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

Provides a method for evaluating projectile seating and retention characteristics as related to projectile fallback within the weapon chamber. ~~Describes~~ techniques and tools for measuring seating and determining retention characteristics. Applies to separate-loading ammunition. Does not apply to artillery projectiles fired with fixed and semifixed ammunition.

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U. S. ARMY TEST AND EVALUATION COMMAND
DEVELOPMENT TEST II - COMMON TEST OPERATIONS PROCEDURES

AMSTE-RP-702-103
*Test Operations Procedure 4-2-802 29 July 1975

PROJECTILE SEATING AND FALLBACK

SECTION I
GENERAL

1. Purpose and Scope.

a. This TOP describes procedures for evaluating the seating ability of separate-loading field artillery projectiles when seated with an automatic or semiautomatic rammer or when hand rammed. A properly seated projectile is characterized in terms of seating depth and retention (extraction) forces. Data are analyzed to determine susceptibility to fallback.

b. Artillery projectiles fired with fixed and semifixed ammunition are not included in this document.

2. Background. The seating of a projectile in a cannon affects the chamber volume, establishes a retention force, and, in turn, influences chamber pressure, projectile velocity, and firing safety. In loading a cannon with separate-loading ammunition, the projectile is rammed into its seated position and is followed by the propelling charge. The distance from the base of the seated projectile to the rear face of the breech ring is known as the seating distance. The seating distance is a measure of ramming uniformity. It is affected by the erosion of the forcing cone and the size and resistance of the rotating band.

*This TOP supersedes MTP 4-2-802, 29 September 1965.

In recent years a number of incidents related to the unseating and falling back of projectiles in the chamber of a weapon have been investigated. Fallback is characterized by the projectile falling back several inches following loading and breech closing. It occurs when the tube is elevated and when gravitational forces acting on the projectile exceed retention forces provided by elastic deformation of the rotating band and frictional resistance between the projectile bourrelet and tube. The likelihood of fallback increases as the tube is elevated. Investigations and further tests have determined that projectile seating and fallback characteristics can be major factors in determining the safe or unsafe firing of a projectile. Adverse results of the following nature can exist:

a. Projectile rotating bands can shear or break up from the sudden impact with the forcing cone of a tube when fired after fallback has occurred.

b. Fuze and ogive sections of a projectile can be damaged when fired after fallback has occurred.

c. Shear or breakup caused by fallback of a fully loaded HE projectile can cause an in-bore premature or an out-of-bore premature; duds and wide dispersions in projectile range can also be expected. In view of these adverse conditions, it is necessary to establish test operating procedures to observe and check out the possibility of fallback.

3. Equipment and Facilities.

a. Applicable weapon system with tube and rammer assembled as used in field ramming.

b. T-bar gage, depth of ram, graduated to 1/16-inch intervals (figs. 1 and 2).

c. Applicable inert projectiles with base threaded for assembling a 1-inch threaded outside diameter (OD) rod.

d. Three compression load cells with an internal bore greater than 1 inch in diameter (internal bore not required when using push method) and ranging in capacity from 0 to 5,000, 0 to 30,000, 0 to 50,000 pounds (fig. 3). (An alternate method uses three tension load cells of the same capacities which thread into the 1-inch steel rod (g below) between the projectile and the steel crossbar (h below). This necessitates cutting the rod and threading both ends to fit the female threads of the load cells.)

e. Thrust bearing with an inside diameter (ID) greater than 1 inch.

f. Recorder to receive signals from the load cells.

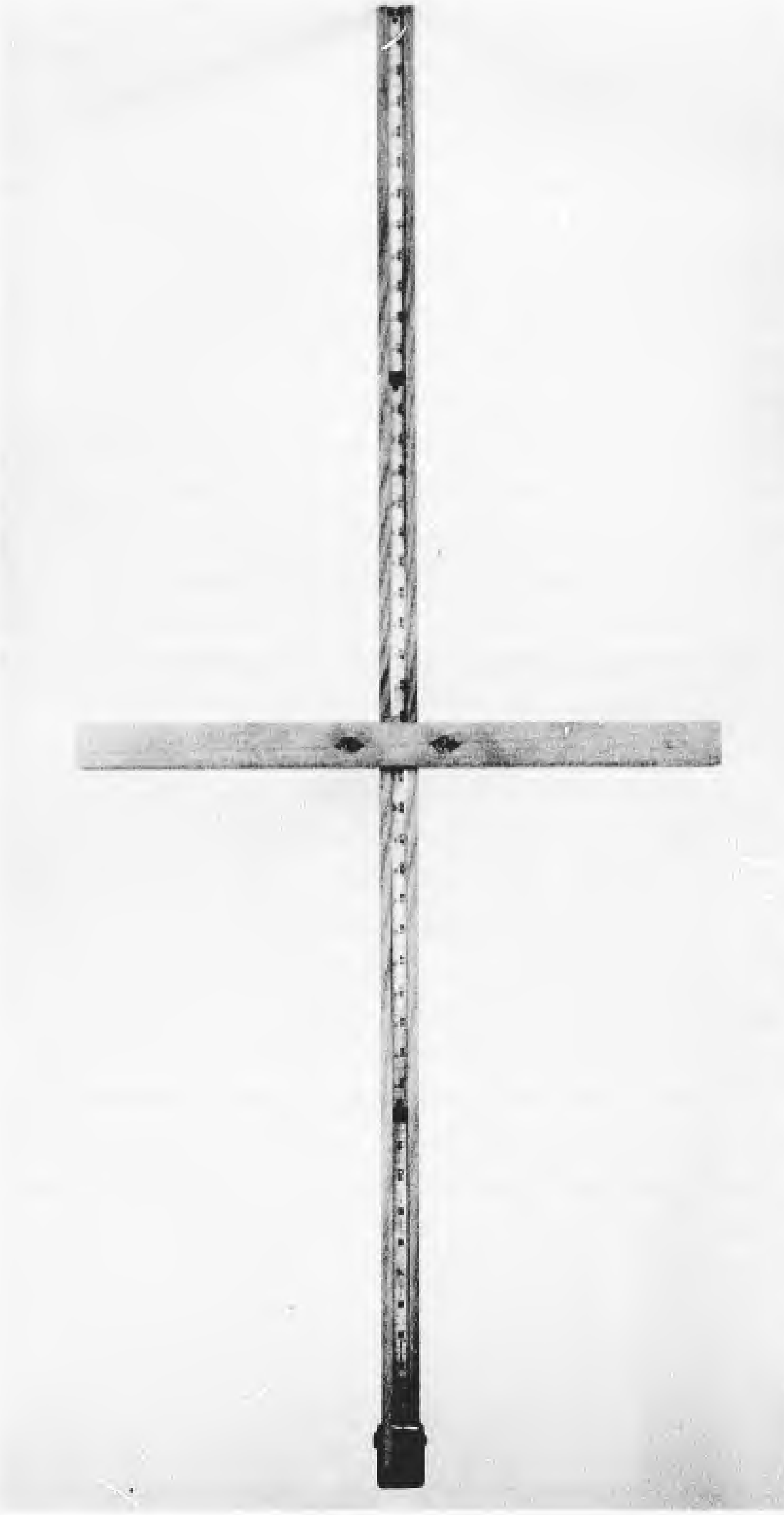


Figure 1. Closeup of Short Seating Stick With Sliding Bar Locked at Approximately 23-1/4-Inch Position.

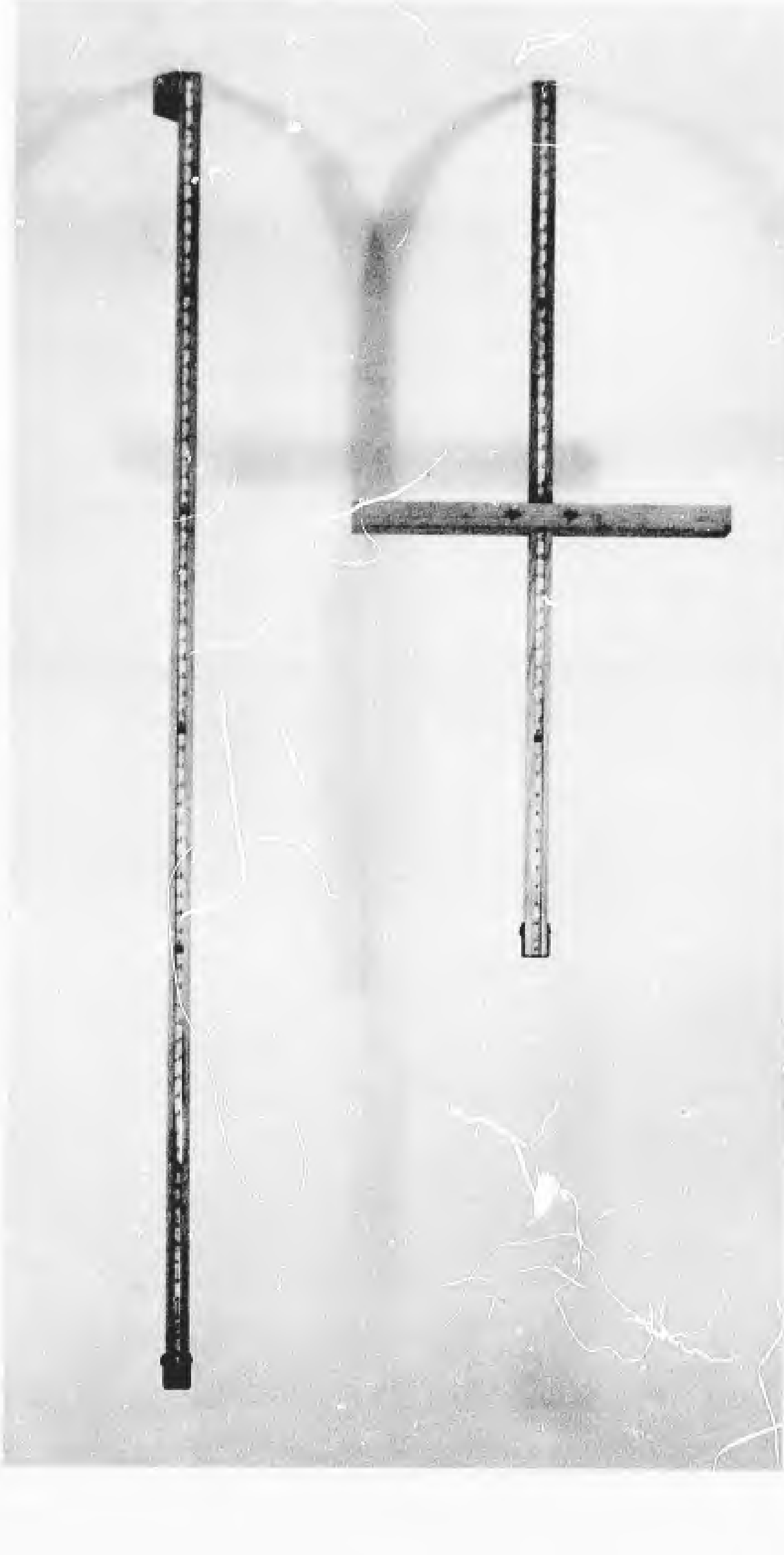


Figure 2. Comparative View of Long (Without Crossbar) and Short Seating Sticks.

Figure 3. Overall Layout of Components Used in Measuring Projectile Retention Force.

g. One-inch-diameter steel rod (length determined from depth of ram - approximately 10 inches longer than the average seating depth), threaded (eight threads per inch) at both ends to 1 inch and 3 inches, respectively.

h. Two-inch-square (or slightly larger) steel bar, 16 inches long, with a 1-inch clearance hole at the center.

i. One-inch, 8-hex steel nut.

j. Adjustable or box wrench for 1-inch hex nut.

k. High-speed framing camera (can be used on certain weapons to determine ramming velocity.)

l. Deramming device (fig. 4).

m. Hydraulic jack.

n. Strain gages, BLH Type SPB3-18-100 or equivalent (alternate BLH Type C1 or equivalent).

o. Suitable recording instrument (oscilloscope, strip chart recorder, etc.).

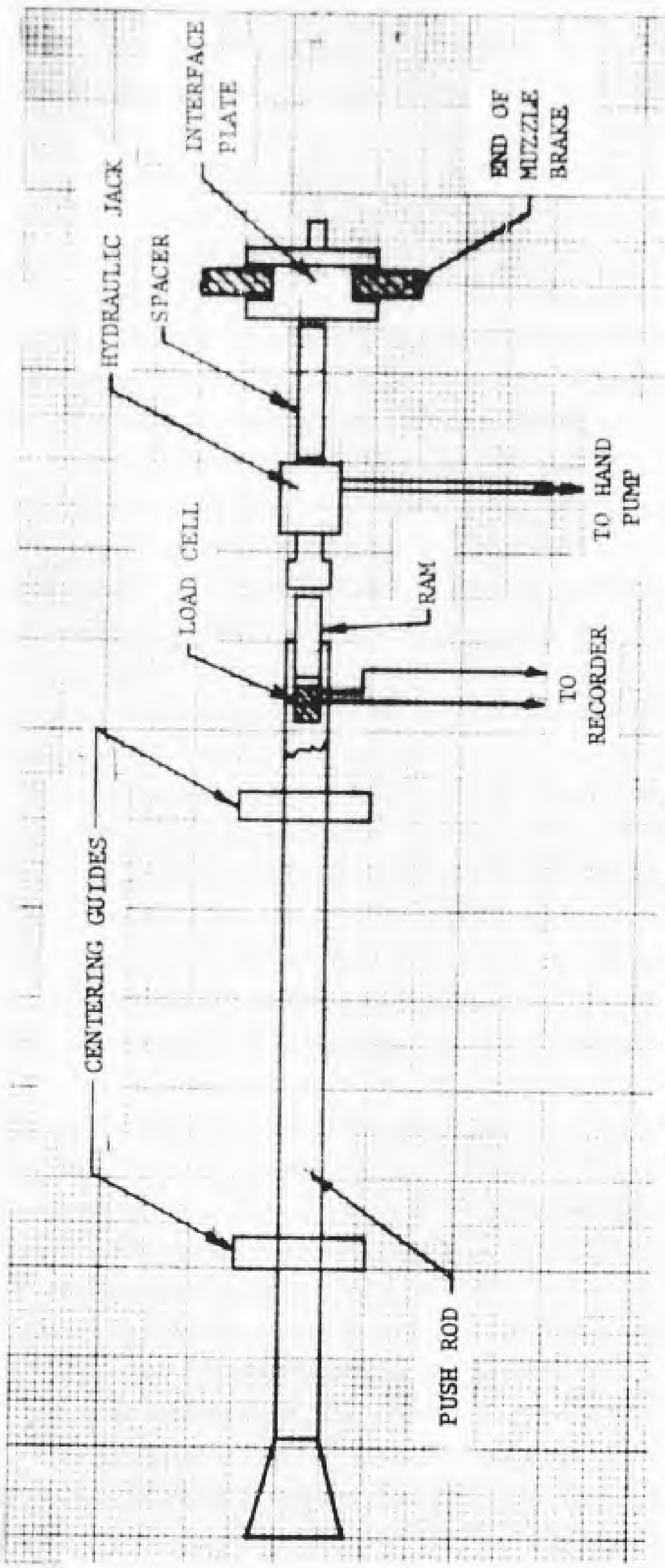
SECTION II
TEST PROCEDURES

4. Preliminary Activities.

a. The procedures governed by the following TOP's/MTP's are performed as prerequisites to conducting the required test phases.

	TITLE	PUBLICATION NO.
(1)	Measurement of Internal Diameters of Cannon	3-2-801
(2)	Rotating Band Seating Measurements	4-2-803
(3)	Cannon Tube Service Life	3-2-829
(4)	Physical Measurement of Projectiles	1-2-504

Particular attention should be given to the internal tube dimensions around the forcing cone, the projectile bourrelet dimensions, and the projectile rotating band dimensions as they compare with design specifications.



Note: Parts dimensioned to fit appropriate weapon.

Figure 4. Deramming device for removal of projectiles from weapons equipped with muzzle brakes (push method).

b. During the preparation of weapons with automatic rammers, the hydraulic pressure of the system is carefully adjusted (and monitored throughout the test), and the rammer is adjusted and centered to comply with specified limits.

c. Instrumentation, projectiles, and fixtures are prepared and assembled for proper fitting, clearances, and calibration. Load cells are interchanged periodically for calibration check at the end of a group of extraction trials.

d. Personnel are briefed on their requirements prior to the test to enable the test operation to run smoothly.

5. Measurement of Projectile Seating.

5.1 Objective. To obtain projectile seating characteristics data as a function of ramming conditions and tube life for later correlation with retention force and ballistic performance when applicable.

5.2 Standards. No problems shall be encountered in closing the breech, firing the weapon, or in projectile action that can be attributed to unsatisfactory seating. (There are no minimum-maximum criteria for projectile seating depth. Considerable variation is possible from tolerance buildups and tube wear.)

5.3 Method. The projectile is rammed into position. To measure projectile seating a long or short seating stick (fig. 2) is used, depending on chamber suze. The end of the stick is placed against the rear of the projectile. The sliding bar is positioned against the rear face of the breech ring and locked with a thumbscrew. The projectile seating distance indicated on the front edge of the sliding bar is recorded.

An accurate measurement can also be taken with a metal tape strip tied to a rod, using a crossbar to mark the exact location (fig. 5). Seating distance measurements for firing of separate-loading ammunition shall be taken on all propellant tests, range firings, and all other firings where chamber pressures and velocities are recorded.

5.4 Data Required. Record of projectile seating measurements for each rammed projectile.

5.5 Analytical Plan. For each test condition, seating measurements are summarized by calculating the average and standard deviation. These values are plotted versus tube wear, velocity, chamber pressure, and any other variables deemed appropriate.

6. Measurement of Extraction (Retention) Forces.

6.1 Objective. To obtain projectile retention characteristics data and attempt to relate it to projectile fallback within the weapon chamber.

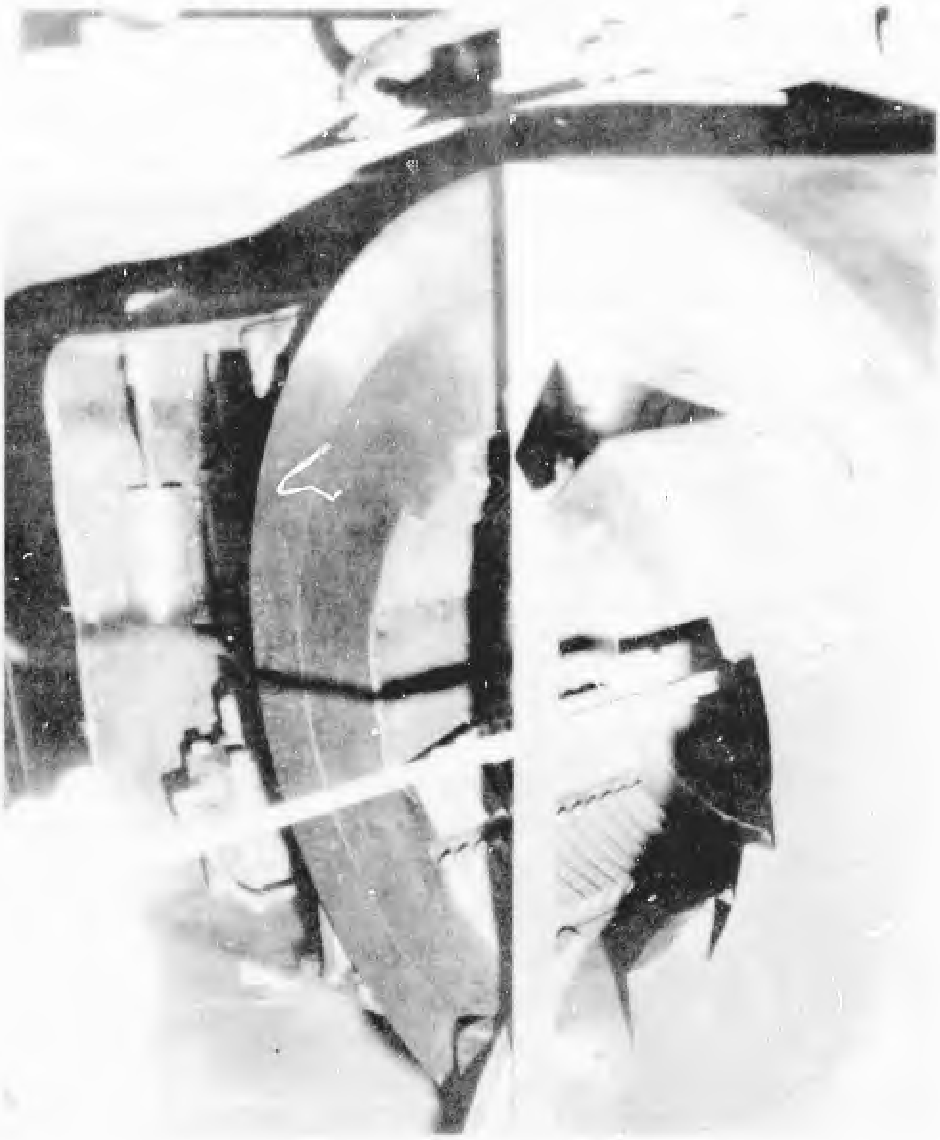


Figure 5. Making Seating Measurement on the 175-mm Gun.

6.2 Standards. Fallback under any conditions is unacceptable. However, no specific values for minimum extraction force to prevent fallback have been established. If data produce a mean and standard deviation that show the potential for extremely low values, the possibility of fallback may be considered to exist.

6.3 Methods.

6.3.1 Pull Method. A typical group of projectiles are selected. Physical dimensions of the projectile bourrelets and rotating bands, projectile weights, and tube dimensions are recorded in accordance with TOP's/MTP's 3-2-800, 3-2-801, and 3-2-803. Projectiles which do not meet drawing requirements are not used. The cannon tube remaining service life is compared with that established in TOP/MTP 3-2-829. The ramming of projectiles is performed as shown in table 1, using a new tube and an old tube. Ramming is conducted at the prescribed elevation for the system. Projectiles will be inert, and each will be modified for screwing a threaded 1-inch-diameter steel rod into the base for extraction purposes. Seating depth is measured as described in paragraph 5.3. Each projectile is rammed only once in this test. The 1-inch steel rod (approximately 10 inches longer than the average seating depth) is threaded into the projectile base after ramming. A 2-inch square by 16-inch long steel crossbar, a compression load cell of the appropriate capacity, a thrust bearing with an ID greater than 1 inch, and cylindrical spacers are fitted over the rod. A 1-inch hex nut is threaded to the rod, and an adjustable or box wrench is used to screw it tight for the final extraction. (See figs. 3 and 6). A recorder attached to the load cell receives the signals that are read out in electrical units that are later changed to force units. The selection of the appropriate load cell is based on anticipated results based on experience and judgment. Until sufficient data are obtained for each weapon, trial and error methods of selection may be necessary.

Table 1 - Outline of Ramming Conditions

Group	Condition	Projectile Quantity[a] Dry Tube	Projectile Quantity[a] Oily[b] Tube
	Automatic and Semiautomatic Ramming Systems (Using a Hydraulic Mechanism)		
[c]1	Power ram at minimum specified psi[d]/new tube	25	5
[c]2	Power ram at maximum specified psi[d]/new tube	25	5
[e]3	Hand ram at normal crew positions/new tube	25	5
4	Ram cold projectile in warm/new tube at condition that produces lowest extraction forces	25	5
5 through 8	Repeat 1 through 4 in a worn tube (0 to 25% wear life remaining)	100	20
	Total	200	40
	Hand Ramming Systems Only		
[e]1	Hand ram at normal crew position/new tube	50	5
[e]2	Hand ram cold projectile in warm/new tube	50	5
3 and 4	Repeat 1 and 2 in worn tube (0 to 25% wear life remaining)	100	20
	Total	200	20

See footnotes on following page.

[a]Chamber, forcing cone, and origin of rifling are swabbed with lubricating oil, preservative, PL-special, VV-L-800 prior to each round.
[b]Sample size may be reduced when there is only a minor change in the ramming system design.
[c]Tube should be bumped once on the upper or lower stop, alternating the bump position for each round prior to extracting.
[d]Psi refers to the hydraulic system pressure that operates the rammer.
[e]Each hand-rammed group should be conducted in 5- or 10-round groups with 5 different gun crews.

CAUTION: Personnel should not stand directly in front of the extraction rod while the nut is being tightened. Occasionally, when the projectile becomes unseated, the projectile and rod assembly will jump back a distance of 2 to 3 feet and serious injury could result. All personnel must therefore stand to one side of the rod while the nut is being tightened.

On certain weapons with chain-driven rammers, the ramming velocity can be measured by photographing the ramming chain by high-speed framing camera running at approximately 100 to 1000 frames per second (depending on precision required). Paintmarks should be placed on the ramming chain at convenient intervals and two marks placed on the loading tray at a known distance. A time code should be used with the camera for backup information.

6.3.2 Push Method. This method is applicable to weapons that utilize a muzzle brake. Projectile selection, cannon criteria, and ramming procedures are identical to those described in 6.3.1 above. The projectiles used with this method do not require any modification; they may not, however, be rammed more than once. The deramming device (fig 4) is inserted in the tube through the muzzle until the cone-shaped end rests against the fuze on the projectile. The interface plate is secured to the muzzle brake, and the hydraulic jack and spacers as required are put into position. The hand pump is then operated until sufficient force is generated to push the projectile out of the forcing cone. Force values are obtained by a compression load cell located between the push rod and the piston of the hydraulic jack. It is not necessary to entirely remove the deramming device prior to each round; it is only necessary to retract the push rod a sufficient distance to prevent contact with the projectile during ramming.

6.4 Data Required. The following data are required:

a. Tube internal dimensions, characteristics, and wear life.

b. Projectile weights.

c. Rotating band and bourrelet measurements.

d. Seating depth.

e. Retention (extraction) force (load cell results).

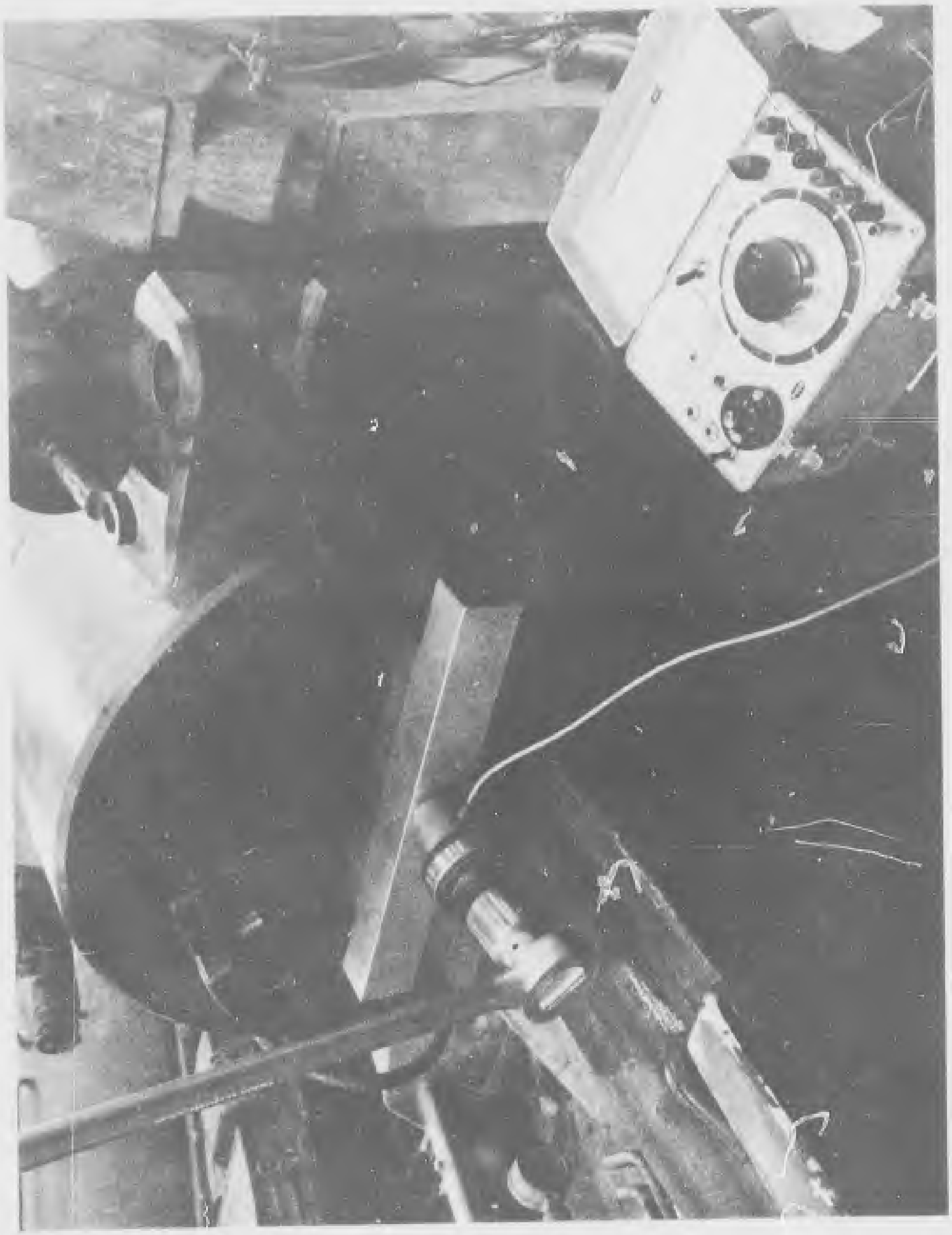


Figure 6. Complete Assembly of Extraction Components and Instrumentation for Retention Force Measurement.

6.5 Analytical Plan. Each type of measurement for each test condition is summarized by calculating the average and standard deviation. Extraction force is plotted versus rotating band and bourrelet dimensions and versus seating depth. Fallback potential is investigated by estimating the fraction of extraction forces less than some preassigned low value at a stated confidence level. This is accomplished by application of one-sided tolerance limit techniques for normally distributed random variables. Differences among conditions with regard to mean extraction force are sought by application of analysis of variance or other statistical methods as appropriate.

7. Monitoring of Projectile Fallback.

7.1 Objective. To provide a positive method of determining whether projectile fallback has occurred prior to firing. Fallback is monitored on separate-loading ammunition whenever the customer or test agency believes that a fallback problem might exist based upon prior experience with the weapon or the projectile. Also, monitoring is often conducted during the development testing of new ammunition.

7.2 Standards. Strain gage output shall remain constant during the time period between projectile seating and firing.

7.3 Method. Projectile fallback is monitored by positioning sensitive strain gages around the tube at the origin of rifling. Two types of gages may be used:

a. Semiconductor type (BLH type SPB3-18-100 or equivalent), one gage mounted circumferentially at the origin of rifling.

b. Wire type (BLH C-1 or equivalent), two gages in series, mounted circumferentially 180° apart at the origin of rifling.

The gages form one leg of a Wheatstone Bridge, the output of which is monitored on suitable equipment (oscilloscope, strip chart recorder). Seating of the projectile in the forcing cone produces a hoop strain which is detected by the gages, the output appearing as a step function. The output of the gage has some baseline which increases when the projectile, seated in the forcing cone, induces a stress in the tube. If this stress is removed, i.e., the projectile falls back, the output returns to the baseline value. (Some thermal drift may occur depending on the rate of fire and tube heating; this appears as a gradual change, however, whereas a fallback would appear as a step function.) The output is monitored during the conduct of the test to determine positively whether a projectile has fallen back.

7.4 Data Required. No quantitative data are obtained. A visual observation for the absence of a level shift prior to firing is adequate.

7.5 Analytical Plan. Not applicable.

8. Reduced Sampling Plan. The quantity of projectiles rammed in each of the conditions specified in table 1 may be reduced when only minor changes have been introduced in the design of the ramming system. It is suggested that measurements obtained with a sample of standard projectiles or conditions be compared with those obtained with the newly designed system.

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

APPENDIX
REFERENCES

1. TECOM Supplement 1 to AMCR 385-12, "Life Cycle Verification of Materiel Safety."

2. Brooks, Thomas L., "M109A1 Self-Propelled Howitzer Fallback Investigation," Technical Note R-TN-74-011, Gen Thomas J. Rodman Laboratory, Rock Island Arsenal, Rock Island Ill., April 1974.