

LEVEL II

US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURES

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Test Operations Procedure 4-2-016
AD No.

6 AMMUNITION, SMALL ARMS

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SECTION I GENERAL

1. Purpose and Scope. This TOP provides guidance for planning tests of small arms ammunition to assure their conformance with MN's, DP's, and other standards. Tests to satisfy the requirements for the particular test item and test type (i.e., development test, initial production test, etc.) can be selected from those listed in section II.

2. Background. The term "small arms ammunition" for this TOP is defined as a fixed round of ammunition, varying in size from caliber .22 (or smaller) to 30-mm, but including the shoulder-fired 40-mm grenade. The ammunition is divided into three specific categories:

- a. Fuzed and nonfuzed service ammunition, both combat and noncombat type such as caliber .22 rimfire, riot control, and disintegrating ammunition.
- b. Blank ammunition.
- c. Dummy or training ammunition.

The testing of 40-mm grenades is not discussed in this TOP since grenade tests are covered in TOP 4-2-080. 78 06 22 005

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<u>TEST SUBJECT TITLE</u>	<u>PUBLICATION NO.</u>
Cook-Off (para 16)	TOP/MTP 3-2-045, 3-2-059
Functioning and Casualty/Metal Parts Integrity (para 17)	
Fuze Sensitivity (F) (para 18)	
Rough Handling (para 19)	TOP/MTP 4-2-602
Secured Cargo (Transportation Vibration) (para 20)	TOP 1-2-601
Projectile Torque (para 21)	
Bullet Pull (para 22)	
Noise and Blast (para 23)	TOP 1-2-608
Impulse-Recoil Measurements (para 24)	TOP 3-2-826
Weapon Compatibility (para 25)	TOP/MTP 3-2-045, 3-2-059
d. Fragmentation-Lethality (F) (para 26)	TOP/MTP 3-2-608, 4-2-813
e. Accuracy and Dispersion (para 27)	TOP 4-2-829, TOP/MTP 3-2-045, 3-2-059
f. Time of Flight (Range Tables) (para 28)	TOP/MTP 4-2-604, 4-2-827
g. Tracer Evaluation (para 29)	
h. Flash (para 30)	TOP/MTP 3-2-045, 3-2-059
i. Smoke (para 31)	TOP/MTP 3-2-045, 3-2-059
j. Waterproofness (para 32)	MIL-STD-331
k. Salt-Fog (para 33)	MIL-STD-810C
l. Temperature-Humidity (para 34)	TOP/MTP 4-2-820, AR 70-38
m. Sympathetic Detonation (para 35)	MIL-STD-444
n. Armor Penetration (para 36)	TOP 2-2-710
o. Helmet Penetration (para 37)	TOP 2-2-710

<u>TEST SUBJECT TITLE</u>	<u>PUBLICATION NO.</u>
p. Fungus (para 38)	MIL-STD-810C
q. Human Factors Engineering (para 39)	TOP 1-2-610, MIL-STD-1474
<u>Blank Ammunition (para 40)</u>	
r. Function and Casualty (para 40.1)	
s. Weapon Compatibility (para 40.2)	TOP/MTP 3-2-045, 3-2-059
t. Noise Level (para 40.3)	TOP 1-2-608
u. Flash and Smoke (para 40.4)	TOP/MTP 3-2-045, 3-2-059
v. Tampering (para 40.5)	
<u>Dummy or Training Ammunition (para 41)</u>	
w. Inspection (para 41.1)	
x. Physical Measurements (para 41.2)	
y. Serviceable Life (para 41.3)	

SECTION III SUPPLEMENTARY INSTRUCTIONS

NOTE: Paragraphs 5 through 39 are applicable to service ammunition.

5. Test Planning. DT II planning requires a comprehensive test program for which the test director must be thoroughly familiar with the stated requirements (MN, DP, etc.). All instructional material issued with the test ammunition by the manufacturer, contractor, or government, as well as reports of previous tests conducted on the same model or closely related items, are reviewed and kept available for reference. The developer's safety statement is reviewed and used for integrating safety into the test design, for planning, for preparing the test procedures, and for handling and shipping the test items prior to the issuance of the safety release.

An adequate number of test cartridges is required to represent the population from which the sample has been drawn. If the sample is too small to produce adequate or statistically significant results, a decision relative to acceptability may not be made with confidence. Although economy of test is also considered, the sample size of each sub-test must be sufficient to provide reasonable assurance that comparison of test results to requirements will be meaningful.

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

6. Initial Inspection. All cartridges received for testing are inspected for damage and defects (external). Inspection standards for small arms ammunition through caliber .50 are contained in MIL-STD-636. (APG personnel should refer to SOP 385-292, Inspection Procedures for All Ammunition and Related Items Subjected to Testing.) All ammunition considered questionable or unserviceable due to shipping damage will be restricted from the test.

7. Physical Measurements. Since it is not feasible to check all measurements of a complete round of ammunition (particularly if it is a fuzed HE round), engineering judgment must be used to select critical areas for check. These, as a minimum, should include (methods are as shown in TOP/MTP 4-2-800):

a. Complete cartridge.

- (1) Weight.
- (2) Center of gravity.
- (3) Length.
- (4) Profile.
- (5) Projectile diameter at bourrelet (or rotating band of larger caliber ammunition).

b. Components (cartridge must be disassembled).

- (1) Bullet: weight, length, and moments of inertia.
- (2) Propellant: weight, type, and general appearance.

Fuzed ammunition requires a sample with certified-inert components for examination to determine whether the safety features prescribed by the drawing are present. Critical components (based on engineering judgment) are compared with drawings. Sampling from the rounds furnished is on a random basis and must be sufficient to provide, as a minimum, statements at the lower 90 percent confidence limit (see TOP/MTP 3-1-002). A complete set of cartridge and component drawings is required prior to test initiation, and the requirement should be noted in the plan of test.

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8. Safety Evaluation. When a complete DT II type test of small arms ammunition is to be conducted prior to a man-machine evaluation phase and an operational test (OT), the information necessary for the preparation of a safety release recommendation is usually generated from the cumulative results of various subtests. When the man-machine evaluation and the OT tests are to be conducted concurrently with a DT II test, however, a separate safety evaluation test must be conducted as soon as possible following initial inspection, and the results reported in letter form to the appropriate TECOM directorate. A safety recommendation reflects engineering judgment based on a careful study of all features, particularly those relating to hazardous conditions or unsafe design. Any or all of the subtests in this TOP, but particularly those listed in paragraphs 9 through 25, should be considered as part of a safety evaluation. In general, however, preliminary safety recommendations can be made for a given design based on a limited number of rounds fired under given conditions.

9. Velocity Measurements. Velocity of small arms ammunition generally is computed from the time of flight of the bullet as it passes through two lumiline screens. The technique is as shown in TOP 4-2-805. The prescribed instrumental points (middistance between start and stop screens) are usually as shown in table 1.

Table 1 - Instrumental Points Between Velocity Screens

<u>Instrumental Point,</u> <u>Distance from Muzzle</u>		<u>Ammunition</u>
<u>feet</u>	<u>meters</u>	
5	1.52	Shotgun
15	4.57	Cal .30 carbine, cal .22, 5.56-mm, 9-mm, and cal .38
25.5	7.62	Cal .45
78	23.77	Cal .30, 7.62-mm, cal .50, 20-mm, and 30-mm

The base line or distance between lumiline screens is controlled by the location of the first (start) screen. This first screen is positioned forward of the blast and muzzle flash and should be protected by a vertical piece of 1-inch-thick plywood. A hole is cut in the plywood blast screen of sufficient size to allow the projectile to pass through unimpeded. Velocities can be measured either single shot or for extended-burst firings. Single-shot firings are usually performed with a sample of the test cartridges each conditioned to -60° , $+160^{\circ}$,* and $+70^{\circ}$ F to determine the effect of temperature on the velocities produced.

To determine the contribution of variables when single-shot testing ammunition for velocity levels, a control lot of the same caliber as the test lot and a like number of test cartridges are fired alternately throughout the test. The control lot will have been extensively tested

*Includes effects of solar radiation.

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to establish the velocity (also pressure) under conditions of +70° F in a series of Mann-type barrels (para 3). The control ammunition is always fired after being conditioned to +70° F, and the amount that the tested velocity misses the assessed value is added algebraically to the test cartridge velocity. Values are reported as corrected velocity along with the "as tested" (uncorrected) velocity. The rate of fire during the test should not exceed one round per half-minute interval, and the barrel should be cooled to ambient temperature following each sequence of firing.

10. Pressure Measurements. Pressure measurements for small arms ammunition can be taken at two stations: chamber, for all ammunition, and port for all ammunition fired from a gas-operated weapon; the latter is usually measured simultaneously with chamber pressures and at the location of the gas port of the intended weapon.

Mann-type barrels with pressure stations (chamber and port) are used to conduct the pressure measurement test. The barrels must conform to the basic weapon in length, rifling, chambering, and position of the gas port. Copper crusher gages can be used to measure peak pressures at both stations. Time-pressure histories can be recorded using piezoelectric pressure transducers rather than copper crusher gages. The techniques for the use of both the crusher type and the piezoelectric transducer are described in TOP/MTP 3-2-810. Velocities should be measured during this phase for informational purposes. Firings are conducted with samples of the test ammunition conditioned to -60°, +160° *, and +70° F to determine the effects of temperatures on the resulting pressures. Control ammunition is fired alternately along with the test ammunition, and the pressures are corrected similarly to the method described for velocity corrections (9 above).

11. Action Time. The purpose of the action time test is to determine the time interval between the application of initiating energy to the primer and exit of the projectile from the muzzle. This information is useful for determining ammunition compatibility with weapons that are capable of high rates of fire or are externally powered. In the case of high-rate-of-fire weapons, the bolt must be locked in position until the projectile leaves the bore to maintain propellant pressures. For the externally powered weapon (i.e., not gas operated) the possibility exists that bolt unlocking can occur either when the projectile is in the bore or prior to ignition of the propellant (in cases of extremely long action-times generally referred to as "hangfires") and result in possible ejection of a cartridge in the process of ignition.

Firings are conducted single shot from a Mann-type barrel using an instrumented breech to obtain initiation and an infrared detector to determine projectile exit from the bore. A counter chronograph is used to indicate the time from initiation to projectile exit. An infrared detector will not record reliably with some projectiles due to discarding

*Includes effects of solar radiation.

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sabots, gas escapage, etc. In these instances, lumiline screens are placed in front of the weapon muzzle to determine when the projectile passes a given point (chronograph stop time) and to provide data for calculating the velocity of the projectile. The time for each projectile to travel from the muzzle to the first screen is computed using previously obtained ballistic data and the recorded velocity observed for each round. This time is subtracted from the total time observed to obtain the action time. Firings are conducted with the ammunition conditioned at -60° , $+160^{\circ}$,* and $+70^{\circ}$ F to determine temperature effects.

12. Fuze Arming Distances. Fuzed HE ammunition must be safe (i.e., not armed) for a prescribed distance forward of the weapon muzzle. This assures that inadvertent "close in" impacts will not cause the fuze to function and expel fragments in close proximity to the weapon. Minimum (none armed) and maximum (all armed) arming distance requirements are established in the appropriate requirements documents. These distances are verified by firing a statistically adequate sample of the test cartridges single shot from the service weapon to impact on a vertical functioning target. This target is placed initially at the minimum prescribed distance, then the firing test is repeated at the maximum distance. Firing of 45 rounds at each distance is often prescribed. If no arming occurs at the minimum distance, it may be said that there is a probability of .95, with 90 percent confidence, that the fuze will not be armed at that distance. Forty-five armings at the maximum distance would give the same probability of arming. Other sample sizes will provide other probabilities as stated in TOP/MTP 3-1-002. The functioning target material is thick enough to cause the fuze to function reliably (see plate sensitivity, para 18b), but not so thick as to cause deflagration of the explosive filler in the projectile. If a plate sensitivity test has not been conducted or no guidance on sensitivity is provided in the requirements document, a 0.040-inch-thick aluminum plate is used for a functioning target.

If the arming distances stated in the requirements document are not met or no parameters on the minimum and maximum distances are provided, they may be established using one or both of the following procedures.

a. When the number of available rounds is small, or for obtaining preliminary information, the Langlie method is suitable. This procedure requires that the gun-to-target distance be adjusted round by round based on an analysis of the results of preceding rounds fired. For the Langlie method:

(1) An upper limit of distance and a lower limit of distance are selected: the upper limit being a distance at which it would be expected that all fuzes would be armed, the lower limit one at which no fuze would be armed. (It is better to select this interval too large than too small.)

(2) The target is placed at a distance midway between the upper and lower limits, and the first round is fired.

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(3) If the first round functions, the target for the second round is placed halfway between the distance for the first round and the lower limit. If the first round does not function, the target distance for the second round is halfway between the distance for the first round and the upper limit.

(4) If the first two rounds result in a reversal (one function and one nonfunction), the distance for the third round is halfway between the distances for the first and second rounds. If the first two rounds function, the distance for the third round is halfway between the second-round distance and the lower limit. If the first two rounds produce nonfunctions, the distance for the third round is halfway between the second-round distance and the upper limit.

(5) If the first three rounds fired in the sequence produce all functions or all nonfunctions, selection of new limits is advisable and the sequence started anew.

(6) Succeeding rounds are fired using the following rules:

If the preceding pair of rounds resulted in a reversal, the next-round distance is halfway between the distance for the two rounds of the pair.

If the preceding pair of rounds did not produce a reversal, the last four rounds are examined. If the number of functions and nonfunctions is equal, the next-round distance is halfway between the distances for the first and last round of that group. If the last four rounds did not have an equal number of functions and nonfunctions, the last six, eight, etc., are examined, until the number of functions and nonfunctions is equal. The distance used is always halfway between the distances for the first and last round of the group examined.

If the above conditions cannot be satisfied and the last round resulted in a function, the distance for the next round is halfway between the distance for the last round and the lower limit; otherwise (last round was a nonfunction), halfway between the distance for the last round and the upper limit.

The above procedure is followed until the rounds allocated are expended.

(7) The data are plotted and the maximum likelihood estimates of the mean and standard deviation for the arming distance are calculated.

b. When a large number of rounds are available, a more efficient method of determining arming distance (the target is moved after a group of rounds is fired rather than after each round) is as follows:

(1) Based on engineering judgment and experience from the testing of similar items, a point halfway between the estimated minimum and maximum

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arming distance is selected. A functioning target is located at this point and a 10-round sample size fired. Based on the results of this firing the functioning target is moved to bracket the distances. The procedure is repeated until the minimum, maximum, and 50-percent arming distances have been located.

(2) The data are used for calculation of maximum likelihood estimates of the mean and standard deviation of arming distance, as with the Langlie method above.

Additional firings may be conducted with ammunition conditioned to high and low temperatures to determine the effect on the arming and nonarming distances established at ambient range temperature.

13. Muzzle Impact Safety. This test is conducted to verify that the safety devices of the fuze are so arranged that they will prevent detonation of the fuze-projectile combination at any impact short of the minimum prescribed distance. This test is usually conducted following the fuze arming test (12 above). A functioning target of the same thickness as used in the fuze arming test is placed as close in front of the muzzle as feasible. A series of single-shot firings are conducted to determine whether the fuze functions when it strikes the target. The successful completion of this test (no functions) usually implies similar safety of the fuzed round while in the bore of the weapon.

14. Out-of-Line Detonator. There is a requirement for fuzed cartridges that the fuze not be armed while in the bore of the weapon. This is accomplished by creating an interruption in the explosive chain in the fuze mechanism. This interruptive mechanism can be in the form of a slider that is spun outward by centrifugal force as the projectile spins during flight, allowing uninterrupted movement of the firing pin on projectile impact, or, as in many fuzes, a ball rotor containing a detonator held out of line during barrel travel. Regardless of the method used to interrupt the fuze firing chain, there must be a test to determine the extent of hazard should an explosive element function in the "out-of-line" position.

The basic procedures for this test are described in test 115 of MIL-STD-331. The test consists of firing one or more explosive components in sample fuzes, checking the effectiveness of the explosive train interrupter, and determining whether or not there is ejection of parts, deformation, or shattering that might result in unsafe conditions. There is no set of standard equipment for this test because the fixtures must be designed to hold in place the parts of the particular fuze being evaluated. Modification to the test fuze is usually necessary. In the case of a percussion-fired fuze, a hole might be drilled through the side of the fuze and a special firing pin inserted for initiating the sensitive explosives in their unarmed position. With an electrically initiated fuze, special holes may have to be drilled to insert an initiator for the detonator. For all types of fuzed projectiles, the test, starting with a fuze in the unarmed position, is conducted as a systematic investigation of the effects of firing sequentially, or simultaneously all ex-

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plosive components of the explosive train. The order and manner of firing should be designed to expose any possibility of defeating the purpose of the fuze interrupter.

15. Self-Destruct. When HE ammunition is employed in the air defense role, firings may be conducted in the direction of friendly troops or installations. It is desirable, therefore, that failures to hit the aircraft not result in live HE ammunition impacting or functioning in friendly areas. Ammunition designated for this role must always contain a mechanism (mechanical or pyrotechnic) to initiate the projectile after a preset time of uninterrupted flight. The purpose of this test is to verify that the ammunition possesses such a mechanism and that it functions within the prescribed time delay.

This test is usually accomplished by firing the ammunition single shot and determining the time from firing to self-destruct. The elapsed time is recorded using an initiator, usually a recoil-operated switch, to start a chronograph and an infrared detector to stop the timing action with the occurrence of an airburst function. Firing elevations must be such that the minimum and maximum permissible times are at least within the field of the infrared detector. A second method that can be used, if an infrared detector is not available, is to time the interval from firing to self-destruct manually with stopwatches. Doppler velocimeters may be required to obtain self-destruct times if the visual and infrared signatures are small. If required, the range to self-destruct can be calculated by use of the data established in the time-of-flight test described in paragraph 27.

16. Cook-Off. The purpose of this test is to determine the minimum number of rounds that can be fired before the chamber of the weapon becomes sufficiently heated to cause the round to fire from heat condition. Within the small arms area, both cartridges with HE fuzed projectiles and cartridges with inert nonfuzed projectiles have to be considered. The cook-off testing of nonfuzed ammunition is described in TOP/MTP 3-2-045, Machine Guns and Automatic Weapons, and TOP/MTP 3-2-059, Hand and Shoulder Weapons.

Fuzed, HE-loaded ammunition presents another problem in that, in addition to the primer-propellant possibility of cook-off, there exists in the complete cartridge the following components that can be ignited by conductive heating:

HE-filled projectile.

Fuze with, normally, an explosive detonator and booster.

It is of prime importance to develop the cook-off characteristics of each explosive component relative to the other, so that the significance of the explosive event may be determined. The firing of the primer or propellant under these conditions generally causes uncontrollable firing of the weapon, which under some circumstances would be critical. The ignition of the fuze or shell body components (prior to the ignition of

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the primer or propellant) poses a serious problem in that the weapon will most certainly be damaged and personnel close to the weapon may be injured. Emphasis should therefore be directed to fuze-projectile components relative to the cook-off level of the primer-propellant. This can be accomplished in two ways:

a. **Static test.** The individual component is subjected to increasing temperatures and the level at ignition recorded. Components should be assembled into a complete cartridge with all components inert except the one under investigation; e.g., live detonator, inert booster, inert HE projectile, inert propellant, and inert primer when testing detonator sensitivity; for booster sensitivity the test is repeated with the booster live, all other components inert; etc. These data will result in comparable cook-off temperatures for each cartridge component.

b. **Dynamic test.** The ammunition is fired in the weapon to determine the cook-off characteristics of each cartridge component relative to the number of rounds fired. These data are of particular interest to the user. Again, as in a above, individual component cook-off levels are determined by having only the selected component live loaded. Firings are conducted as outlined in TOP/MTP 3-2-045 or 3-2-059 to establish round level versus component cook-off.

Any HE cartridge whose fuze or projectile components will cook off with the firing of fewer rounds (lower temperature level) than required for ignition of the primer or propellant is considered unacceptable.

17. Functioning and Casualty/Metal Parts Integrity. The purpose of this test is to determine whether the test ammunition will perform satisfactorily in the appropriate service weapons. Since the primary purpose of this test is to determine ammunition performance, it is important that the service weapon contribution to failures be kept at a minimum. Weapons and barrels should not be fired beyond their serviceable life, and weapon adjustment, cleaning, and parts replacement schedules should be strictly adhered to.

a. For 20-mm acceptance firings vertical witness screens to detect metal parts and fragments are positioned normal to the line of fire. These screens, usually of 1/4-inch-thick plywood (but of much greater thickness if recovery of separated parts is required), have a hole cut in the center to allow the projectiles to pass through unimpeded. Velocity measurements are made, as described in paragraph 9, to verify service weapon velocities and rates of fire. As a minimum, witness screens should be placed at several locations: as close to the muzzle as feasible (normally 10 to 15 feet - 3 to 4-1/2 meters) to contain muzzle blast, immediately before each velocity screen, and at 100 and 200 feet (30-1/2 and 61 meters) forward of the weapon. Additional screens may be placed at intermediate distances of investigation.

Firings of belt-fed automatic weapons are usually conducted in 50-round bursts with complete weapon cooling after each 100 rounds. Magazine-fed weapons are fired as rapidly as practical in increments as near to 50 and 100 rounds as the magazines will permit. The firings are directed through the witness screens, and, during the weapon cooling period (every 100 rounds), the screens are examined for fragment imprints and the cartridge cases are examined for firing defects.

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b. For other munitions different screen material and positioning (distances and orientations) or other firing arrangement such as firing through a tube is necessary as well as different weapon cooling cycles and other aspects.

Evaluation firings are normally conducted with the ammunition conditioned to 70° F; it may be desirable, however, to investigate performance at high and low temperatures.

18. Fuze Sensitivity.

a. Graze*. This test is conducted to determine whether the fuze HE round will function when fired to impact on horizontal targets, over the ranges of intended use. A statistically adequate sample of the test cartridges are fired to impact against a horizontal target at the minimum, median, and extreme tactical ranges of the cartridge. The spectrum of impact media should extend from a relatively soft surface (dry, disked earth) to a hard surface (concrete or macadam) for complete sensitivity evaluation. Possible intermediate impact media may be mud, water, sod, hardpan, etc., with extreme care used in defining the media; i.e., moisture content, depth of condition, preliminary preparations used, smoothness, surface hardness, etc. To further aid in keeping variables to a minimum it is most desirable to continue using the same impact area and move the weapon to adjust for range requirements. The percentage (number) of rounds functioning on initial impact is recorded to determine functioning reliability versus range and impact medium. Height of weapon muzzle, relative to the impact area, is recorded for each impact medium and range. Angles of projectile approach are computed using data generated from the time-of-flight test (para 28). In some tests, data on the distance from the point of projectile impact to the point of detonation are required. High-speed cameras are positioned normal to the line of fire to observe and record these actions.

b. Plate. Plate firings are conducted to determine the minimum thickness of plate that will reliably function the fuze HE projectile. Two other parameters are considered during these firings: range and angle of obliquity**of the plate. Initial attempts are made to fire into a plate positioned at the minimum tactical range and at maximum plate angle as proposed in the ROC's, DP's, specifications, etc. Plates are sloped back and away from the gun. If the fuze round functions with the required reliability on the plate, the range is then increased. If the round does not meet the reliability standards established, the plate obliquity is decreased until the functioning standards are met. It might

*Graze sensitivity is the ability of a fuze to be initiated by grazing; that is, when the missile (projectile) strikes a surface at a glancing angle (up to 80° to 90°) from the normal. Ref. MIL-STD-444.

**Acute angle between the trajectory at the point of impact of a projectile and the perpendicular to the surface of the target at the point of impact.

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be of further interest to decrease the plate thickness at the maximum plate angle for information purposes. This procedure is repeated at the median and maximum tactical ranges.

c. Rain, light brush, and grass. This phase of the test is conducted to determine whether the fuzed HE projectile will function on raindrops, light brush, or heavy grass. A functioning target of 1/16-inch chipboard is positioned 100 meters forward of the gun, and a statistically adequate sample of rounds are fired through the target. If a projectile functions on the chipboard, it is judged not rainsafe and it will function on light brush and heavy grass. Chipboard is used rather than foliage because of the difficulty of providing reproducible foliage targets.

In the area of small arms, no simulated functioning targets are known to exist at present for the conduct of tests to assure, with high confidence, that a fuzed round will not function in rain. A rain test facility is available at Holloman Air Force Base, New Mexico, where a simulated rain environment can be produced out to 1800 feet (548.6 meters). Infrared camera coverage of the entire range is used to determine functioning. Rounds are fired through the simulated rain with drop sizes of 1.5-mm and 4.0-mm. Another approach to a rain test is given in TOP/MTP 4-2-806.

19. Rough Handling. This test is conducted to evaluate the capability of packaged and loose rounds of ammunition to withstand the shocks and vibrations that could be encountered as a consequence of transport or employment on the battlefield. There are various phases of the test for which the procedures are described in TOP/MTP 4-2-602, Rough Handling Tests. They represent intentional or accidental drops of crated ammunition from trucks, hovering helicopters, or forklifts (7-foot drop test); accidental drops of crated ammunition during ship loading (40-foot drop test); drop of uncrated ammunition during man-handling (5-foot drop test); and transport of unpackaged ammunition (either in ammunition boxes or in belts) loosely placed on the cargo bed of a truck or trailer (loose cargo test). Except for the 40-foot drop test, tests are conducted at both low and high temperatures.

After being subjected to the phases of the test, except for the 40-foot drop test, firing of the cartridges should be from the service weapon and observations made for functioning characteristics as follows:

a. Nonfuzed ammunition - velocity, weapon functioning, and case casualties.

b. Fuzed ammunition - same as for nonfuzed cartridges, plus functioning against a plate target as established in the fuze sensitivity phase, paragraph 18b.

Following the 40-foot drop test, the ammunition should not deflagrate and it should be safe to dispose of. There is no performance test.

20. Secured Cargo (Transportation-Vibration). The secured cargo test (formerly called transportation-vibration test) simulates the vibration that ammunition experiences when shipped from the factory to the point of issue, by a combination of rails, ship, aircraft, truck, and trailer. Since the vibration from a two-wheeled trailer is more severe than from any of the other transport modes, the vibration schedule that is employed follows that for the two-wheeled trailer. The secured cargo test is described in TOP 1-2-601. The ammunition is vibrated in its case which is secured tightly to the vibration table. Some cases are vibrated at +145° F and some at -50° F. Other temperatures may be used when other conditions are stipulated.

Following exposure to the vibration environment, the ammunition is unpackaged and examined for damage; samples are re-conditioned to the vibration temperature and fired to detect any differences in performance from rounds that have not been vibrated. In some instances, a lower temperature of -60° F may be required to satisfy cold or extreme cold conditions of AR 70-38.

21. Projectile Torque. The purpose of this test is to determine the force required to rotate the projectile in an assembled cartridge. When a projectile is assembled into a case, it is retained in assembly by crimping (indenting) the case into an annular recess in the projectile body. This prevents movement along the longitudinal axis of the projectile so that during feeding into the weapon the projectile will not separate from the case. This crimping also maintains a seal against moisture penetration. Each cartridge type will require rotational resistance values in inch-pounds established by applicable ROC's, DP's, etc.

To determine whether the cartridge meets the minimum torque requirement, the cartridge case is held firmly and a calibrated torque wrench (with adapters) is used to attempt to cause rotation of the projectile. The load is gradually applied until the prescribed minimum is reached and is maintained for 1 minute. Because of the potential hazards associated with this test, particularly when HE-fuzed rounds are being evaluated, all personnel will be behind barricades and the test accomplished remotely.

22. Bullet Pull. The purpose of this test is to determine, under controlled conditions, the force required to remove the projectile from the case of an assembled cartridge. Bullet-pull data are used as a measure of the uniformity and efficiency of the crimp holding the bullet in the case. Bullet-pull forces required by caliber are listed in the applicable specification. The method is to use a tensile testing machine equipped with a collet head and T-slotted fixture to hold in the extractor

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groove of the cartridge. A force is applied slowly (e.g., 0.125 to 0.250 inch per minute for 20-mm cartridges, 3 to 6 inches for caliber .45 and other cartridges as specified) until the projectile separates from the case. The data are compared with the requirements of the applicable cartridge specification. The propellant from each cartridge case is examined for caking or agglomerates, foreign material, evidence of contamination, or other visually determined undesirable conditions.

23. Noise and Blast. Noise and blast measurements are made in accordance with TOP/MTP 3-2-811. The firing is conducted from the applicable weapon(s) for which the ammunition was designed.

24. Impulse-Recoil Measurements. This test is conducted to determine the amount of energy directed rearward against the shoulder of a rifleman or the mounting system of the weapon. The test normally is conducted with the use of a ballistic pendulum as described in TOP 3-2-826, Kinematic Tests of Small Arms. An approximation of the measurements to within 5 to 10 percent may be calculated using the projectile weight, velocity, and weapon weight. The methods and equations for use of the pendulum or approximate calculations are shown in TOP 3-2-826.

25. Weapon Compatibility. This test is conducted to assure that the ammunition under test will have no deleterious effects on the service weapon and associated equipment (blank-firing adaptors, scopes, mounts, flash hiders, feed systems, etc.). This test is divided into two phases: reliability-endurance, and barrel performance. The test methods for machine guns and automatic weapons are in TOP/MTP 3-2-045; hand and shoulder weapons, TOP 3-2-059.

26. Fragmentation-Lethality. The effectiveness of HE projectiles is based on the amount of blast and fragmentation damage inflicted on impact. To assess this damage, realistic targets must be used. The fragmentation characteristics can be assessed by conducting a fragmentation test as prescribed in TOP/MTP 4-2-813. Where applicable, the effectiveness of the fragments against personnel may be determined by making lethal area computations as described in TOP/MTP 3-2-608.

27. Accuracy and Dispersion. The purpose of this test is to determine the inherent accuracy and dispersion of the test ammunition and its contribution to the overall accuracy of the weapon system. The basic procedures are described in TOP/MTP 4-2-829, Vertical Target Accuracy and Dispersion.

The initial firings are conducted using Mann-type barrels from a fixed rest to determine the single-shot dispersion and accuracy of the test ammunition over the tactical ranges. Unless specified otherwise, 10-round targets are fired with realignment of the barrel on an aiming point before each round. A boresight is used for this purpose. Prior to firing for record purposes, three fouling rounds are fired. The im-

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target should be large enough to contain all rounds fired. If the dispersion of the group is expected to be 4 feet square, the target should be 8 by 8 feet which allows a 100 percent factor both vertical and horizontal. All firings should be conducted under low wind conditions to minimize projectile drift due to weather factors at the time of the test. The suggested wind limits relative to target distance are as follows:

- a. Ranges of 25 to 100 meters - below 10 mph wind.
- b. Ranges of 125 to 300 meters - 5 to 8 mph wind.
- c. Beyond the 300-meter range - below 5 mph wind.

Except when specified otherwise, the X and Y coordinates of all rounds are measured, or printed with an automatic target scorer (see TOP 4-2-829). From the coordinate data, horizontal and vertical standard deviations, horizontal and vertical spread, extreme spread, mean radius, and deviation of the center of impact (CI) from the point of aim (when applicable) are obtained. In some instances the point of aim may not fall on the target; subsequently, a reference point such as the center of the target, a corner of the target, or some other fixed point on the target may be used.

Following the test of the ammunition from the Mann barrel, firings are conducted from the service weapon in all applicable modes of fire and ranges. The resulting data are compared with those from the Mann barrel firings to determine the ammunition contribution to the accuracy and dispersion of the particular weapon. Accuracy and dispersion tests for machine guns and automatic weapons are described in TOP/MTP 3-2-045, and similar tests for hand and shoulder weapons are in TOP/MTP 3-2-059.

28. Time of Flight (Range Tables). This test is conducted to determine the exterior ballistic characteristics of the test ammunition. Exterior ballistic data are required to prepare firing tables. The test is conducted in accordance with TOP/MTP 4-2-604, Range Firings of Small Arms Ammunition, and TOP/MTP 4-2-827, Time of Flight and Ballistic Coefficient.

29. Tracer Evaluation. This test is conducted to determine the visibility and performance (length and time of trace) of the tracer element in the ammunition. The test is conducted under both night and day conditions; at night to determine the physical characteristics of the trace and in daytime to determine the visibility during hours of light.

Firings are normally conducted from the weapon in a single-shot mode of fire. For the night phase, reference lights are positioned along the line of fire at predetermined distances and a camera(s) is positioned perpendicular to this line. The camera is placed so that the reference lights are within the field of view; in some instances

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it is necessary to use more than one camera. The camera shutter remains open during the firing of each cartridge so that each tracer appears as a line across the exposed film. Multiple exposures may be recorded on the same plate or film by tilting the camera in small uniform increments. The time of trace from tracer ignition to burnout is recorded manually with stopwatches.

Daylight firings are similarly conducted except that only the time of trace is recorded. The observers (timers) are behind the weapon and positioned to allow complete view of the trajectory. The same personnel employed for timing under night conditions should be used so that reaction times for the stopwatches will be comparable.

The following terminology is used in reporting by actual count the defects occurring during the tracer evaluation:

Blind: No trace during any part of the trajectory.

Short: Tracer did not reach required length, but no other defects.

Short Igniter: Only igniter burned.

Early: Bright trace starts too soon and ends before reaching the required distance.

Delayed: Bright trace starts late and traces the required distance.

Long: Bright trace starts too soon and traces the required distance.

Partial: Bright trace starts too late and does not trace the required distance.

Bursting Bullet: Bullet explodes with loud report and does not continue in normal flight.

Igniter Muzzle Flash: Particles of burning igniter and tracer composition are blown from the bullet.

Tracer Muzzle Flash: Tracer composition is blown from the bullet and the bullet continues in flight. It traces for not over 25 yards.

Tracer evaluation testing is generally accomplished at the range ambient temperature; it may be of interest, however, to condition some test cartridges to high and low temperatures to determine whether there is any temperature effect on performance.

30. **Flash.** Cumulative muzzle and breach flash are observed for both the test ammunition and standard ammunition when fired from service weapons. The method of test will be in accordance with TOP/MTP 3-2-045 or 3-2-059.

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31. Smoke. This test is conducted in accordance with the smoke test as described in either TOP/MTP 3-2-045 or 3-2-059. For comparative performance purposes, a like number of standard-issue rounds are fired under identical conditions as the test rounds. Results are compared and a relative rating is given the test ammunition.

32. Waterproofness. This test is conducted to determine the ability of the seals around the primer, case mouth, and fuze (if any), to withstand submersion in shallow water. Fuzed small arms ammunition is generally tested in accordance with test 108 of MIL-STD-331; this test requires submersion of the cartridges in a water solution of sodium fluoresceinate (uranin) with subsequent disassembly and inspection under ultraviolet light. Unfuzed small arms ammunition is usually tested for a hermetic seal by placing test cartridges underwater in a transparent test chamber and reducing the air pressure to a predetermined amount (usually 5 psi below atmospheric). Observations are made to detect bubbles escaping from the cartridges. The presence of two or more bubbles indicates a lack of waterproofness. Details of the hermetic seal waterproofness test are given in ANCR 715-505.

33. Salt-Fog. This test is conducted to determine the deleterious effects of a salt-laden atmosphere on the test ammunition. A sample of the ammunition is subjected to the salt-fog test outlined in method 509 of MIL-STD-810C. At the end of the 48-hour exposure period the ammunition is removed from the conditioning chamber. After inspection for rust and corrosion buildup, an attempt is made to fire half of the sample in the service weapon. If the salt deposits and corrosion buildup prevent satisfactory functioning of the weapon, standard lubricant for the weapon is applied to the ammunition. If this fails, the rounds are cleansed with water or a cleaning solvent to remove deposits and a third attempt is made to fire them in the weapon. Fuzed ammunition is fired to impact against a target determined to reliably function the fuze as established in the fuze sensitivity test (para 18b). After firing, the cartridge cases are examined for evidence of gas burn-through and for evidence of binding in the chamber of the weapon. A circumferential case rupture or a case burn-through is considered a justifiable reason for cessation of further firing tests.

The remaining rounds of conditioned ammunition are stored under standard ambient conditions as defined in paragraph 3.1 of MIL-STD-810C for an additional 48 hours. After this period, an attempt is made to fire the rounds in the service weapon using the methods previously described.

34. Temperature-Humidity. Samples of the test ammunition are subjected to a temperature cycling and humidity test under the "warm-wet" climatic conditions of AR 70-38. The ammunition is exposed to the schedule shown in table 2 for a period of 10 days. The schedule conforms to the high humidity-temperature cycle of TOP/MTP 4-2-820.

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Table 2 - Storage Schedule for Humidity Test (24 Hours)

<u>No. of Hours</u>		<u>Temperature °F</u>	<u>Relative Humidity, %</u>
2	increase to..	105.....and.....	90
16	maintain at..	105.....and.....	90
2	decrease.....	105 to 70...increase to.	95
4	maintain at..	70.....and.....	95

Following the storage period the cartridges are fired from the service weapon along with a like number of test cartridges that have not been subjected to storage. Velocities are recorded as outlined in paragraph 9 and are compared (conditioned to unconditioned) to determine the effect of the storage under high humidity conditions on the performance of the test cartridge. Any weapon malfunctions, such as failure to fire or failure to extract or eject, that might be attributable to storage of the cartridge under high humidity conditions are recorded.

35. Sympathetic Detonation. The purpose of this test is to determine whether the test ammunition is susceptible to sympathetic detonation.* A standard container of ammunition is prepared so that the centermost cartridge can be initiated externally. The container is closed and the specially prepared round is initiated. This can be accomplished with an electrically fired detonator in the propellant of a nonfuzed round; in an HE round, the detonator would be in the HE-filled projectile. After a waiting period, as imposed by local safety regulations, the container is examined to determine the extent of damage and the number of rounds that have functioned other than the specially prepared round. Multi-explosions must be anticipated when HE (fuzed) ammunition is subjected to this test; all induced detonations must therefore be conducted with test personnel under adequate cover.

Additional efforts should be made to function the test ammunition by firing small arms ammunition into exposed rounds to determine the possibility of detonation under tactical situations. This will require multiple attempts against HE (fuzed) ammunition; i.e., firing into the fuzed area (head-on and perpendicular to the major axis), the HE body, and the propellant area. Nonfuzed rounds will require attempts to ignite the propellant only. If the test cartridge cannot be initiated by this method, the fact that the test round is susceptible to sympathetic detonation (if true) is somewhat tempered by the improbability of this event's occurring under tactical situations. Test sample sizes should be such that this evaluation can be made with a high degree of confidence (at least 90 percent).

*"Explosion caused by the transmission of a detonation wave through the air from another explosion." Ref. MIL-STD-444.

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36. Armor Penetration. This test is conducted to verify that the armor-piercing round (AP) will meet the requirements established in the characteristics document. For a suitability test, it is necessary only to test against these characteristics; it might be of interest, however, to determine additional information such as:

a. V_{50} - that striking velocity at which a 50 percent probability of target defeat at a fixed obliquity can be expected. Striking velocity is readily convertible to range.

b. θ_{50} - that target obliquity at which a 50 percent probability of target defeat at a fixed range can be expected.

Testing is conducted as described in TOP 2-2-710, Vehicular Armor.

37. Helmet Penetration. Helmet-penetration tests are conducted to determine if the round under test will meet the criteria established in the requirements document for helmet penetration. The surface area of a helmet contains many obliquities; however, due to its symmetry, two orientations, side and rear, can provide a good exposure of these many obliquities.

There are three ways of conducting a helmet-penetration test:

a. Emplacing helmets in an array at the required range and shooting at them.

b. Positioning the helmet close to the weapon and downloading the ammunition to the velocity level of that of the range under consideration.

c. Determining the ballistic limit of the helmets.

The type of test will depend on the criteria to be addressed and on the test directive.

37.1 Helmets Positioned at Required Range.

a. The test will be accomplished by arraying helmets in an upright position (with a liner installed) on a rack. Two orientations of the helmets (side and rear) will be exposed for projectile impacts. In the M1 helmet (the present standard Army helmet) the side and rear portions contain the thinnest and thickest areas. These two surfaces also contain a reasonably comprehensive set of obliquity angles.

b. The rack for the helmets should consist of a minimum of four shelves, with each shelf holding six to eight helmets. The array of helmets is placed at the specified range of interest and projectiles are fired until the needed number of valid hits are recorded.

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c. A valid hit is an impact in an area of the helmet where the resulting complete or partial penetration is not influenced by the condition of the helmet due to a prior hit in that area. A valid hit is irrespective of the angle of obliquity of the area of impact on the helmet. The only exception is a projectile striking the bottom edge of the helmet; this is not a valid hit. The test is conducted at a range which is usually close to the maximum effective range of the weapon and the ammunition; therefore, the hits on the helmets will be randomly dispersed. A minimum of 15 valid hits for each orientation (a minimum of two orientations) of the helmet are required.

d. Data relative to penetration (i.e., complete or partial in accordance with the Navy criterion as defined in TOP 2-2-710), will be recorded. Other comments, such as "cracked" or "dented", will also be recorded.

e. The approximate angle of obliquity relative to a zone on the surface of the helmet at the point of projectile impact will be recorded. For the M1 helmet the data will be categorized into three obliquity* zones: 0° to 27°, 28° to 42°, and 43° to 90°. Each zone contains approximately 1/3 of the projected area of the M1 helmet when it is positioned upright on a horizontal surface. There will be a minimum of four valid impacts in each zone for each orientation. Two sample helmets should be painted (one from the side, one from the rear) to show the three obliquity zones; they can then readily be used by the test director at the test site for determining the zone of impact. Typical photographs of sample damage to the helmets (and liners) will be taken and included in the test report.

f. A point estimate of a weighted probability of obtaining a complete penetration is calculated by considering each zone as having a weight of one. A sample data-reduction process for the rear of the helmet is in table 3.

TABLE 3. SAMPLE CALCULATION FOR WEIGHTED PROBABILITY OF PENETRATION

<u>Zone of Helmet (Rear of Helmet)</u>	<u>No. of Hits</u>	<u>No. of Complete Penetrations</u>	<u>Weight</u>	<u>Weighted Probability</u>
Low obliquity (0° to 27°)	4	4	1	4/4 X 1 = 1.0
Medium obliquity (28° to 42°)	8	4	1	4/8 X 1 = 0.5
High obliquity (43° to 90°)	5	1	1	1/5 X 1 = 0.2
TOTALS	17	9	3	1.7

Note: Weighted probability of a complete penetration on the rear of the helmet: $1.7/3 = 0.57$.

*Obliquity is the angle between the direction of the attack and a line drawn normal to the target surface at the point of impact.

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g. The weighted values for the side and the rear of the helmet are averaged to give the final point estimate of the probability of a complete penetration of a random hit on the helmet.

h. A confidence interval on the overall probability of penetration can also be calculated, using the assumption that the number of penetrations per number of valid hits is a binomial random variable. If the probability of the helmet not being penetrated is required, rather than penetration, it can be calculated by subtracting the probability of penetration from 1.0. A confidence interval of this probability can also be calculated. Different types of helmets can be compared with regard to either of the above probabilities through the use of a chi-square statistic for comparing the equality-of-penetration rate (or protection rate).

37.2 Helmets Positioned Close to the Gun.

a. If remaining-velocity data are available for the ammunition being tested, the propellant in the cartridges can be downloaded to give an impact velocity of the projectile on a target close to the gun equal to that occurring at the range under consideration. The helmets are positioned close to the gun and it is usually possible to impact on the helmet at a location within an inch of the aiming point; thus, very few projectiles and very few helmets are required to provide a good sampling of the various obliquities of the helmet.

b. Before firing at the helmets, projectiles are fired at the reduced propellant charge to ensure that the velocities are correct and that excessive yaw does not occur at the short range at which the projectile will hit the helmet. If yaw, measured by firing through yaw cards of photographic paper, exceeds 10° consistently, a short-range test cannot be conducted. If at least $1/3$ of the projectiles show acceptable yaw, of 5° or less, this test method can be used.

c. As in the testing at actual ranges, two orientations of the helmet will be tested: side and rear. The helmet with a liner will be placed on a stand or rack, which tilts it slightly forward (about 5°) to give the effect of the projectile trajectory at actual ranges. Five projectiles are fired into each of the three zones of the helmet, as previously described in paragraph 37.1e. Judgement is used in eliminating unnecessary firing (e.g., if there are no complete penetrations against the medium obliquity area, it may be assumed that there will be no complete penetrations against the high-obliquity area).

Velocity and yaw data will be recorded on each projectile fired to ensure the correct velocity and less than 5° yaw for all valid impacts. The data are recorded and a point estimate of the probability of penetration of the helmet is determined as described in paragraph 37.1f.

37.3 Ballistic Limits of Helmets. Ballistic limit data for penetration of helmets can be obtained by using the up-and-down firing technique described in TOP 2-2-710.

38. Fungus. This test is conducted to determine whether fungus, streptomycetes, or bacteria to which the test ammunition will be exposed under tactical situations will degrade the performance. If all components are certified for fungus resistance, no fungus test is necessary per TOP/MTP 4-2-818; otherwise, samples of the test ammunition are subjected to the applicable portions of a fungus resistance test as outlined in that document. Following the fungus exposure, the cartridges are wiped clean and examined for any damage; the rounds are then fired from the service weapon and functioning observed. Fuzed ammunition is fired to impact against a target determined to reliably function the fuze as established in the fuze sensitivity test (para 18b). Tracer ammunition is fired for daylight trace observation as described in paragraph 29. Cartridge cases are examined following the firing test to determine any firing defects resulting from the exposure.

39. Human Factors Engineering. Throughout all phases of fuzed and non-fuzed ammunition testing the test item is evaluated for man-item relationships. This includes, but is not limited to: ease of handling; readily recognizable markings on the various types of ammunition (i.e., HE, AP, discarding-sabot, etc.); effects of flash, smoke, blast and toxic fumes; and other factors as applicable. This evaluation also applies during the testing of blank and dummy or training ammunition outlined in 40 and 41 below.

40. Blank Ammunition. Blank ammunition is used during training exercises to simulate the firing of live ammunition and must therefore possess certain characteristics of the related live cartridge. Blank ammunition, along with the associated blank-firing attachment (BFA), must reasonably reproduce the noise, flash, smoke and weapon-functioning characteristics of the live cartridge. The blank cartridge and BFA must also meet safety requirements in that (a) no fragments should be expelled forward of the weapon and (b) the physical appearance of the blank should be easily discernible from that of a live round to preclude the inadvertent firing of a live cartridge with the BFA attached. To check for these requirements the tests outlined in 40.1 through 40.4 below are conducted.

40.1 Function and Casualty. Testing is conducted from the appropriate service weapon with the BFA attached. The firing is similar to that described in paragraph 17. A single witness screen is placed in the line of fire and at the minimum distance at which unburned propellant expulsion is permitted (as prescribed in the applicable requirements document). This witness screen should be of 0.0025-inch-thick kraft paper.

40.2 Weapon Compatibility. The blank cartridge and associated BFA are subjected to a weapon compatibility test as described in paragraph 25.

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40.3 Noise Level. The tests conducted are identical to those in paragraph 23. Noise levels are compared with those of the service cartridge for compliance with the applicable requirements documents.

40.4 Flash and Smoke. The tests are as described in paragraphs 30 and 31. Service cartridges are fired for comparative performance characteristics.

40.5 Tampering. Specific designs of individual cartridges may require special testing such as determining the results of tampering with the blank cartridges or associated blank firing devices.

41. Dummy or Training Ammunition. Dummy or training ammunition is used to check the service weapon by hand cycling and in some instances to interrupt burst firings by linking a cartridge in an extended belt of live ammunition to cause cessation of firing at prescribed intervals. A dummy or training cartridge should therefore possess the characteristics of the service cartridge in relation to weight, center of gravity, and profile; it should also be easily discernible from the live cartridge in appearance. Testing should be limited to checking those characteristics plus determination of serviceable life by use in the intended service weapon (either by hand cycling or as burst fire interrupter).

41.1 Inspection. The rounds are inspected for noticeable defects, damage, and markings that readily distinguish the dummy or training round from the representative live round.

41.2 Physical Measurements. A sample of dummy rounds are inspected and critical areas such as those listed under paragraph 7a determined (i.e., weight, center of gravity, length, etc.). These data are compared with those for the representative live round.

41.3 Serviceable Life. A sample of the dummy rounds are cycled (hand or otherwise) through the service weapon until the cartridges become unserviceable or until the life requirements of the dummy rounds as specified in the applicable requirements document have been met. During the evaluation, if possible, the cycling parts of the weapon under normal spring tensions are allowed to feed, simulate firing, and extract the rounds.

Recommended changes to this publication should be forwarded to Commander, U. S. Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, Md. 21005. Technical information may be obtained from the preparing activity: Commander, U. S. Army Aberdeen Proving Ground, ATTN: STEAP-MT-M, Aberdeen Proving Ground, Md. 21005. Additional copies are available from the Defense Documentation Center, Cameron Station, Alexandria, Va. 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX
REFERENCES

1. AR 70-38, "Research, Development, Test, and Evaluation of Material for Extreme Climatic Conditions."
2. AMCR 715-505, "Ammunition Ballistic Acceptance Test Methods."
3. MIL-STD-210B, "Climatic Extremes for Military Equipment."
4. MIL-STD-331, "Fuze and Fuze Components, Environmental and Performance Test for."
5. MIL-STD-444, "Nomenclature and Definitions in the Ammunition Area."
6. MIL-STD-636, "Visual Inspection Standards for Small Arms Ammunition Through Caliber .50."
7. MIL-STD-810C, "Environmental Test Methods."
8. MIL-STD-1474, "Noise Limits for Army Materiel."

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