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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-103
*Test Operations Procedure 4-2-045 26 February 1985
AD No.

DEMOLITION-INITIATING EQUIPMENT

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1. SCOPE. This TOP provides guidance for planning tests of demolition-initiating equipment to assure conformance with requirements documents. Tests to satisfy the requirements for the particular test item and test type can be selected from those listed in paragraph 4. This procedure does not apply to firing devices (fuzes) as defined in Appendix A, to initiating components of special demolition items or kits, or to their tools and accessories. This TOP does not cover mines and demolitions; for testing procedures regarding these items, see TOP 4-2-505.[1] **

Demolition-initiating equipment consists of the explosive and nonexplosive items used to initiate standard or expedient demolition explosive charges.

*This TOP supersedes TOP 4-2-045 dated 2 February 1972.

**Footnote numbers correspond to reference numbers in Appendix B.

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The equipment includes electrical power sources and circuit-testing devices, blasting caps, time blasting fuses, detonating cords, and a variety of tools and accessories. Categories of demolition-initiating equipment are defined in Appendix A. The demolition charges include munitions specifically designed for demolition purposes as well as other munitions used as booby traps or, because of their explosive content, as expedient demolition charges. Most antitank mines, for example, incorporate a secondary fuze well that can accommodate a firing device to enable them to be used as booby traps or demolition charges. The demolition-initiating equipment required for a specific task can range from a single item to all of those listed above. Selection would be based on target location and type, the demolition charge, the availability of items, and the preference of the user.

Demolition-initiating equipment must perform with a high degree of reliability with respect to both safety and performance. The destruction of a bridge during a withdrawal may have to be performed in darkness, under pressure from the enemy, and may require the simultaneous initiation of several explosive charges. A premature initiation of any explosive element, in addition to the extreme immediate hazard to personnel, could prevent further withdrawal of troops and equipment. Conversely, the failure of any component to function as intended could result in capture of the bridge in a usable condition.

2. FACILITIES AND INSTRUMENTATION. These are covered in the references of Appendix B.

3. REQUIRED TEST CONDITIONS. Not applicable.

4. TEST PROCEDURES.

4.1 Initial Inspection and Physical Measurements. Review literature pertinent to the test item for familiarization with performance requirements, operational characteristics, the functions of components, and the results of previous tests. The literature includes the test directive, drawings, draft equipment publications, the SOP, field and technical manuals (Appendix B), and reports of previous tests.

a. Inspect the test item and packaging for damage and defects. Inspect the system support package for completeness against the list of contents. Report shortages by Equipment Performance Report (EPR) to the appropriate commodity command, with a copy to TECOM. Do not begin testing until missing items are received or a waiver is furnished by Headquarters, AMC (per DARCOM 700-15[2]). Excesses should also be reported, although this need not delay the start of testing.

b. Assemble and print a characteristics data sheet, suitable for the formal report and other uses, consisting of a photograph of the test item (exploded or cross-sectional view preferred), reduced in size and combined, on a glossy 8- by 10-inch print, with a listing of all principal physical and performance characteristics. Guidance is contained in TOP 4-2-500.[3]

4.2 Safety Evaluation. The safety evaluation is conducted to assure that tests can be conducted with minimum risk to personnel. A successful safety evaluation permits a safety release by TECOM, as defined in AR 385-16.[4] The safety

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evaluation is normally the first phase of testing conducted; a preliminary safety evaluation, as a minimum, is required within 30 days after test initiation.

a. The safety evaluation of demolition-initiating equipment must demonstrate that the equipment is safe to transport and handle over a range of temperatures and that it is not subject to accidental initiation. The subtests that comprise the safety evaluation are paragraph 4.2.1 below, the 40-foot drop (TOP 4-2-601[5]), rough handling (TOP 4-2-602[6]), transportation vibration (TOP 1-2-601[7]), and radio frequency hazards (TOP 3-2-616[8]).

b. The developer is required by AR 385-16 to submit a safety assessment report before testing begins. A review of this report is mandatory. The purpose of the review is to identify design or performance characteristics that merit particular attention.

c. Review developmental test data to identify aspects of design or performance that deserve particular attention. Valid test results can be used to satisfy safety evaluation requirements or to supplement the results of limited additional tests.

d. Review the maintenance literature (usually a draft equipment publication). Particular emphasis is placed on the adequacy of any warning statements and adherence to established safe operating procedures.

4.2.1 Performance Safety Check. This subtest, the first phase of the safety evaluation, consists of taking a sample of the size shown in Table 1 and operating (or functioning) each of the items at ambient temperature. If no safety problem or hazard is encountered, the remainder of the safety evaluation is conducted.

TABLE 1 - PERFORMANCE SAFETY CHECK REQUIREMENTS

Equipment Category	Minimum Sample	Para No.
Blasting machine	6	4.3.1.1
Electric firing device	6	4.3.2
Circuit tester	6	4.3.3.2
Electric blasting cap	20	4.3.4.1
	20	4.3.4.2
Nonelectric blasting cap	20	4.3.5
Time blasting fuse	10	4.3.6.1
	10	4.3.6.2
Detonating cord	10	4.3.7.1
	10	4.3.7.2

4.3 Performance Tests.

4.3.1 Blasting Machines. Three types of firing performance tests are described below. Two use electric blasting caps incorporated in a firing circuit. The other, the simulated firing performance test, involves the use of an oscilloscope to display the electrical output of the blasting machine. The results of all three tests are considered in the durability test.

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4.3.1.1 Firing Performance Test. Perform at least two tests as described below with each blasting machine.

a. Prepare an electric firing circuit that satisfies guidance document essential requirements with respect to maximum number of blasting caps and length and type of firing wire. Record the circuit parameters.

b. Check the continuity of the firing circuit with a standard circuit tester. Perform step c only after any unsatisfactory condition is corrected.

c. Connect the firing circuit to the blasting machine, and activate the blasting machine.

d. Record the number of electric blasting caps fired.

e. Rate each firing attempt as a success or a failure. A successful firing attempt is one that results in the firing of all blasting caps or one in which the cause of failure is attributable to a firing circuit condition.

4.3.1.2 Optional Firing Performance Test. The purpose of this optional test is to determine whether the blasting machine will initiate a firing circuit that satisfies guidance document desired requirements. These requirements normally specify a greater number of blasting caps, a longer length of firing wire, and wire of higher resistance than specified for essential requirements. When conducted, perform the test as in 4.3.1.1 above except that:

a. The firing circuit used satisfies the guidance document desired parameters.

b. The number of blasting machines used and the number of firing attempts per blasting machine are optional.

4.3.1.3 Simulated Firing Performance Test.

a. Measure and record the resistance of the firing circuit specified in paragraph 4.3.1.1 to the nearest ohm, and determine the test item electrical output characteristics during testing for comparison with data generated during this test.

b. Prepare an electric circuit having the measured resistance.

c. Instrument the test circuit with an oscilloscope set with a minimum sweep time of 20 milliseconds.

d. Connect the blasting machine to the test circuit, and activate the blasting machine.

e. Photographically record the voltage trace produced on the oscilloscope; identify the photograph by blasting machine number and retain for use in step f below.

f. For each subsequent actuation of the blasting machine, compare the voltage trace observed on the oscilloscope with that photographically recorded. Record each actuation that produces an equivalent trace repeat as a successful

firing. If the voltage trace is not equivalent, repeat the test in 4.3.1.1 before conducting additional simulated firings.

4.3.1.4 Durability Test. Subject each blasting machine undergoing this test to repeated firing attempts until it becomes inoperable or the number of successful operations (firing missions) required by the guidance document is achieved. Firings conducted by all of the previously described methods are considered. Most of the firing tests will necessarily be conducted by the simulated method. Each firing attempt made in the optional firing performance test 4.3.1.2 is considered to be a successful firing. Record the total number of successful firings and the cause of any failure, if determined.

4.3.2 Electric Firing Devices.

Circuit Tester Output. Measure the electrical output of each firing device in the circuit test mode by the method described in paragraph 4.3.3.

4.3.2.1 Circuitry Performance Test.

a. Prepare an electric firing circuit consisting of an electric blasting cap and 100 feet of two-conductor No. 18 AWG wire for each pair of firing device terminals.

b. Place all electric firing device switches in the OFF or SAFE position, and connect the firing circuits.

c. Check the continuity of each firing circuit with the integral circuit test mechanism. Correct any unsatisfactory circuit condition. Record the results of the circuit continuity check.

d. Individually fire and inspect each circuit after each firing to determine whether only the planned firing occurred. Record the inspection results.

e. Repeat steps a. through d. with each electric firing device.

4.3.2.2 Firing Performance Test. Perform at least two tests as described below with each electric firing device.

a. Prepare the maximum number of circuits that the device can fire simultaneously. The parameters of the firing circuits, with respect to number of electric blasting caps and length and type of wire, are designed to represent the maximum essential requirements expressed in the guidance document. Record the circuit parameters.

b. Connect the firing circuits and perform continuity checks as in 4.3.2.1.b and c above.

c. Fire all firing circuits simultaneously. Inspect for initiation of the blasting caps in each circuit, and record results.

4.3.2.3 Optional Firing Performance Test. The purpose of this optional test is to determine whether the electric firing device will initiate firing circuits that satisfy the desired requirements of the guidance document. When conducted, perform the test as in 4.3.2.2 above, except that:

a. The firing circuits are constructed to meet the desired firing circuit parameters.

b. The number of electric firing devices tested and the number of firing attempts per device are optional.

4.3.2.4 Durability Test. Each electric firing device subjected to this test is repeatedly fired until the device becomes inoperable or the number of successful firings required by the guidance document is achieved. Each previous firing is considered (those conducted by the optional method are considered successful firings regardless of the results obtained), and additional firings are performed by one or more of the following methods. Record method used and the results obtained.

a. With electric blasting caps. The circuit parameters may vary to those specified by the essential requirements of the guidance documents.

b. As in a above with flashbulbs used in lieu of electric blasting caps (if this substitution can be made satisfactorily).

c. With suitable instrumentation to indicate proper electrical output.

4.3.3 Circuit Testers.

4.3.3.1 Electrical Output Measurement. Prepare an electric circuit with a resistance of 2.00 ohms, and connect to the circuit tester. Measure the electrical output by the appropriate method indicated below.

a. Battery-powered circuit testers. Measure the current for a 2-second period when the circuit tester is activated. The output is satisfactory if the current does not exceed 0.20-ampere at any time.

b. Generator-powered circuit testers.

(1) Instrument the test circuit with an oscilloscope.

(2) Photographically record the voltage trace produced on the oscilloscope when the circuit tester is activated.

(3) Identify the photographic record with the circuit tester number.

(4) Select the 10-millisecond interval with the highest apparent output. Compute and record the output for this interval. The output is satisfactory if it does not exceed 1.4 milliwatt-seconds for the 10-millisecond interval.

4.3.3.2 Circuit Tests. Conduct each of the following tests at least once with each circuit tester.

a. Prepare a firing circuit consisting of one electric blasting cap and 100 feet of two-conductor No. 18 AWG wire, and connect to the circuit tester terminals; activate the circuit tester. Record the circuit tester response and whether or not the blasting cap is initiated.

b. Connect the circuit tester to a variable resistor with a maximum resistance exceeding that which the guidance document requires the item to check. Step (1) follows if the circuit tester is of the galvanometer type. Step (2) follows if the circuit tester is of the indicator lamp type.

(1) Set the variable resistor at 10 ohms. Actuate the device and record the galvanometer reading. Repeat this step at each 10-ohm interval until a full-scale reading is obtained on the circuit tester. Record the galvanometer reading for each 10-ohm increment.

(2) Set the variable resistor at the maximum resistance value at which the guidance document requires the circuit tester to indicate a continuous circuit. Actuate the circuit tester. If the indicator lamp does not light on any of three consecutive actuations, reduce the resistance value by 10 ohms. If the indicator lamp lights on all three actuations, increase the resistance value by 10 ohms. Repeat this step until the maximum resistance value at which the lamp lights on three consecutive actuations is identified. Record this value.

4.3.3.3 Durability Test. Consider each previous actuation of devices subjected to this test. Perform additional actuations until the circuit tester fails or the number of actuations required by the guidance document is achieved. Perform the additional actuations with the circuit tester connected to a circuit having a resistance value of one-half that which previously produced a full-scale meter reading or three consecutive indicator lamp outputs. Record the number of successful circuit tests performed.

4.3.4 Electric Blasting Caps.

4.3.4.1 Nonfunctioning Test. The purpose of this test is to determine whether the electric blasting cap is subject to initiation by the maximum current level permissible for circuit testers. In this test, expose individual blasting caps to a current of 0.20 ampere for 5 seconds. Record any blasting cap initiations, and destroy nonfunctioning caps.

4.3.4.2 Individual Functioning Test. Test individual electric blasting caps as follows:

a. Prepare a test circuit capable of supplying a 0.45-ampere current to individual blasting caps.

b. Expose each blasting cap to the 0.45-ampere current for at least 10 seconds.

c. Measure and record the delay between current application and blasting cap firing to the nearest millisecond.

d. Destroy any blasting caps that fail to function.

4.3.4.3 Multiple Firing Test.

a. Prepare a firing circuit consisting of 500 feet of two-conductor No. 18 AWG firing wire and 10 series-connected electric blasting caps.

b. Check the circuit continuity with a circuit tester. Correct any unsatisfactory condition disclosed.

c. Initiate the blasting caps with a standard 10-cap-capacity blasting machine. (Record the blasting machine model and serial numbers.)

d. Inspect to determine whether all blasting caps fired, and record the inspection results.

4.3.4.4 Effectiveness Test.

a. Install the blasting cap in a standard TNT demolition block, and initiate it.

b. Observe for complete detonation of the TNT demolition block. Record the results as complete or incomplete detonations.

c. Repeat the test with standard composition C-4 demolition blocks and with other explosives specified by the guidance document.

4.3.5 Nonelectric Blasting Caps.

4.3.5.1 Initiation Test.

a. Assemble the blasting cap to a length of time blasting fuse, and ignite the fuse. Record whether or not the blasting cap functions.

b. Repeat the test with blasting caps assembled to a standard firing device with coupling base.

4.3.5.2 Effectiveness Test. (Conduct in accordance with para 4.3.4.4).

4.3.6 Time Blasting Fuse. NOTE: The three tests described may be performed concurrently.

4.3.6.1 Ignition Test. Assemble a length of time blasting fuse to a standard fuse igniter, and activate the igniter. Record whether or not the fuse ignites.

4.3.6.2 Burning Time Test.

a. Assemble a measured length (at least 3 feet) of time blasting fuse to a fuse igniter, and activate the igniter.

b. Measure the burning time of the time blasting fuse with a stopwatch, and record the burning time per foot.

4.3.6.3 Effectiveness Test. Assemble a length of time blasting fuse to a fuse igniter and a nonelectric blasting cap, and activate the fuse igniter. Record whether or not the blasting cap ignites.

4.3.7 Detonating Cord.

4.3.7.1 Initiation Test.

a. Tape a blasting cap to a length (at least 3 feet) of detonating cord. Place the blasting cap 6 inches from one end of the detonating cord with the explosive end of the cap toward the other end of the cord.

b. Initiate the blasting cap.

c. Inspect for complete detonation of the cord excluding the 6-inch-long section, and record the inspection results.

4.3.7.2 Propagation Test. Perform each of the following tests.

a. Square knot connection:

(1) Tie two 5-foot lengths of detonating cord together with a square knot. Place the connected lengths in a straight line. Tape a blasting cap to one end as described in 4.3.7.1.a.

(2) Initiate the blasting cap, and record whether or not propagation occurs across the knot.

b. Girth hitch connection:

(1) Place two lengths of detonating cord approximately 5-feet long perpendicular to each other; one is assumed to be a main line, the other a branch line. Connect the branch line to the main line with a girth hitch with one extra turn.

(2) Initiate the main line with a blasting cap. Record whether or not the detonation propagates from the main line to the branch line.

4.4 Extreme Operating Temperatures. If the test items perform satisfactorily (as well as being safe) at the extreme temperatures during the transportation-vibration phase of the safety evaluation, no further extreme-temperature test is needed. If performance shortcomings are observed however, additional extreme-temperature tests are required in accordance with the guidance document. If temperatures are not shown, -37° C (-35° F) and 63° C (+145° F) are used if the intermediate conditions of AR 70-38[9] are specified. If, instead, the cold climate of AR 70-38 is specified, the low temperature test is conducted at -46° C (-50° F). If the hot-dry climate is specified, the high temperature test is conducted at 63° C on the assumption that the kit permitted by AR 70-38 consists of shade; if exposure to the open sun is required, a test temperature of 74° C (+165° F) will be necessary. In all cases, performance will be at the conditioning temperature and in accordance with the sample sizes and procedures shown in Table 1.

NOTE: The 63° C for intermediate conditions and the 74° C for hot-dry conditions take into account the effects of both air temperature and solar radiation but are only approximations. If a solar radiation facility is available, it is preferable to expose the test items to the diurnal cycles described in TOP 4-2-826[10] to obtain more precise temperatures.

4.5 Reliability and Durability. The reliability subtest and the durability subtest are usually combined and considered as one since the same data are used for both and since durability is actually a special case of reliability. The reliability and durability subtest not only uses the data from all of the other

subtests, but also requires additional data from special trials under ambient conditions to provide a statistically adequate number of trials.

a. When a reliability requirement is stated, use TOP/MTP 3-1-002[11] as an aid in determining the number of trials required and the number of failures that can be tolerated to achieve the desired reliability with the desired confidence. A precise definition of what constitutes a reliability failure is a prerequisite to a reliability analysis. For explosive items, e.g., blasting caps, a minimum sample size must be statistically determined based upon the stated reliability requirements. For items that function repeatedly, e.g., blasting machines, a minimum sample size and a minimum number of functionings per test item must be determined. If economic considerations dictate a reduced test, prior approval to accept a lesser confidence must be obtained. Make two reliability analyses as follows:

(1) Overall reliability which includes a summation of all the satisfactory and unsatisfactory samples from all subtests.

(2) Selected reliability which includes all sample groups except those in which a statistically significant failure rate is attributable to a particular subtest.

b. Durability is, of course, associated only with items that function repeatedly. Though durability is closely related to reliability, a durability failure may be quite different from a reliability failure since the former is so significant that it would require that the test item be scrapped or be given a major overhaul. The sample size and the number of functioning tests for durability are based upon requirements and are prescribed in TOP 1-2-502.[12]

4.6 Human Factors Evaluation. Throughout all testing, observe the compatibility of the person with the test item. Any difficulties in operation, identification, handling, assembling, etc., are typical areas of concern. In addition, identify human factors aspects associated with the maintenance test package (e.g., clarity of instructions, adequacy of warnings, ease of using special tools). Detailed instructions for these design and human performance measurements are prescribed in TOP 1-2-610.

4.7 Logistic Support. Consult TECOM Supplement 1 to DARCOM 700-15. A draft equipment publication is usually furnished or various manuals are available. These should be reviewed as stated in paragraph 4.6 above. If a maintenance package is required but not furnished, the commodity command must be notified immediately as indicated in paragraph 4.1. Any maintenance problems are reported by EPR form (refer to DARCOM 70-13[13]) and discussed in the final report. Special performance tests to evaluate maintenance are not required since the required data are obtained throughout all testing, especially during the reliability and durability subtest.

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APPENDIX A
CATEGORIES OF DEMOLITION-INITIATING EQUIPMENT

1. Blasting Machine

The blasting machine is a manually powered generator for initiating electric blasting caps. Blasting machines are rated according to the number of electric blasting caps, connected in series, which the machine will reliably initiate. Current items are rated as 10-, 30-, 50-, and 100-cap capacity with the caps connected in a 500-foot-long firing line. The machine is used by attaching the firing line lead wires to the two terminal posts provided and then briskly actuating the machine handle.

2. Electric Firing Device

Electric firing devices serve the same purpose as blasting machines. They are, in general, of more recent origin and more varied in design and utility as indicated by the following general characteristics;

a. Most of the devices are powered by an internal battery and incorporate a capacitor. One developmental device, however, uses a blasting machine as the power source, and another uses an external battery pack as a supplementary power source to increase the output.

b. The devices usually incorporate a number of pairs of terminals and switches to permit the selective firing of a many as 10 firing circuits. One item, however, has no switches and one pair of terminals; firing is accomplished by attaching one of the firing line lead wires to a terminal then touching the other wire to the other terminal. The individual circuits of multicircuit devices can be internally connected in series or in parallel.

c. A self-test feature is usually incorporated in the form of an indicator lamp or voltmeter.

d. A circuit test feature is usually incorporated in the form of an indicator lamp or galvanometer.

3. Circuit Tester

The circuit tester is used to check the continuity of electric firing circuits. Two types, the blasting galvanometer and the electric test set, are used. The galvanometer measures circuit resistance while the electric test set indicates a continuous circuit by means of an indicator lamp. The electrical output of both types is necessarily restricted to less than the minimum required to initiate an electric blasting cap. The power source is an internal battery or a manually powered generator.

4. Firing Device

A firing device is essentially a fuze. Test procedures applicable to firing devices for mines and demolitions, and to similar items such as fuze igniters, are covered in TOP 4-2-505 which also descirbes the various types of firing devices.

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5. Electric Blasting Cap

The electric blasting cap is used to initiate a high-explosive charge. A pair of lead wires is internally connected by a bridge wire embedded in an ignition charge. Current from a blasting machine, electric firing device, or a battery heats the bridge wire and initiates the ignition charge. The military or special electric blasting cap is instantaneous, and a single cap will reliably detonate the less sensitive military explosives such as TNT, tetrytol, and military dynamite. Commercial electric caps are also used for military purposes but are not considered in this TOP. Both instantaneous and delay commercial electric caps are available and are, in general, less powerful than the military variety.

6. Nonelectric Blasting Cap

The nonelectric blasting cap is identical to the electric cap with the exception that flame produced by an attached firing device, safety fuse, or detonating cord is used to initiate the ignition charge. The flame-producing item is inserted in the open end of the nonelectric cap and the cap then crimped onto the item.

7. Time Blasting Fuse

The time blasting fuse is used to provide a delay in the initiation of a demolition charge. The fabric-covered cord has a black powder core. In use, one end of a length of time blasting fuse is crimped in a nonelectric blasting cap, the other end is ignited with a match or fuse igniter.

8. Detonating Cord

Detonating cord, sometimes called primacord, has a high-explosive core. It is used to transmit a detonation wave from one point to another -particularly in connecting several physically separated demolition charges. Detonating cord is initiated with a blasting cap.

9. Tools and Accessories

This category includes all of the many components used to assemble and connect the active components in a demolition firing train. It includes crimpers, pliers, knives, wire, priming adapters, detonating cord clips, tape, adhesive paste, waterproofing compound, and carrying boxes and bags.

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APPENDIX B

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