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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TOP 4-2-080	2. GOVT ACCESSION NO. AD-A126011	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE "GRENADES"		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY ABERDEEN PROVING GROUND (STEAP-MT-M) ABERDEEN PROVING GROUND, MARYLAND 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DARCOM-R 310-6
11. CONTROLLING OFFICE NAME AND ADDRESS US ARMY TEST AND EVALUATION COMMAND (DRSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005		12. REPORT DATE 17 March 1983 13. NUMBER OF PAGES 24
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Accuracy	Grenade
Ammunition, Small Arms	Hand Grenade
Dispersion	Rifle Grenade
Fuze	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides a method of evaluating the performance of hand-thrown and rifle-launched grenades. Discusses initial inspection and safety precautions. Includes tests for safety evaluation: performance, shock, vibration, and environmental; tests for accuracy and dispersion, arming distance, throwing range (hand grenades), ballistic characteristics, functioning, reliability, recoil and velocity measurements, armor penetration, muzzle flash, mud, frozen rain, frost and snow, bullet impact, sympathetic detonation, and graze impact sensitivity.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-103
Test Operations Procedure 4-2-080 — 17 March 1983
AD No.

GRENADES

Page

Paragraph 1. SCOPE. 1
2. FACILITIES AND INSTRUMENTATION 2
3. REQUIRED TEST CONDITIONS 2
4. TEST PROCEDURES. 3
4.1 Initial Inspection 3
4.2 Safety Evaluation. 3
4.3 Range and Dispersion 15
4.4 Vertical Target Accuracy and Dispersion. 15
4.5 Throwing Range (Hand Grenades) 15
4.6 Ballistic Characteristics. 15
4.7 Functioning Reliability. 16
4.8 Recoil Measurements. 16
4.9 Velocity Measurements. 16
4.10 Armor Penetration. 16
4.11 Muzzle Flash 17
4.12 Human Factors Evaluation 17
4.13 Mud. 17
4.14 Freezing Rain. 18
4.15 Sympathetic Detonation 18
4.16 Bullet Impact. 18
4.17 Graze Impact Sensitivity 18
4.18 Water Immersion. 18
4.19 Fragmentation. 18
4.20 Logistic Supportability. 19
5. DATA PRESENTATION. 19

Appendix A. DETAILED PROCEDURES SUGGESTED FOR PERFORMING ACCURACY TESTS OF HAND GRENADES. A-1
B. REFERENCES B-1

1. SCOPE. This TOP provides guidance for planning tests of hand-thrown and rifle-launched grenades to ensure their conformance with requirements documents. Subtests to satisfy the requirements for a particular test item and type (development test [DT] I, II, etc.) can be selected from those listed in paragraph 4. The procedures apply to high-explosive grenades (e.g., HE or illuminating). This TOP does not contain procedures peculiar to chemical, smoke, or riot control grenades or 40-mm barrel-launched grenades.

Soldier Operator-Maintainer Test and Evaluation (SOMTE) is included in the subtests of throwing range of hand grenades, recoil measurements, and human factors evaluation.

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A grenade is a small container filled with a high explosive or chemical intended for use against enemy forces at relatively short ranges. Approximate ranges are 30-40 meters for hand grenades and 200 meters for rifle-launched grenades.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Drop tower	12 m high
Pneumatic launcher	as described herein
Shock and vibration equipment	
Ballistic pendulum	as described in TOP 3-2-066[1]*
Lumiline screens	

2.2 Instrumentation.

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT**
Electric timer or stopwatches	±0.1 second
Movie cameras	64 frames/second
Velocity instrumentation	±0.1%

3. REQUIRED TEST CONDITIONS.

3.1 Safety Precautions. Considerable potential hazards exist in grenade tests; the following safety precautions are therefore applicable:

a. Initially, launch all grenades remotely. Rifle grenades are launched from the applicable weapon. Hand-thrown grenades are launched from a pneumatic or mechanical device.

b. Mount the rifle or launcher in a stand to permit remote firing.

c. Do not lift or handle hand grenades by the pull ring. Do not remove the safety pin until just before launching. If the grenade is not launched, replace the safety pin before the grenade is removed from the test fixture or rifle.

d. Handle rifle grenades with care to prevent damage to the stabilizer assembly.

e. Do not attempt to recover a grenade that fails to function. Remove it by means of the mechanical dud retriever or destroy in place.

3.2 System Tests. In the case of rifle grenades, the launching system must be evaluated along with the warhead. The rifle and its grenade cartridge (or standard service cartridge if the grenade is meant to be launched in the "bullet trap" manner) must be exposed to the same temperatures as the grenades during function testing. It is also necessary to test the grenades with all of the rifles that may be employed for launching.

*Footnote numbers correspond to reference numbers in Appendix A.

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

4. TEST PROCEDURES.

4.1 Initial Inspection. Review available literature and drawings pertaining to the test item, and become familiar with the operating features to determine whether engineer design tests have revealed conditions that should be investigated further. Adhere to all applicable safety requirements contained in the safety assessment report and in other documents.

Upon receiving test items, select samples for thorough examination and comparison with drawings. Note any difficulty encountered in removing safety pins or otherwise performing arming operation. If handling and arming instructions have been prepared, check these for adequacy and accuracy. If such instructions have not been prepared, they should be drafted during this examination. Inspect each grenade for damage, loose or bent safety pins, bent levers, loose fuzes, and improper assembly.

4.2 Safety Evaluation. This is a portion of the development test that is conducted before SOMTE and before operational testing (OT) to establish that a specific test item can be functioned with minimal risk to operating personnel. A successful safety evaluation provides the testing activity with sufficient information for recommending that a safety release be issued by TECOM (see TECOM Suppl 1 to DARCOM/AMC 385-12[2]) to appropriate OT activities. A successful safety evaluation also permits the test activity to authorize military personnel to conduct SOMTE operations. The safety evaluation is normally the first part of DT. During the remainder of DT, safety observations are continually made by civilians and SOMTE personnel, and these observations are recorded in the final report under the safety evaluation subtest. Configuration changes that significantly affect safety will require further safety evaluation following DT II.

4.2.1 Safety Features. External devices include safety pins and levers intended to restrict the movement of working parts. The adequacy of these provisions should be confirmed by manipulating them in various ways on inert-loaded models. The possibility of unintentional disengagement of safety devices must be thoroughly investigated. Particular attention must be devoted to the possibility of accidentally triggering the unit while performing the arming operation. Verification must be made that the fuze safe and arming device has passed the detonator out-of-line test for non-propagation.

4.2.2 Shock, Vibration, and Environmental Exposure. To be considered safe, grenades must be subjected to applicable conditions of environmental exposure and rough handling including shock and vibration without unsafe incident. Exposure conditions that may be selected and used for a safety evaluation are shown in Table 1.

4.2.3 Functional Tests of Hand Grenades. Performance tests will, in many cases, be conducted after exposure to one or more of the conditions given elsewhere in this procedure. The major concern of a safety evaluation test in regard to functioning of the environmentally treated or conditioned items, is that no unsafe condition or potential hazard shall be encountered.

a. Safety Pin Withdrawal (at conclusion of rough handling test, Item 10, Table 1). This test is conducted with live fuzes (some assembled to live grenades; others to inert grenades) at ambient temperature. The fuzed grenade is placed in a holder that provides a 1.5-meter drop onto a steel plate 5 cm or more

thick (see Figure 1). After the rough handling test, the safety pin pull ring is attached to a spring scale which is pulled to release the safety pin, and the force in pounds is read directly from the scale (Figure 2). When the grenade is released from the holder, the safety lever trips a microswitch that starts a timer; the functioning of the fuze is detected by a microphone near the impact, the impulse stopping the timer. The fuze delay time is read directly from the timer (Figure 3). Grenades are dropped in at least 10 orientations, two grenades per orientation (fuze up, fuze down, fuze horizontal, fuze 45° nose up, and fuze 45° nose down).

b. Fuze Functioning Characteristics. A pneumatic launching device (Figures 4 and 5) is used to simulate hand throwing of HE grenades. The safety pin pull ring withdrawal force in pounds is determined by means of a spring scale (Figure 6). With the safety pin removed, a column of pressurized air or inert gas is released to the grenade holder (Figure 7) to launch the grenade. The fuze delay time is measured by a method appropriate to the accuracy requirement, such as an electric timer (as in Fig. 3) or manually operated stopwatches. The order of functioning is noted and recorded.

4.2.4 Functioning Tests of Rifle Grenades. Performance tests will, in many cases, be conducted after exposure to one or more of the conditions listed in Table 1, or one or more of the conditions given elsewhere in this procedure.

a. Functioning Test. Grenades are tested by launching from typical rifles to determine functioning ability against various impact media and under extreme conditions. The grenades are assembled to projection adapters and launched from a rifle or mounted in a test fixture (see Figure 8). Fuze delay times are determined and high- or low-order functioning noted. These tests are usually conducted using all rifle types that may launch the grenades.

Tests are conducted by launching from the rifle, varying the elevation to impact on soft ground, firm ground, and hard-surfaced roads. If the grenade fuze has a graze impact element, graze sensitivity should be evaluated.

b. Self-Destruct Feature Test. Some fuzes of rifle-launched grenades contain a self-destruct feature. For measurement of the self-destruction delay time, the fuzed grenade is held firmly in a jig or holder (which is destroyed by the functioning grenade), or use inert grenades with live fuzes. The safety pull ring is removed by pulling an attached lanyard from a safe cover. Any other safety features requiring physical impetus to arm the grenade are actuated or defeated to function the grenades.

c. Arming Test. Arming distances are determined using 1-in plywood as the target. When grenades are designed to automatically become armed when fired, the test is conducted at 5 meters only. Otherwise, the firing distance is varied to determine the maximum and minimum ranges at which arming occurs, as described in TOP 4-2-806.[3]

d. Use of Wrong Launching Cartridge. To determine whether a dangerous situation will occur if an error in selecting the launching cartridge is made, all types of cartridges that could possibly be used in the rifle (ball, AP, tracer, etc.) will be employed in an attempt to launch the various grenades. Five cartridges of each type should be used for each type of grenade.

TABLE 1
Shock, Vibration, and Environmental Safety Tests of
Hand, Rifle, and Barrel-Launched Grenades[a]

Item	Conditioning or Stress[b]	Explosive Condition[c]		Subsequent Tests		Minimum Sample Size
		Grenade Loading	Fuze	Hand Grenade Test	Rifle-Launched Grenade Test	
1	Standard ambient temperature, 21°C ±3° (including excess pressure)	HE loaded	live	A,B	A,C	24
2	Low temperature storage	HE loaded	live	A	A,C	96
3	Low temperature functioning[d]	HE loaded	live	A,B	A,C	(96)
4	High temperature storage	HE loaded	live	A	A	96
5	High temperature/solar radiation [d](combined) functioning	HE loaded	live	A,B	A,C	(96)
6	Temperature-humidity cycling	HE loaded	live	A	A	48
7	Temperature shock	inert	live	A,B	A,C	48
8	Secured cargo vibration (low temperature)	HE loaded	live	A,B	A,C	48
9	Secured cargo vibration (high temperature)	HE loaded	live	A,B	A,C	48
10	Sequential rough handling	HE loaded	live	A,B	A,C	96
11	Electromagnetic initiation hazards	inert		F	C	--
12	Fuze sensitivity	inert	live	---	C	--
13	Air delivery	inert	live	A,B	A,C	--
14	12-m drop	HE loaded	live	A,D	A,E	10
15	Salt fog	HE loaded	live	A,B	A,C	12

[a]Launching system also exposed as required
[b]Not all conditions apply in every case
[c]Indicates most hazardous required condition; in certain cases, some grenades may be inert.
[d]May often be conducted sequentially with temperature storage tests.

Test A - Examine for damage.
B - Launch remotely and measure time to function; apply performance test when applicable.
C - Launch remotely and observe functioning; determine arming distance if required; apply performance tests when applicable.
D - Dispose of grenade.
E - Drop a second time, nose down, to assure that first drop did not arm grenade; then dispose of grenade.
F - Only if a requirement exists; follow by test B or use special instrumented inert grenade to measure current flow in electrical detonation circuit.

Remarks (keyed to Item Nos. above):

1. A standardized ambient temperature; rifle grenades are fired at 112% of rated maximum service chamber pressure.

2. To test for climatic category C2 (cold) of AR 70-38[4], -46° C shall be used; for category C3 (severe cold), -51° C shall be used.
3. Functioning tests shall be conducted at -46° C for climatic category C2 and -51° C for climatic category C3.
4. The grenades will be cycled seven times in accordance with the specified climatic category of AR 70-38.
5. A test temperature of 63° C is used for both climatic categories A1 (hot dry) and A2 (basic hot) of AR 70-38. The rationale is that in climate A2, the grenades may be fully exposed to the sun which when combined with the 43° air temperature produces a grenade temperature of about 63° C. However, if the grenades are in climate A1, it is expected that they will be protected from the sun by ventilated shade, for example. Additional high temperature tests will follow the sequential rough handling and secured cargo vibration tests.
6. The procedures of TOP 4-2-820[5] will satisfy AR 70-38.
7. MIL-STD-810C/D,[6] Method 503.1.
8.& 9. Based on TOP 1-2-601[7] for 2-wheeled trailer plus aircraft; applicable to packaged complete grenades; both 63° C and -46° C (regardless of the category of AR 70-38 specified).
10. Ref. TOP 4-2-602.[8] The sequence begins by dropping enough packages to contain 96 grenades at 2.1 meters, with half dropped at the prescribed low temperature and half at the high. About 1/4 are inspected and fired; the remainder are given the loose cargo test at the same temperatures. Some are inspected and fired. The remainder (about 1/2) are unpackaged and dropped 1.5 meters at the same temperatures. All are inspected and fired; all drops are on heavy steel plates.
11. Ref. TOP 1-2-511.[9] Assures that electromagnetic radiation will not initiate the fuze.
12. Ref. TOP 4-2-806. Assures that the fuze when armed will not function on raindrops or on certain specific targets.
13. Packaged grenades are dropped to impact at 7.6 m/s in firm soil simulating a parachute drop per TOP 4-2-509.[10]
14. Ref. TOP 4-2-601.[11] For packaged grenades, the test is for the ability to resist shock without exploding and to be safe for disposal. This represents an accidental drop into a ship's hold. Packages are dropped to impact at various orientations.
15. Ref. MIL-STD-810C/D, Environmental Test Methods.

Other safety tests that must be run whenever unproven fuzes or explosive loadings are being evaluated include jolt and jumble in accordance with MIL-STD-331A.[12] See also the remaining text of this TOP. A salt fog test may also be conducted in accordance with Method 509.1 of MIL-STD-810C/D. A sand and dust test may be conducted in accordance with Method 510.1 of MIL-STD-810C/D. Grenades are function tested after environmental exposure and visual examination.

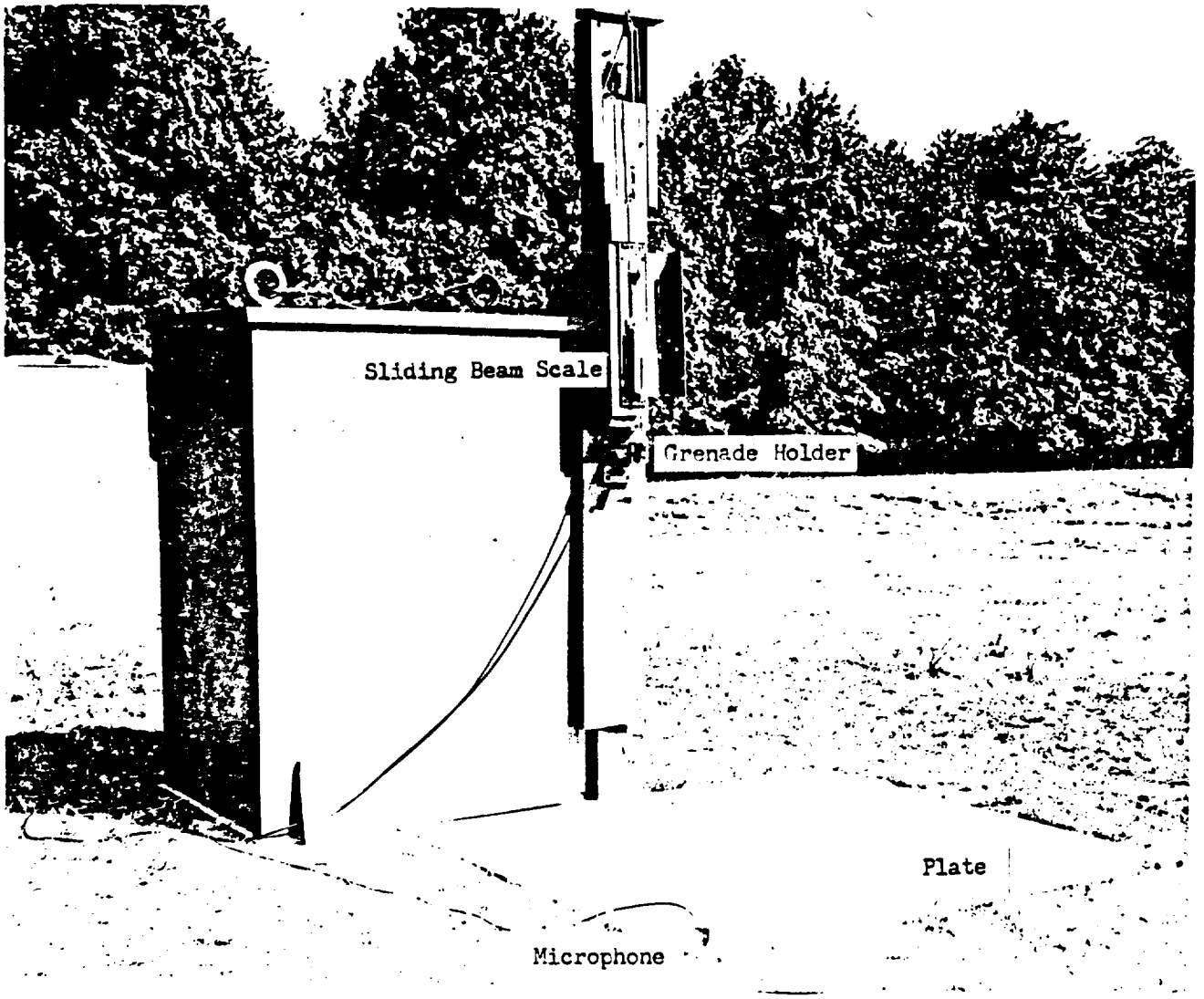


Figure 1. Setup for 1.5-meter drop test.

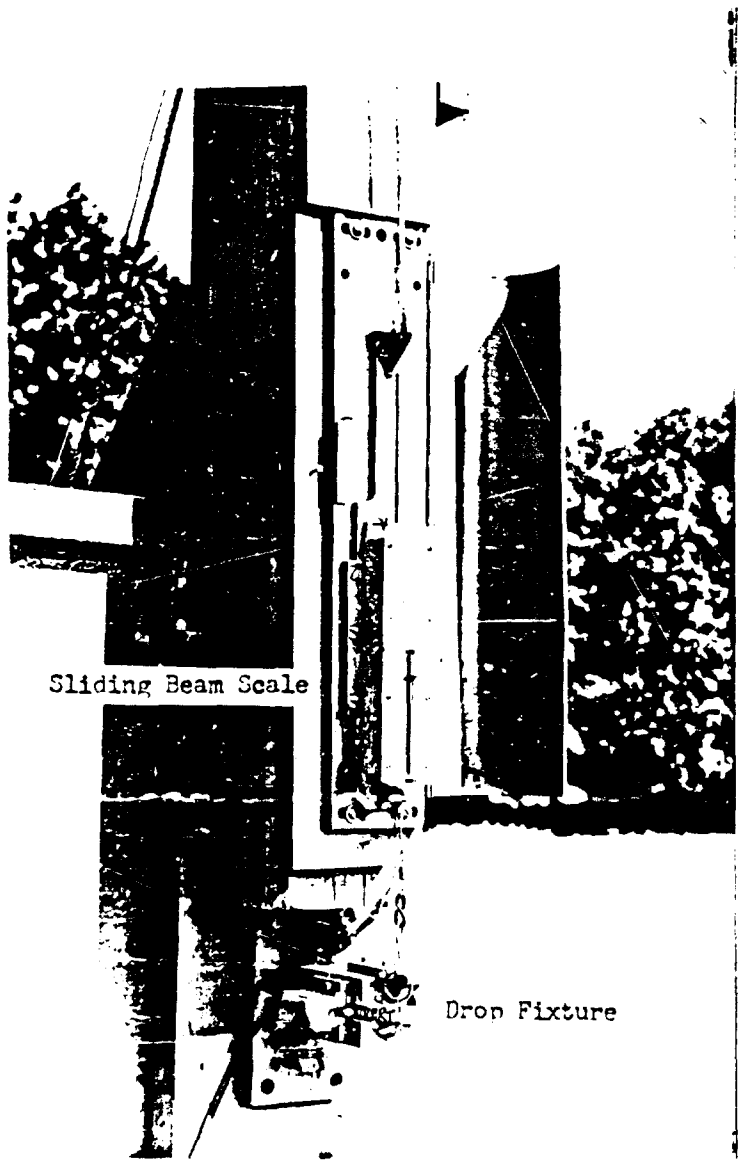


Figure 2. Sliding beam scale and drop fixture, 1.5-m drop test.

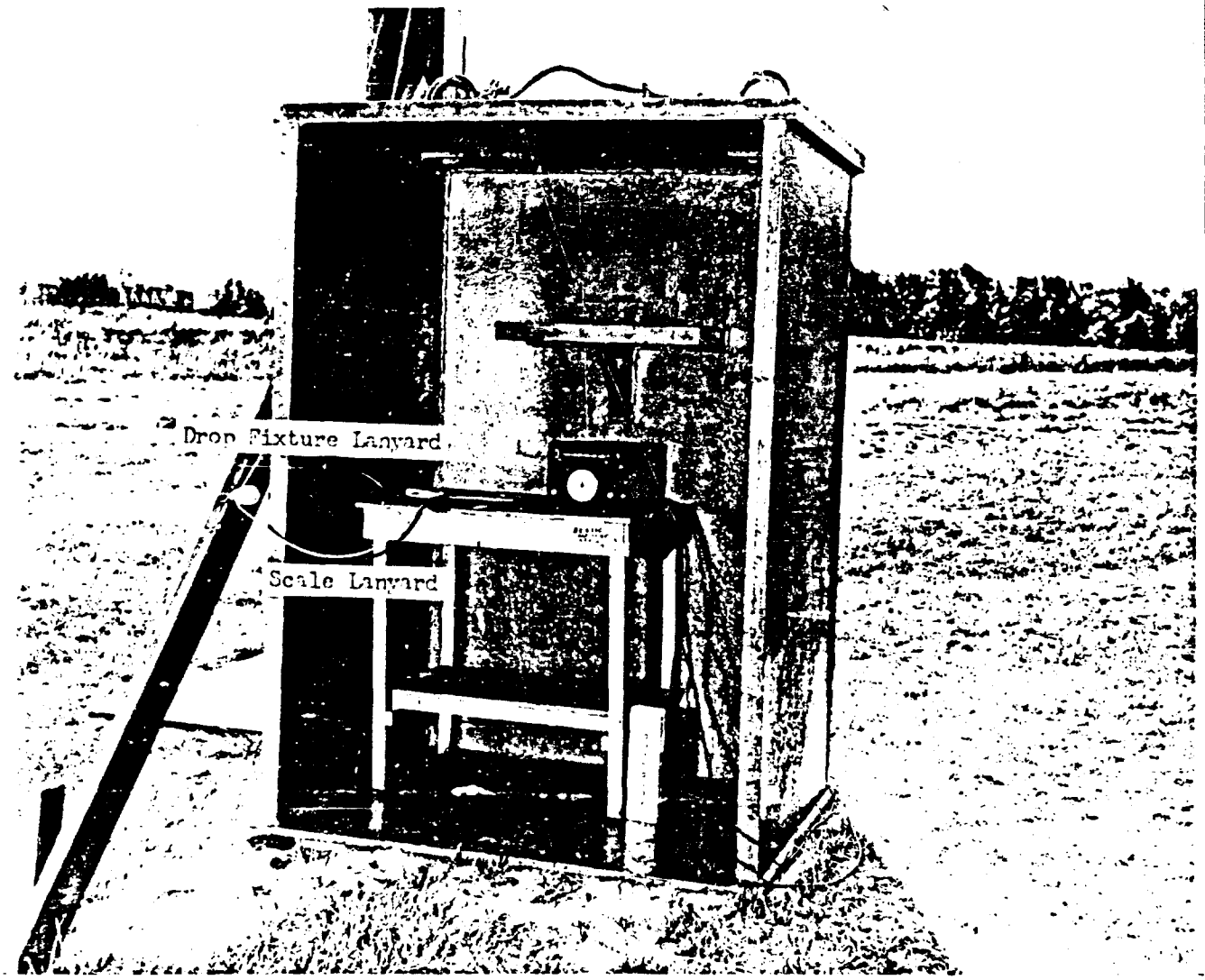


Figure 3. Electric timer and lanyards for drop fixture.

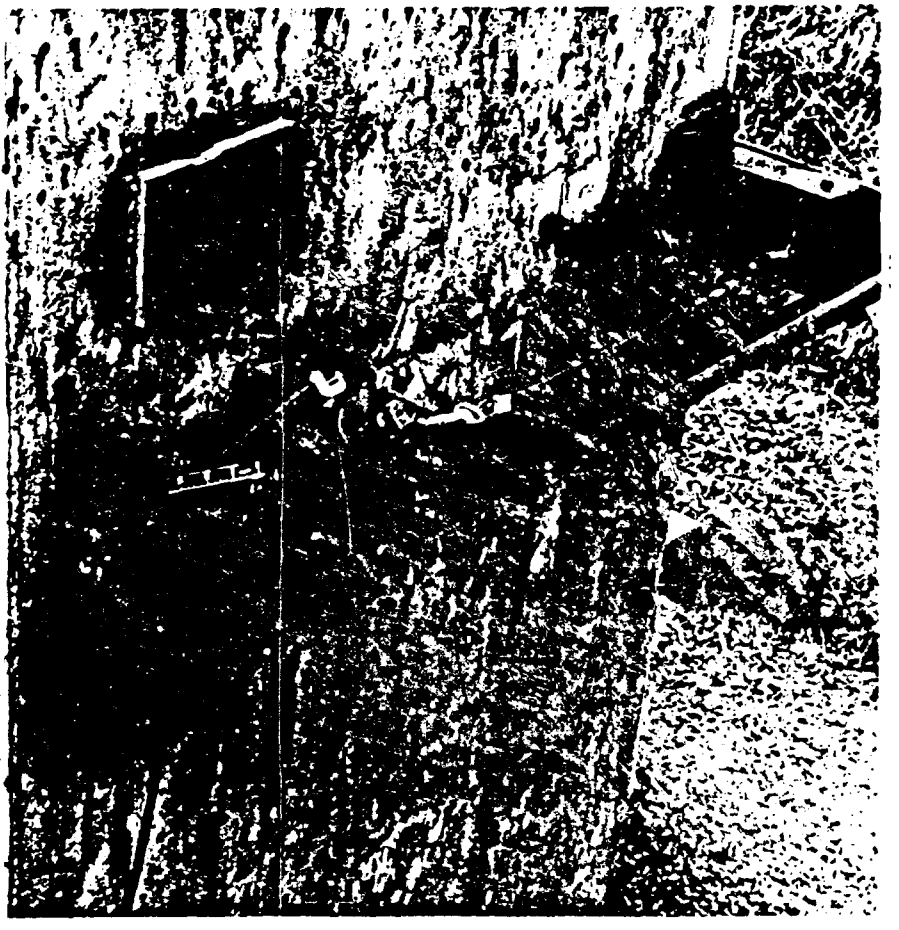


Figure 4. General view of pneumatic launcher (outside).



Figure 5. Closeup view of pneumatic launcher grenade holder.

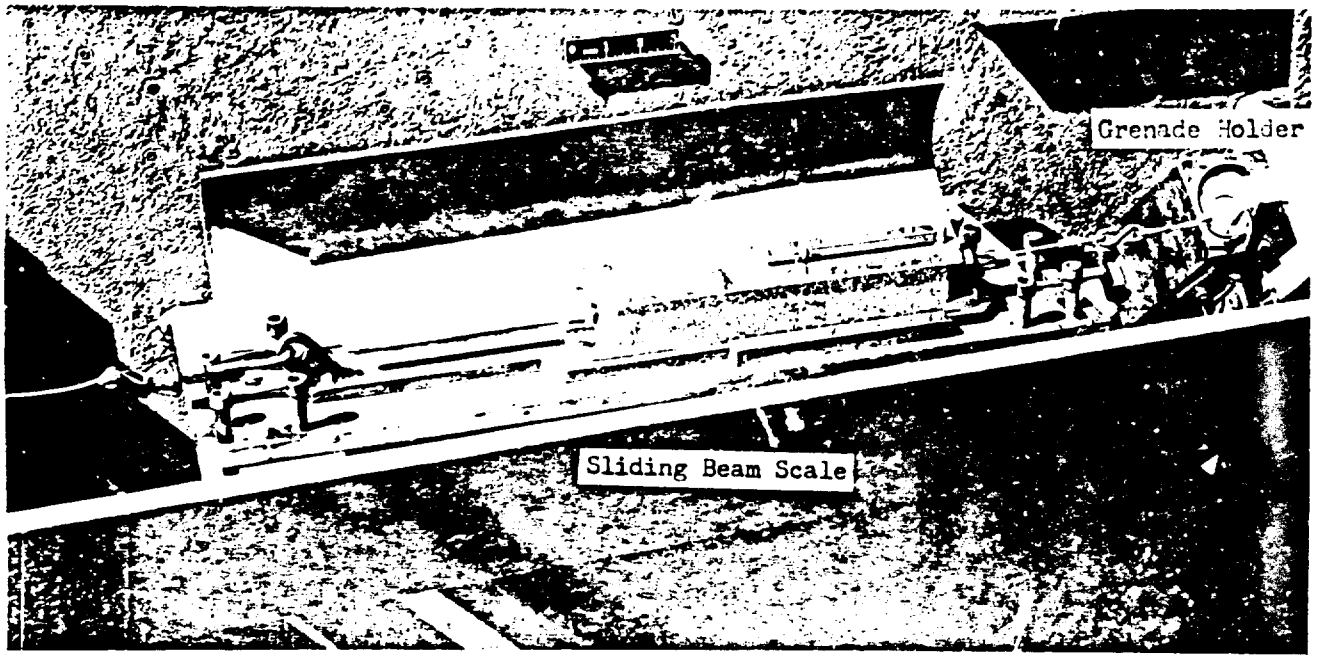


Figure 6. Sliding beam scale and grenade holder on pneumatic launcher.

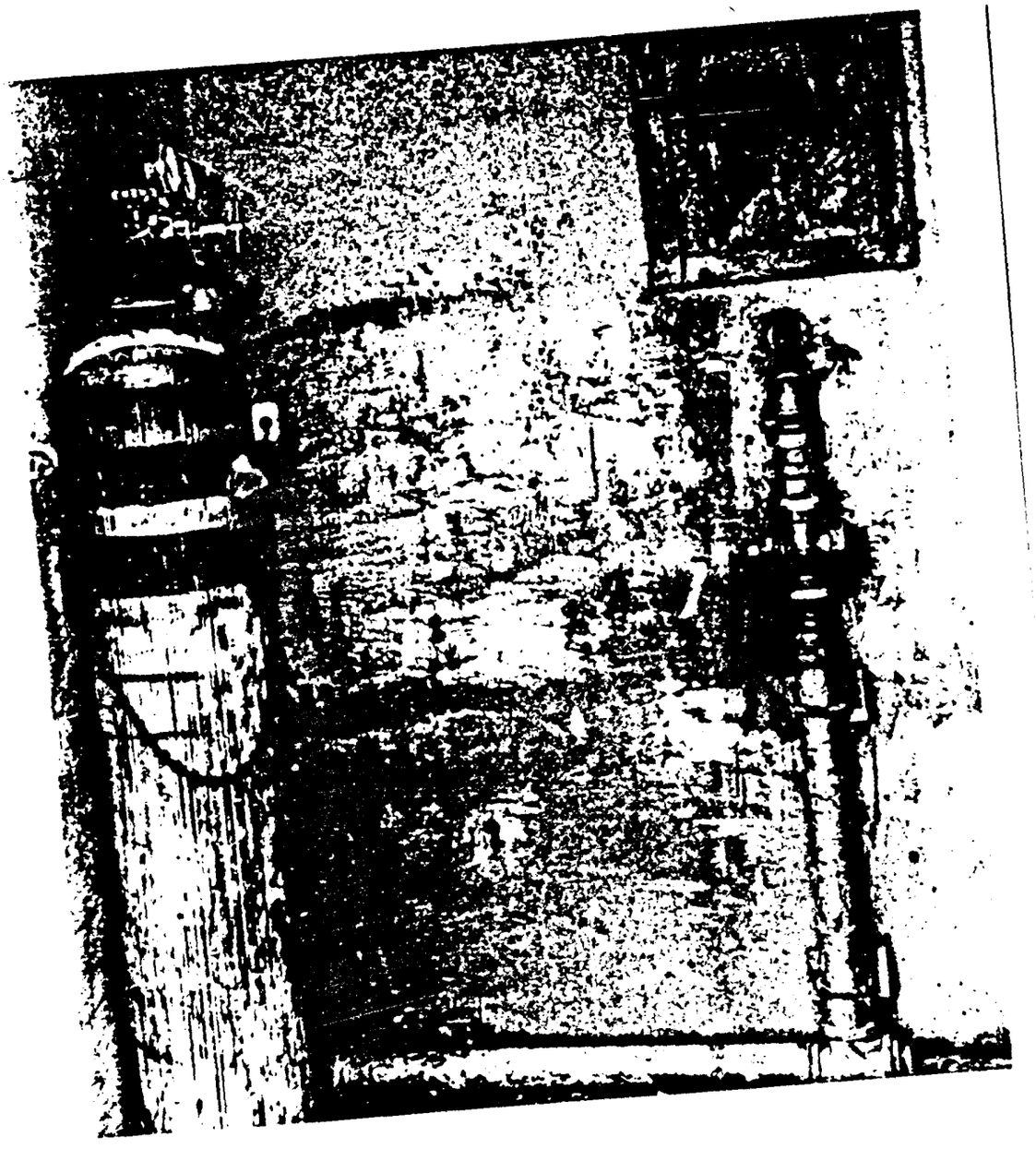


Figure 7. Pressurized inert gas or air and air release (inside launcher [Fig. 4]).

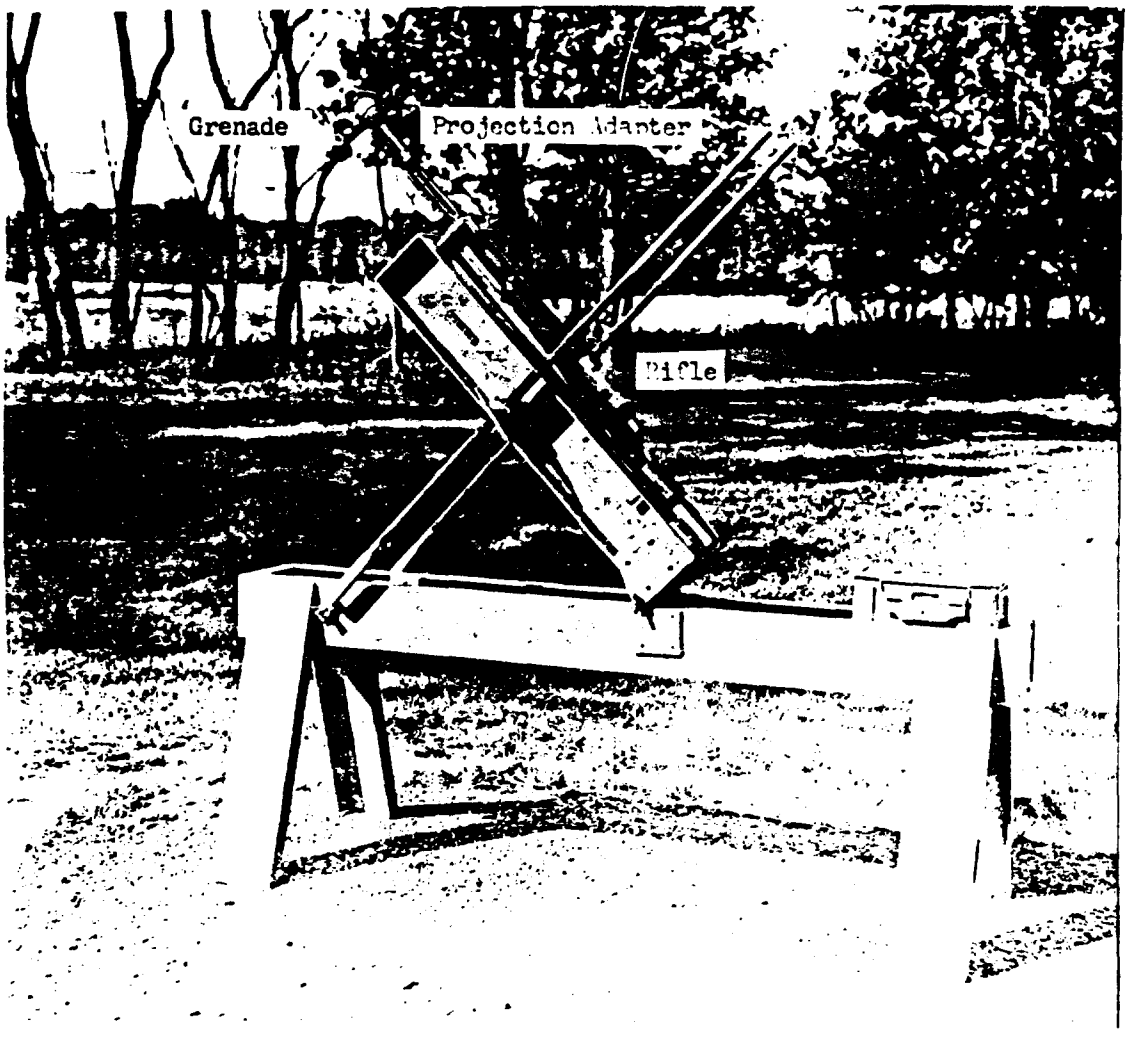


Figure 8. Rifle mount with rifle, launcher, and grenade in firing position.

d. Static Detonator Safety. The static detonator test is conducted to check the safety of the fuze design when the detonators or any other elements containing an explosive more sensitive than standard lead-charge explosive, are fired in an unarmed fuze. The test is conducted in accordance with MIL-STD-331A, Test 113.

e. Impact-Safe Distance. This test is conducted to determine the distance from the weapon within which the fuze will not function as a result of impact, when fired free to arm. The test is conducted in accordance with MIL-STD-331A, Test 208.

f. Drop Test for Nonfunctioning Height. For certain impact fuzes, a further test may be conducted to evaluate sensitivity. The test involves dropping inert-loaded grenades, with fuzes armed, nose downward from various heights onto a prescribed hard surface to determine the maximum height that will not cause a function. A pulley and rope arrangement is used for lifting the grenades. When

the maximum nonfunctioning height is believed to be determined, it is confirmed with five additional drops.

4.3 Range and Dispersion Tests with High-Angle Fire. Range and dispersion are determined for rifle-launched grenades, using samples that are statistically adequate, by firing the grenades from a rifle mounted in a fixed rest. Firings are conducted with the rifle elevated to achieve a minimum, an extreme, and one or more intermediate tactical ranges. Rifle grenades are usually fired at weapon elevations of 30°, 45°, and 60°, using a sight with a level, and are seated at various positions on the launcher to control initial velocity. Initial launch velocity and coordinates of impact are recorded for each shot. From these data, center of impact (in terms of range and deflection), probable error in range and in deflection are determined for each setting of elevation and rifle launcher position. Firings are not conducted when wind velocities exceed 16 km/hr.

4.4 Vertical Target Accuracy and Dispersion with Direct Fire. Recognizing that a rifle grenade will be fired into enclosed buildings or at vehicles, there is a need to know the vertical target accuracy and dispersion, using the direct-fire sight attached to the rifle. This is accomplished by launching inert-loaded grenades against a vertical target constructed of plywood or other suitable material. Ten single-shot firings constitute firing at one range. Data recorded are initial velocity, range to target, impact coordinates, and surface meteorological. Surface winds are limited to 16 km/hr. These data are generated over a series of ranges, from minimum to maximum, to establish probable errors, range versus elevation, and other information as required. TOP 4-2-829[13] discusses the general subject of vertical target accuracy and dispersion. (As explained in TOP 4-2-829, accuracy is the ability to center impacts on the point of aim, while dispersion is a measure of the impact spread about the center of impact.) Vertical target tests for hand-thrown grenades are further discussed in Appendix A.

4.5 Throwing Range of Hand Grenades. The distance that grenades can be thrown by hand, with and without arctic mittens, is determined. Three to five soldiers are required for this test. Each soldier throws a sufficient number of inert grenades to determine the average throwing distance. Maximum and minimum ranges and standard deviations are also calculated from the range of data. Ranges are determined for standing, kneeling, prone, and crouch (underhand) positions. A group of standard hand grenades should be included for comparison purposes. In addition, data on soldier safety and human factors are collected for evaluation in separate subtests. Details on required anthropometric measurements and suggested methods for testing hand grenades for accuracy are contained in Appendix A.

4.6 Ballistic Characteristics. The exterior ballistic characteristics determinations described below are conducted with a like sample of standard rifle grenades and compared statistically at the stated confidence interval. A time-of-flight test for computation of ballistic coefficient is conducted, when required, in accordance with TOP/MTP 4-2-827.[14] Range firings are conducted with rifle grenades as specified, to establish firing tables for high-angle fire and to evaluate the flight characteristics of the grenades over a wide range of conditions. For range firings, it is desirable to use inert grenades to permit closer observation of the impacts. For these firings, a wide range of rifle elevations is used, and the grenades are placed at various positions on the grenade launcher (ring

position 1 to full engagement). Tests are not conducted when surface winds exceed 16 km/hr.

Before firing, measurements are made of the grenade stabilizer tubes, the most critical locations being at the base and 2.5 cm forward of the base. Recovery tests are conducted as necessary to evaluate launching damage.

4.7 Functioning Reliability. Reliability data will be collected throughout all testing associated with grenade functioning. Mission or item/system reliability parameters can be evaluated with these data on grenade functioning. Additional firings are conducted as necessary against various impact media to determine the effect of the different surfaces on functioning reliability. These additional functional firings are conducted at minimum, maximum, and extreme tactical ranges. The spectrum of these impact media should extend from a relatively soft (mud) to a relatively hard (concrete, macadam) surface for complete evaluation. Malfunctions will be reported as incidents as prescribed by DARCOM-R 70-13[15] and as part of data presentation (see para 5 of this TOP).

4.8 Recoil Measurements for Rifle Grenades. The recoil momentum of the rifle or launcher is measured by the use of the ballistic pendulum procedure described in TOP 3-2-826[16].

When evaluating the recoil effects on the rifleman, guidelines in TOP 3-2-504[17] should be followed. These guidelines are based on measured recoil energy and provide the number of rounds a rifleman is permitted to fire in a day. Shoulder firing is done only from the standing and kneeling positions -not from the prone position. Shoulder firings are begun by launching the grenade from ring position 1 of the launcher, then from each succeeding ring position from which the grenade can be safely launched. (NOTE: This is done only if separate launching equipment is used, e.g., M7A3 for M1 rifle.) Subjective evaluation of the recoil effects depends mainly upon the rifleman's physical reactions and observations.

4.9 Velocity Measurements. Velocity is computed at a distance of 6 meters from the muzzle of the launcher, using two sets of lumiline screens, each set of screens having an electric counter. One set of screens is placed 4 and 8 meters from the launcher, and the other set 4.5 and 7.5 meters from the launcher. The ratio of projectile times of flight over the two base lines should not differ from 1.20:1 (ratio of time of flight over the 3.7-meter base line to that of the 3-meter base line) by more than ± 0.005.

4.10 Armor Penetration Test. Armor tests of high explosive antitank (HEAT) rifle grenades are conducted against solid or laminated armor plate at 0° and 60° obliquities, and other obliquities as specified. Firing is conducted at a short range (20 meters if possible) to minimize the angle of trajectory at time of impact, a factor that must be considered for high obliquity targets. Some tests require measurements of total penetration, in which case, the thickness of armor needed for the test can be approximated from former tests of HEAT projectiles. Other tests combined with the penetration test by reducing obliquity in 5° increments if satisfactory performance is obtained at 60°. Additional information on penetration and lethality of HEAT warheads is contained in TOP's 2-2-710[18] and 2-2-617.[19] Should penetration tests against reinforced concrete be required, they are conducted at 0° obliquity at short range. Hand-held HEAT grenades are tested in a similar fashion.

4.11 Muzzle Flash. Resultant muzzle flash of a single launch of a rifle grenade is recorded in accordance with TOP 3-2-045.[20] Firings are conducted using both test and standard rifle grenades for comparative performance purposes.

4.12 Human Factors Evaluation (HFE). Although HFE is addressed as a separate subtest, the pertinent data including SOMTE HFE are collected mainly during other tests, as indicated in Table 2.

TABLE 2
HFE Data Obtained During Other Subtests

Subtest	Relevant HFE Observations
Initial inspection Safety Evaluation	1. Adequacy of instructional literature and drawings 2. General adherence to safety regulations 3. Problems in removing safety pins 4. Problems in the arming operation 5. Possibility of accidental disengagement of safety devices 6. Possibility of accidental triggering during arming operation 7. Force required to remove cotter pin
Throwing range of hand grenades	8. Evaluation of weight, shape, and handling comfort of grenade with respect to throwing distance
Recoil measurements	9. Recoil effects on rifleman when launching direct-fire grenades
Noise and blast	10. Adherence to acoustical noise limits when firing from a rifle

In reporting, such data or observations may be detailed under the applicable subtest but are also summarized in the HFE subtest to ensure a complete and integrated HFE evaluation.

In addition to the above data, a limited exercise, using five or more soldiers for HFE data, is performed to evaluate the item with regard to the ability of soldiers to perform routine and contingency tasks while carrying or wearing the grenades in conjunction with the normal complement of combat gear. The exercise could include running, crawling, climbing, jumping, etc. Safety-related factors such as the inability of the fuze to function when the safety lever is loosely gripped but the safety pin is out, accidental release of the safety lever, etc., are to be evaluated using inert grenades. Qualitative evaluations of fuze function signature effects are to be evaluated during function tests.

A prepared task checklist can contribute a structured approach to the collection of data, as would relatively simple questionnaires (or interviews) in the case of subjective aspects of HFE data. Examples of such data-collection techniques are contained in the HEDGE[21] documents.

4.13 Mud. The mud test for rifle grenades is performed as described in TOP 3-2-045, immersing both the grenade and the rifle with adapter. Muzzles are taped shut before exposure. The exposure is made first with the grenade separate from the rifle, and secondly, with the grenade mounted on the rifle. Similar exposure can be made with hand grenades, if necessary for HFE.

4.14 Freezing Rain. Performance is checked when the test item is covered with a thin coating of frozen rain (TOP 2-2-815[22]).

4.15 Sympathetic Detonation. This test determines the conditions under which grenades may be subject to a sympathetic detonation. The conditions are established by placing containers of grenades in groups, each group containing grenades placed fuze down, fuze up, and horizontal at various distances from a central grenade which is statically detonated. Recorded data will include the orientations and resultant damage. Movies can be taken of the action.

4.16 Bullet Impact. This test is conducted to determine the sensitivity of grenades to small arms fire. Single rounds of 5.56- and 7.62-mm and caliber .50 ammunition are fired into the grenade from a minimum distance of 15 meters. Order of functioning, if any, is recorded. Movies may be taken of the action.

4.17 Graze Impact Sensitivity. The ability of the fuze of antitank grenades to function properly when striking high-obliquity targets is covered under 4.10 above. (Sensitivity to raindrops and light brush is covered in TOP 4-2-806.)

If a rifle grenade fuze contains a graze impact element, additional tests are required to determine the adequacy of the fuze performance on graze impact, i.e., the ability to function on soft earth and hard surfaces at low angles to the ground (as in the case of an antitank grenade that misses its target). Tests for graze impact sensitivity can be conducted by firing the grenade from a weapon elevated approximately 2° and supported in a rest in such a manner that the forward end of of the launcher is 50.8 cm above the ground, or under other conditions as specified. Graze impact tests are conducted both on firm level ground and on hard surfaces.

4.18 Water Immersion. Ten to 20 grenades are immersed in water (at 21° C nominal ambient temperature) to a depth of 1 m. This immersion continues for 24 hours. Immediately (or as soon thereafter as is practical) after removing the grenades from the water, they are function tested. Malfunctions or other anomalies noted during visual examination or function testing are noted.

4.19 Fragmentation Tests. For fragmenting grenades or other types when measurement of fragment size distribution and velocity are of interest, detonate five test items individually in a fragmentation arena. Procedures are described in TOP 4-2-813.[23] If 100% recovery of all fragments is desired, this can be accomplished by functioning additional test items in a sand pit. Estimates of munition lethality against appropriate targets are generated from the test results. If required, maximum travel of fragments can be computed (for safety reasons) from the data provided by the fragmentation test.

4.20 Logistic Supportability. Test data will be collected during the "initial inspection" test procedure (para 4.1) and, as appropriate, during all other testing. These test data will support evaluation of the system support package as prescribed by TECOM Suppl 1 to DARCOM-R 700-15.[24] Logistic supportability evaluation for ammunition items is limited, but can consist of one or all of the following elements:

a. Design for maintainability

b. Technical data and literature to include transportation and handling instructions

c. Special or unique tools
d. Transport, handling, and packaging methods
e. Personnel and training factors

5. DATA PRESENTATION.

a. Assemble, reduce, and summarize raw test data in accordance with the requirements stated herein and in each referenced TOP. Processing will include but not be limited to the following elements:

1) Identification data for each test specimen, test facility, and measurement system.
2) Complete data on the results of the firing of each test round.
3) Comprehensive description of test conditions.
4) Photographs for permanent documentation of significant test results and procedures.
5) Complete description of any safety incidents and/or hazards encountered, with appropriate restrictions, warnings, or design changes indicated.

b. Organize the test data in appropriate tables and graphs. Compute the mean and standard deviation of all numerical values for each parameter measured, and determine the effect of environmental factors. Compare performance data with the requirements and evaluate narratively in a comprehensive test report.

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

APPENDIX A

DETAILED PROCEDURES SUGGESTED FOR PERFORMING ACCURACY TESTS OF HAND GRENADES

1. Anthropometric and strength data (optional). In addition to background demographic data, anthropometric and strength data concerning test participants will be recorded, including: stature, weight, shoulder height, arm length, and various hand dimensions. It is necessary that the sample of participants includes representative 5th and 95th percentiles of strength and physical stature.

Dynamic and static strength tests will be conducted in accordance with methods and instrumentation outlined in USARIEM Report No. T-2/79.[25] Strength tests will be conducted on primary muscle groups having actions representative of throwing mechanics instead of secondary muscle groups. The difficulty in isolating and quantifying secondary muscle groups makes these data questionable predictors of grenade-throwing capability. Strength testing will attempt to isolate and quantify the strength characteristics of the following primary muscle groups:

Muscle	Associated Motor Action
1. Deltoid	humeral flexor, extensor, adductor, abductor, medial (internal) and lateral (external rotator)
2. Latissimus dorsi	humeral extensor, adductor, and medial rotator
3. Pectoralis major	humeral flexor, adductor, and medial rotator
4. Triceps brachii	humeral extensor, adductor, and medial rotator, radial and ulnar extensor

These muscle groups and the associated actions representative of throwing mechanics are arbitrarily broken down into the following three categories:

a. Initial throwing motion.

1) Technique. The starting point for the grenade throw is with the forearm (radius/ulna) completely flexed, the upper arm (humerus) held in an imaginary plane parallel to the ground at shoulder level and the hand (palm upward) placed behind the neck. Throwing motion begins ?with elevating and retracting the shoulder blade and hyper-extending the humerus, followed by abduction and lateral rotation of the humerus. Forward movement of the throw is then begun by adduction and medial rotation of the humerus and extension of the forearm until the humerus becomes perpendicular to the body.

2) Test method. A strength test of the muscle groups involved in the initial stages of throwing will be approximated by having a subject stand with the shoulder blade perpendicular to a wall, right foot placed against the wall, and left foot angled 45° outward. (This assumes a right-handed participant.) The subject assumes a comfortable throwing position and is allowed to flex both knees and rotate the torso while "throwing" a handle attached by a pulley system to a force gage. Subjects are instructed to apply maximum force to the handle for 4 seconds throughout the complete range of motion. Five measurements will be taken and an average obtained for the maximally developed force during the initial throwing phase.

b. Midrange throwing motion.

1) Technique. After completion of the initial throwing phase, the humerus is elevated, flexed, adducted, and medially rotated while the shoulder blade is protracted and the forearm is extended. The end of this phase occurs when the forearm is fully extended.

2) Test method. The strength test will begin with each subject as follows: back against a wall and throwing arm held perpendicular to body, elbow flexed 90° and the back of the hand held against the wall. The force-measuring pulley system is adjusted so that the handle rests in the subject's hand when the arm is held in this position. The subject is instructed to pull the handle down and away from the wall, keeping both shoulder blades and humerus in position against the wall. Maximum force will be maintained for 4 seconds. Five measurements will be averaged to obtain the maximum force developed during the midrange throwing phase.

c. Final throwing motion.

1) Technique. After completion of the midrange throwing phase, the forearm is fully extended and flexed downward, adducted, and medially rotated.

2) Test method. Each subject will stand with shoulder blades against a wall and with arms held in an imaginary plane parallel to the ground at shoulder level and forearm flexed 90° at the elbow. The maximum force applied over a 4-second period will be measured as the subject grasps the handle (palm downward) of the force-measuring pulley system adjusted so that the handle rests in the subject's hand 30 cm in front of the chest and in the same plane. Five measurements will be taken and averaged to obtain the maximum force necessary to pull the handle toward the ground.

d. Data analysis and presentation. Force measurements will be presented in tabular form with appropriate measures of variability and central tendency. One-way analysis of variance tables will be constructed for each of the representative throwing motion measurements to determine if any of the strength measurements are realistic predictors of throwing success for the grenade being tested.

2. Throwing Tests. The actual testing of a grenade will be primarily concerned with range and accuracy. Fifteen soldier test participants (previously subjected to the anthropometric and strength measurements as required) randomly selected and representing a range of body sizes will be familiarized with the test item. After limited practice with inert grenades, they will be required to engage a vertical panel target with throws from various ranges. The target panel will be a vertical surface 3 m high by 7 m long (or sized as appropriate) upon which the impacting grenades will leave a mark. A 1-m-square "aiming bull" will be placed at a height of 1.5 m above the ground.

Test participants wearing field clothing with helmets and body armor will engage the targets first at 10 m, and then in succession at ranges increased by 5-m increments (15, 20, 25 m), with each participant taking two throws at each range. Each participant will be dropped from the rotation of throwers after completely missing the target twice at any range. Repeat efforts will not be allowed during a given sequence. Inert-loaded grenades will be used.

This cycle will be repeated three times in the uniform described above and twice in complete chemical protective gear with protective masks if required. All throws will be from the standing position. The thrower will be permitted a short step and a simple windup, but no exaggerated movements or stepping which is not representative of a hasty combat throw. Unlike misses, repeats of throws that are determined to be unlike combat throws will be permitted.

Following a rest period of about 10 minutes, the test participants will be divided into two groups. The first group will repeat the above sequence from a kneeling position, while the second will repeat the sequence kneeling and wearing a field jacket and military shell glove with the liner. After one sequence each is completed, the conditions for the two groups will be reversed. The kneeling position, for the purpose of this test, will be any comfortable position in which at least one knee remains on the ground throughout the throw.

Participants will be instructed to try to strike the target as near the aiming mark as possible. Each impact will be recorded to the nearest 10 cm in terms of vertical and lateral miss distance. Records of the numbers of 1-m-square target bull hits versus valid attempts will also be kept. Estimations of miss distances will be made in the case of overthrows, ground strikes, and lateral misses. The ability of the lower percentile participants to throw the hand grenades to a safe distance will be determined by comparing the distances thrown to the safe distances from fragmentation effects (para 4.19).

Photographs/video tapes of the throwing activity will be made as considered necessary.

3. Test Data Analysis and Presentation. Objective data, including demographic data and throwing data will be presented in tabular form with appropriate statistical reduction. Subjective data will be summarized and presented along with significant individual comments. Subjective data which involve numerical ratings will be summarized for statistical parameters.

Throwing data will be presented in terms of both vertical and lateral displacement of impact for each throw, by each individual for all conditions. For each individual, the CEP of impacts will be determined at each range. The maximum range at which the target bull can be hit 50% of the time will be designated as the maximum effective range for that individual. Maximum effective range will then be correlated with height, weight, and upper body strength by calculating a multiple correlation coefficient. The weights thus determined will be applied to data from 5th, 50th, and 95th percentile individuals in statistics from general Army populations in an effort to predict the maximum effective range for these participants.

APPENDIX B

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26. TOP 3-2-030, Grenade Launchers, 12 May 1972.

27. DARCOM Suppl to AR 385-16, "System Safety Engineering and Management", 22 January 1982.

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