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

Describes procedures for evaluating recoilless weapon performance characteristics; includes planning, physical measurements, proof tests, stress-strain, cookoff, rate of fire, high and low temperatures (74 °C [165° F] and -46° C [-50° F]), durability and endurance, rough handling and vehicle transport, flash tests, and human factors evaluation. Identifies supporting tests.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-102
*Test Operations Procedure 3-2-066 5 August 1983
AD No.

RECOILLESS RIFLES

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1. SCOPE. This TOP provides guidance in writing test plans and conducting tests on recoilless rifles to ensure conformance with requirements documents. This TOP does not include operational tests or environmental tests at climatic test sites.

2. FACILITIES AND INSTRUMENTATION.

As specified in referenced TOPs.

*This TOP supersedes TOP 3-2-066 dated 16 February 1973.

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3. REQUIRED TEST CONDITIONS. Test planning requires the review of test guidance literature, establishing test safety SOP's, determination of test phase sequence, selection of sample sizes, etc. In selecting subtests, take into consideration previous testing. This can often lead to reducing test scope. Conduct "high-risk" subtests and those that relate to "critical issues" (per AR 70-10[1*]) first, since they support the safety evaluation. Schedule other subtests in the most economical sequence.

4. TEST PROCEDURES. Subtests (in preferred order of completion with respect to high risk, short duration) to be considered in forming a test plan are as follow.

4.1 Initial Inspection. Conduct this subtest in accordance with TOP 3-2-800.[2]

4.2 Physical Measurements. In addition to making physical measurements in accordance with TOP 3-2-802[3] and determining whether the weapon physical measurements conform to applicable drawings, the following should be considered:

a. Check the safety devices that prevent the weapon from firing before the loader has moved to a safe position for proper functioning. Do this when the weapons are "dry-fired" at least 100 times for operational checks. (Repeat measurements of critical breech mechanism parts after the dry firing of normally three test weapons.)

b. Correct cant on ground-mounted weapons with the sight mount. The sighting device is mounted on the weapon and aligned with the bore axis (normally accomplished on a boresight target using the azimuth and elevation adjusting screws in the sight mount). Check the boresight lines on the muzzle at this time for orientation with the tube axis. The weapon is canted to the right by shimming the left side of the mount. The amount of cant is measured with a gunner's quadrant on the leg or at any appropriate position. Cant the weapon and re-level the sight until the cant angle at which the sight can no longer be leveled is determined. Repeat the process on the right side for cant determination in the opposite direction.

c. Record handwheel traverse and elevation torque measurements; the number of handwheel turns for extreme elevation, depression, and 360° traverse; measurements of trigger pull, lanyard pull, firing pin protrusion, and headspace; breech mechanism spring calibrations, etc., for compliance with applicable military specifications of the test item (e.g., MIL-C-14383D(WV) for 106-mm rifle).

4.3 Weapon Characteristics. Conduct this subtest in accordance with TOP 3-2-500.[4]

a. Operate in accordance with applicable military specifications.

b. Make sure cartridge case detent, upon insertion of a round, depresses and returns without erratic movement or binding.

c. Make sure the breechblock operating lever, when depressed and rotated through its range of travel, opens the breech for ejection of the empty cartridge case. Make sure the cam in the base of the lever operates to permit rotation of the lever when the lever is depressed and to engage the slots in the hinge block to prevent rotation when the lever is not depressed.

*Footnote numbers correspond to reference numbers in Appendix A.

d. The cannon shall meet the physical and performance requirements contained in the appropriate military specification.

e. The firing mechanism shall be incapable of firing a round until the breechblock has been completely closed and the handle rotated to the firing position.

4.4 Safety Evaluation.

4.4.1 Proof Test. Before firing the weapon, mount it on a standard mount (e.g., M79 for a 106-mm rifle), stargage and borescope the gun tube, and establish reference (trammel) points for all members likely to change position or be deformed. The vent dimensions are recorded, and a line is scribed at the junction of the tube and chamber for observation of any tube rotation.

Fire one round at 113% upl ±4%. Additional rounds with pressures not exceeding 117% may be fired when, in the judgment of the test director, the results from this round are questionable or inconclusive.

4.4.2 Ballistic Pendulum.

a. Mount the weapon in a ballistic pendulum (see Figure 1), to determine the amount of recoil. When firing recoilless rifles from the ballistic pendulum, record the horizontal deflection of the assembly in centimeters. This deflection will be assigned a positive or negative sign, depending on the direction of initial movement. A positive sign denotes pendulum movement in the direction opposite that taken by the projectile; a negative sign denotes movement in the same direction as the projectile.

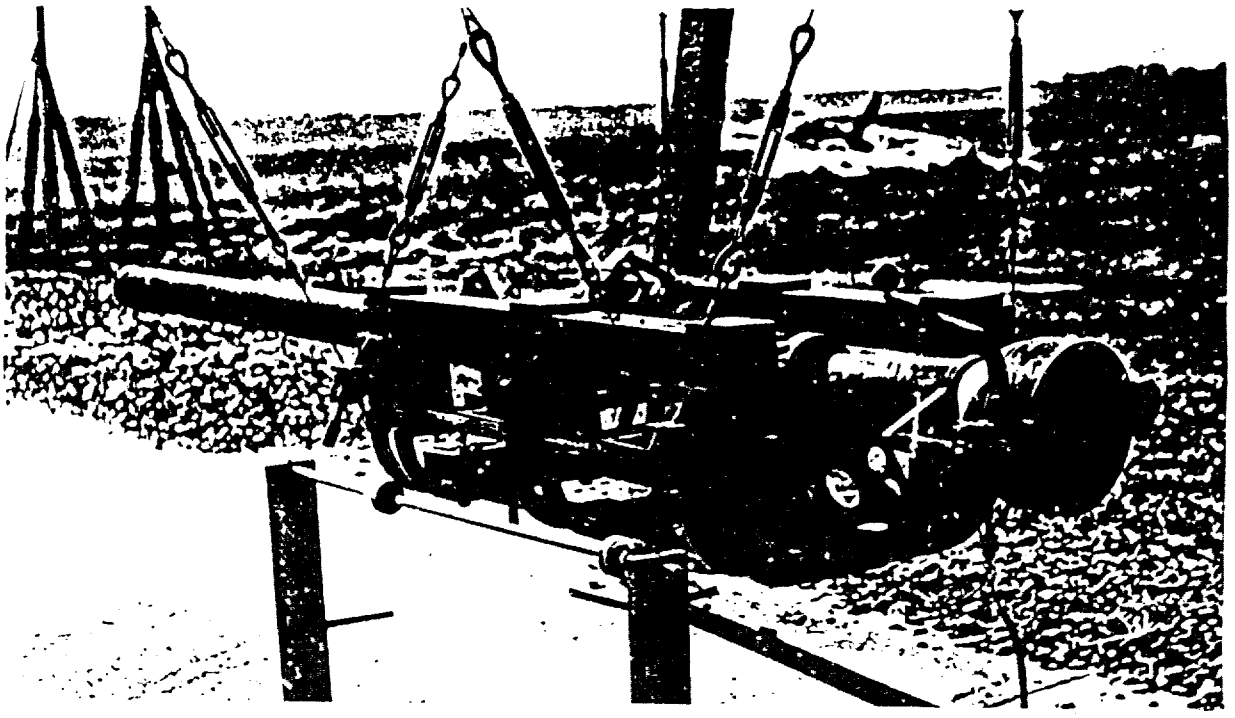


Figure 1. Recoilless rifle mounted in ballistic pendulum.

b. Convert the measured horizontal deflection of the system (weapon and cradle) to momentum units by means of:

$$M = \frac{wd}{100\sqrt{gL}}$$

in which: M = momentum (kg-seconds)
w = weight of suspended system (kilograms)
g = 9.8 m/sec^2
d = horizontal deflection (centimeters)
L = effective length of the pendulum suspension (meters) from the point of suspension to the weapon's center of gravity

The design of the pendulum should ensure that the deflection does not exceed one-twentieth of the effective length of suspension. The effective pendulum length is given by:

$$L = \left(\frac{T}{2\pi}\right)^2$$

in which T is the observed period of oscillation (seconds), taken as the average time for 10 successive oscillations. (One oscillation is the time for the recoilless rifle to travel from an extreme rearward position to a forward position and back again.) Combining the above two equations gives an expression for the conversion factor M ÷ d:

$$\frac{M}{d} = \frac{w\pi}{50gT} = \frac{0.006411w}{T} \text{ kg-sec/cm}$$

c. Assemble the ammunition used for firings (see Table 1) from reference or calibration components whose performance is known.

d. Measure velocity, recoil, and chamber pressure for all rounds fired. Record boresight shift in mils (if any) and probable cause.

e. After the firings, repeat all inspections.

TABLE 1
SEQUENCE OF FIRING

No. of Rounds	% of Weapon Upl	Data Measured: Velocity (mps)	Pressure (kPa)	Recoil Momentum (kg-sec)
1	113 ±4	--	x	--
3-5	*	x	x	x

*Service charge rounds, i.e., rounds loaded for service velocity with resultant pressure less than the weapon upper pressure limit (upl) at 21° C [70° F].

4.4.3 Stress-Strain. This subtest (normally performed during customer developmental testing) is conducted to determine the maximum stresses that the weapon may encounter during use. Strain gages are attached to the weapon on the longitudinal and circumferential axes along its entire length to record maximum strains. These are converted to stresses for determination of weapon safety or weak areas. The gages are positioned at predetermined critical areas (see

TOP/MTP 3-1-006[5]) where stress risers are likely to occur (e.g., at a sharp corner conducive to higher stress under a load and thus subject to failure). These positions are generally determined from the pressure-strength curves for the weapon design. The curves are obtainable from the design agency. Firings are normally performed with service-loaded ammunition conditioned to 63° C (145° F).

4.4.4 Cookoff and Rate of Fire. In most cases, a cookoff test and rate-of-fire determination are not required for recoilless rifles since they are not expected to be fired at a high rate. If such tests are required, the gun tube and chamber are instrumented with thermocouples at the "hot spots". (These positions are determined by firings from the weapon using heat-sensitive paint.) The weapon is assembled to its tactical mount, if applicable, or to a facility mount that is modified to accept the weapon. The rounds fired are at ambient temperature with inert projectiles and service charge. (Testing should be conducted with wind velocities of less than 8 km/hr [5 mph].) Sufficient rounds are fired at the maximum possible rate until the limiting weapon temperature or a lesser temperature equilibrium is attained. A "cookoff" round is then chambered and the time and temperature at cookoff noted. If none occurs, the test is terminated. If cookoff occurs, the test is repeated at a lower rate of fire and lower maximum weapon temperature (about 28° C [50° F] less) than in the previous test. This process is continued, decreasing the rate of fire and maximum temperature until no cookoff occurs. Rates of fire and weapon temperatures are recorded throughout. After the above firings, all before-fire measurements are repeated. Since a high-explosive warhead should theoretically also be susceptible to cookoff, assurance must be obtained from the developer that the warhead requires significantly higher temperatures to cook off than does the propellant.

4.4.5 Blast and Noise. Conduct this subtest in accordance with TOPs 1-2-608[6] and 4-2-822.[7]

4.4.6 Extreme Temperatures. The extreme temperature limits are usually derived from the requirements documents which specify certain climatic categories of AR 70-38[8], or from procurement specifications that give specific temperatures.

4.4.6.1 Low Temperature. To conduct a low temperature test to meet the "cold" climate of AR 70-38, subject the completely assembled weapon with mount and accessories to the cold soaking until all weapon parts have attained -46° C. Since recoilless weapons cannot be fired within a conventional chamber, special facilities have been designed. A mobile conditioning unit or especially built cabinets that can be emplaced (over the weapon) and removed with a mobile crane are used. Once the cabinet is removed, firing is done immediately, before any significant temperature change occurs. Thermocouples are used at critical positions to record temperatures of the various assemblies. To decrease conditioning time, the chamber temperature can be lowered, e.g., to -51° C (-60° F.), for a time, and then stabilized at -46° C.

a. Clean and lubricate the tube, using cleaner lubricant preservative (CLP) NSN 9150-01-053; this multipurpose cleaner/preservative replaces both bore cleaner (CR) and LAW for use in cold regions.

b. Conduct cold-to-warm-to-cold cycles of the fire control and anti-condensations fire control containers.

c. Include manipulation and misfire drills with personnel wearing cold weather handwear, when conducting cold chamber testing.

d. Perform trigger pull, lanyard pull, handwheel effort, sight, and general operational checks at the cold temperature. Immediately following removal from the cabinet, fire five rounds (inert-loaded and at ambient temperature to prevent frosting) as rapidly as possible to check weapon operation. Make observations for parts interference, malfunctions, and operational difficulties for comparison with ambient temperature performance.

e. Check boresight retention statically by aligning the sight and tube axis on a target cross at least 30 m (100 ft) from the muzzle. The sight mount is subjected to several sharp blows with the hand or a rubber mallet, and the boresight is checked for retention. Repeat this procedure several times.

NOTE: IAW FM9-207, January 1978, the normal backblast danger area must be increased 100% when firing at low temperatures.

f. Record the following data:

(1) Handwheel traverse and elevating torque measurements at extreme temperature and after firing when the weapon has returned to ambient temperature

(2) Trigger torque and lanyard pull at extreme temperature

(3) Ease of loading and firing each weapon at extreme temperature

(4) Description (and photograph if applicable) of any damage or defect attributable to extreme temperature conditioning and/or firing

(5) Post-fire inspection data to include stargage, magnetic particle inspection, and spring calibration

4.4.6.2 High Temperature. A high temperature test is usually conducted to evaluate components such as the sight and elevating and traversing mechanism; it is not conducted to evaluate the barrel and breech. A temperature of 74° C will satisfy the "hot-dry" climatic requirements of AR 70-38. This temperature was derived by averaging the peak temperatures recorded at various points on a recoilless rifle when it was exposed in a chamber to approximately the solar radiation-high air temperature diurnal cycle of AR 70-38. Holding the temperature at 74° C for 48 hours is usually adequate to uncover potential deterioration from heat. The checks that are performed at high temperature are the same as those described above for low temperature. Projectiles that are fired are preconditioned to 63° C. Occasionally, it is desirable to replace the 74° C test with several cycles that follow the solar radiation-high temperature diurnal cycle of AR 70-38. This produces more realistic temperatures but does not permit firing because of facility limitations.

Record data as listed in 4.4.6.1.f.

4.5 Accuracy and Dispersion. Conduct this subtest in accordance with TOP 4-2-829.[9]

4.6 Projectile Velocity. Conduct this subtest in accordance with TOP 4-2-805.[10]

4.7 Boresight Retention. Conduct this subtest in accordance with TOP 3-2-604.[11]

4.8 Rain. Conduct this subtest in accordance with TOP 2-2-815.[12]

4.9 Sand and Dust. Conduct this subtest in accordance with TOP 3-2-045.[13]

4.10 Mud. Conduct this subtest in accordance with TOP 3-2-045.

4.11 Salt Fog. Conduct this subtest in accordance with MIL-STD-810C.[14]

4.12 Durability and Endurance. A durability test yields a precise determination of the probability that an item will successfully survive to its projected service life without encountering a durability failure. Service life is generally considered ended when the muzzle velocity and/or dispersion are significantly degraded.

Since a durability test, as described in TOP 1-2-502[15], requires large sample sizes and a great amount of firing, it is almost never authorized. Instead, an endurance test is conducted. The typical endurance test is an abbreviated version of a durability test. While it does not produce quantitative measures of service life to a prescribed statistical confidence, it can provide quantitative information on reliability and a general idea of service life.

The critical factor in the endurance test of the weapon system is generally vent erosion. Conduct firings, taking measurements of recoil and periodically inspecting for material soundness and vent measurements, until unsatisfactory velocities and forward recoils are obtained, thus marking the life of the vent. Replacing the vent of some recoilless rifles (e.g., the 106-mm) is permitted at least once during the prescribed weapon life. When replacement vents are used, firing can be continued to ascertain the life of the barrel, which is revealed by unsatisfactory velocity and dispersion.

The typical endurance test involves two to four vents, with several hundred rounds being fired per vent.

4.13 Rough Handling and Vehicle Transport. The ability of materiel to withstand rough handling is a measure of its ruggedness and how well it will withstand combat use. There are several rough handling tests, one being the loose cargo or bump test used to simulate the transportation of loosely stowed cargo in the back of a truck over rough terrain (see TOP 4-2-602[16]). Transportation over primary and secondary roads (TOP 2-2-511[17]) is also performed on items such as the 106-mm recoilless rifle that are designed for vehicle transport. In addition, the test item is dropped several times from a height (1.5 m [5 ft]) equivalent to that of a 2-1/2-ton cargo truck bed onto a hard soil surface or macadam. Rough handling and transportation must be integrated with the firing sequence so that a typical life profile is achieved. Operational checks are performed periodically and any damage from rough handling procedures assessed.

4.13.1 Road Test.

a. After all firing phases have been completed, place each weapon and its associated mount aboard a utility truck, and check for adequacy of the locking devices.

b. When proper installation is assured, drive each weapon system the specified number of laps over cross-country course No. 1 (see TOP 1-1-011[18]).

NOTE: MIL-M-12942F(WV)[19] specifies that the M79 mounts be assembled with the M206 cannon, mounted on a 1/4-ton truck, and driven over "unpaved rough roads or across country a minimum distance of 25 miles...". Current test practices indicate that the 40-km (25-mile) cross-country course with the 16-km (10-mile) "load vibration test course" when the payload, rather than the vehicle, is being evaluated.

c. Perform visual inspections after the first and third laps to ensure the integrity of the locking/clamping devices. After the final lap, check the mount for operability of the elevating and traversing mechanisms, and dry-fire the weapon to check for damage to the firing mechanism.

d. After the road test has been completed, fire the weapon to verify the integrity of the system. Firing will duplicate a mount proof firing, as specified in MIL-M-12942F(WV).

e. Inspect the cannon and mount for material soundness.

f. Record the following data:

(1) Any binding or looseness of the weapon and mount aboard the truck

(2) The ability of the locking devices to attach and retain the mount aboard the vehicle

(3) Any degradation in functioning of the elevating and traversing mechanisms as a result of the road test

(4) Any damage or deformation of the weapon or mount due to the road test

(5) Any malfunctions or misfires due to the road test

4.14 Flash. Muzzle and breech flash tests are performed to determine the detectability of the weapon through its flash signature as compared to that of control weapons. Blinding effects are also observed. The weapon is assembled to its tactical mount and all firings are conducted during the hours of darkness. A high-speed motion picture camera is mounted to the side of the firing point with two reference scales located to facilitate photogrammetric data reduction. The camera is started and the weapon is fired. From the film, the length, height, and duration of the breech and muzzle flash are determined.

A system with a signature familiar to the user should be fired as a control or for comparison purposes.

4.15 Human Factors. During testing, the test item is evaluated for its compatibility with man. This includes but is not limited to ease of access and manipulation of elevation and traverse handwheels, firing and sighting devices, ease of mounting and dismounting the weapon, when applicable; ease of opening the breech, loading, and closing the breech; any sharp protrusions that may hinder ease of operation; blast, noise, and flash hindrances. Conduct this test in accordance with TOP 1-2-610.[20]

Any CBR protective equipment/clothing that must be worn by test personnel must not interfere with their ability to perform their duties or inhibit bodily movement.

4.16 Reliability. Conduct this subtest in accordance with AMCP 702-3[21] and MTP 3-1-002.[22]

4.17 Logistic Support. Conduct this subtest in accordance with TECOM Suppl 1 to DARCOM 700-15.[23]

5. DATA REDUCTION AND PRESENTATION. Include appropriate tables and charts. The average, standard deviation, and 90% confidence interval on the true average will be calculated for velocity, momentum, and pressure.

Boresight shift, bore diameter measurements, material soundness, magnetic particle inspection, and bore surface characteristics will be assessed.

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