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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Provides procedures for evaluating the safety of cannon and recoilless weapons during development testing. Covers electrical firing circuit checks, safety inspections, firing tests for launch safety, and operational tests by military test and evaluation personnel. Applies to artillery; cannon (guns, howitzers, mortars) and recoilless rifles.		

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

DRSTE-RP-702-102

Test Operations Procedure 3-2-805

12 July 1977

AD No.

SAFETY EVALUATION OF CANNON AND RECOILLESS WEAPONS

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1. SCOPE. This TOP provides procedures for evaluating the safety of cannon (guns, howitzers, mortars) and recoilless weapons during development testing.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

<u>ITEM</u>	<u>REQUIREMENT</u>
Firing range	Selected from DARCOM-P 70-1 <u>1/</u> to suit the weapon and type of firing to be conducted (direct, indirect, etc.)
Temperature chamber	To condition the weapon and ammunition to temperatures ranging from -52.1° C (-60° F) to 62.8° C (145° F)
High-speed photography	Framing camera, 16-mm, 1000 frames/sec or faster, for recording of test events

1/ DARCOM-P 70-1, DARCOM Test Facilities Register.

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2.2 Instrumentation.

<u>ITEM</u>	<u>MAXIMUM ERROR OF MEASUREMENT*</u>
a. <u>All Weapons.</u>	
Projectile velocity measuring equipment (TOP 4-2-805)	Velocity to 3,048 m/s (10,000 fps) $\pm 0.1\%$
Weapon pressure measuring equipment (TOP 3-2-810)	Pressure to 689,480 kPa (100,000 psi) $\pm 2\%$
Strain gages	50.8 to 7,620 cm/cm (20 to 3,000 in./in.) $\pm 2\%$
Meteorological equipment:	
Windspeed	0 to 44.7 m/s ± 0.8 m/s (0 to 100 mph $\pm 1-3/4$ mph)
Wind direction	360° $\pm 3^\circ$
Ambient temperature	-35° to +50° C $\pm 0.2^\circ$ C
Relative humidity	5% to 100% RH $\pm 1\%$
b. <u>Guns and Howitzers.</u>	
Recoil motion measuring equipment (TOP 3-2-815)	Velocity to 18.3 m/s (60 fps) $\pm 5\%$
Timing device to measure recoil cycle time (electronic timer activated by a micro-switch)	± 0.01 sec
c. <u>Mortars.</u>	
Temperature measuring equipment (thermocouples and recorder)	$\pm 1.1^\circ$ C ($\pm 2^\circ$ F)
d. <u>Recoilless Rifles.</u>	
Ballistic pendulum (TOP 3-2-066)	Horizontal deflection to ± 0.13 cm (± 0.05 in.)

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*Values may be assumed to represent ± 2 standard deviations; thus the stated tolerances should not be exceeded in more than 1 measurement out of 20.

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3. PREPARATION FOR TEST.

3.1 Planning.

a. Review the safety statement (provided in accordance with TECOM Suppl 1 to DARCOM-R 385-12), 2/ the range safety data (provided in accordance with DARCOM-R 385-24), 3/ and all previous test reports of similar or related systems.

Assemble information on the physical characteristics of the test item (TOP/MTP 3-2-500), its method of operation, maintenance requirements, and expected modes and areas of deployment.

b. Based on the information assembled above, plan a comprehensive testing program to demonstrate the safety of the system or to identify features that may cause injury or illness to personnel or damage to materiel during field use. Include in the program the following essential features:

(1) Preliminary examinations and limited tests necessary to certify, through a safety release in accordance with DARCOM-R 385-12, that the item is safe for further testing. Performance tests appropriate for this phase are described in paragraph 5 below.

(2) Selected physical performance and reliability tests to verify that the item under test satisfies minimum design and construction requirements for safe field deployment. Tests required are selected from the appropriate system TOP (see 3.3d below) based on the characteristics of the system under test.

(3) Systematic observations and analyses of the test system throughout all phases of development testing to identify and investigate any actual or potential health or safety hazards to personnel and equipment that may result from operation and maintenance of the system by representative users, and to verify the adequacy of the developer's range safety data.

3.2 Personnel. Familiarize test personnel with the technical and operational characteristics of the item under test, as described in the applicable technical manuals, requirements documents, or manufacturer's literature. Review all special warnings and safety SOP's prepared before commencing the safety evaluation.

3.3 Test Item.

a. Record weapon identification (nomenclature, model and serial numbers, etc.) and physical characteristics in accordance with TOP 1-2-504.

2/ DARCOM-R 385-12 with TECOM Suppl 1, Life Cycle Verification of Materiel Safety.

3/ DARCOM-R 385-24, Development of Army Range Safety Regulations.

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b. Visually examine the weapon for any missing, damaged, or improperly fitting parts and for any interferences with proper operation.

c. Check breech and firing mechanisms for proper functioning.

d. Perform prefiring checks of the weapon in accordance with the following:

TOP/MTP 3-2-509 for artillery cannon.

TOP/MTP 3-2-050 for mortars.

TOP/MTP 3-2-066 for recoilless weapons.

e. Borescope all weapon tubes furnished for test in accordance with TOP 3-2-803 and record the condition of the bore.

f. Gage and record bore and chamber diameters in accordance with TOP 3-2-802.

g. Inspect critical weapon components such as breechblocks, breech rings, etc., for cracks or defects, using one of the nondestructive methods of inspection described in TOP 3-2-807. Magnetic particle inspection is frequently used for determining the presence and extent of defects.

3.4 Ammunition. Insure that a separate safety evaluation has been conducted in accordance with TOP 4-2-504 for all ammunition items to be used in the test.

3.5 Instrumentation.

a. Install instrumentation to measure the following, as applicable, in accordance with the listed reference.

(1) Muzzle velocity as described in TOP 4-2-805.

(2) Weapon chamber and recoil system pressures as described in TOP 3-2-810.

(3) Strain on designated components as determined by strain gages (TOP/MTP 3-1-006) or brittle lacquer (TOP/MTP 3-2-809).

(4) Recoil system motion (distance versus time of travel) as described in TOP 3-2-815.

(5) Mortar tube temperature by affixing thermocouples as described in TOP/MTP 3-2-050.

b. Position high-speed framing cameras, as required, to record loader-rammer velocities, trouble areas, weapon stability, and the effect of firing shock on nearby equipment.

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4. TEST CONTROLS.

a. Test weapon systems in the configuration and under the conditions in which they are to be deployed and operated by the field army.

b. Insure that the safety evaluation is planned, conducted, and reported by engineering personnel who are occupationally qualified in the specific commodity under test, and coordinated with a qualified safety engineer.

c. Establish procedures and precautions necessary to insure that the highest feasible degree of safety of test personnel and auxiliary equipment is followed during all phases of the safety evaluation.

d. Record meteorological data (TOP/MTP 3-1-003) immediately before each firing trial and at least hourly while firing is in progress. When the maximum ordinate is below 300 meters, record surface meteorological data for each round fired.

e. Use inert-loaded projectiles and inert fuzes for all preliminary firing trials unless live-loaded rounds and fuzes are essential to a given test. Use projectiles with solid fillers for wear and fatigue tests of the cannon and for velocity and precision firings. Use projectiles inert-loaded with sand and steel filler for proofing and for tests that evaluate the carriage and recoil mechanism. (Inert fillers are described in the appendix to TOP 4-2-501.)

5. PERFORMANCE TESTS.

5.1 Method. Conduct a preliminary safety evaluation, consisting of the operations described below, to identify any hazards that may be encountered in further testing. In addition, throughout all subtests conducted to evaluate performance and reliability factors make observations to determine the existence of hazards or potential hazards. Investigate all identified potential hazards further by the conduct of special trials of the equipment under "worst case" conditions as selected by the test engineer. Determine the adequacy of all design features intended to eliminate or minimize potential hazards, and investigate any potential hazards which may occur or become more serious with additional operating hours. If any unsafe or potentially unsafe condition that cannot be corrected, prevented, or easily avoided by test personnel is observed during the test, the test will be suspended until the condition is resolved.

5.1.1 Electrical Firing Circuit Check. (When applicable)

a. Examine the firing circuit diagram for adequacy of design and safety features and for compliance with weapon specifications.

b. Determine by visual examinations and simulated firing trials that firing switches, buttons, or levers are located to minimize chances

of accidental firing and that all circuit connections are protected against accidental grounding or shorting.

c. Electrically wire a dummy round to record the passage of current through the dummy primer. Pass the wires from the dummy primer through the projectile and out the barrel of the weapon to a recorder.

d. Insert the dummy round in the chamber and attempt to "fire" the round three times at selected steps in the process of closing and locking the breech. Repeat the procedure at least ten times and investigate the source of any current recorded at the primer.

e. Repeat the firing circuit check after each series of firing trials and environmental test described below, to determine whether the circuit is affected by firing shocks or extreme environmental conditions.

5.1.2 Launch Safety Phase.

5.1.2.1 Guns and Howitzers.

a. Proof-fire the complete system (i.e., cannon, recoil mechanism, carriage and mount) using the guidelines presented in TOP/MTP 3-2-509.

b. Conduct safe service life tests as described in TOP 3-2-829.

5.1.2.2 Mortars.

a. Proof-fire the test item in accordance with TOP/MTP 3-2-050.

b. Rapidly fire a sufficient number of rounds to heat the mortar tube to the maximum allowable temperature specified for the tube. When this temperature is reached, fire 200 inert-loaded rounds conditioned to 62.8° C (145° F) at a rate that will maintain the tube at the maximum allowable temperature.

c. Perform stargage, borescope, and nondestructive inspections of the weapon after completion of firing in accordance with TOP 3-2-800.

d. Condition the weapon to -45.6° C (-50° F) for 24 hours or until complete temperature stabilization is assured.

e. With the weapon conditioned to the above temperature, fire one round conditioned to 21.1° C (70° F) and visually examine the weapon for damage. Repeat the test until five rounds have been fired, allowing the weapon to return to -45.6° C (-50° F) between rounds.

f. Inspect the weapon for structural damage (TOP 3-2-807) and stargage (TOP 3-2-802) the tube after firing.

5.1.2.3 Recoilless Weapons.

a. Proof-fire the test item in accordance with paragraph 7 of TOP 3-2-066 using both service and excess pressure rounds.

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b. Determine the adequacy of the safety devices that prevent inadvertent firing of the weapon. Attempt to actuate firing mechanisms remotely under each possible mode of safety setting using both simulated and actual rounds.

c. Determine the recoil momentum as described in TOP 4-2-606 by firing three work control rounds whose recoil level has been established by comparison with calibration ammunition.

d. Inspect the weapon for structural damage (TOP 3-2-807) and stargage (TOP 3-2-802) the recoilless rifle after firing.

5.1.3 Operational Safety Phase. Include the following subtests as part of the development test for the respective test items to evaluate operational safety.

a. Noise and blast measurements in accordance with TOP/MTP 3-2-811.

b. Toxic hazard measurements in accordance with TOP 2-2-614.

c. Extreme temperature tests in accordance with the system TOP.

d. Radioactive component checks and swipe tests in accordance with TOP 3-2-711 and TECOM Pamphlet 385-2 ^{4/}, if applicable.

e. Extended operation of the test item in a simulated tactical scenario by military test and evaluation personnel representative of the individuals who are expected to emplace, fire, and move the item under field conditions.

5.2 Data Required.

5.2.1 Launch Safety Phase.

5.2.1.1 Guns and Howitzers. Record test data and observations as required by the proof-firing test and basic firing program of TOP/MTP 3-2-509 and the safe service life tests of TOP 3-2-829.

5.2.1.2 Mortars. Record the following:

a. Test data and observations required by the proof-firing test of TOP/MTP 3-2-050.

b. Weapon temperatures throughout the firing of paragraphs 5.1.1.2b and e.

c. Results of stargage (TOP 3-2-802), borescope (TOP 3-2-803), and nondestructive inspections (TOP 3-2-807) after each firing test.

5.2.1.3 Recoilless Weapons.

a. Test data and observations required by the proof-firing test of TOP 3-2-066.

^{4/} TECOM Pamphlet 385-2, Radiological Safety-Swipes and Surveys

- b. Extent of rearward blast area which may be hazardous to personnel.
- c. Recoil momentum.
- d. Results of stargage (TOP 3-2-802) and nondestructive inspections (TOP 3-2-807) after each firing test.

5.2.2 Operational Safety Phase. For each weapon, record:

- a. All hazards or potential hazards encountered during firing tests, inspections, maintenance, and movement operations.
- b. Adequacy of safety warnings, labels, and procedures.
- c. Results of firing circuit checks.
- d. Sound pressure levels.
- e. Rear blast damage areas, damage or potential damage from muzzle blast.
- f. Toxic gases that exceed specified limits.
- g. Results of extreme-temperature firings.
- h. Conditions of use such as temperature, humidity, and other environmental data.
- i. Operator's evaluation of range safety data.
- j. Results of radioactive component inspections and swipe tests, if applicable.

6. DATA REDUCTION AND PRESENTATION.

- a. Tabulate all data and compare these data with established criteria.
- b. Based on data recorded during preliminary safety tests, prepare a safety release recommendation for submittal to TECOM. Detailed results of the test need not be included, but a statement similar to one of the following is made:

(1) "No undue hazards beyond those normally associated with the firing of similar weapons were detected as a result of the following safety evaluation tests: (List the tests.) Subject weapon is considered safe for the purpose of further testing provided the following restrictions are observed:" (List the restrictions.)

(2) "The subject weapon cannot be considered safe for further testing due to the following hazards encountered in tests:" (List the hazards.)

- c. Assemble and tabulate all results and safety information generated during the preliminary safety tests conducted in accordance with this TOP and the performance tests conducted as described in the appropriate

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system TOP. Assign the proper category of hazard level for each hazard identified.

(1) Report hazard level 4/ and classification (deficiency, shortcoming, etc.) in accordance with DARCOM-R 700-38 (para 4f) and TECOM Supplement 1. 5/ Report the conditions of use under which each hazard was observed and describe any features that require further investigation, including any hazards that could occur or increase as a result of increased operating hours.

(2) Prepare a statement concerning the adequacy of the developer's range safety data. If the data received is determined to be inadequate, recommend necessary modifications.

(3) Describe narratively all safety hazards identified and recommend actions required to eliminate or avoid each potential hazard.

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5/ MIL-STD-882, System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for.

6/ DARCOM-R 700-38 with TECOM Suppl 1, Test and Evaluation - Incidents Disclosed During Materiel Testing.