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ARTILLERY AMMUNITION

Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland

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13. ABSTRACT
Provides a consolidation of test procedures for artillery ammunition including all field artillery, antiaircraft artillery, and tank ammunition, 37-mm and larger. Discusses safety precautions, test sequencing, and initial inspection; safety evaluation including propellant checkout, design strength, transportability, and EMI; extreme temperature testing; reliability; and human factors and maintenance evaluations.

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ARTILLERY AMMUNITION

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SECTION I
GENERAL

1. Purpose and Scope. This TOP provides a consolidation of the procedures for testing artillery ammunition for conformance with ROC's, DP's, and other requirements. The test director, in preparing a test plan for a development test II (ET) or other proving ground test of artillery ammunition, can select from the subtests listed those that are pertinent to the particular test requirement.

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The TOP includes all field artillery, antiaircraft artillery, and tank ammunition, 37-mm and larger. It does not cover fuzes (see TOP/MTP 4-2-055); mortar and recoilless rifle ammunition, rockets, grenades, or nuclear materials; or development test II (ST) or field environmental tests.

2. Background. The basic unit of artillery ammunition is the complete round, which includes all components necessary to fire a weapon once. The major components are the fuze, projectile, propelling charge, and primer. The primer initiates the burning of the propelling charge which drives the projectile out of the weapon toward the target. The fuze, assembled to the projectile, senses the target and causes the projectile to function at the desired time.

The life cycle of artillery ammunition encompasses each item from the determination of its need to its ultimate phaseout. Once a new item is conceived, testing becomes an integral part of its life cycle. This covers the detailed design, building of prototypes, testing, type classification, and production under AMC.

3. Equipment and Facilities. Equipment and facilities are covered in the references of section II.

SECTION II TEST PROCEDURES

4. Supporting Tests. Supporting tests (in preferred order of completion) to be considered in formulating a development test II (ET) plan, with TOP/MTP and other references, are listed below.

<u>TEST SUBJECT TITLE</u>	<u>PUBLICATION NO.</u>
a. <u>Tests of Complete Rounds</u>	
(1) Initial Inspection (refer to para 8)	
(2) Physical Measurements	4-2-800
(3) Ammunition Characteristics	4-2-500
(4) Safety Evaluation:	4-2-504
Transportation Vibration (refer to para 12)	1-2-601 (when published)
Rough Handling (refer to para 13)	4-2-602
Propellant Checkout (refer to para 10)	
Strength of Design (refer to para 11)	
40-Foot Drop (refer to para 14)	4-2-601

<u>TEST SUBJECT TITLE</u>	<u>PUBLICATION NO.</u>
Radio Frequency Hazards (refer to para 15)	1-2-511
Projectile Design	4-2-501
Blast Pressure (Noise):	
Procedures	3-2-811
Instrumentation	4-2-822
(5) Accuracy and Dispersion	3-1-004, 4-2-829
(6) Projectile Velocity	4-2-805
(7) Sand and Dust	4-2-819
(8) Salt Spray	MIL-STD-810B
(9) Extreme Temperatures (refer to para 19)	
(10) Humidity	4-2-820
(11) Immersion	MIL-STD-810B
(12) Rain	2-2-815
(13) Thermal Shock	MIL-STD-331
(14) Altitude (refer to para 20)	
(15) Solar Radiation	4-2-826
(16) Fungus Resistance	4-2-818
(17) Human Factors Evaluation (refer to para 17)	
(18) Reliability (refer to para 16)	
(19) Maintenance Evaluation (refer to para 18)	

b. Tests of Components

(1) Fuzes	4-2-055
(2) Cartridge Cases	4-2-704, 4-2-705
(3) Projectiles:	4-2-501, 4-2-800
Rotating Bands	4-2-803
Seating	4-2-802
Unbalance	4-2-801
Spin	4-2-811
Terminal Effectiveness	4-2-812, 4-2-813
Time of Flight, Ballistic Coefficient	4-2-827
Velocity	4-2-805
Accuracy and Dispersion	3-1-004, 4-2-829
(4) Propelling Charges	4-2-608, 4-2-700
(5) Ignition Systems	4-2-701

SECTION III
SUPPLEMENTARY INSTRUCTIONS

5. Review of Test Guidance. The subtests that are selected by the test agency are governed by the applicable ROC, DP, and test directive from the supervising agency. Acceptable performance levels are usually stipulated. When an ROC or DP does not exist, inquiries are made of the appropriate directorate at Headquarters, TECOM.

6. Safe Operations During Testing. All hazardous test operations must be covered by a standard operating procedure (SOP) that provides compulsory safety measures to be followed. Safety measures for routine operations are prescribed in the AMCR 385-100. The safety statement furnished by the developer is reviewed for any unusual requirements. If a hazardous test is contemplated, the test director should assure that a suitable local SOP covers the testing. The test plan will specify any special safety precautions and provide guidance for the writing of an SOP if none is available.

7. Sequence of Testing. The order in which test phases are conducted is governed by the type of test, availability of equipment, and effect of a test phase on the test item. In general, a safety evaluation should be conducted immediately after the initial inspection so that safety recommendations can be disseminated to appropriate agencies. Thereafter, high-risk subtests are identified and scheduled early in the test. When possible, two or more subtests are conducted concurrently for economic purposes.

8. Initial Inspection and Measurements.

a. An initial inspection is conducted to assure that the ammunition is not damaged. The ammunition components are identified by comparison with the producer's data card. The shipment is checked for completeness.

b. If a maintenance manual is required but not furnished, the commodity command should be notified immediately. Testing is not started until items missing from the maintenance test package (which, for artillery ammunition, would consist only of a manual, if applicable) are received unless a waiver is furnished by AMC.

c. Characteristics data (TOP/MTP 4-2-500) are obtained for the ammunition and components and compared with requirements. A characteristics data sheet, consisting of a general or exploded view of the round and a listing of the important features, is prepared.

d. If sample numbers are required, they are assigned at this time.

9. Safety Evaluation. The safety evaluation phase of the DT II (ET) or DT III follows the initial inspection. This test is conducted to enable the test agency to recommend that a safety release for service testing be issued by TECOM (TECR 385-6). The test also provides assurance that the round is safe for handling by personnel at the proving ground. The safety of an explosive round is based on the following considerations (for further discussion see TOP/MTP 4-2-504):

- a. Compatibility of the round with the design limits of the weapon - assurance that the chamber pressure of the round at high temperature will not exceed the design criteria for the weapon.
- b. Launch safety - assurance that the round will not function in the bore or short of the arming distance of the fuze.
- c. Flight safety - assurance that the round will not function after fuze arming but function as prescribed by the fuze setting. In addition, there shall be no separation of projectile parts (other than sabots) and no evidence of erratic flight.
- d. Transportation, handling, and storage safety - ability of the item to withstand the rigors of shipping, rough handling by the user, and climatic conditions associated with storage.
- e. R-f hazards - a determination that the item is safe from r-f hazards up to the limit to which the item is exposed.

10. Propellant Checkout. When a new or improved propellant or ignition system is introduced, a test is required to insure compatibility of the service velocity charge with the pressure limits of the weapon. Ten rounds, loaded to the assessed service charge, are conditioned to 145° F and fired. The average pressure for this series must be below the weapon design pressure by three standard deviations. If the assessed charge fails to meet this restriction, new charges are assessed until an acceptable one is found. This new charge becomes the basis for firing table values.

11. Strength of Design. This test, formerly called metal parts checkout, is performed to insure that a projectile can withstand the maximum forces of launch. Ten inert-loaded rounds are fired at excess pressure and recovered. For projectiles designed to the same pressure limit as the weapon, the test pressure will be 5 percent over the upper pressure limit (upl) of the weapon; for projectiles of design strength less than that of the weapon, the test pressure will be 5 percent above the upl of the propellant design pressure. Measurements of the projectile before and after firing determine whether or not the projectile is distorted by firing. Detailed procedures for firing the various type rounds are contained in TOP/MTP 4-2-501. Additional physical properties to be considered and techniques for obtaining data on these characteristics are found in TOP/MTP 4-2-800.

12. Transportation Vibration. A portion of the rounds fired in the safety evaluation phase are subjected to a laboratory vibration test simulating the mode of transportation that the item is likely to encounter in field use. The rounds are boxed and securely fastened to the vibrator. Test temperatures of +145° and -50° F are used and the rounds are vibrated in two planes. Schedules of vibration rates and durations are in TOP 1-2-601.* An explanation of laboratory vibration techniques is contained in TOP 1-1-050.*

13. Rough Handling. Separate from the transportation-vibration test that simulates the transport of packaged items by rail, air, ship, truck, and trailer, the rough handling test simulates the severe shocks, bumps, and drops that an item may receive when thrown loosely on the bed of a truck, dropped from a tailgate, or dropped while being loaded into a weapon. Rough handling tests (including sampling plans) are covered by TOP/MTP 4-2-602.

a. The items are subjected in sequence to a 7-foot drop in their original containers, a loose-cargo vibration test also in containers, and a 5-foot drop unpackaged. Some of the samples are removed after each individual test so that the cause of any damage can be isolated, and the remaining samples undergo all rough handling tests. All rounds are inspected, any damage is assessed, and the rounds considered acceptable are fired.

b. In addition to the sequential tests, a separate 10-foot drop unpackaged is required for tank ammunition. These rounds are not fired but must be safe to handle and dispose of after the drop.

14. 40-Foot Drop. This test is conducted in accordance with TOP/MTP 4-2-601 and the samples are not fired. The test criterion is that the samples must be safe for handling and disposition.

15. Radio Frequency Hazards. Electronic circuitry associated with certain artillery ammunition (e.g., electric primer or other electroexplosive device) may be susceptible to accidental initiation by stray radiation. The test director should identify the susceptible components and determine the circumstances under which a potentially hazardous condition exists. A procedure for testing a round for hazards of initiation by electromagnetic radiation in the r-f portion of the spectrum may be found in TOP 1-2-511.

16. Reliability. Functioning reliability is a statistical characteristic that is addressed in most requirements documents. Analytical planning is normally based upon the assumption that the probability of successful functioning is constant from shot to shot. If this assumption does not seem reasonable across the full range of operating conditions, separate

*When published; otherwise use MIL-STD-810B.

assessments can be planned for within classes of operating conditions for which the assumption is justifiable. Sample sizes can be determined using standard statistical techniques for the binomial distribution. The sample size required for testing is a function of the specified minimum acceptable values for functioning reliability and the associated decision risks that are considered acceptable. General guidance for the design of reliability subtests can be found in AR 702-3 and AMCP 702-3.

The reliability associated with launch safety, if stated at all, is so high that it is impractical to fire enough rounds to prove it. The practical approach therefore is to assume that a single explosion occurring during launch is considered too many; thus, the reason for the malfunction must be determined and corrected.

17. Human Factors Evaluation. Throughout testing, observations are made of the compatibility of the gun crew and the ammunition. Any difficulty in changing or setting fuzes, including operation while wearing arctic mittens; any difficulty in identifying, handling, or loading the round; and any excessive noise, blast, or flash are typical areas of concern. In addition, human factors aspects associated with the maintenance test package (e.g., clarity of instructions, adequacy of warnings, ease of using special tools, etc.) are identified when applicable.

18. Maintenance Evaluation. TECR 750-15 requires that a maintenance evaluation be conducted during DT II and DT III when suitability for Army use or release is being assessed. While artillery ammunition is not ordinarily considered a maintenance-significant item (TECR 750-15 and TOP 1-2-501), manuals may be required and these should be reviewed for adequacy. Any maintenance problems are to be reported by Equipment Performance Report (EPR) form (TECR 70-23) and discussed in the final report.

19. Extreme Temperatures. Extreme temperature tests are usually conducted during safety evaluation. Any additional rounds fired for performance are temperature soaked and fired in accordance with the climatic categories of AR 70-38 which, when applied to ammunition, are interpreted as follows:

<u>Climatic Category of AR 70-38</u>	<u>Assumed Condition of Ammunition</u>	<u>Test Temperature, °F</u>
Intermediate hot-dry	Sitting in sun	145
Intermediate cold	Covered	-30
Hot-dry	Under shade	145 (from inter- mediate hot- dry)*
Cold	Uncovered in open	-50
Extreme cold (seldom used)	Uncovered in open	-70

*High temperature storage test (nonfiring) is performed at 160° F.

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20. Altitude. Neither an altitude test nor a temperature-altitude test (as in MIL-STD-810B, for example) is conducted on ammunition except when specifically directed or when there is reason to believe that the fuze is highly sensitive to atmospheric pressure. In accordance with the findings of TECOM Project 9-CO-011-000-062, Effects of high Altitude Upon Ammunition During Transportation by Aircraft, ammunition is not transported by cargo aircraft except under special emergency conditions, and even then the cargo compartments are pressurized, with temperatures never below 0° F regardless of the outdoor temperature. Additionally, the possibility of sudden decompression, without a complete loss of aircraft, is remote.

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APPENDIX
REFERENCES

1. AR 702-3, "Quality Assurance - Reliability Handbook."
2. AMCR 385-100, "Safety Manual."
3. AMCPM 702-3, "Reliability Handbook."
4. TECR 70-23, "Equipment Performance Reports."
5. TECR 385-6, "Verification of Safety of Materiel During Testing."
6. TECR 750-15, "Maintenance Evaluation During Testing."
7. MIL-STD-331, "Fuze and Fuze Components."
8. MIL-STD-810B, "Environmental Test Methods."