot weapons.

(3) For weapons capable of both semiautomatic and full automatic fire, fire the first half of each 120-round cycle (adjust round count to the nearest full magazine) in the semiautomatic mode at a rate of approximately one shot per second, and fire the second half in bursts of 3 to 5 shots at a rate of approximately 85 spm.

(4) Weapons with only full automatic fire capability are fired in three- to five-round bursts at a rate of approximately 85 spm.

d. Machine Guns. Machine guns are tested in the same manner as hand and shoulder weapons except that the firing cycle consists of 200 rounds. The first 100 rounds are fired in five- to seven-round bursts at a rate of approximately 85 spm. The remaining 100 rounds are fired in two bursts of 50 rounds each. Cyclic rates will be recorded for the 50-round bursts.

4.9.3 Data Required.

Record the following:

a. Number of rounds fired.

b. Weapon orientation and elevation.

c. Malfunctions in accordance with paragraph 5

d. Cyclic ROF.

e. Photographs of the test set up and firing procedures.

4.10 Belt Pull Capacity.

4.10.1 Background.

Belt fed weapons must be able to pull the ammunition with enough force to overcome the weight of the belt and any drag associated with a particular mounting geometry and hardware. This test should be done early in the test sequence to assure that proposed test mounts, or proposed operational mounts, will be compatible with the weapon.

CAUTION: The nature of this test may cause the weapon to stall part way through the loading cycle. A release of tension from the ammunition belt or antisurge spring may cause the weapon to fire unexpectedly.

4.10.2 Method.

a. Clean and lubricate one weapon and mount it to an unyielding test mount. Determine the maximum belt pull for left- and right-hand feeding of machine guns and automatic weapons (if alternate feed is provided) by using a 10-round belt of ammunition and three dummy rounds.

Attach a cable to the third dummy round and use an antisurge spring between the other end of the cable and a transducer (load cell) which is fixed to a rigid mounting point.

b. Base the selection of the antisurge spring(s) on historical characteristics of weapons similar to the test weapon. The spring must be long enough to permit gradual load application leading ultimately to stalling of the weapon due to excessive belt load. The rate of the spring(s) before being deflected is less than the belt pull capacity of the weapon, and when stressed, is greater than the capacity of the weapon without exceeding the elastic limit of the spring(s). Some experimentation may be necessary to determine suitable antisurge springs and transducers.

c. Use a low-friction ammunition guide tray to support the ammunition. The tray (or feed chute if required) is open at the top so that the rounds are not restricted in upward motion. The sides of the tray or feed chuting should fit the rounds closely enough to limit the motion of the rounds along their longitudinal axis.

d. Fire the weapon in a continuous burst until it stops. Record the load cell output continuously and convert the raw data to force.

e. An alternate procedure, required in some weapon specifications, utilizes a weight on the end of the belt that the weapon must be capable of lifting. The details of what weight to use, distance to be lifted, number of rounds in the belt, etc., must be determined from the specific weapon specification.

f. Repeat the procedure three times (more trials may be necessary if results are erratic).

g. Repeat the test using the alternate feed direction for weapons so designed.

4.10.3 Data Required.

Record the following:

a. Continuous time versus force on the transducer and maximum force attained.

b. Photographs of the test set up.

c. Identification of the ammunition.

d. Records of unusual requirements needed to clear the weapon after it has stalled.

e. Records of all maintenance actions performed.

4.11 Blocked Barrel.

4.11.1 Background.

This test is performed to determine the danger to personnel and the damage to a weapon resulting from firing the weapon with an obstructed bore. The three types of obstruction detailed below are considered to be the most likely to be encountered by Soldiers in combat; other possibilities may apply to specific weapons or unusual operational conditions.

CAUTION: These tests may result in the catastrophic destruction of the weapon. Failure modes may include burst barrels or failure of the locking mechanisms. Debris and fragmentation may be projected in any direction. Firings must be performed remotely with suitable safety barricades to protect personnel and property.

4.11.2 Method.

a. Test Set Up.

(1) The test weapon must be fired remotely due to the possibility of catastrophic weapon failure.

(2) Witness screens must be placed around the weapon to determine if any debris is projected toward the shooters position or toward nearby personnel. The witness screens may be of any convenient material; chipboard and corrugated cardboard are acceptable. The screens are arraigned to box in the area behind the muzzle at a distance of 1 m from any point of the weapon. The screens should be 2 m high, centered on the plane of the weapon.

(3) Each test requires a single round of ammunition. Use the type of cartridge most likely to be employed in combat.

(4) The weapon must be thoroughly inspected after each shot. The weapon must be inspected by NDT before its use in any subsequent firings.

b. Muzzle Obstruction.

(1) This test simulates the blockage of a barrel resulting from inadvertently thrusting the muzzle into mud, slush, etc.

(2) Pack heavy grease (such as the type described in Military Performance Specification (MIL-PRF)-23827C[19]) into the muzzle of the weapon to a depth of 50 mm (2-in.). Check the depth by inserting a marked probe or cleaning rod into the breech of the barrel and adjust accordingly. It may be necessary to remove and replace the flash suppressor to facilitate the procedure.

(3) Place the weapon in the mount, load a single round of ammunition, and fire the weapon remotely.

(4) Inspect the weapon for external and internal damage, this may require complete disassembly.

(5) Inspect the witness screens and record the location and size of any fragment impacts or holes.

(6) Inspect the fired cartridge case for evidence of overpressure, blown primer, rupture, etc.

c. Water Filled Bore.

(1) Perform this test in the same manner as the muzzle obstruction test except that the bore is filled with water and the mount must hold the weapon at a slight elevation to prevent the water from draining from the bore.

(2) Some experimentation may be required to find a safe and effective way to fill the bore with water. One method is to completely submerge the weapon in water with the bolt open and the muzzle slightly elevated. Once the bore fills with water, keep the weapon submerged and load and lock one round in the chamber. Keep the loaded weapon slightly elevated while moving it to the mount and fire it as quickly as is safely possible. An alternate method is to seal the muzzle with tape or a plastic cap, fill the bore from the breech, load one round while keeping the weapon in depression, and fire as quickly as safely possible.

d. Bullet Obstruction.

(1) Perform this test in the same manner as the muzzle obstruction test except that the obstruction is a bullet just forward of the chamber.

(2) Place a bullet, of the same type as used by the cartridge being fired, into the weapon chamber. Force the bullet forward so that its base will just touch the tip of the bullet of a live cartridge after the breech has been locked. Load the live round and fire the weapon.

4.11.3 Data Required.

Record the following:

a. Photographs of the test set up.

b. Records and photographs of damage sustained by the weapons.

c. Measurements and photographs of impacts on the witness screens.

d. Results of weapon inspections, including NDT.

e. Maintenance requirements to return the weapons to serviceability, if possible.

4.12 Barrel Performance.

4.12.1 Background.

a. Barrel performance of machine guns and automatic weapons is of a concern from both a logistical and operational viewpoint. The receiver life of most automatic weapons is multiples of the barrel life. The user needs barrel performance information to determine operational requirements such as the need to carry spare barrels or how many to have readily available. The logistician needs the information to plan for stockage levels and manufacturing capabilities.

b. Barrel performance data testing can often be combined with the Reliability and Durability test, paragraph 4.3. However, a separate barrel performance test may be required for specific firing schedules such as for overhead fire applications or training scenarios. Testing of barrel performance may also be required to analyze changes in the design of the barrels. Data from barrel performance testing is also used to develop barrel wear gauges.

c. The nature of this test requires firing an unusually large number of rounds per day. Personnel should be provided with suitable PPE such as heavy gloves and attire for protection from hot gun barrels and expended cartridge cases. The large number of rounds fired may also increase weapon combustion products to levels above those more typically encountered. Since weapon barrels are fired to, or past, the limits of serviceability, personnel must consider the possibility of erratic bullet flight and deviations from the established LOF.

4.12.2 Method.

a. Thoroughly inspect the test barrel(s). Record the bore dimensions at 25 mm (1-in.) intervals for the entire length of the barrel. Inspect the bore with a borescope; photograph or make video recordings of any defects, discontinuities, or areas of concern. Determine the chamber dimensions by chamber casts. If possible, check the inspection results for compliance with barrel drawings and specifications.

b. Determine the specific firing schedule to be used for the test. The firing schedule may be specified in the requirements documents or may be determined by the user, usually based on a tactical situation. Use the firing cycles detailed in the Reliability and Durability test, paragraph 4.3, if no other information is available. All planned test schedules should be conducted with one lot of ammunition. If additional ammunition lots are required, they should be of the same DODIC and CC as the first lot.

c. Initiate the test by firing three targets (one 10-round burst per target). Muzzle velocities and cyclic rates are recorded for each burst. The targets should be set at 100 m from the weapon, unless otherwise specified. Targets must be capable of recording the X and Y coordinates of the bullet impacts and must facilitate inspection of the impacts to determine bullet yaw. A common technique is to determine X and Y coordinates with an electronic target and to determine bullet yaw with a paper target placed in the LOF at 25 m.

d. Fire the barrels using the predetermined firing schedule. Repeat the barrel inspections and target firings at 2,000-round intervals unless otherwise specified.

e. Terminate the test when the barrels become unserviceable or when a predetermined round count is reached. Use the following criteria to determine unserviceability if no other information is available:

(1) A barrel wear gauge designed for the specific barrel under test indicates that the barrel is unserviceable.

(2) Twenty percent or more of rounds fired at the targets, or 20 percent of any group of rounds or more, exhibit yaw of 15 degrees or more.

(3) The mean velocity of any 30 consecutive rounds drops 6 percent or more below the mean velocity of the first 30 rounds fired.

(4) The average dispersion of three consecutive 10-round targets is double that of the initial three targets.

f. Degradation happens very rapidly near the end of the barrel life; therefore, the 2,000-round inspection interval should be reduced if it is evident that the barrel is near the end of its life. Test personnel must always be alert for indications of imminent barrel failure. These indications may include an increase in muzzle flash, erratic flight of bullets, an increase in the malfunction rate, or any other significant change in weapon performance.

g. Firing schedule interruptions during barrel performance tests must be avoided in order to produce the best quality data. Therefore, weapons must be maintained to a high standard. Inspect the ammunition prior to starting each firing cycle to assure its proper condition. Also, periodically inspect weapon mounts and instrumentation.

4.12.3 Data Required.

Record the following:

a. Barrel bore measurements.

b. Chamber dimensions.

c. Details of the firing cycle.

d. Identification of the ammunition.

e. Velocities and cyclic rates from the target firings.

f. Target dispersion statistics.

g. Target yaw measurements.

h. Weapon maintenance actions.

i. Weapon stoppages and malfunctions in accordance with paragraph 5.

j. Observations of any adverse weapon effects due to the firing schedule.

4.13 Toxic Fumes.

4.13.1 Background.

a. Small arms weapons emit weapon combustion products/toxic fumes when they are fired. These products can degrade human performance, adversely affect short-term and long-term health, and can be lethal.

b. Small arms weapon firings can produce a variety of gases. The most common gases of interest include ammonia (NH_3), carbon dioxide (CO_2), carbon monoxide (CO), hydrogen cyanide (HCN), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Primers, propellants, bullets, and/or casings may generate metallic fumes. Sample planning shall be coordinated with the APHC as part of an overall Health Hazard Assessment.

4.13.2 Method.

a. TOP 02-2-614[20], Toxic Hazards Test for Vehicles and Other Equipment, contains detailed instructions for the selection of instrumentation, sampling procedures, and interpretation of results. Sample planning shall be coordinated with the APHC as part of an overall Health Hazard Assessment.

b. Weapon combustion product test data from open free-field firings are not normally beneficial due to the rapid dissipation of the gasses and the significant effects of even very light winds.

c. If the small arms under test are designed to be used in armored combat vehicles (ACV), they should be tested in accordance with TOP 02-2-614, paragraph 4.2. Coordinate specific firing schedules with the organization responsible for testing the ACV as well as with the APHC.

d. Small arms combustion product tests are conducted in an enclosed chamber for a variety of assessments. Objectives for conducting weapon combustion testing shall be clarified to each participating organization up front.

e. The enclosed chamber may contain some or all parts of the weapon, the weapon mount, a homogenizing fan to evenly disperse the air, and the sampling equipment. The chamber shall have the ability to be sealed to permit worst-case user environments from a combustion product standpoint. The enclosed chamber size or volume will affect the concentrations of combustion products. Therefore, it is essential that all objectives for collecting weapon combustion data are communicated and understood by each participating organization during the planning process.

f. Toxic gas concentrations are continuously monitored with state-of-the-art instrumentation. Analytes of interest may vary, but include NH_3, CO_2, CO, HCN, NO, NO_2, and SO_2.

g. Air samples are collected for metallic particulates during the firing scenarios. Conduct air sample and analysis in general accordance with the National Institute for Occupational Safety and Health (NIOSH) Method 7300[21], which includes using filter cassettes and collection analysis via collection inductively coupled atomic emission spectroscopy (ICP-AES).

h. If the sample plan includes metallic particulate sampling, then the possibility of particulate re-entrainment in range areas can obstruct test results. Collecting air samples in general accordance with NIOSH 7300 while simultaneously aggregating the surface areas inside of the chamber using pressurized air shall be conducted before the test to eliminate the possibility of particulate re-entrainment. If results detect any particulate during the background check, then the chamber must be cleaned and re-evaluated before testing the weapon.

i. Remotely fire all trials and scenarios for the test weapon and/or ammunition before changing the test parameters. Record the concentrations of gasses and continue sampling a minimum of 15 minutes. The total sample time required is dependent upon the criteria for each analyte.

j. Repeat each firing scenario for a minimum of three trials before changing any test scenarios. Carefully purge the chamber between trials and re-clean the weapon and chamber if necessary. Following each test, clean the interior surfaces of the chamber by vacuuming or lightly damp mopping to remove any firing residue. Remove spent cartridge cases, ammunition containers, etc. after each trial.

4.13.3 <u>Data Required</u>.

Record the following:

a. Concentrations and times for each precise data measurement and for each gas measured effluent gas measured.

b. Metallic particulate concentration levels as well as particulate size. Particulate matter can be collected as total dust or at various cut-point size(s).

c. Chamber dimensions.

d. Description and photographs of the weapon mounting.

e. Positions of sampling probes and the homogenizing fan.

f. Chamber temperature and RH.

g. Number of rounds fired in each trial.

h. Identification of the weapons and ammunition.

i. Time duration of each trial and time of day when it was fired.

4.14 Recoil Energy and Kinematics.

4.14.1 Background.

a. Firing a small arms weapon produces a rearward force that must be absorbed by the shooter or by the weapon mount. Excessive recoil can degrade training, injure the shooter, and damage weapon mounts.

b. A weapon kinematics study is often performed in conjunction with recoil measurements. The kinematics study relates the acceleration and speed of a weapon's moving parts to the weapons receiver. Such a study can clearly identify the effect of weapon modifications; for example, the effect upon bolt carrier displacement and velocity caused by changing the muzzle brake or adding a sound suppressor. A kinematics study is also a diagnostic tool to investigate weapon problems such as poor functioning with certain types of ammunition or high parts breakage rates.

4.14.2 Method.

a. The recoil energy of a weapon may be measured by firing from an appropriate test fixture and calculating the results. TOP 03-2-826A[22], gives detailed procedures for measuring recoil using five-wire and three-wire suspended pendulums. The TOP also provides the calculation methods to determine the recoil in terms of momentum and kinetic energy. Other facilities, such as a weapon cradle mounted on linear bearings, may also be used to measure recoil.

b. The test weapon should be in the lightest configuration in which it is likely to be employed. Magazine fed weapons should be tested with an empty magazine (other than the single round to be fired). Test the weapon both with and without muzzle devices, such as flash suppressors and muzzle compensators, if the items are designed to be operator removable. Use the ammunition that will give the greatest recoil; if there is any doubt repeat the test with other possible cartridge types.

c. Fire three trials with each weapon configuration. Calculate the recoil values in accordance with TOP 03-2-826. Results should indicate recoil energy in units of meter-kilograms (foot-pounds). Also, calculate recoil momentum in units of kilogram-seconds (pound-seconds).

d. TOP 03-2-826 also details the procedures for doing the kinematic study and the instrumentation and equipment required. Each test is unique. The test weapon may have to be modified so that the needed measurements can be made.

4.14.3 Data Required.

Record the following data:

a. Specific facility used.

b. Firing procedure.

c. Weapon configuration and weight.

d. Type of ammunition fired.

e. Calculated recoil energy and momentum.

f. Displacement and velocity versus time measurements.

4.15 Ammunition Compatibility.

4.15.1 Background.

a. Small arms weapons typically fire multiple types of cartridges. Cartridge types include combat ammunition, training ammunition, non-lethal ammunition, grenade launching cartridges, etc.

b. Weapons must function properly with all types of ammunition likely to be used; this ammunition may be identified in requirements documents, operator's manuals, etc. Any cartridge that can be loaded must be **safe to fire**, even if it is not designated for use in a specific weapon. Selection of the types of ammunition should be coordinated with the ATEC System Evaluator and Test Manager.

c. It is not generally feasible to repeat all the weapons tests with each possible type of ammunition. The test methods shown below determine the ability of the test weapon to function properly with a specific ammunition type under most conditions. The methods should be tailored if specific ammunition compatibility requirements are identified.

d. This test analyzes the weapon/ammunition interaction; it does not test the ammunition itself. Ammunition test procedures are given in TOP 04-2-016.

4.15.2 Method.

a. Functioning Compatibility, Ambient Temperature.

(1) Clean and lubricate three test weapons. The weapons must have demonstrated proper performance in previous tests.

(2) Follow the procedures of the Reliability and Durability test, paragraph 4.3.2 for each type of ammunition selected. For hand and shoulder weapons fire one 1,200-round cycle from each weapon. For machine guns, fire one 2,000-round cycle from each weapon.

(3) Thoroughly inspect each weapon. Pay particular attention to any unusual wear, deposits, or maintenance requirements.

b. Functioning Compatibility, High Temperature (if required by the test plan or requirements documents).

(1) Clean and lubricate three test weapons, use the lubricant specified for the specific test temperature.

(2) Follow the procedures of the extreme temperatures test, paragraph 4.5.1.a, for extreme high temperature for each type of ammunition selected.

(3) For the high temperature, fire two 240-round cycles for each hand and shoulder weapon and fire five 200-round cycles for each machine gun.

(4) Thoroughly inspect each weapon. Pay particular attention to any unusual wear, deposits, or maintenance requirements.

c. Functioning Compatibility, Low Temperature (if required by the test plan or requirements documents).

(1) Clean and lubricate three test weapons, use the lubricant specified for the specific low test temperature.

(2) Follow the procedures of the extreme temperatures test, paragraph 4.5.1.b, for extreme low temperature for each type of ammunition selected. Fire four 240-round cycles for each hand and shoulder weapon and fire ten 200-round cycles for each machine gun.

(3) Thoroughly inspect each weapon. Pay particular attention to any unusual wear, deposits, or maintenance requirements.

d. Safety Compatibility.

(1) This test procedure is designed to demonstrate that a particular type of cartridge may be fired without endangering the shooter; it does not demonstrate proper weapon function with the ammunition. It is useful for those types of cartridges rarely encountered and not likely to be available in quantity to an individual Soldier (grenade launching cartridges, line-throwing cartridges, door breaching rounds, etc.).

(2) Clean and lubricate one test weapon.

(3) Mount the weapon so that it can be fired remotely. Witness screens must be placed around the weapon to determine if any debris is projected toward the shooters position or toward nearby personnel. The witness screens may be of any convenient material; chipboard and corrugated cardboard are acceptable. Position the screens to box in the area behind the muzzle at a distance of 1 m from any point of the weapon. The screens should be 2 m high, centered on the plane of the weapon.

(4) Remotely fire five rounds of each type of ammunition being analyzed.

(5) Inspect the weapon for external and internal damage; this may require complete disassembly. Inspect the witness screens and record the location and size of any fragment impacts or holes. Inspect the fired cartridge cases for evidence of excess pressure, blown primers, etc.

(6) Repeat the procedure for each type of ammunition being analyzed.

4.15.3 Data Required.

Record the following:

a. The full nomenclature of ammunition, including the DODIC, CC and lot number.

b. Test temperatures.

c. Cyclic ROF.

d. Any weapon damage noted during inspection.

e. Evidence of bullet instability.

f. All maintenance actions performed.

g. Muzzle velocity.

h. Target accuracy and dispersion, and distance to the target.

i. Results of witness screen inspections.

j. Malfunctions, breakages, and replacement parts in accordance with paragraph 5.

4.16 Accessory Compatibility.

4.16.1 Background.

Small arms weapons employ a variety of accessories. Many accessories are attached directly to the weapon (grenade launchers, muzzle devices, slings, bayonets, detachable bipods, laser detonators, flashlights, fire control devices, detachable sights, etc.); other accessories, such as cleaning kits and weapon bags, are issued to support the weapon. Due to the large variety of accessories, it is not possible to identify a specific test method. However, general guidance is provided below.

4.16.2 Method.

a. Attached Accessories.

(1) Attach the item to the weapon and check that it remains secure. If necessary, use the procedure of paragraph 4.8, Rough Handling, to verify the security of the attachment.

(2) Inspect the attachment's arrangement for possible interference with loading, fired case ejection, etc. If needed, for example for blank firing attachments, fire one cycle (paragraph 4.3, Endurance, 120 rounds for hand and shoulder weapons or 200 rounds for machine guns) for verification.

(3) Observe for interference with other accessories or weapon features. For example, check that the weapon sights are not obscured by the accessory or that the accessory does not interfere with cleaning and maintenance.

b. Support Accessories.

(1) Use the accessory for its intended purpose and observe its ability to do what it is supposed to do. For example, use the support cleaning kit to clean the weapon and record the results.

(2) Integrate support accessories into the overall tests. For example, use an intended barrel bag to store and transport spare barrels during testing, and observe for fit, wear, and durability.

4.16.3 Data Required.

Record the following:

a. Photographs of the accessory, mounted and unmounted.

b. Observations of attachment security.

c. Results of any firing tests or rough handling tests.

d. Observations of interference with the weapon or other accessories.

e. Comments concerning the effectiveness and durability of support accessories.

4.17 Logistics Supportability.

4.17.1 Background.

The scope of a logistic supportability varies widely depending on the characteristics of the test item and the acquisition life cycle phase in which the evaluation occurs. AR 700-127[23] and ATEC Regulation 73-1 give an overview of types of data required. Guidance for a specific test is given in documents such as the SEP and TEMP; these documents establish the logistic support issues and criteria to be addressed by the test.

4.17.2 Method.

a. Logistic supportability testing will normally be conducted simultaneously with other testing. Perform separate test functions if necessary to assure that all appropriate criteria are addressed.

b. 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:

(1) Tools and test, measurement, and diagnostic equipment (TMDE).

(2) Operator manuals and maintenance manuals (review for accuracy and completeness).

(3) Parts replaced (including reason for replacement and round count).

(4) Safety aspects of maintenance operations.

(5) Human factors aspects of maintenance operations.

(6) Design for maintainability.

(7) Transportation, packaging, and handling.

(8) Time required for maintenance actions.

(9) Effectiveness of training and training requirements.

4.17.3 Data Required.

Record the following:

a. Data from the performance of the above items.

b. Identification of Test Incident Reports (TIRs) or other relevant reports.

4.18 Post-Firing Inspection.

4.18.1 Background.

Weapons are inspected after each test to determine if any damage or degradation has occurred and to verify that they are suitable for the next scheduled test.

4.18.2 Method.

a. Inspect each weapon at the completion of each test. The complexity of the inspection will depend on the severity of the test just completed. For example, the small number of rounds fired for the toxic fumes test would require a minimal post-firing inspection while the more abusive Reliability and Durability test requires a more detailed inspection.

b. The minimum inspection is the CIL. The CIL is done at the operator's level; however, specialized tools and cleaning equipment may be used to expedite the effort. Disassemble the weapon to the "field strip" level and do following inspections:

(1) Inspect the bore and chamber for residue and deposits (preserve samples of any unusual deposits for analysis).

(2) Clean and visually inspect the bore and chamber.

(3) Inspect sliding and mating surfaces for wear, chipping, galling, etc.

(4) Check springs for breakage and manually exercise them as a check on proper function.

(5) Visually inspect exposed parts of the firing pin, extractor, ejector, etc.

(6) Examine load bearing components such as locking lugs and bolts.

(7) Clean, lubricate and reassemble the weapon.

(8) Hand cycle a dummy cartridge to check for proper chambering, sear action, extraction, and ejection.

(9) Check that safety switches, fire selectors, etc. performed as intended.

(10) Manually check the security if weapon attachments such as sights, attachment rails, sling swivels, etc.

(11) Manually check the operation of external items such as collapsible buttstocks and bipods.

(12) Perform airflow testing for gas-powered weapons, if applicable.

c. A comprehensive inspection is performed at the conclusion of the test program, or at any point in the test program at the determination of the test officer. The inspection includes the CIL and may include the following as determined by the test officer:

(1) Bore and chamber measurements.

(2) Magnetic particle or dye penetrant inspection of components subjected to stress during firing (e.g., bolt, locking lugs, barrel, and muzzle device).

(3) Free length or force-displacement curves for all springs, as appropriate.

(4) Firing pin protrusion and indent.

(5) Trigger pull force.

(6) Radiographs of gas tubes, sealed buffers, etc.

4.18.3 Data Required.

Record the following information:

a. Results of manual and visual inspections, including photographs as required.

b. Analysis of unusual residue.

c. Bore and chamber measurements.

d. Force-displacement spring data.

e. Trigger pull force.

f. Radiographs.

g. Results of magnetic particle and dye penetrant inspections.

4.19 Human Factors Analysis.

4.19.1 Background.

a. Small arms are useful only to the degree that Soldiers can operate them effectively and safely. Detailed instructions for human factors tests are given in TOP 01-2-610[24], Human Factors Engineering, Part I, Test Procedures, and TOP 01-2-610[25], Part II, Human Factors Engineering Data Guide for Evaluation (HEDGE).

b. Detailed human engineering information is given in MIL-STD-1472G[26] and in MIL-HDBK-759C[27].

c. Human factors tests can be performed informally by accumulating data throughout all testing, or they can be performed formally by a test dedicated purely to human factors.

4.19.2 Method.

a. Informal Human Factors Analysis.

(1) 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, ease of loading and firing in various positions, tendency of the weapon to "ride up", recoil effect, etc., are typical areas of concern. Use the task checklists for individual weapons and for crew served weapons contained in TOP 01-2-610, Part II, for guidance.

(2) Review the operator's manual (if provided) for accuracy and ease of understanding.

(3) Take advantage of opportunities to "piggy back" human factors testing. For example, provide military issue cold weather gloves to weapon operators during extreme cold functioning tests and observe for the ease of loading, manipulation of safety devices, etc.

(4) If military personnel are required for testing, determine if Military Occupational Specialty (MOS) qualified Soldier-Operator/-Maintainer Test and Evaluation (SOMTE) personnel assigned to ATEC are available to support the testing. If SOMTE are not available, ensure a Test Schedule and Review Committee (TSARC) request is submitted one year prior to the start of testing, or as early as possible. A Safety Release (SR) and Human Research Protection Plan (HRPP) must be obtained from the U.S. Army Evaluation Center (AEC) prior to using military personnel as test participants. Record their observations and remarks in accordance with TOP 01-2-610.

b. Dedicated Human Factors Test.

(1) Review requirements documents and the TEMP, SEP, etc., for human factors requirements.

(2) Consult with a human factors engineering specialist, AST Test Manager and evaluator to plan the test. Analyze 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.) in accordance with TOP 01-2-610 and ATEC Policy Bulletin (PB) 009-15[28] (Standardizing ATEC Survey Concepts). Interview forms and survey questionnaires developed by the tester will require validation by the AST.

4.19.3 Data Required.

Record the following:

a. Observations of human factors throughout testing.

b. Information from questionnaires and interviews.

c. Instrumentation and facilities used.

d. Physical measurements such as test item weight and dimensions, force require to charge the weapon, etc.

e. Anthropomorphic data.

f. Participant skills, MOS, etc.

g. Details of test procedures.

4.20 Supplemental Tests.

There are many possible Small Arms tests that are rarely needed but should be considered in the planning process. The subjects and methods below give general guidance for some specific tests.

4.20.1 Fungus.

a. This test is performed to determine if exposure to fungus will degrade the test weapon. A fungus test is not necessary if all the components of the weapon are certified as not susceptible to fungus effects; this determination may also be made by review of the materials comprising the weapon. The procedure for the fungus test is given in MIL-STD-810G CN1, Method 508.7. It is not necessary to submit complete weapons to the fungus test; spare parts, unserviceable weapons, and broken parts may suffice if they represent all of the materials from the test weapon.

b. The five fungus types are provided in Table 9 (MIL-STD-810G CN1, Table 508.7-1).

TABLE 9. U.S. FUNGUS TEST

FUNGUS	FUNGUS SOURCES IDENTIFICATION NO.[a]			MATERIALS AFFECTED
	NRRL[b]	USDA[c]	ATCC[d]	
Aspergillus flavus	NRRL A5244	QM 380	ATCC 9643	Leathers, textiles, rubber. Electrical insulation, varnish, wax, packing materials, etc.
Aspergillus versicolor	NRRL 20734	QM 432	ATCC 11730	Leathers, adhesives, textiles, automotive components such as gaskets, distributors, cables, hoses, polyvinyl chloride (PVC), breakers solenoids, switches
Penicillium funiculosum	NRRL 3647	QM 474	ATCC 11797	Textiles, plastics, cotton fabric, polymers, automotive components such as gaskets, distributors, cables, hoses, PVC, airborne equipment such as breakers, solenoids, switches, remote transmission accessories
Chaetomium globosum	NRRL 1870	QM 459	ATCC 6205	Cellulose and any components containing paper and paper products such as packing materials, textiles, polymeric hydrocarbons and some synthetic polymeric materials
Aspergillus brasiliensis (formerly known as niger)	NRRL 3536	QM 386	ATCC 9642	Textiles, vinyl, conformal coatings, etches glass, insulation, leather, etc.; resistant to tanning salts

Notes:

[a] A catalogue number used by suppliers to identify various species within their collection.

[b] U.S. Department of Agriculture, Northern Regional Research Center, ARS Culture Collection, 1815 North University Street, Peoria, IL 61604.

[c] U.S. Department of Agriculture, Northern Regional Research Center, Quartermaster Collection, 1815 North University Street, Peoria, IL 61604.

[d] American Type Culture Collection, 10801 University Blvd, Manassas, VA 20110-2209. (All suppliers may distribute the fungus in a lyophilized state or on agar slants. Need USDA permit for ATCC 11797 which is considered a plant pathogen. See USDA site for permit information).

4.20.2 Altitude (Low Air Pressure).

Small arms may need to be transported in unpressurized aircraft cargo compartments. This test is needed if any components of a weapon are susceptible to changes in air pressure. These components include seals and gaskets, internal voids, fluids (as in buffers) that may boil or evaporate, etc. General guidance for this test is given in the NATO document AECTP 300, Method 312.5, Procedure I, Storage/Air Transport.

4.20.3 Proof Firing.

Almost all small arms are proof fired by the manufacturer and do not have to be proof fired when received for test. If proof firing is needed it can be performed by obtaining the proper proof cartridge for the caliber of weapon being tested. Remotely fire one proof round and five standard rounds, then inspect the weapon for adverse effects. All load bearing components should be subject to magnetic particle or dye penetrant inspections. Prior to conducting proof firing, check for weapon proof mark. The proof mark varies by weapon type.

4.20.4 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC).

The purpose of these tests is to ensure that the test item is able to function in its intended electromagnetic environment without its own performance being degraded and without degrading the performance of other nearby systems. Most small arms are purely mechanical and as such are not susceptible to EMI/EMC. However, some modern small arms contain electronic components the can create safety and operational concerns relative to EMI/EMC. These components can include, but are not limited to, fuze setters, communication devices, fire control systems, etc. Guidance for EMI/EMC testing is given in TOP 01-2-511A[29], MIL-STD-461G[30], and MIL-STD-464C[31]. Modification of the test weapon may be required; for example, a fuze setter activated by passage of a projectile through the muzzle brake may have to be modified to allow activation without actually firing the weapon. Coordinate the details of the EMI/EMC as early as possible with both the materiel developer and the team performing the actual test.

4.20.5 Parts Interchange.

Parts interchange tests are performed late in the development cycle, usually as part of a Production Qualification Test (PQT) or Logistic Demonstration. The specific parts that must be interchangeable are determined by the item manager. The test is performed by disassembling the weapon and reassembling in an interchanged condition. The general procedure is to use the same number of weapons as there are parts to be interchanged. For example, use ten weapons if there are ten parts to be interchanged. Number the weapons 1 through 10, and set up the same number of parts containers identified as A through J. Disassemble weapon No. 1 and sequentially place the parts in the parts containers starting with container A. Disassemble the second weapon in the same order, but place the first part in container B and continue with the last part being placed in container A. Continue the process until all the weapons are disassembled and each container has all the parts needed to reassemble a complete weapon. Assemble the weapons in the interchanged configuration and observe for proper fit and function (a firing test may be required). Careful record keeping will allow identification of the origin of any part, and will allow reassembling the weapons back to their original configuration if desired. They may also be left in the interchanged condition. A sample matrix is provided in Table 10.

TABLE 10. SAMPLE PARTS INTERCHANGE MATRIX

COMPONENT/ ASSEMBLY	WEAPON NUMBER									
	1	2	3	4	5	6	7	8	9	10
Barrel assembly	1	2	3	4	5	6	7	8	9	10
Receiver assembly	2	3	4	5	6	7	8	9	10	1
Heatshield assembly	3	4	5	6	7	8	9	10	1	2
Cocking handle assembly	4	5	6	7	8	9	10	1	2	3
Cover & feed mechanism assembly	5	6	7	8	9	10	1	2	3	4
Trigger mechanism assembly	6	7	8	9	10	1	2	3	4	5
Handguard assembly	7	8	9	10	1	2	3	4	5	6
Rear sight assembly	8	9	10	1	2	3	4	5	6	7
Buttstock & buffer assembly	9	10	1	2	3	4	5	6	7	8

4.20.6 Unlubricated.

This subtest determines whether the test item will function in an unlubricated condition. It is an indication of a weapon's ability to function in an adverse condition, particularly in those circumstances when scheduled lubrication cannot be accomplished. Degradation in weapon performance is common; test personnel should be prepared to deal with numerous common and uncommon types of malfunctions.

a. Remove **all** lubrication (except dry film lubricant applied at time of manufacture) to all parts of three weapons to be tested. This is best accomplished by detailed disassembly, cleaning all parts, then washing all the parts in clean solvent.

b. Fire at least 1,000 rounds of ammunition using a Reliability and Durability test firing schedule (see paragraph 4.3 for discussion of possible firing combinations). Ammunition should be fired in an "as issued" condition with no attempt to remove any traces of lubricant or to clean the ammunition components.

c. Weapons will not be lubricated unless the weapon is rendered inoperable by the test environment. If this occurs, perform minimum restorative maintenance necessary to return the weapon to operating condition, and resume firing.

d. Weapons with adjustable gas systems are set at "minimum" until problems dictate a change. Firing will be with each progressive adjustment available until either the weapon operates properly or the maximum power setting has been used.

e. At the conclusion of firing, inspect the weapons for unusual wear, evidence of galling, and any other condition caused by the unlubricated conditions.

4.20.7 Fouling.

This subtest determines the effects of combustion residue buildup on weapon performance. The test is performed at cool ambient temperatures to encourage condensation and the accumulation of residue. A relatively small number of rounds are fired at large time intervals to prevent weapon heating that would tend to evaporate residue deposits.

a. Maintain three test weapons in accordance with the maintenance literature for a temperature of -7 ± 2 °C (20 ± 5 °F). Condition the weapons, ammunition (300 rounds per hand or shoulder weapon, 500 rounds per machine gun), and magazines in an environmental facility at -7 °C (20 °F) for at least 12 hours before initiating firing.

b. Two firings are performed each day for five days. The daily firings are separated by a minimum of 4 hours. For hand and shoulder weapons, each firing consists of 30 rounds fired semi-automatically at a rate of approximately one round per second. For machine guns, each firing consists of 50 rounds fired in three- to five-round bursts. Firings should be performed from within the conditioning chamber. If this is not possible, remove the weapons for firing and replace them into the conditioning chamber as quickly as possible.

c. Weapons are not maintained during this test unless a weapon is rendered inoperable by the test environment. If this occurs, perform minimum restorative maintenance, and continue testing until completed. Do not remove the weapon from the test environment to perform maintenance.

4.20.8 Smoke.

a. Background. The smoke cloud accumulated during weapon firing can obscure the target from the shooter. The cloud is also a signature effect that can reveal a firing position. The smoke produced by firing a weapon is highly dependent on the ammunition used and the prevailing meteorological conditions, particularly the RH and wind speed and direction. This test has mostly become obsolete due to subjectivity.

b. Method.

(1) Small arms smoke tests are performed as comparison-type tests in a windless environment. A test weapon is fired in alternate trials with a known standard weapon. The smoke cloud accumulated at the weapon during firing is analyzed from the standpoints of target obscuration when viewed from directly behind the weapon and visibility (or signature) of the cloud from a distance beyond the muzzle. The results will determine if the test weapon provides an increase or decrease in smoke as compared to the standard weapon.

(2) Disassemble, clean, lubricate with prescribed substance, and reassemble one test and one standard weapon.

(3) To judge the size and density of the smoke cloud and the degree of target obscuration, use a checkerboard target approximately 2.4 m^2 with 0.3-m black and white squares

placed in line with the weapon at a range of 100 m. Elevate the weapon to fire slightly above the target. Position a video camera behind the weapon in line with the weapon sights so as to photograph the aim point as seen by the firer. Place a second video camera perpendicular to the muzzle of the test weapon at a distance that will record the expected smoke cloud; the background for this camera should be of a contrasting color and contain features to show the relative size of the smoke cloud (an open field or the side of a building may be appropriate).

(4) Firings must be performed in wind conditions as low as possible and at a RH less than 75%.

(5) Fire three rounds to condition the barrel. For hand and shoulder weapons, photograph both a single-shot and a ten-round series fired as rapidly as possible. For machine guns, fire a three-round burst and a 20-round burst. Some experimentation may be necessary to determine camera settings, camera positions, and rounds fired needed to produce a useable video image.

(6) Replace the test weapon with the standard weapon and repeat the firings exactly as was done for the test weapon.

(7) Repeat the firings with different types of ammunition, if required.

c. Data Required. Record the following:

(1) Description of test set up.

(2) Identification of the type of cameras, settings, etc.

(3) Identification of the test and standard weapons.

(4) Type of ammunition fired.

(5) Metrological conditions, particularly wind and RH.

(6) Photographs of the smoke produced by the test and standard weapon.

5. DATA REQUIRED.

5.1 General.

The purpose of recording weapon functioning data is to establish an accurate, complete historic profile of the items being analyzed. For some tests, the definitions listed in the following tables 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 the tables.

a. Malfunctions and stoppages are classified into standardized groups in the following categories:

(1) Malfunction and Performance Codes (paragraph 5.2).

(2) Attribution Codes (paragraph 5.3).

(3) Safety Categories (paragraph 5.4).

(4) Significance to the Operator (paragraph 5.5).

b. Guidance concerning keeping track of incidents by round count is given in paragraph 5.6. Paragraph 5.7 describes some commonly used miscellaneous codes and abbreviations.

5.2 Malfunction and Performance Codes.

a. The cycle of operation of most small arms weapons, from pistols and revolvers to heavy machine guns, 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 affect weapon performance while still permitting continuation of firing. Other malfunctions, referred to as stoppages, immediately prevent further firing until corrected. Examples of malfunctions that cause stoppages are weapon failure to feed, extract, or eject. These may or may not be caused by a part failure. Examples of malfunctions that do not cause stoppages are a damaged weapon sear or solenoid components that cause uncontrolled fire; loss of weapon flash suppressor; and loosening and shifting of a sight.

b. Commonality of abbreviations, malfunction codes, and weapon performance definitions is required for reports, TIRs, etc. The lists of standardized terminology in Tables 11 and 12 are designed to be used for all of our external and internal documentation and communication. The lists have been deliberately kept as short as practical to limit the multiplicity of codes. However, you have the option of adding codes or terms if the nature of a specific test requires it. Any such special terms or codes must be defined in detail in reports or TIRs.

c. The codes in Table 11 are arranged in the approximate order of function of conventional small arms weapons. It is critical to understand that these codes describe the condition of the weapon as determined primarily by visual observation. It is not uncommon for a specific weapon malfunction to have several possible causes, or conversely, a single weapon condition may generate several different types of malfunctions. The malfunction codes in this list are just the first step in recording and analyzing the event.

TABLE 11. BASIC CODES

CODE	DEFINITION/REMARKS
Bolt Failed to Move (BFM)	Used for weapons firing from an open bolt to indicate that the bolt made no forward movement when the bolt sear was released by pulling the trigger. Also used for those cases where the bolt is held rearward by a manually operated bolt latch and fails to move forward when the latch is released.
Failure to Strip Round (FSR)	The bolt properly engaged the cartridge but stalled or failed to push the round out of the magazine or link.
Failure-to-Feed (FFD)	A cartridge was not fed into the proper position in front of the bolt.
Bolt Failed to Close (BFC)	The bolt properly stripped the cartridge but stopped short of the forward most position.
Bolt Failed to Lock (BFL)	The bolt locking surfaces or locking mechanism are not engaged even though the bolt is in the forward most position.
Bolt Closed on an Empty Chamber (BCE)	There is no cartridge in the chamber even though the bolt is forward and locked.
Failure-to-Fire (FFR)	The weapon failed to fire when the trigger was pulled.
Failure to Unlock (FUL)	The weapon fired but the bolt is still in the locked position.
Failure to Extract (FXT)	The fired cartridge case is still in the chamber or the bolt has not moved back far enough to activate the ejector.
Failure-to-Eject (FEJ)	The bolt moved to, or through, the proper position for ejection but the case did not eject.

d. When possible, these more specific codes (Table 12) may be used to describe the malfunction.

TABLE 12. EXTENDED CODES

CODE	EXTENDED CODE	DEFINITION
BFM	FDS	Failure of safety to disengage.
	FTF	Failure of trigger to function.
BFC	STB	Stubbed round.
	BUR	Bolt under rode cartridge.
	BOR	Bolt overrode cartridge.
FFD	BSP	Belt separation.
	DFD	Double feed.
	FFU	Failure of round to feed up from the magazine.
	FBC	Failure of the bolt to cycle back far enough to pick up the next cartridge.
FFR	FSO	Failure to sear off, firing pin did not strike properly positioned cartridge.
	FCP	Failure of cartridge primer, the primer has a proper indent but did not fire.
FXT	FEX	Failure of extractor to engage or stay engaged with the cartridge.
	FES	Case stuck in chamber such that bolt/extractor cannot extract it.
FEJ	CSB	Case spin back (fired case exited but bounced back into the weapon).

5.3 Attribution Codes.

The **source** or **cause** of the malfunction must be determined and attributed to some underlying cause. This is sometimes easy, as in the case of an obviously broken part, but often requires careful thought and experimentation. Common attribution codes are shown in Table 13.

TABLE 13. ATTRIBUTION CODES

ATTRIBUTION CODE	DEFINITION
AMO	Ammunition. Problems clearly caused by deficiency of the ammunition.
GUN	Malfunction that is induced by the weapon itself despite proper maintenance and proper operator performance.
LNK	Link. Problems clearly caused by a deficiency of the link or links.
MAG	Malfunctions identifiable as induced by the magazine.
PER	Personnel. Problems induced by operator error (repetitive PER may identify a human factors problem or a deficiency in operator training procedures).
REP	Repetitive malfunctions. The special category termed "repetitive" is used when repeated stoppages due to a faulty component occur, and corrective action is not immediately determined or incorrect action is taken. For example, if a series of identical gun stoppages occurs and the first stoppage is attributed to the gun because of a faulty gun component, the three identical stoppages that follow are charged as repetitive, assuming that the fault was correctable after the first occurrence. When repetitive malfunctions occur due to faulty gun design rather than component failure and immediate action by the operator is not possible, each such stoppage is charged to the gun instead of repetitive.
SYS	System. Problems that cannot be attributable to a single cause, but are caused by the interaction of more than two components.
TST	Test. Malfunctions induced by the test set up, such as an improper weapon mount, wrong part installed, etc.

5.4 Safety Categories.

All malfunctions and stoppages will be reviewed for safety implications in accordance with MIL-STD-882E[32]. Determine the proper severity category and mishap probability in accordance with MIL-STD-882E, Tables 1 and II.

5.5 Classification of the Significance of a Malfunction to the Operator.

Incidents are divided into four classes in accordance with the following definitions:

a. Class 1. The operator is able to return the weapon to an operational condition within 10 seconds using only tools and equipment carried in an operational scenario. This class is often referred to as "correctable by immediate action".

b. Class 2. More than 10 seconds are required using only tools and equipment carried in an operational scenario. This class is often referred to as "operator correctable failures".

c. Class 3. A failure not correctable by the operator because it requires a higher level of maintenance or the use of tools and parts that the operator is not authorized to carry on his person. It is correctable, however, at the lowest level organizational maintenance.

d. Class 4. A failure that is not correctable in the field; the weapon must be evacuated to a higher-level maintenance (such as depot level) or is unrepairable and must be scrapped.

NOTE: These are the general class definitions. Always check the test item FDSC for class definitions specific to the test item.

5.6 Round Counts.

a. 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, multi-directional 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.

b. Use the cumulative round count to correlate firing data throughout the test. Record the round count at each event such as a malfunction, magazine change, change of firing cycle, maintenance action, etc. The final record will identify the exact conditions and sequence of each round fired.

5.7 Miscellaneous Common Codes.

Miscellaneous common codes are provided in Table 14.

TABLE 14. MISCELLANEOUS COMMON CODES

CODE	DEFINITION
A	Full automatic fire.
B	Burst fire.
CIL	Clean, inspect, and lubricate.
FRA	Failure to remain assembled.
GFE	Government-furnished equipment.
NT	No test, data are not reportable as test data.
rpm	Rounds per minute
SA	Semiautomatic.
spm	Shots per minute
SS	Single shot.
UNK	Unknown.

6. PRESENTATION OF DATA.

a. Present data in formats that is factual, comprehensive, and easy to understand. General guidance on presentation of data in reports is given in ATEC Pamphlet 73-1[33], Test and Evaluation Volume II; use this guidance for both printed and electronic presentations.

b. Level 1 through 3 data is not usually published but it is retained for future use or analysis (see ATEC Pamphlet 73-1, Test and Evaluation Volume II, Chapter 4, for data level definitions). Data levels 4 and 5 form the basis for test reports, safety release recommendations, etc.

c. Test results are analyzed by suitable statistical procedures for comparing samples, for obtaining point or interval estimates of a parameter, and for determining from test results whether specific requirements have been satisfied. ITOP 03-1-005, provides guidance on analyzing and presenting test results.

d. A TIR spreadsheet is created from a specialized version of the Army Test Incident and Reporting System (ATIRS) known as Gridview. ATIRS is designed for database housing of Army performance, Reliability and Maintainability (RAM), and TIR information for both the Operational and Developmental testing community and Department of Defense (DOD) contracts. Required information for analyzing these parameters are determined during the test planning phase and then collected during test using ATIRS. The output is then used to analyze the necessary parameters. The example in Figure 3 shows typical information collected during a small arms test to analyze RAM and safety issues.

Date, 2015	Subtest	Weapon No	Barrel	Round No	Rounds Fired	Cycle No	Stoppage Type	Class	Attributed To	Remarks	TIR No
12-Oct	ENDURANCE	A2	A	15	4,934	10	NA	NA	NO STOPPAGE	Endurance cycle 10 was completed on barrel A The remaining 15 rounds were fired with no further stoppages	K2-A
12-Oct	ENDURANCE	A2	B	200	5,134	10	NA	NA	NO STOPPAGE	Endurance cycle 10 was completed on barrel B Two hundred rounds were fired with no stoppages	K2-A
12-Oct	ENDURANCE	A2	A	0	5,134	11	FRA	NA	GUN	Prior to firing round 1, the roller on top of the bolt carrier that actuates the feed pawl broke off and fell into the trigger assembly not allowing the bolt to fully close The weapon was taken to the maintenance shop for repair	K2-A0011
12-Oct	ENDURANCE	A2	A	10	5,220	11	FEJ	1	GUN	A Failure-to-Eject stoppage occurred on round number 10 The casing did not eject from the chamber The casing was cleared and the round fired successfully	K2-A0012
14-Oct	ENDURANCE	A2	A	20	5,333	11	NA	NA	NO STOPPAGE	Endurance cycle 11 was completed on barrel A The remaining 20 rounds were fired with no further stoppages	K2-A
14-Oct	ENDURANCE	A2	B	200	5,533	11	NA	NA	NO STOPPAGE	Endurance cycle 11 was completed on barrel B with no stoppages	K2-A
15-Oct	ENDURANCE	A2	A	144	5,733	12	NA	NA	NO STOPPAGE	Endurance cycle 12 was completed on barrel A The remaining 144 rounds were fired with no further stoppages	K2-A
15-Oct	ENDURANCE	A2	B	200	5,933	12	NA	NA	NO STOPPAGE	Endurance cycle 12 was completed on barrel B with no stoppages	K2-A
15-Oct	ENDURANCE	A2	A	8	5,941	13	FFR	1	NO STOPPAGE	A Failure-to-Fire stoppage occurred on round 8 The round was cleared and inspected Inspection revealed a full indent on the primer The round was reloaded and fired successfully	K2-A0013
15-Oct	ENDURANCE	A2	A	192	6,133	13	NA	NA	GUN	Endurance cycle 13 was completed on barrel A The remaining 192 rounds were fired with no further stoppages	K2-A
16-Oct	ENDURANCE	A2	B	200	6,333	13	NA	NA	NO STOPPAGE	Endurance cycle 13 was completed on barrel B with no stoppages	K2-A
16-Oct	ENDURANCE	A2	A	10	6,343	13	FFR	1	GUN	A Failure-to-Fire stoppage occurred on round 10 The round was cleared and inspected Inspection revealed a full indent on the primer The round was reloaded and fired successfully	K2-A00114
16-Oct	ENDURANCE	A2	A	15	6,348	13	FFR	1	GUN	A Failure-to-Fire stoppage occurred on round 15 The round was cleared and inspected Inspection revealed a full indent on the primer The round was reloaded and fired successfully	K2-A0015

Figure 3. Sample TIR spreadsheet.

APPENDIX A. ABBREVIATIONS.

ACV	armored combat vehicle
AEC	U.S. Army Evaluation Center
AECTP	Allied Environmental Conditions and Test Publication
APHC	Army Public Health Center (Provisional)
AR	Army Regulation
AST	Acquisition System Team
ASTM	American Society for Testing and Materials
ATCC	American Type Culture Collection
ATEC	U.S. Army Test and Evaluation Command
ATIRS	Army Test Incident and Reporting System
C	Celsius
CC	condition code
CDD	Capability Development Document
CIL	cleaned, inspected, and lubricated
cm	centimeter
cm/hr	centimeter per hour
CO	carbon monoxide
CO_2	carbon dioxide
COI	center of impact
CPD	Capability Production Document
dB	decibel
DC	direct current
DOD	Department of Defense
DODIC	Department of Defense Identification Code
DSM	Data Source Matrix
DTP	Detailed Test Plan
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
F	Fahrenheit
FDSC	Failure Definition and Scoring Criteria
ft	foot or feet
ft-lb	foot-pound
$g/min/m^2$	grams per minute per square meter
HCN	hydrogen cyanide
HEDGE	Human Factors Engineering Data Guide for Evaluation
HRPP	Human Research Protection Plan
Hz	Hertz

APPENDIX A. ABBREVIATIONS.

ICD	Initial Capability Document
ICP-AES	inductively coupled atomic emission spectroscopy
in.	inch
in./hr	inch per hour
ITOP	International Test Operations Procedure
J	Joule
kg	kilogram
km/hr	kilometers per hour
l	liter
lb	pound
lb/in.	pound inches
LOF	line-of-fire
m	meter
m/s	meter per second
MIL-HDBK	Military Handbook
MIL-PRF	Military Performance Specification
MIL-STD	Military Standard
ml	milliliter
mm	millimeter
MOS	Military Occupational Specialty
mph	miles per hour
MSDS	Material Safety Data Sheet
N/cm	Newton centimeters
NATO	North Atlantic Treaty Organization
NDT	nondestructive test
NET	New Equipment Training
NH_3	ammonia
NIOSH	National Institute for Occupational Safety and Health
NO	nitric oxide
NO_2	nitrogen dioxide
NRRL	Northern Regional Research Laboratory (now the National Center for Agricultural Utilization Research)
PB	Policy Bulletin
PoA	point of aim
PPE	personal protective equipment
PQT	Production Qualification Test
PVC	Polyvinyl chloride

APPENDIX A. ABBREVIATIONS.

qt	quart
RAM	Reliability and Maintainability
RFTS	Request for Test Services
RH	relative humidity
ROF	rate-of-fire
rpm	rounds per minute
SEP	System Evaluation Plan
SLR	single-lens reflex
SO_2	sulfur dioxide
SOMTE	Soldier-Operator/-Maintainer Testing and Evaluation
SOP	Standard Operating Procedure
spm	shots per minute
SR	Safety Release
SSR	Sniper Support Rifle
TEMP	Test and Evaluation Master Plan
TIR	Test Incident Report
TM	Technical Manual
TMDE	test, measurement, and diagnostic equipment
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
USDA	U.S Department of Agriculture

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-TM 24 June 2016

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 03-2-045A Small Arms - Hand and Shoulder Weapons and Machine Guns, Approved for Publication

1. TOP 03-2-045A Small Arms - Hand and Shoulder Weapons and Machine Guns, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP contains a compilation of procedures for testing hand and shoulder weapons and machine guns, including crew served weapons and light automatic cannons up to 50 millimeter in caliber. The test procedures are meant to help standardize testing and to aid the development of Detailed Test Plans, Test and Evaluation Master Plans, and similar planning documents.

2. This document is approved for publication and will be posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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RAYMOND G. FONTAINE
Director, Test Management Directorate (G9)

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Small Arms Systems Division (TEDT-AT-FP-S), U.S. Army Aberdeen Test Center, 400 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.