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Test Report

PROTOTYPE QUALIFICATION TEST - GOVERNMENT
OF
CONUS-PRODUCED SAW AMMUNITION (M855/M856)

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SECTION I. EXECUTIVE DIGEST

1.1 SUMMARY

The estimate of overall performance of the CONUS-produced M855 Ball and M856 Tracer ammunition is gained from the four performance indices (logistic supportability, safety and health, human factors, and ammunition reliability), and from the test criteria.

In order to successfully meet logistic supportability aims, the ammunition must meet its own performance requirements as well as not contribute to performance shortfalls on the part of the weapons in which the ammunition is fired. The ball and tracer ammunition were generally successful in fulfilling these aims. In those instances where the ammunition partially met individual criteria, the defects were not at a lot-rejection level (Ref. Table 3.2-10). These defects tended to be grouped around a weapon type. Problems with the primer of the cartridge, excluding misfires, were evident only in the M249 SAW. Variations in firing pin length are known to contribute to an increase in the occurrence of perforated indents. Peripheral leaks and blown primers also occur infrequently at high temperature. Defective primers (missing components) caused the misfires charged to ammunition in both weapons. Failures to feed and chamber, caused by ammunition damaged during packaging, is a quality control problem, not one of ammunition design. The M856 Tracer cartridge performed well in the M249 SAW and in most of the M16A2 Rifles. The one exception produced repetitive feeding stoppages due to gas tube fouling. Detailed investigations, done by both the test agency and test sponsor (Ref. Para 3.3.4f), failed to reproduce the condition in other rifles. Although undesirable, this condition has been classified as an isolated occurrence, not representative of the ammunition's normal performance in the rifle. The combined ammunition defects have been classified as shortcomings (App. C, Paras. 2.4 and 2.5) for the two ammunition types.

Safety and health was not degraded by use of the test ammunition. The hazards found with the ammunition (i.e., metal parts separations; blown, perforated, and leaky primers; case splits; and gas tube fouling were all classified as acceptable risks (Ref. Para 3.3.4). There were three safety-related shortcomings found. The uncontrolled fire of the M16A2 Rifle when firing in the 3-round controlled burst mode is not a new problem with this device. Although not a hazard to the shooter, it can create a hazardous condition to personnel within the danger zone of the firing (App. C, Para. 2.1). The two shortcomings with the M249 SAW relate to the problems with links falling back into the gun mechanism during reloading (App. C, Para. 2.2), and breakage of the metal tab on the receiver of the gun which is the attachment point for the handguard assembly (App. C, Para. 2.3). Both problems are not new to the weapon. They require careful consideration in the means used to correct them so that other safety/reliability problems are not created (Ref. Para 3.3.5). The two safety deficiencies found, caused major weapon damage. One in the M249 was a cook-off during firing in a high temperature environment (App. C, Para. 1.1). The weapon had experienced a feeding stoppage where the cartridge was partially chambered. The cumulative heating of the weapon in this environment was sufficient to place the gun in the cook-off danger zone. Failure to clear the stoppage immediately resulted in damage to the weapon when

the cook-off occurred. The only practical way to help avert this type of problem is through training (Ref. Para 3.3.5). The other deficiency was personnel caused. Damage sustained by an M16A2 Rifle during the water spray test was the direct result of the shooter failing to drain water from the bore of the rifle prior to firing (App. C, Para. 1.2). Again, training is the only means available to minimize the occurrence of this type of problem (Ref. Para 3.3.5).

Human factors aspects of this test were generally favorable (Ref. Para 3.4.5). The ejection pattern of fired cases from both the M16A2 Rifle and M249 SAW was acceptable (the first few rounds from the rifle fired at low temperature were directed rearward). The recoil of the weapons was not excessive. Minor target obscuration/downrange detection from smoke of the fired rounds was noted. Muzzle flash from the ball ammunition was fully controlled. In some instances, use of tracer ammunition did produce detectable signatures at the gun (these two conditions were similar to results from firing the control ammunition). Impulse noise levels did not exceed those of the control ammunition; both require use of hearing protection (ear muffs or plugs). The weapon stoppages which the shooter was called upon to clear during firing did not pose major problems, although the link fall-back-caused feeding stoppages in the SAW were not clearable by immediate action. The plastic 200-round container, used as the on-weapon magazine in the SAW, caused increased belt tension at low temperature. This condition is considered the primary cause for the feeding stoppages which occurred in that environment. Also, because of the low temperature, the material used in the magazine tended to lose its "memory". The antifallback tab at the mouth of the magazines sometimes would not return to hold and prevent rounds from falling back into the magazine whenever the feed cover of the gun was raised to clear a stoppage. Stoppages at low temperature place an added burden on the gunner. The stoppages caused by gas tube fouling in the M16A2 Rifle were clearable by immediate action. Although undesirable, and an added operational burden placed on the gunner, the weapon was not rendered totally inoperable.

The ammunition reliability estimates are based on the combined firing of all weapons. The reliability of the M855 Ball ammunition was fully satisfactory in all operating environments (Ref. Table 3.5-11). The degraded performance of the M856 Tracer cartridges was due primarily to the poor performance of the one M16A2 Rifle which experienced gas tube fouling (Ref Table 3.5-11).

After this capsule review of the four areas of performance in this test program, a more detailed perspective of how the ammunition performed follows.

The test criteria listed in Appendix A and keyed to their respective subtests in Section 2 of this report, are summarized in Table 1. Each criterion has been categorized as either a performance (P), technical (T), or safety (S) requirement. After this table, there is a discussion of the criteria which were not fully met.

TABLE 1. COMPLIANCE WITH TEST CRITERIA.

Criterion Item No.	Criterion Type	Compliance, by Wpn/Ammo Type ^a								Remarks
		M16A2				M249				
		P	T	S	M	PM	M	PM	M		PN
1/55	X	X ..	.. ..	.. ..	.. X	.. ..	.. ..	.. ..	.. ..	Defect & casualty.
2/55	X .. ..	.. ..	.. ..	.. X	.. ..	X ..	.. ..	.. ..	.. ..	Defect & Casualty.
3	.. X ..	.....	.....	.....	.....	.....	.....	.....	.....	Publications. Partially met.
4	X .. X	.. ..	.. ..	.. ..	X ..	X ..	.. ..	.. ..	.. ..	Packaging.
5	.. .. X	.. ..	.. ..	.. ..	X ..	X ..	.. ..	.. ..	.. ..	Safe to fire.
6	.. .. X	X ..	X ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	Safe to fire.
7	.. .. X	.....	.....	.....	.....	.....	.....	.....	.....	Store, handle, transport, disposal. M855 & M856 both met.
8	X .. X	.....	.....	.....	.....	.....	.....	.....	.....	Human factors. M855 & M856 both met.
9	X	X ..	X ..	X ..	X ..	X ..	.. ..	.. ..	.. ..	Reliability.
^c 10	.. X ..	.....	.....	.....	.....	.....	.....	.....	.....	Mann barrels met.
11	.. X ..	.....	.....	.....	.....	.....	.....	.....	.....	Ammo characteristics: M855 & M856 both met.
^c 12	.. X ..	.....	.....	.....	.....	.....	.....	.....	.....	M196 Ammo characteristics met.
^c 13	.. X ..	.....	.....	.....	.....	.....	.....	.....	.....	Pressure gage calibration met.
14	X .. ..	.....	.....	.....	.....	.....	.....	.....	.....	M856 night trace met.
^c 15	X .. ..	.....	.....	.....	.....	.....	.....	.....	.....	M196 night trace met.
16	.. .. ..	.....	.....	.....	.....	.....	.....	.....	.....	Criterion replaced by item 17.
17	X .. ..	.....	.....	.....	.....	.....	.....	.....	.....	M856 Mann barrel accuracy met.
18	.. .. ..	.....	.....	.....	.....	.....	.....	.....	.....	Criterion replaced by item 19.
19	X .. ..	.....	.....	.....	.....	.....	.....	.....	.....	M855 Mann barrel accuracy met.
20	X .. ..	.....	.....	.....	.....	.....	.....	.....	.....	M855 Mann bbl. penetration met. M856 fired for information

TABLE 1. (CONT'D)

Criterion Item No.	Criterion ^b Type			Compliance, by Wpn/Ammo Type ^a				Remarks
				M16A2		M249		
	P	T	S	M855 M PM	M856 M PM	M855 M PM	M856 M PN	
21	..	X	..	.....	.....	.....	.....	Waterproofness. M855 & M856 both met.
22	X	..	..	.....	.....	.....	.....	M855 Mann barrel velocity met.
23	X	..	..	.....	.....	.....	.....	M856 Mann barrel velocity met.
24	X	..	..	.....	.....	.....	.....	M855 Mann barrel chamber pressure met.
25	X	..	..	.....	.....	.....	.....	M855 Mann barrel port pressure met.
26	X	..	..	.....	.....	.....	.....	M856 Mann barrel port pressure met.
27	X	..	..	.....	.....	.....	.....	M855 & M856 Mann barrel velocity at temperature extremes met.
28	..	..	..	.....	.....	.....	.....	Criterion replaced by item 29.
29	X	..	..	.....	.....	.....	.....	M855 & M856 Mann barrel chamber pressure at temperature extremes met.
30	X	..	..	.....	.....	.....	.....	M855 Mann barrel port pressure at temperature extremes met.
31	..	..	..	.....	.....	.....	.....	Criterion replaced by item 32.
32	X	..	..	.....	.....	.....	.....	M856 Mann barrel port pressure at temperature extremes met.
33	X	..	..	.....	.....	.....	.....	M855 & M856 Mann barrel action time met.
34	..	..	..	.....	.....	.....	.....	Criterion replaced by item 35.
35	X	..	..	.....	.....	.....	.....	M855 Mann bbl. dispersion met.
36	..	..	..	.....	.....	.....	.....	Criterion replaced by item 37.
37	X	..	..	.....	.....	.....	.....	M856 Mann bbl. dispersion met (retest).
38	..	X	..	.....	.....	.....	.....	M855 & M856 bullet extraction force met.
39	..	X	..	.....	.....	.....	.....	M855 & M856 residual stress met

TABLE 1. (CONT'D)

Criterion Item No.	Criterion ^b Type			Compliance, by Wpn/Ammo Type ^a								Remarks
				M16A2				M249				
	P	T	S	M855		M856		M855		M856		
			M	PM	M	PM	M	PM	M	PN		
40/48	..	X	..	.....	.....	.....	.....	.....	.....	.....	M249, M16A1, M16A2 before-test condition met.	
41	X	..	..	.....	.....	.....	..	X	X	..	M249 function & durability (not ammo caused): MRBF either not met, or partially met dependent on test environment.	
42/50/51	X	..	..	X	..	..	X	X	..	X	..	Barrel life.
43	X	..	..	.....	.....	.....	.....	.....	.....	.....	.....	M249 operation in extreme temperatures: Hot - partially met. Basic cold - met.
44	X	..	..	.....	.....	.....	X	..	X	..	.....	M855 M856 smoke & flash in M249 (no test required in M16A2).
45/54	X	..	..	X	..	X	..	X	..	X	..	Cook-off.
46	X	..	..	.....	.....	.....	.....	.....	.....	.....	.....	M855, M856 rough handling both met (accuracy not evaluated).
47	X	..	..	X	..	X	..	X	..	X	..	Noise.
49	X	..	..	X	..	.....	.....	.....	.....	.....	.....	M855 ballistic match with weapon sight elevation settings. (M856 tracer match evaluated in item 17 and 37). M249 not required to be tested.
51	X	..	..	X	..	..	X	.....	.....	.....	.....	M16A2 rifle part life (excluding barrel).
52	X	..	..	X	..	..	X	.....	.....	.....	.....	M16A2 rifle function performance.
53	X	..	..	..	..	..	..	.....	.....	.....	.....	M16A2 rifle provisional criterion not used.
56	X	..	..	X	..	..	X	X	..	X	..	Fouling.
57	X	..	..	X	..	X	..	X	..	..	X	Metal parts integrity.

^a M= criterion met. PM= criterion partially met.

^b P= performance, T= technical (non-firing), and S= safety related criterion.

^c Criterion not related to performance of the test item.

Five of the 53 test-item-related criteria were partially met; all others were met. Criteria 1 and 2 dealt with prefiring ammunition defects and fired case casualties. The M855 Ball ammunition fired in the M249 SAW at high temperature induced a variety of primer-related defects (blown, pierced, and leaks). Only the blown primers caused stoppages and these were readily clearable. Pierced primer defects were waived by the developer until the firing pin length problem in the M249 SAW can be corrected. The M856 Tracer ammunition produced fouling which resulted in a higher-than-desired stoppage rate attributable to ammunition. This is also the basis for partially meeting criterion item No. 56 with this round.

Criterion item No. 3 deals with the publications which direct and control ammunition throughout its life cycle. Most of these documents discuss ammunition in general terms. Since they often address small arms ammunition as a group, instead of the 5.56-mm M855 and M856 rounds specifically, there is a general obsolescence found in the documentation. The documents need to be brought up to date so that there is no question that they apply to 5.56-mm ammunition as well as the other calibers that are referenced.

Criterion item No. 37 deals with dispersion of the M856 cartridge. Although the ammunition did meet the requirement upon retest, there have been a great deal of problems experienced in refining production so that the rounds will always satisfy the dispersion requirement. This is an area which requires continued vigilance.

Criterion item No. 41 relates to functioning and durability of the M249 SAW. The gun-caused problems experienced during test with failed extractors and other component parts, caused the weapons not to satisfy performance requirements in the individual subtests. This problem-should be corrected when the product-improved SAWs are fielded in the near future.

Criterion item No. 57 relates to integrity of the projectile metal parts. Indications of fragment ejection from the tracer rounds occurred, but were discounted as being caused by impact on the witness panels supports. There were no indications of failure during firing of the ammunition in the other subtests. Ball ammunition gave infrequent signs of lead exudation from the base of the projectile, both in the metal parts test and during the endurance firings when a round was chambered in a hot barreled M16A2 Rifle for longer than 30 seconds before being fired. There were no signs of metal parts separations and this condition was not counted as a failure.

The overall performance of the CONUS-produced M855 Ball ammunition was satisfactory. The few irregularities found during testing do not prevent this round from being considered acceptable for use in both the M16A2 Rifle and M249 SAW.

The overall performance of the CONUS-produced M856 Tracer ammunition was satisfactory for use in both the M16A2 Rifle and M249 SAW. The fouling problem experienced in one M16A2 Rifle, (which was the cause for the M856 cartridge failing to fully satisfy its reliability requirement), is considered an isolated occurrence, not indicative of that ammunition's performance in the rifle. No fouling problems were experienced with the same ammunition in the M249 SAW.

1.2 TEST OBJECTIVE

The overall objective of this test was to establish a data base, adequate to allow determination of the suitability of the CONUS-produced M855 Ball and M856 Tracer ammunition when fired in the M16A2 Rifle and M249 SAW.

1.3 TESTING AUTHORITY

This test was authorized by the U.S. Army Test and Evaluation Command (TECOM) test directives, 5 August 1982, amended 21 October 1982 (planning) and 16 May 1984, amended 11 June 1984 and 14 September 1984 (execution). (See Appendix D, references 1 through 4, and 8).

1.4 TESTING CONCEPT

Overall planning, execution, and reporting of this project was the responsibility of the U.S. Army Combat Systems Test Activity at Aberdeen Proving Ground, Md.

Part II of the test program (ammunition acceptance tests, with the ammunition fired from Mann barrel test fixtures), was conducted by U.S. Army Armament Research, Development and Engineering Center personnel at their Ft. Dix New Jersey test site. These data are contained as part of this report.

Testing was initiated in August 1982 and completed in June 1988 at Aberdeen Proving Ground, Md.

Since manufacture and delivery of the test items was spread over a long time base, testing was broken into major parts, each a self-contained series of tests of the M855 Ball and/or M856 Tracer ammunition.

- (1) Part I was a non-fired analytical assessment of the results of testing in the other three parts of the program. The analysis were divided into four major groupings: logistic supportability, safety, human factors, and ammunition reliability.
- (2) Part II assessed the ammunition when fired in Mann barrels and was a duplication of the standard ammunition lot acceptance tests. These tests consisted of an initial materiel inspection; projectile trace; penetration; waterproofness; velocity, pressure, and action time; dispersion and accuracy; bullet pull, and residual stress tests. Trajectory of the ammunition was also determined using a tracking radar (Hawk velocimeter). These tests were accomplished by personnel from ARDEC at their Ft. Dix, New Jersey test site, from June 1984 to April 1986. (USACSTA also conducted trajectory tests in April 1986 at Aberdeen Proving Ground, Md.).
- (3) Part III assessed the ammunition when fired from the M249 SAW. Testing consisted of an initial materiel inspection, range-ambient temperature endurance and reliability, high temperature (+68 °C), low temperature (-54 °C) temperature/humidity, smoke and flash,

cook-off, salt fog, metal parts integrity (three temperatures), rough handling (high and low temperatures), noise, and water spray.

- (4) Part IV assessed the ammunition when fired from the M16A2 Rifle. Testing consisted of an initial materiel inspection, range-ambient temperature endurance and reliability, high temperature (+68 °C), low temperature (-54 °C), tracer (three temperatures), cook-off, noise, water spray, and metal parts integrity (three temperatures).

The overall statistical design of the test was derived from the TECOM Independent Evaluation Plan/Test Design Plan (IEP/TDP), which assured that an adequate data base was created.

During the protracted delivery of the CONUS-produced M856 Tracer ammunition for testing, the test sponsor requested, and TECOM concurred in, two increases in the scope of testing.

- (1) Part V of the program added the safety assessment of the CONUS-produced M855 Ball round, linked with the OCONUS-produced (FN-Belgian) M856 Tracer round (linked 4-ball/1-tracer), fired from the M249 SAW. Safety testing of this hybrid lot of ammunition was necessary to allow use of the newly adopted SAW for training, etc.
- (2) Part VI of the program added the safety assessment of the OCONUS-produced M856 Tracer ammunition when fired from the M16A2 Rifle. This supported the United States Marine Corps (USMC) requirement for a tracer round for the rifle for training and other uses.

Standard packaging for the linked ammunition for the M249 was developed, tested, and adopted independently of the ongoing SAW ammunition test. Since the packaging test was a more realistic representation of how the ammunition would fare in an operational environment, the test agency suggested, and TECOM concurred, in its use as a substitution for that portion of the test program.

Additional range-ambient temperature endurance testing of the M16A2 Rifle with CONUS-produced M856 and M196 Tracer ammunition was requested by the test sponsor and concurred in by TECOM, in response to the need to evaluate a fouling problem with the M856 cartridge.

The change in M856 Tracer design late in the testing was a result of a change in manufacturer. The Lake City Army Ammunition Plant (LCAAP) was operated by Remington Arms Co. during production of the ammunition for this test. This operation was taken over by Olin Corp., who instituted design and manufacturing changes to the projectile, necessary to improve its performance. Since a full evaluation of the new rounds could not be made during DT-II, the test agency requested and received a small pre-production sample from the test sponsor to use in determining if any change to ballistic match had occurred. TECOM concurred in this action which required no additional expenditure of funds or time, since these rounds were fired concurrently with the other rounds previously scheduled for testing.

The criteria in the original detailed test plan (App. D, Ref. 5) were based on the Quality Evaluation Plan (QEP) for the XM855E1 Ball and XM856E1 Tracer rounds. Delays in successful fabrication of the first rounds for use in

testing necessitated changes in the test plan to reflect publication of MIL-C-63989 (for the ball round) and MIL-C-63990 (for the tracer round). Concurrent with replacement of the QEP's by the Military Specifications, there was also a change in the nomenclature of the rounds from XM to M numbers. Further refinement to the specifications paralleled the manufacture of the ammunition, so that there was another change to the MIL-Spec's (Revision A). Most of the criteria and their paragraph references remained unchanged. Those that either changed references, or specification requirements, are listed as superseded in appendix A of this report and their replacement criterion is then given. All other criteria reflect only the change to a revision A reference. A revision B of MIL-C-63990 which was recently adopted, was not used in this assessment. Basic changes were to tighten up the dispersion requirements of the tracer round. This was done after design and manufacturing process changes were made to the projectile. These changes were not addressed during this test, except to fire a pre-production sample for trajectory.

1.5 SYSTEM DESCRIPTION

The M249 Squad Automatic Weapon (SAW) type classification action was completed on 1 February 1982. At that time two foreign-produced rounds of ammunition, the Belgian (Fabrique Nationale) SS109 Ball and L110 Tracer were type-classified and designated M855 and M856, respectively. These improved 5.56 x 45-mm rounds were the basis for NATO Standardization Agreement (STANAG) 4172. Prior to development of a continental United States (CONUS) produced equivalent to the foreign made ammunition, both the M16A2 Rifle and M249 SAW used the FN-made rounds. After adoption of CONUS-made ammunition, the of-fshore procurement of the ammunition will terminate. Both the foreign and domestically made rounds bear the same M855 and M856 designation since they are designed to be ballistically matched and are all NATO-standard rounds.

The 5.56 x 45-mm Ball ammunition produced within CONUS for use in the M16A2 Rifle and M249 Squad Automatic Weapon (SAW) is designated M855. Its construction consists of a boxer-primed brass case, double-base smokeless ball propellant, and a bimetallic projectile. The projectile consists of a gilding metal jacket, lead core, and steel nose filler (penetrator).

The 5.56 x 45 mm tracer ammunition of CONUS production is designated M856. it is constructed similar to that of the ball round, except there is no steel nose filler in the projectile and the bullet jacket material is gilding-metal-clad steel. An internal cavity in the base of the projectile contains the tracer mix.

The control ammunition, manufactured outside the continental United States (OCONUS-produced) by Fabrique Nationale (FN) of Belgium, differs from the CONUS-produced ammunition in two respects: propellant and Berdan-primed cartridge case. The test and control ammunition can be differentiated by manufacturer designations, both in the ammunition lot number and cartridge headstamp markings. Both manufacturer types are NATO-standard rounds and are completely interchangeable in the weapons designed for their use.

SECTION 2. SUBTESTS

2.1 INTRODUCTION

The test details are indexed in the major information groupings as shown in Table 2.1-1. This format follows the original test plan closely, but adds the supplemental tests required to assess special lots of ball and tracer ammunition required as interim fixes until the CONUS-produced rounds were tested and evaluated.

TABLE 2.1-1. INDEX OF TEST DETAILS

Test Section No.	Testing Identification	Page No.
I	Common Test Assessments: Logistic Supportability, Safety and Health, Human Factors and Ammunition Reliability.	3-1
II	Ammunition Fired from Mann Barrels: Inspections, Trajectory and Projectile Trace, Penetration, Waterproofness; Velocity, Pressure and Action Time; Dispersion and Velocity, Bullet Pull, and Residual Stress.	4-1
III	Ammunition Fired from M249 Saw: Inspections Endurance and Reliability, High Temperature, (+68°C), Low Temperature (-46°C), Temperature and Humidity, Smoke and Flash, Cook-Off, Salt-Fog, Metal Parts Integrity, Secured Cargo and Rough Handling, Noise, and Water Spray.	5-1
IV	Ammunition Fired from M16A2 Rifles: Inspections, Endurance and Reliability, High Temperature (+68°C), Low Temperature (-46°C), Tracer, Cook-Off, Noise, and Water Spray.	6-1
V	Special Safety Test: Mixed U.S. M855 and Belgian M856 in the M249 Saw.	7-1
VI	Special Safety Test: M856 Tracer fired from M16A2 Rifle.	8-1

3.1 TEST PART I - INTRODUCTION

This part of the report presents information relating to common test assessments. These are shown in Table 3.1-1.

TABLE 3.1-1. INDEX OF SUBTESTS

<u>Para No.</u>	<u>Subtest Description</u>	<u>Page No.</u>
3.1	Introduction.....	3-1
3.2	Logistic supportability	3-1
3.3	Safety and health	3-16
3.4	Human factors	3-22
3.5	Ammunition reliability.....	3-27

3.2 LOGISTIC SUPPORTABILITY

3.2.1 Objective and Issues

- a. Test objective. Determine if the CONUS-produced M855 and M856 cartridges meet the requirements for logistic supportability.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Is the CONUS-produced M855 and M856 ammunition compatible with the SAW and M16A2-rifle?
- d. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for cartridge M855 Ball and M856 Tracer?
- e. Other issue. Are all of the test item's RAM requirements met? (Note, issues will be addressed by the independent evaluator; they are included here for completeness only.

3.2.2 Criteria

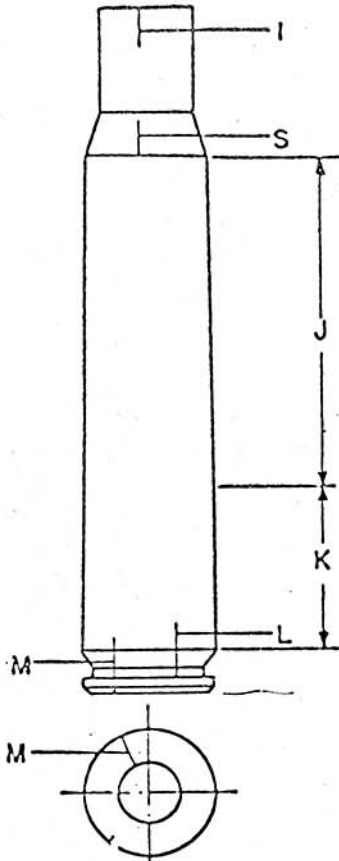
- a. The quality of the CONUS-produced M855 Ball ammunition shall conform to the requirements of paragraphs 4.5.6.4 and 4.5.7.2 of MIL-C-63989A (ref 15) for numbers of allowed pre-firing defects and fired case casualties (Test Agency devised, TECOM approved).
- b. The quality of the CONUS-produced M856 Tracer ammunition shall conform to the requirements of paragraphs 4.5.6.3 and 4.5.7.2 of MIL-C-63990A (Ref. 19) for numbers of allowed pre-firing defects and fired case casualties (Test Agency devised, TECOM approved).

- c. All technical publications identified as relevant to the inspection, transportation and handling, storage, and disposal of the test ammunition (including M27 links, and associated packaging and packing), shall adequately cover procedures necessary to assure fulfillment of logistic supportability requirements (Test Agency devised, TECOM approved).
- d. The adequacy of the packaging, packing, and preservation of the CONUS-produced ammunition (including M27 links), shall preclude degradation of weapon reliability due to ammunition damage sustained during transportation and handling of that ammunition (Test Agency devised, TECOM approved).

3.2.3 Test Procedure

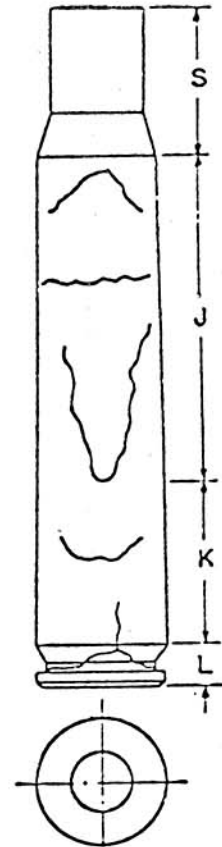
- a. The available technical literature on small arms ammunition logistic supportability was reviewed for its adequacy relative to the test items. The four areas of interest were: inspection, transportation and handling, storage, and disposal.
- b. Data on ammunition packaging protection were taken from the PIP test of the SAW ammunition container (TECOM Project No. 2-MU-023-SAW-001) (Ref. 25) at the direction of TECOM. There was no other ammunition packaging testing done as part of the SAW ammunition evaluation.
- c. All ammunition was inspected for defects prior to test firing, except the prepackaged ammunition used in the M249 SAW. The defects found were categorized in accordance with Reference 15 and 19 procedures. This was in addition to the inspections performed in paragraph b, above.
- d. All fired case defects were recorded and categorized as in paragraph c, above. Cartridge case splits and rupture classifications are defined in Figure 3.2-1.
- e. Assignment of numerical values for the various categories of failures has been made based on conversion of the Mil-Spec values into failure rate per 1000-rounds fired. This information is presented in Table 3.2-1. In a similar manner the performance of the weapons has been assigned values based on the same type of conversion for the M16A2-rifle and M249 SAW. This information is presented in Tables 3.2-2 and 3.2-3, respectively.

SPLITS



- I - MOUTH OR NECK
- J - IN UPPER $\frac{2}{3}$ BODY SECTION
- K - IN LOWER $\frac{1}{3}$ BODY SECTION ABOVE EXTRACTOR GROOVE
- L - IN SIDEWALL EXTENDING INTO EXTRACTOR GROOVE
- M - IN SIDEWALL EXTENDING INTO PRIMER POCKET
- S - IN SIDEWALL OF SHOULDER

RUPTURES



- S - NECK & SHOULDER
- J - IN UPPER $\frac{2}{3}$ BODY SECTION
- K - IN LOWER $\frac{1}{3}$ BODY SECTION ABOVE EXTRACTOR GROOVE
- L - IN HEAD & IN EXTRACTION GROOVE

NOTE: - IF A SPLIT EXTENDS THROUGH THE UPPER $\frac{2}{3}$ BODY SECTION IT SHALL BE CLASSIFIED J PROVIDED THE SPLIT DOES NOT EXTEND THROUGH THE MOUTH. IF THE MOUTH OF THE CASE IS SPLIT AND THE SPLIT IS WITHIN THE UPPER $\frac{1}{3}$ OF THE BODY IT SHALL BE CLASSIFIED I; HOWEVER IF THE MOUTH IS SPLIT AND THE SPLIT IS LONGER THAN $\frac{1}{3}$ OF THE BODY LENGTH IT SHALL BE CLASSIFIED IJ.

Figure 3.2-1 Classification of Cartridge Case Defects For Small Arms Ammunition

TABLE 3.2-1. CONVERSION FORMAT FOR MILITARY SPECIFICATION
ASSESSMENT OF CARTRIDGE DEFECTS AND CASUALTIES

Failure Type	Item No.	Defect Class	Defect Description	Mil-Spec Values ^a		Rate Per 1000 Rd ^b	
				Acc ^c	Rej	Acc	Rej
Weapon-related	1	Critical	Bullet in bore.	0	1	0.0	0.62
	2	Critical	Misfire - no vent hole in case.	0	1	0.0	0.62
	3	Major	Misfire - other causes	1	3	0.62	1.88
	4	Major	Failure to extract.	0	2	0.0	1.25
	5	Major	Weapon stoppages (except those caused by misfire, complete case rupture, or failure to extract.	0	2	0.0	1.25
Primer	6	Major	Perforation of firing pin indent in primer cup.	0	1	0.0	0.62
	7	Major	Escape of gas through primer cup (excludes indent perforation).	1	3	0.62	1.88
	8	Major	Loose primer.	0	2	0.0	1.25
	9	Major	Blown primer.	0	1	0.0	0.62
	10	Major	Dropped primer.	0	2	0.0	1.25
	11	Minor	Escape of gas around periphery of primer cup: a. 50% or more. b. Less than 50%.	3 5	7 9	1.88 3.12	4.38 5.62
Longitudinal case split	12	Major	Body (J zone).	3	7	1.88	4.38
	13	Major	Body (K zone).	0	2	0.0	1.25
	14	Major	To head (L zone).	0	2	0.0	1.25
	15	Major	Through head (M zone).	0	2	0.0	1.25
	16	Minor	Neck & shoulder (I or S zone).	5	9	3.12	5.62
Circumferential case rupture	17	Major	Partial rupture - shoulder or body (J or S zone).	1	3	0.62	1.88
	18	Major	Partial rupture - body (K zone).	0	1	0.0	0.62
	19	Major	Partial rupture - head (L zone).	0	1	0.0	0.62
	20	Major	Complete rupture.	0	1	0.0	0.62

(See footnotes on following page).

- ^a Values extracted from Table IV of reference 15 (M855 Ball) and reference 19 (M856 Tracer) for first sample accept/reject criteria.
- ^b Rates per 1000-rounds fired are based on 1600-round totals shown in Table III of references 15 and 19 for first sample accept/reject criteria: 800-rounds for each weapon type (i.e. M16A2 and M249).
- ^c The cumulative second sample (retest) values shown in the Military Specifications were not used.
- ^d The computed failure rates based on cumulative second sample (retest) values was not used. Whenever a failure rate exceeds the first sample accept rate, but does not exceed a first sample reject rate, suitable statistical analysis may be used to determine its significance.

Note: The pre-firing inspection was visually performed. Minimum weight was not evaluated. The permitted defect rate for the pre-firing inspection was 1.50% for defects classified as minor, 0.25% for defects classified as major and zero percent for critical defects.

TABLE 3.2-2. MALFUNCTION AND PART FAILURE RATES
ALLOWED FOR M16A1 AND M16A2 RIFLES.

<u>Malf Code</u>	<u>Malfunction Types</u> ^a	<u>Max No. Allowed</u> ^b	<u>Malf Rate Per 1000 rd</u>
FFD	Failure to feed	4	0.66
FTC	Failure to chamber	3	0.50
FTL	Failure to lock	2	0.33
FFR	Failure to fire	2	0.33
FEX	Failure to extract	1	0.17
FEJ	Failure to eject	2	0.33
FBR	Bolt fails to remain rearward	3	0.50
OTH	All other	0	0
Allowed total of all types combined		9	1.50

<u>Unserviceable Parts</u>	<u>Min Life Rd</u>	<u>4-Wpn Total</u> ^c
Ejector spring	3000	2
Extractor spring	2000	4
Other parts	3000	1
Allowed total of all parts combined		4

^a Weapon-caused malfunctions.

^b Number allowed per rifle during 6000-rounds firing.

^c Part failures only given for a 4-rifle total. The numbers shown are for the M16A1-rifle. Only 2 extractor springs and 3 total (all parts) failures are permitted with the M16A2-rifle.

^d Other parts limited to trigger spring, disconnect spring, hammer spring, extractor pin, and extractor.

Note: All data are based on Table I of reference No. 26 and 27.

TABLE 3.2-3. MALFUNCTION AND PART FAILURE RATES ALLOWED FOR M249 SAW^a

<u>Failure Class</u>	<u>MRBF</u> ^b
I & II	3,333
II	6,250
III	15,000

^a All data are based on information given in paragraph 3.4.10 of reference No. 28. The types of stoppages and malfunctions, by specific quantity, are not broken out; only the failure rate is defined. The following class definitions have been used to assist in determining the type of failure: Class I - immediately clearable failure/stoppage. A failure clearable by the operator within 10 seconds, using prescribed immediate action procedures. Class II - clearable failure/stoppage. A failure not immediately clearable, but clearable by the operator in more than 10 seconds, but less than 10 minutes; with or without the use of the basic issue items of tools, equipment and/or parts available to him. Class III - severe failure/stoppage. A failure not correctable by the operator, either because the corrective action requires higher level maintenance, or authorized operator correction cannot be accomplished because of the unavailability of necessary tools, equipment, or parts.

^b The Mean Rounds Between Failure (MRBF) specified in the criterion for each class of failure/stoppage is based on weapon-caused problems.

3.2.4 Test Findings

- a. The tests referred to in Tables 3.2-4 through 3.2-9 are a consolidation of the similar environmental conditions. They were: (1) range-ambient temperature endurance and reliability. (2) +68°C temperature. (3) -46°C temperature. (4) temperature/humidity (M249 only). (5) smoke and flash. (6) cookoff. (7) salt-fog. (8) metal parts integrity - fired at three temperatures: +21°C, +68°C, and -46°C. (9) noise. (10) water spray. (11) sand/dust (M249 only). (12) accuracy (M16A2 and Mann barrel). (13) secured cargo and rough handling (M249 only).
- b. The exhibited quality of the CONUS-produced M855 Ball ammunition is shown in Table 3.2-4 when used in the M16A2 rifle; Table 3.2-5 when used in the M249 SAW, and Table 3.2-6 when fired from Mann barrel test fixtures (no defects were noted in 520-rounds fired).

TABLE 3.2-4. QUALITY OF CONUS-PRODUCED M855 BALL AMMUNITION FIRED FROM M16A2 RIFLES

Inspection Indices	No. of Defects/Casualties, by Test ^a						
	Ambient	High Temp	Low Temp	Rain	cookoff	Salt Fog	Total
<u>Case splits:</u>							
I	33	3	5	0	b ₄	-	45
S	2	0	0	0	0	-	2
J	0	0	0	0	0	-	0
K	0	0	0	0	0	-	0
L	0	0	0	0	0	-	0
M	0	0	0	0	0	-	0
<u>Case rupture:</u>							
S	0	0	0	0	0	-	0
J	0	0	0	0	0	-	0
K	0	0	0	c ₁	0	-	1
L	0	0	0	0	0	-	0
<u>Primer defect:</u>							
leak	0	0	0	0	0	-	0
loose	0	0	0	0	0	-	0
perforated	0	0	0	0	3	-	3
other	3	0	0	0	0	-	3
TOTALS	38	3	5	1	7	-	54

See footnotes on following page.

- ^a A total of 84,468 rounds/fired-cases was inspected for defects.
^b A total of 28 other case mouth defects noted which were classified as pre-firing defects.
^c Personnel error (failure to evacuate water from the bore) caused case rupture, which caused major weapon damage. This is not chargeable to the ammunition.

TABLE 3.2-5. QUALITY OF CONUS-PRODUCED M855 BALL AMMUNITION FIRED FROM M249 SAW

Inspection Indices	No. of Defects/Casualties, by Test ^a						
	Ambient	High Temp	Low Temp	Rain	cookoff	Salt Fog	Total
<u>Case splits:</u>							
I	^b 85	^c 14	^e 0	^f 0	^g 1	0	100
S	4	1	0	0	0	0	5
J	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0
<u>Case rupture:</u>							
S	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0
<u>Primer defect:</u>							
leak	0	0	0	0	0	0	0
loose	0	0	0	0	0	0	0
perforated	21	^d 1	0	0	2	0	24
other	0	^d 3	0	0	0	0	3
TOTALS	110	19	0	0	3	0	132

- ^a A total of 120,434 rounds/fired-cases was inspected for defects.
^b A total of 119 other defects noted that were classified as pre-firing defects.
^c A total of 2 other defects noted that were classified as pre-firing defects.
^d A total of 3 blown primers occurred.
^e A total of 5 pre-firing defects noted.
^f One pre-firing defect noted.
^g A total of 9 other defects noted that were classified as pre-firing defects.

- b. The exhibited quality of the CONUS-produced M856 Tracer ammunition is shown in Table 3.2-6, when used in the M249 SAW; when fired in the M16A2-rifle (19,665 rounds fired) and in Mann barrel firing fixtures (540 rounds fired), no defects were found.

TABLE 3.2-6. QUALITY OF CONUS-PRODUCED M856 TRACER
AMMUNITION FIRED FROM M249 SAW

Inspection Indices	No. of Defects/Casualties, by Test ^a							Total
	Ambient	High Temp	Low Temp	Rain	cookoff	Salt	Fog	
<u>Case splits:</u>								
I	5	4	0	0	0	0	0	9
S	0	0	0	0	0	0	0	0
J	2	0	0	0	0	0	0	2
K	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0
M	0	0	0	0	0	0	0	0
<u>Case rupture:</u>								
S	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0
L	0	0	0	0	0	0	0	0
<u>Primer defect:</u>								
leak	0	0	0	0	0	0	0	0
loose	0	0	0	0	0	0	0	0
perforated	0	0	0	0	0	0	0	0
other	0	0	0	0	0	0	0	0
TOTALS	7	4	0	0	0	0	0	11

^a a total of 25,886 rounds/fired-cases was inspected for defects.

c. The following technical publications were reviewed for content and adequacy as related to the M855 and M856 CONUS-produced ammunition.

- 1) MIL-A-48078, Ammunition, Standard Quality Assurance Provisions, General Specification for, 19 July 1976. This document generalizes the QA provisions and specifications for small arms ammunition .
- 2) MIL-STD-636, Visual Inspection Standards for Small Arms Ammunition through Caliber 50, 5 June 1958. This document visually and graphically depicts the types of defects and their classification.

This document, because of its vintage, does not define the standards for 5.56-mm ammunition. The information, however, is useful since it defines defects that may be present in all small arms cartridges.

- 3) MIL-STD-1168A, Lot Numbering of Ammunition, 28 February 1975. This document prescribes the procedures for assigning lot numbers to small arms ammunition.
- 4) MIL-STD-709C, Ammunition Color Coding, 6 May 1976. This document prescribes the different color codes that must be used to identify small arms ammunition types.

The green color used on the tip of the M855 Ball projectile to differentiate that projectile from the M193 Ball projectile (no color marking) is not a prescribed identification in accordance with this document.

- 5) MIL-STD-644A, Visual Inspection Standards and Inspection Procedures for Inspection of Packaging, Packing and Marking of Small Arms Ammunition, 3 December 1962. This document prescribes standards and procedures to be used in inspection of small arms ammunition packaging.

This document is outdated. It does not contain information on 5.56-mm ammunition.

- 6) Drawing No. 7643674, Classification of Cartridge Case Defects, Small Arms Ammunition. This document dimensionally defines the location of defects found in small arms ammunition.

This document is fully applicable to 5.56-mm ammunition.

d. Other technical publications relating to handling and destruction of small arms ammunition were unavailable for review. One possible addition required in such documents is the disposition of the plastic 200-round capacity magazine. It is not known if burning of the material would produce toxic gases. Also, if this magazine is determined to be reuseable, what inspection procedures would be required to assure that damaged magazines are not reloaded with ammunition.

e. The ammunition, in its PA108 container, was subjected to a series of handling and transportation test (Ref. 25). These tests consisted of secured-cargo vibration, sequential rough handling, and 12-meter pallet drop. Test results are summarized as follows:

(1) Secured-cargo vibration. Pre-test inspection revealed no damage or other defects. Post-test inspection revealed that the wires around several of the wooden shipping boxes were broken and one pull tab disconnected from an ammunition belt. No ammunition damage was noted. This test was done at both high and low temperature extremes.

(2) Sequential rough handling. Pre-test inspection revealed no damage or other defects. Post-test inspection revealed the packaging produced minor damage (e.g. disconnected pull tabs), but the ammunition remained serviceable. This test was done at both high and low temperature extremes.

(3) 12-Meter pallet drop. The palletized PA108 ammunition container will not withstand the effects of this drop without sustaining major damage to the bottom row of containers. The ammunition, however, is not rendered totally unserviceable. Safe handling and disposal remains possible.

(4) After-test firing of ammunition was done at -46°C temperature with a portion of the ammunition from the sequential rough handling test; a total of 6400-rounds was randomly selected. All firing was from an M249 SAW (Serial No. 005741) fired with three different barrels. There were 27 stoppages: 1 failure to feed (belt separation), 23 failures to chamber damaged rounds, and 3 failures to eject fired cases. A total of 25 rounds was not fired as a result of these stoppages.

(5) The other 6400-round sample of ammunition from the sequential rough handling test was fired from the same weapon and barrels at a temperature of $+68^{\circ}\text{C}$. There were 50 stoppages: 4 failures to feed (3 belt separations and 1 bolt under ride), 45 failures to chamber damaged rounds, and 1 failure to eject. A total of 64-rounds was not fired as a result of these stoppages.

3.2.5 Technical Assessment

- a. Table 3.2-7 analyzes the ammunition defects/fired case casualties resulting from testing the CONUS-produced M855 Ball and M856 Tracer ammunition. This summary includes only incidents chargeable to ammunition.

TABLE 3.2-7. ANALYSIS OF AMMUNITION DEFECTS AND FIRED - CASE CASUALTIES

Defect Indices	Criteria ^a		No. of Defects/Casualties, by Ammo Type							
	Acc	Rej	M855 ^b				M856 ^b			
			Pre	Fire	Tot	Rate	Pre	Fire	Tot	Rate
Weapon stoppage (FFR) ^c	0.62	1.88	-	4	4	0.02 ^f	-	1	1	0.02 ^f
(FFD) ^d	0.00	1.25		1	1	.01 ^f	-	15 ^e	15	.33 ^f
(FTC) ^g	0.00	1.25		1	1	.01 ^f	-	2	2	.04 ^f
Case splits (zone):										
I & S	3.12	5.62	164 ^h	152	316	1.54	0	9	9	.20
J	1.88	4.38	0	0	0	.00	0	2	2	.04
Primer defects:										
Perforated indent	0.00	0.62	-	24	24 ⁱ	.12 ^f	-	0	0	.00
Peripheral leak 50%	3.12	5.62	-	3	3 ^j	.01 ^f	-	0	0	.00
Blown primer	0.00	0.62	-	3	3 ^j	.01 ^f	-	0	0	.00

^aAccept (Acc) and Reject (Rej) criteria expressed as a failure rate per 1000-rounds examined/fired.

^bThe pre-firing defects (Pre) and fired case casualties (Fire), and their totals (Tot) are expressed as whole numbers. The Rate is per 1000-rounds examined/fired and is to be compared against the criteria.

^cFailures-to-fire: Three M855 Ball and one M865 Tracer in M16A2-rifle; One M855 in M249 SAW.

^dOther short-recoil caused stoppages (Failure to extract and failure of the bolt to remain to rear) are listed under this singular Failure-to-Feed (FFD) category.

^eOccurred as a result of gas tube fouling in one M16A2-rifle fired with all-tracer rounds. May be influenced by bore finish - see Ref. 41, and/or gas port location - see Ref. 42.

^fExceeds criterion acceptance, but not the rejection limit.

^gAll Failures-to-chamber occurred in the M249 SAW.

^hAlthough classified as pre-firing defects as a result of inspection after firing, these defects were also included in the firing defects total. These pre-firing defects are classified as MINOR, with an allowed 1.50% defect rate. The actual rate was less than 0.001 %.

ⁱAll occurred in M249 SAW (Perforated indent waived by Ref. 22).

^jAll occurred in M249 SAW.

- b. Assessment of the protection afforded the ammunition by its packaging and packing was made difficult by the variation in weapon performance. The M249 SAW used during the packaging test (Ref. 25) produced unsatisfactory performance not attributed to the ammunition and/or containers. The exhibited MRBF for class I and II stoppages combined was 143.8-rounds (89 in 12,800-rounds). Only 3.84 stoppages in 12,800-rounds is allowed. Since there were no type II stoppages, the 1-in-6, 250-rounds allowed was met (2.0 allowed in 12,800-rounds). Since the class III stoppage rate permitted is 1 in 15,000-rounds, no estimate was made. There were no occurrences of this type during the 12,800-rounds tested in this M249 SAW.
- c. In order to further assess the effect that the use of CONUS-produced M855 Ball and M856 Tracer ammunition had on the M16A2-rifle and M249 SAW, the number of stoppages and component part failures have been tabulated and the failure rates (M16A2-rifle), and MRBF rates (M249 SAW), have been computed (refer to Paragraph 3.5.4). These data show that under non-adverse conditions, operation of the weapons is basically unchanged by use of the CONUS-produced Ball and Tracer ammunition. This statement is also true for use in adverse conditions environments, although there was an increase in ammunition-caused stoppages in one rifle (gas tube clogging). The use of the test ammunition generally did not influence weapon durability.
- d. Based on the analysis of the results, the following is concluded:
- (1) The test criterion 3.2.2a, relating to performance of M855 Ball ammunition, was met except for fired case casualties while firing the M249 SAW.
 - (2) The test criterion 3.2.2b, relating to performance of the M856 Tracer ammunition, was met except for ammunition-caused malfunctions while firing the M16A2-rifle.
 - (3) The test criterion 3.2.2c, relating to the adequacy and applicability of technical publications relating to the ammunition, was partially satisfied, to the extent investigated. A general review and updating of the majority of publications is necessary to bring their general content into the present, even though their content could be construed to include the 5.56-mm family of ammunition (although referencing only 30 caliber and above).
 - (4) The test criterion 3.2.2d, relating to the adequacy of the ammunition packaging, packing, and preservation, was met.

3.3 SAFETY AND HEALTH

3.3.1 Objectives and Issues

- a. Test objective. Determine if the CONUS-produced M855 and M856 cartridges meet the requirements for safety.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical Issue. Has the CONUS-produced M855 and M856 ammunition compatible with the SAW and M16A2-rifle?
- d. Critical Issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for cartridge M855 Ball and M856 Tracer?

3.3.2 Criteria

- a. The CONUS-produced M855 and M856 ammunition must be safe to fire in the M249 SAW (Test Agency devised, TECOM approved).
- b. The CONUS-produced M855 and M856 ammunition must be safe to fire in the M16A2-rifle (Test Agency devised, TECOM approved).
- c. The CONUS-produced M855 and M856 ammunition must be safe to store, handle and transport, and dispose of during its expected life (Test Agency devised, TECOM approved).

3.3.3 Test Procedure

- a. All safety-related data from the testing done in parts II, III, and IV of this program were compiled, analyzed, and presented in this section of the report. Safety information on the special tests are covered entirely in sections V and VI of this report. The CONUS-produced M855 and M856 ammunition was assessed for safety using TECOM TOP 3-2-045 (Ref. 36), 3-2-016 (Ref. 43), and 3-2-504 (Ref. 39) for guidance.
- b. The criterion 3.3.2c required assessment over the life expectancy of the ammunition. Determining the effects of long-term storage is beyond the scope of this test program. Any adverse effects of short-term storage noted during testing were reported. Estimates of potential long-term adverse effects were then made based on the short-term performance.

- c. The safety-related incidents which occurred during testing were classified in accordance with MIL-STD-882B (Ref. 44). Further guidance concerning classification of deficiencies and shortcomings was gleaned from TECOM TOP 1-1-012 (Ref. 45). Figure 3.3-1 provides the matrix for determining the hazard probability/severity of an incident.
- d. The ammunition developer's Safety Assessment Report (SAR) (Ref. 46) was reviewed. A safety release recommendation was prepared based on that document and the results of the various test firings and inspections from this assessment.

3.3.4 Test Findings

- a. Section II - Mann barrel firing.
 - (1) No safety-related incidents occurred during this part of the test.
- b. Section III - M249 SAW firing.
 - (1) Incidents charged against the ammunition are listed in Table 3.3-1.
 - (2) Incidents charged against the weapon are listed in Table 3.3-2.
 - (3) The hazard classifications given in the two tables were derived from Figure 3.3-1.

TABLE 3.3-1. AMMUNITION-CAUSED SAFETY HAZARDS FOUND DURING FIRING OF CONUS-PRODUCED M855 AND M856 CARTRIDGES IN M249 SAW.

<u>Incident Description</u>	<u>Ammo Type</u>	<u>Hazard Severity</u>	<u>Hazard Probability</u>	<u>Hazard Classification</u>
Blown primer	M855	IV	C	Acceptable
Perforated primer	M855	IV	C	Acceptable
Primer leak 50%	M855	IV	C	Acceptable
Case splits	Both	IV	C	Acceptable

Note: All incidents went undetected by the operator during firing. They were detected as a result of fired-case inspection.

TABLE 3.3-2. WEAPON - CAUSED SAFETY HAZARDS FOUND DURING FIRING OF CONUS-PRODUCED M855 & M856 CARTRIDGES IN M249 SAW.

<u>Incident Description</u>	<u>Ammo Type</u>	<u>Hazard Severity</u>	<u>Hazard Probability</u>	<u>Hazard Classification</u>
Link fall-back	Both	III	C	Shortcoming(App.C,Para 2.2)
Broken forend tab	Both	III	C	Shortcoming(App.C,Para 2.3)
Cookoff @ high temp	M856	II	C	Deficiency(App.C,Para 1.1)

Notes: The last two links from the end of a belt of ammunition may fall back into the receiver of the weapon during reloading. This may cause hard-to-clear stoppages and creates the potential for a cookoff with the breech unlocked. The broken forearm tab prevents the handguard from being attached to the weapon. This increases the chance of personnel injury due to contact with a hot barrel. Cookoff of a partially chambered tracer round during clearing of a stoppage resulted in weapon damage (no personnel injury). Major weapon parts had to be replaced before the weapon could be used again.

c. Section IV - M16A2-rifle firing.

(1) Table 3.3-3 lists all chargeable safety related incidents that occurred during firing of the test ammunition in the M16A2-rifle.

(2) The hazard classifications given in the table were derived from Figure 3.3-1.

TABLE 3.3-3. CHARGEABLE SAFETY HAZARDS OBSERVED DURING FIRING OF CONUS-PRODUCED M855 & M856 AMMUNITION IN M16A2 RIFLES

<u>Incident Description</u>	<u>Ammo Charged Type</u>	<u>Against</u>	<u>Hazard Severity</u>	<u>Hazard Probability</u>	<u>Hazard Classification</u>
Metal parts separation	M856 Ammo		IV	C	Acceptable
Metal parts separation	M855 Weapon		IV	C	Acceptable
Case splits	Both Ammo		IV	C	Acceptable
Gas tube fouling	M856 System		IV	C	Acceptable
Case rupture (water)	M855 Personnel		II	C	Deficiency(App.C,Para 1.2)
Uncontrolled fire	M855 Weapon		II	D	Shortcoming(App.C,Para 2.1)

See notes on following page.

Notes: Small fragments from the tracer seal and base of the M856 projectile were expelled along the line of fire for a short distance down range. This is not a problem since personnel in range of those particles would be directly in the line of fire and would receive severe injury from being struck by the projectile in its normal flight.

The traces of lead exudation noted during hot-barrel velocity tests of the M855 Ball round, occurred four times in one of the five rifles used for endurance testing. The problems experienced with irregularities in bore surface finish (Ref. 25) leads to the suspicion that the weapon, rather than the ammunition, is the cause of this problem.

Gas-tube fouling in one of three rifles fired exclusively with tracer ammunition is charged against the system (weapon and ammunition) because of the apparent adverse effect that rifle bore finish may have on tracer performance. This unsatisfactory condition could not be repeated with other rifles, which leads to the suspicion that the weapon exerts some undetermined adverse influence during creation of the fouling deposits.

Cartridge case rupture and the subsequent major component damage (no personnel injury occurred) resulted when the rifle was fired with water in the bore. Failure of the shooter to follow established procedures for evacuating the water prior to firing, will guarantee case failure, weapon damage, and possible injury to the shooter.

Uncontrolled fire when using the 3-round burst control device has been infrequently experienced since the device's introduction. When the device malfunctions, it usually fires four rounds before stopping. In this test incident, the device fired two rounds and then, when the trigger was released, three more rounds. The cause for this erratic performance is not known and was impossible to determine because it was a transient incident.

HAZARD PROBABILITY						
	FREQUENT	REASONABLY PROBABLE	OCCASIONAL	REMOTE	EXTREMELY IMPROBABLE	IMPOSSIBLE
SPECIFIC INDIVIDUAL ITEM	Likely to occur frequently	Will occur several times in life of item	Likely to occur sometime in the life of item	So unlikely, can be assumed that this hazard will not be experienced	Probability of occurrence cannot be distinguished from zero	Physically impossible to occur
FLEET OR INVENTORY	Continuously experienced	Will occur frequently	Will occur several times	Unlikely to occur, but possible	So unlikely, can be assumed that this hazard will not be experienced	Physically impossible to occur
	A	B	C	D	E	F
I CATASTROPHIC - May cause death or system loss	DEFICIENCY	DEFICIENCY	DEFICIENCY	DEFICIENCY	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
II CRITICAL - May cause severe injury or illness, or major system damage	DEFICIENCY	DEFICIENCY	DEFICIENCY	SHORTCOMING	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
III MARGINAL - May cause minor injury or illness, or minor system damage	DEFICIENCY	SHORTCOMING	SHORTCOMING	SUGGESTED IMPROVEMENT	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
IV NEGLIGIBLE - Will not result in injury or illness, or system damage	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE

Figure 3.3-1. Hazard probability versus hazard severity.

3.3.5 Technical Assessment

- a. Compliance with the three criteria is based on there being no deficiencies or shortcomings associated with CONUS-produced M855 and M856 ammunition use in either the M16A1-rifle , M249 SAW, or during firing from Mann test barrels.
- b. Both ball and tracer rounds were in compliance when fired in the Mann barrel, M16A2-rifle, and M249 SAW.
- c. The M16A2-rifle shortcoming (uncontrolled fire in the controlled-burst mode) is a known problem which is being studied by the developer. The use of CONUS-produced ammunition does not cause the problem with the burst control since it also malfunctions with other types of 5.56-mm ammunition.
- d. The M16A2-rifle deficiency (ruptured case due to firing with water in the bore) is not influenced by the type of ammunition fired. It has occurred in the M16A1-rifle while firing M193 Ball rounds. Proper training and its implementation is the only means of preventing this type of accident from happening.
- e. The two M249 SAW shortcomings (link fall-back, and forend tab breakage) require training to detect and correct.

(1) The method of opening the weapon feed cover, determines if the last two links in the feed tray can fall back into the receiver. If the cover is opened with the bolt in the forward position, the links can not fall down into the receiver. If the bolt is retracted prior to opening the cover, then they may pass through the feed tray and become lodged on either the piston assembly or in the 30-round box magazine well on the lower left side of the receiver. Changes to the weapon (removal of the dust cover/magazine latch from the 30-round magazine well would allow uninterrupted passage of any links or fired cases that entered the well. This change could also cause an increase in stoppages during weapon use in adverse conditions environments. A change in training procedures from retracting the bolt prior to opening the cover, to opening the cover and clearing any links present prior to bolt retraction would prevent link fall-back. This change could, however, decrease the personnel safety should an ammunition cookoff occur as the breech was being retracted to clear a hot misfire or other stoppage.

(2) Loss of the forend due to breaking of the tab to which the forend is attached, increases the likelihood that the gunner will be burned by a hot barrel. Periodic inspection of the tab for cracks during routine maintenance will allow the user to find and report this problem before it becomes a failure. Alternate methods of attaching this tab, either as a repair or as a change to the original design of the weapon, is being investigated by the developer as part of the current SAW design change package.

- f. The damage sustained by the M249 SAW can and does occur whenever the weapon experiences a stoppage where a partially chambered round cooks off. The high temperature environment (+68°C), aggravates this condition by reducing the number of rounds that need be fired to produce cookoff. In this instance, the cookoff round was number 195 in a 200-round cycle (round 995 of a 2000-round phase). The cumulative effect of firing 200-rounds at 1-to-2-hour intervals produced weapon temperatures that were apparently well above the safety limit established during cookoff testing. The cookoff, which was estimated to have occurred in less than 30 seconds after the gun stoppage, substantiates the estimate of excessive barrel temperature. The required high reliability of the weapon is its best insurance against occurrence of this type of incident, there being no fail-safe method of preventing these occurrences once the barrel is heated above the cookoff point. Training of the user to be aware of the adverse effects of stoppages in a hot gun will preclude personal injury, but not materiel damage.

All test criteria (Para. 3.3.2) have been met. The shortcomings and deficiencies identified in the subtest are not chargeable to either round of ammunition. These shortcomings and deficiencies must be corrected through proper training and evaluation of technical changes to the weapons, after careful resolution of conflicting safety hazards which may be introduced after design/operating procedure changes have been made.

3.4 HUMAN FACTORS

3.4.1 Objective and Issues

- a. Test objective. Determine if the CONUS-produced M855 and M856 cartridges meet the requirements for human factors compatibility.
- b. Critical Issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical Issue. Is the CONUS-produced M855 and M856 ammunition compatible with the SAW and M16A2-rifle?
- d. Critical Issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for cartridge M855 Ball and M856 Tracer?
- e. Other Issue. Are all of the test items RAM requirements met?

3.4.2 Criterion

The test ammunition shall not contribute to, or be the cause of, human-factors-related incidents which adversely affect the personnel/weapon interface (Test Agency devised, TECOM approved).

3.4.3 Test Procedure

- a. The weapon/ammunition/personnel interface was investigated to determine if the test ammunition adversely changes the existing performance in the following indices: case ejection pattern, recoil force, smoke (both target obscuration and position disclosure), flash (position disclosure), noise, and weapon stoppages which can cause safety hazards (e.g., case-head ruptures).
- b. The data from each test are summarized here when information has been generated on any of the six subjects listed in paragraph 3.4.3 a. Also included in the summary are any human-factors-related subjects not previously specified.

3.4.4 Test Findings

- a. Fired case ejection patterns from both the M16A2-rifle and M249 SAW were generally within the limits of the operator's zone of safety. The rifle's ejection pattern fluctuates within the 1 to 3 o'clock position. Infrequently, ejection occurred between 3 and 5 o'clock position when cyclic rate was unusually low (first few rounds from a cold weapon fired at extremely low temperature) and when weak/broken extractor or ejector springs resulted in loss of control of the ejecting case. The ejection pattern from the SAW was angled forward and down and did not change as a result of low temperature or gun component weakness/failure.
- b. Recoil forces sufficient to operate the M16A2-rifle and M249 SAW were not detrimental to the weapon/personnel interface. No weapon control problems were experienced with either weapon type during automatic fire. Individual gunners fired more than 5000-rounds per day without undue stress.
- c. The smoke generated by firing of the test ammunition in the M16A2-rifle and M249 SAW produced some target distortion/obscuration and, from a down-range location, some visual signature.
- d. The muzzle flash produced by firing of the test ammunition in the M16A2-rifle and M249 SAW was generally controlled by the flash suppressor of these weapons. There were instances, primarily when firing tracer rounds, when detectable muzzle flash was observed.
- e. The impulse noise levels caused by firing the test ammunition from the M16A2-rifle and M249 SAW did not exceed the noise levels produced by the same weapons fired with control ammunition. The shooter is required to wear adequate hearing protection when firing any ammunition from either of these two weapons, since the noise level at the shooter's ear position exceeds 140 dB (the upper limit of impulse noise which can be sustained without use of hearing protection).

- f. The ammunition was not the cause of weapon stoppages in most instances. The first exception was failure-to-fire stoppages (FFR) when a defective primer was the cause. The second was a result of gas tube obturation in one M16A2-rifle as a result of firing all tracer ammunition. This anomalous condition was evaluated in detail to determine its true cause. Additional tests were conducted with M196 Tracer rounds to draw comparisons between that round and the M856 cartridge. An independent study was also done by ARDEC to further enlarge the data base. All testing of the CONUS-produced M856 ammunition was done using the LCAAP (Remington) produced rounds. The current configuration of this round (circa 1988) differs slightly in overall projectile length and in other minor dimensional adjustments as a result of design changes incorporated when Olin Corp. took over management and operation of LCAAP.

The basic investigation centered around determining why only one of three M16A2-rifles exhibited this fouling problem. Borescope inspection of the bores of the weapons revealed that the rifle with the gas tube plugged with bullet jacket material, had the gas port hole in the barrel drilled so that part of the hole was on the land and part of the hole was in the groove, on the driving side of the land. The gas port for the other two rifles was either completely in a land or groove and the fouling was found only in the front end of the tube, ahead of the gas port. The suppressors of the three rifles showed bullet jacket material deposition in the suppressor openings.

The three M16A1-rifles fired with M196 Tracer ammunition for comparison showed no signs of metallic deposition in the flash suppressor. Neither did they exhibit gas tube fouling. Borescope inspection revealed that the location of the gas port in these three rifles was in a groove, or splitting a land/groove on the non-driving side of the land. There was no fouling buildup in the flash suppressors.

After initial discovery of the fouling due to feeding failures (short recoil of the bolt) in the one M16A2-rifle (3727 total rounds fired), a new gas tube was installed in the same rifle. Another 1230-rounds were fired without malfunctions of the weapon due to gas tube fouling. Inspection of the new tube after firing revealed that it also had severe fouling buildup that would have eventually prevented the weapon from operating properly.

- g. Use of the CONUS-produced 200-round plastic ammunition container for the M249 SAW resulted in occurrence of first-round feeding stoppages. An interference between the pull tab and the link port cover caused the first round to be raised up in the feed tray. When the bolt was seared off, it under rode the round and closed on an empty chamber. The remedial action taken at the time was to rapidly close the feed cover when loading a new belt of ammunition. The act of closing the cover rapidly caused the dust cover to raise up and lay on top of the pull tab, instead of pushing it to the right when the cover was closed.
- h. The ammunition originally received for test of the CONUS-produced ball and tracer ammunition in the M249 SAW was packed in the new U.S. made plastic container. This container was found to be hard to release from the weapon after installation. Although modification of existing magazines was an available option (Ref. 24), the test agency requested, and the test sponsor supplied, new production magazines of the latest "improved" configuration. These new magazines were loaded with ammunition from the defective magazines and testing resumed without further occurrence of this type of problem.
- i. Firing of the M249 SAW from the M122 tripod resulted in increased occurrence of feeding stoppages. The 200-round capacity plastic ammunition container was mounted onto the left leg of the tripod by means of a metal clamp-on bracket containing a dovetail and magazine latch surface similar to that of the weapon. The first bracket received from the test sponsor was of an original design. The angle that the magazine presented to the weapon increased the belt pull to an unacceptable level. Subsequently, an "improved" design was received and used, which corrected the problem.
- j. The anti-fallback tab at the mouth of the plastic 200-round containers contributed to the feeding problems at low temperature. The stiffness of this tab increases at low temperature such that the tab loses its "memory" and may allow ammunition to fall back into the magazine when the cover of the gun is opened.

3.4.5 Technical Assessment

Analysis of the test results shows the following:

- a. There were no safety hazards associated with the use of CONUS-produced M855 and M856 ammunition as it relates to the weapon/ammunition/personnel relationship.
- b. The ammunition is fully compatible with the M249 SAW. There is no positive indication that the singular problem experienced with all tracer firing from the M16A2-rifle is indicative of a systemic problem with that weapon/ammunition combination. Monitoring of this potential problem during ammunition acceptance testing is being done as further assurance against fielding ammunition which could contain this latent defect.
- c. From the human factors aspect, the CONUS-produced M855 and M856 ammunition meets the implied requirements of their respective Military Specifications. Also, from the human factors aspect, the CONUS-produced M855 and M856 ammunition meets all of the implied RAM requirements.
- d. The test criterion has been met for the M249 SAW, since it fired with both M855 and M856 CONUS-produced ammunition. The M16A2-rifle satisfies the same criterion with respect to the ball ammunition (M855). Based on the absence of further substantiating evidence that the CONUS-produced M856 Tracer rounds produce excessive gas tube fouling, that rifle/ammunition combination is also judged to have met the criterion.

3.5 AMMUNITION RELIABILITY

3.5.1 Objective and Issues

- a. Test Objective. Determine if the CONUS-produced M855 and M856 ammunition meet the requirement for reliability.
- b. Critical Issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical Issue. Is the CONUS-produced M855 and M856 ammunition compatible with the SAW and M16A2-rifle?
- d. Critical Issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for cartridge M855 Ball and M856 Tracer?
- e. Other Issue. Are all of the test items RAM requirements met?

3.5.2 Criterion

The test ammunition, when fired in weapons specifically designed to fire these cartridges, shall demonstrate a reliability (minimum acceptable value) of 0.9999 at a high confidence level (TECOM devised, based on JSOR requirement for SAW ammunition).

3.5.3 Test Procedure

- a. Information on ammunition performance was gathered from each subtest where either the Mann barrel fixture, M249 SAW, or M16A2-rifle was fired.

3.5.4 Test Findings

- a. The ammunition malfunction summaries are contained in four tables: tables 3.5-1 and 3.5-2 are for ammunition fired at range-ambient or controlled +21°C (+70°F) temperature under non-adverse conditions or other extreme conditions; tables 3.5-3 and 3.5-4 give all other firings of the ammunition when it was subjected to either adverse conditions (e.g. water spray), or extreme temperature.

TABLE 3.5-1. MALFUNCTION DATA FOR CONUS-PRODUCED M855 BALL AMMUNITION FIRED UNDER NON-ADVERSE CONDITIONS^a

Wpn Type	Ammo Type	Total Rd	No. of Weapon-Caused Malfunctions, by Type								TOTAL
			FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	
Weapon/Ball Ammo Combined											
Mann bb1	M855	340	-	0	0	0	0	-	-	-	0
M16A2	M855	64,658	54	10	2	8	0	0	0	0	74
M249	M855	69,959	Class I								24
			Class II								38
			Class III								7
TOTALS	M855	134,957	.....								143
Weapon/Ball Ammo Separated											
Mann bb1	M855	Weapon	-	0	0	0	0	-	-	-	0
		Ammo	-	0	0	0	0	-	-	-	0
M16A2	M855	Weapon	54	10	2	5	0	0	0	0	71
		Ammo	0	0	0	3	0	0	0	0	3
M249	M855	Weapon	Class I								24
		Ammo	.....								0
	M855	Weapon	Class II								38
		Ammo	.....								0
	M855	Weapon	Class III								7
		Ammo	.....								0
WPN TOT	M855	134,957	.....								140
AMMO TOT	M855	134,957	.....								3

^a Includes range-ambient temperature firing for endurance and reliability, smoke/flash, metal parts integrity, noise, inspections, belt pull, and accuracy.

FFD= Failure-to-feed
 FTC= Failure-to-chamber
 FTL= Failure-to-lock
 FFR= Failure-to-fire
 FEX= Failure-to-extract
 FEJ= Failure-to-eject
 FBR= Failure of bolt to remain rearward after last round fired.
 OTH= Other

TABLE 3.5-2. MALFUNCTION DATA FOR CONUS-PRODUCED M856 TRACER AMMUNITION FIRED UNDER NON-ADVERSE CONDITIONS^a

Wpn Type	Ammo Type	Total Rd	No. of Weapon-Caused Malfunctions, by Type								TOTAL
			FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	
Weapon/Tracer Ammo Combined											
Mann bbl	M856	480	-	0	0	0	0	-	-	-	0
M16A2	M856	7,580	5	1	13	1	0	0	0	0	20
M249	M856	15,502	Class I								0
			Class II								1
			Class III								0
TOTALS	M856	23,562	.....								21
Weapon/Tracer Ammo Separated											
Mann bbl	M856	Weapon	-	0	0	0	0	-	-	-	0
		Ammo	-	0	0	0	0	-	-	-	0
M16A2	M856	Weapon	5	1	13	0	0	0	0	0	19
		Ammo	0	0	0	1	0	0	0	0	1
M249	M856	Weapon	Class I								0
		Ammo	.....								0
	M856	Weapon	Class II								1
		Ammo	.....								0
	M856	Weapon	Class III								0
		Ammo	.....								0
WPN TOT	M856	23,562	.....								20
AMMO TOT	M856	23,562	.....								1

^a Includes range-ambient temperature firing for endurance and reliability, smoke/flash, metal parts integrity, noise, inspections, belt pull, and accuracy.

See Table 3.5-1 for malfunction definitions.

TABLE 3.5-3. MALFUNCTION DATA FOR CONUS-PRODUCED M855 BALL AMMUNITION FIRED UNDER EXTREME/ADVERSE CONDITIONS^a

Wpn Type	Ammo Type	Total Rd	No. of Weapon-Caused Malfunctions, by Type								TOTAL
			FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	
Weapon/Ball Ammo Combined											
Mann bbl	M855	180	-	0	0	0	0	-	-	-	0
M16A2	M855	19,810	65	0	0	30	0	1	0	1	97
M249	M855	50,475	Class I								167
			Class II								9
			Class III								0
TOTALS	M855	70,465	.....								273
Weapon/Ball Ammo Separated											
Mann bbl	M855	Weapon	-	0	0	0	0	-	-	-	0
		Ammo	-	0	0	0	0	-	-	-	0
M16A2	M855	Weapon	65	0	0	30	0	1	0	1	97
		Ammo	0	0	0	0	0	0	0	0	0
M249	M855	Weapon	Class I								165
		Ammo	.....								2
	M855	Weapon	Class II								8
		Ammo	.....								1
	M855	Weapon	Class III								0
		Ammo	.....								0
WPN TOT	M855	70,465	.....								270
AMMO TOT	M855	70,465	.....								3

^a Includes high and low temperatures (all tests fired under those conditions), temperature/humidity, cookoff, salt-fog, and water spray.

See Table 3.5.1 for malfunction definitions.

TABLE 3.5-4. MALFUNCTION DATA FOR CONUS-PRODUCED M856 TRACER AMMUNITION FIRED UNDER EXTREME/ADVERSE CONDITIONS^a

Wpn Type	Ammo Type	Total Rd	No. of Weapon-Caused Malfunctions, by Type								TOTAL
			FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	
Weapon/Tracer Ammo Combined											
Mann bbl	M856	60	-	0	0	0	0	-	-	-	0
M16A2	M856	12,085	15	0	38	29	1	0	3	0	86
M249	M856	10,384	Class I								5
			Class II								0
			Class III								1
TOTALS	M856	22,529	.....								92
Weapon/Tracer Ammo Separated											
Mann bbl	M856	Weapon	-	0	0	0	0	-	-	-	0
		Ammo	-	0	0	0	0	-	-	-	0
M16A2	M856	Weapon	3	0	38	29	0	0	1	0	71
		Ammo	12	0	0	0	1	0	2	0	15
M249	M856	Weapon	Class I								3
		Ammo	.....								2
	M856	Weapon	Class II								0
		Ammo	.....								0
	M856	Weapon	Class III								1
		Ammo	.....								0
WPN TOT	M856	22,529	.....								75
AMMO TOT	M856	22,529	.....								17

^a Includes high and low temperatures (all tests fired under those conditions), temperature/humidity, cookoff, salt-fog, and water spray.

See Table 3.5-1 for malfunction definitions.

3.5.5 Technical Assessment

- a. A series of analyses was made to assess ammunition reliability by comparing exhibited performance against weapon performance requirements. This was done by determining what the ammunition's contribution to failure rates per 1000-rounds fired in the M16A2-rifle, and MRBF rates for the M249 SAW. In a similar manner, these numbers were recomputed for failures not caused by the ammunition, and finally for the combined ammunition/weapon "system" performance. This information is contained in Tables 3.5-5 through 3.5-10. The overall reliability of the ammunition is computed in Table 3.5-11 for the ball and tracer ammunition.

TABLE 3.5-5. RELIABILITY ASSESSMENT OF M855 BALL AND M856 TRACER AMMUNITION FIRED IN THE M249 SAW

Test Condition	Ammo Type	Total Rds	Class I & II		Class II		Class III	
			Failures	MRBF	Failures	MRBF	Failures	MRBF
Normal	M855	69,959	0	-	0	-	0	-
Adverse	M855	50,475	3	16,825	1	50,475	0	-
Combined	M855	120,434	3	40,145	1	120,434	0	-
Normal	M856	15,502	0	-	0	-	0	-
Adverse	M856	10,384	2	5,192	0	-	0	-
Combined	M856	25,886	2	12,943	0	-	0	-
Criteria : MRBF =			3,333		6,250		15,000	

TABLE 3.5-6. RELIABILITY ASSESSMENT OF M249 SAW EXCLUDING AMMUNITION-CAUSED STOPPAGES

Test Condition	Ammo Type	Total Rds	Class I & II		Class II		Class III	
			Failures	MRBF	Failures	MRBF	Failures	MRBF
Normal	M855	69,959	62	^a 1,128	38	^a 1,841	7	^a 9,994
Adverse	M855	50,475	173	^a 292	8	6,309	0	^b -
Combined	M855	120,434	235	^a 512	46	^a 2,618	7	17,205
Normal	M856	15,502	1	15,502	1	^b 15,502	0	^b -
Adverse	M856	10,384	3	3,461	0	-	1	^a 10,384
Combined	M856	25,886	4	6,472	1	15,502	1	25,886
Criteria : MRBF =			3,333		6,250		15,000	

^a Does not meet criterion limit.

^b Unchanged from ammunition-only value.

TABLE 3.5-7. COMBINED RELIABILITY ASSESSMENT OF M249 SAW AND CONUS-PRODUCED M855 BALL AND M856 TRACER AMMUNITION

Test Condition	Ammo Type	Total Rds	Class I & II		Class II		Class III	
			Failures	MRBF	Failures	MRBF	Failures	MRBF
Normal	M855	69,959	62	^a 1,128	38	^a 1,841	7	^a 9,994
Adverse	M855	50,475	176	287	9	5,608	0	^a -
Combined	M855	120,434	238	506	47	2,562	7	^a 17,205
Normal	M856	15,502	1	^a 15,502	1	^a 15,502	0	^a -
Adverse	M856	10,384	5	^b 2,077	0	-	1	^a 10,384
Combined	M856	25,886	6	4,314	1	^a 25,886	1	^a 25,886
Criteria :			MRBF =	3,333	6,250	15,000		

^a No change in value from gun-only value.

^b Decrease over gun-only value due to use of the test ammunition is only occurrence where ammunition contributed to failure to meet a criterion.

TABLE 3.5-8. RELIABILITY ASSESSMENT OF M855 BALL AND M856 TRACER AMMUNITION FIRED IN THE M16A2 RIFLE

Test Condition	Ammo Type	Total Rds	Indices	No Malfunctions, by Type, & Their Rates								
				FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	TOTAL
Normal	M855	64,658	No.	0	0	0	3	0	0	0	0	3
			Rate	-	-	-	.05	-	-	-	-	-
Adverse	M855	19,810	No.	0	0	0	0	0	0	0	0	0
			Rate	-	-	-	-	-	-	-	-	-
Combined	M855	84,468	No.	0	0	0	3	0	0	0	0	3
			Rate	-	-	-	.04	-	-	-	-	-
Normal	M856	7,580	No.	0	0	0	1	0	0	0	0	1
			Rate	-	-	-	.13	-	-	-	-	-
Adverse	M856	12,085	No.	12	0	0	0	1	0	2	0	15
			Rate	^a .99	-	-	-	.08	-	.16	-	-	1.24
Combined	M856	19,665	No.	12	0	0	1	1	0	2	0	16
			Rate	.61	0	0	.05	.05	-	.10	-	.81
Criteria: Rate/1000 rd. fired				.66	.50	.33	.33	.17	.33	.50	0	1.50

^a Does not meet FFD malfunction rate of 0.66 for adverse conditions.

TABLE 3.5-9. RELIABILITY ASSESSMENT OF M16A2 RIFLE
EXCLUDING AMMUNITION-CAUSED STOPPAGES

Test Condition	Ammo Type	Total Rds	Indices	No Malfunctions, by Type, & Their Rates									
				FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	TOTAL	
Normal	M855	64,658	No.	54	10	2	5	a ₀	a ₀	a ₀	a ₀	71	
			Rate	.84	.15	.03	.08	-	-	-	-	1.10	
Adverse	M855	19,810	No.	65	a ₀	a ₀	30	a ₀	1	a ₀	1	97	
			Rate	3.28	-	-	1.51	-	.05	-	.05	4.90	
Combined	M855	84,468	No.	119	10	2	35	a ₀	1	0	1	168	
			Rate	1.41	.12	.02	.41	-	.01	-	.01	1.99	
Normal	M856	7,580	No.	5	1	13	0	a ₀	a ₀	a ₀	a ₀	19	
			Rate	.66	.13	1.72	-	-	-	-	-	2.51	
Adverse	M856	12,085	No.	3	a ₀	38	29	0	a ₀	1	a ₀	71	
			Rate	.25	-	3.14	2.40	-	-	.08	-	5.88	
Combined	M856	19,665	No.	8	1	51	29	0	a ₀	1	a ₀	90	
			Rate	0.41	.05	.55	1.47	-	-	.05	-	4.58	
Criteria: Rate/1000 rd. fired				b.66	b.50	b.33	b.33	.17	.33	.50	0	b1.50	

^a Values unchanged from ammunition-only values.

^b Some values exceed this criterion limit in the columns above.

TABLE 3.5-10. COMBINED RELIABILITY ASSESSMENT OF M16A2 RIFLE AND
CONUS-PRODUCED M855 BALL AND M856 TRACER AMMUNITION

Test Condition	Ammo Type	Total Rds	Indices	No Malfunctions, by Type, & Their Rates									
				FFD	FTC	FTL	FFR	FEX	FEJ	FBR	OTH	TOTAL	
Normal	M855	64,658	No.	a ₅₄	a ₁₀	a ₂	8	a ₀	a ₀	a ₀	a ₀	74	
			Rate	.84	.15	.03	.12	-	-	-	-	1.14	
Adverse	M855	19,810	No.	a ₆₅	a ₀	a ₀	a ₃₀	a ₀	a ₁	a ₀	a ₁	a ₉₇	
			Rate	3.28	-	-	1.51	-	.05	-	.05	4.90	
Combined	M855	84,468	No.	a ₁₁₉	a ₁₀	a ₂	38	a ₀	a ₁	a ₀	a ₁	171	
			Rate	1.41	.12	.02	.44	-	.01	-	.01	2.02	
Normal	M856	7,580	No.	a ₅	a ₁	a ₁₃	1	a ₀	a ₀	a ₀	a ₀	20	
			Rate	.66	.13	1.72	.13	-	-	-	-	2.64	
Adverse	M856	12,085	No.	15	a ₀	a ₃₈	a ₂₉	1	a ₀	3	a ₀	86	
			Rate	1.24	-	3.14	2.40	.08	-	.25	-	7.12	
Combined	M856	19,665	No.	20	a ₁	a ₅₁	30	1	a ₀	3	a ₀	106	
			Rate	1.02	.05	.55	1.53	.05	-	.15	-	5.39	
Criteria: Rate/1000 rd. fired				b.66	.50	b.33	b.33	.17	.33	.50	0	b1.50	

b. The ammunition's reliability to fire and function the weapons without causing a stoppage was computed and is shown in Table 3.5-11.

TABLE 3.5-11. AMMUNITION RELIABILITY

Ammo Type	Test Environment	No of Rds	Malf Totals	Pt. Est MRBS	MRBS	Reliability	
					Lower 90% Conf. Limit	Pt. Est	Lower 90% Conf. Lim
M855	Non-adverse	134,957	3	44,986	20,201	0.99998	0.99995
M856	Non-adverse	23,562	1	23,562	6,057	.99996	^a .99983
M855	Adverse	70,465	3	23,488	10,547	.99996	^b .99991
M856	Adverse	22,529	17	1,325	954	.99925	^b .99895
M855	Combined	205,422	6	34,237	19,504	.99997	^c .99995
M856	Combined	46,091	18	2,560	1,861	.99961	^c .99945

^a Reliability of 0.9999 is met at the lower 68% confidence limit.

^b Reliability of 0.9999 is met at the lower 1% confidence limit.

^c Reliability of 0.9999 is met at the lower 1% confidence limit.

c. The test criterion for the CONUS-produced M855 Ball ammunition is met under all test conditions.

d. The criterion for the CONUS-produced M856 Tracer ammunition was met at a lower-than-required confidence level for non-adverse conditions. The increased number of stoppages incurred by one M16A2-rifle during use in adverse conditions resulted in reduced overall ammunition reliability.

4.1 TEST PART II - INTRODUCTION

This part of the report presents information generated during firing of the test ammunition in Mann barrels. These tests are listed in Table 4.1-1.

TABLE 4.1-1 INDEX OF SUBTESTS

<u>Para.</u> <u>No.</u>	<u>Subtest Description</u>	<u>Page</u> <u>No.</u>
4.1	Introduction-----	4-1
4.2	Inspection-----	4-2
4.3	Trajectory and Projectile Trace-----	4-10
4.4	Penetration-----	4-41
4.5	Waterproofness-----	4-45
4.6	Velocity, Pressure and Action Time-----	4-47
4.7	Dispersion and Accuracy-----	4-54
4.8	Bullet Pull-----	4-61
4.9	Residual Stress-----	4-63

NOTE: All tests in this part of the evaluation were conducted at the ARDEC Test Site, Fort Dix, New Jersey, except for trajectory and a portion of the preliminary inspections of the Mann barrels which were done at Aberdeen Proving Ground, Maryland.

4.2 INSPECTION

4.2.1 Objective and Issues

- a. Test objective. To determine if the test and control ammunition met their respective manufacturing specifications.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met the U.S. Safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridges, 5.56-mm M855 Ball and M856 Tracer?
- d. Other issue. Are all of the test item's RAM requirements met?

4.2.2 Criteria

- a. The physical dimensions of the Mann barrels and breech components and firing pin indent requirement for the assembled test apparatus must be as specified in applicable drawings and specifications (Test Agency devised, TECOM approved).
- b. The physical dimensions of the ammunition must be as specified in applicable drawings and specifications (Test Agency devised, TECOM approved).
- c. The other ammunition physical characteristics (i.e., component hardness and weights) must be specified in applicable drawings and specifications (Test Agency devised, TECOM approved).
- d. The pressure transducers used must be in calibration both before and after a test series (Test Agency devised, TECOM approved).

4.2.3 Test Procedure

- a. Basic procedures for establishing weapon and ammunition physical characteristics are found in TOP 3-2-045 (Weapons) and TOP 4-2-016 (Ammunition) (Ref. 55 and 43, respectively). Also used were the engineering drawings and specifications for the Mann barrels and breech components, pressure transducers and ammunition. Specific procedures applicable to this test are listed below.
- b. Barrel bore measurements were taken with an air gauge suitable for measurement of 5.56-mm barrels with rifling rate of twist equal to one turn in 18 cm (7 in.). Measurements were recorded at 3 cm intervals, starting at the origin of rifling and progressing down the bore to the muzzle. The last measurement was taken at the full land/groove diameter at the muzzle.
- c. The bore measurements (i.e., land and groove diameters) were recorded for all sets of lands and grooves (e.g. three sets of measurements per location in a 6-groove barrel). Borescope observations

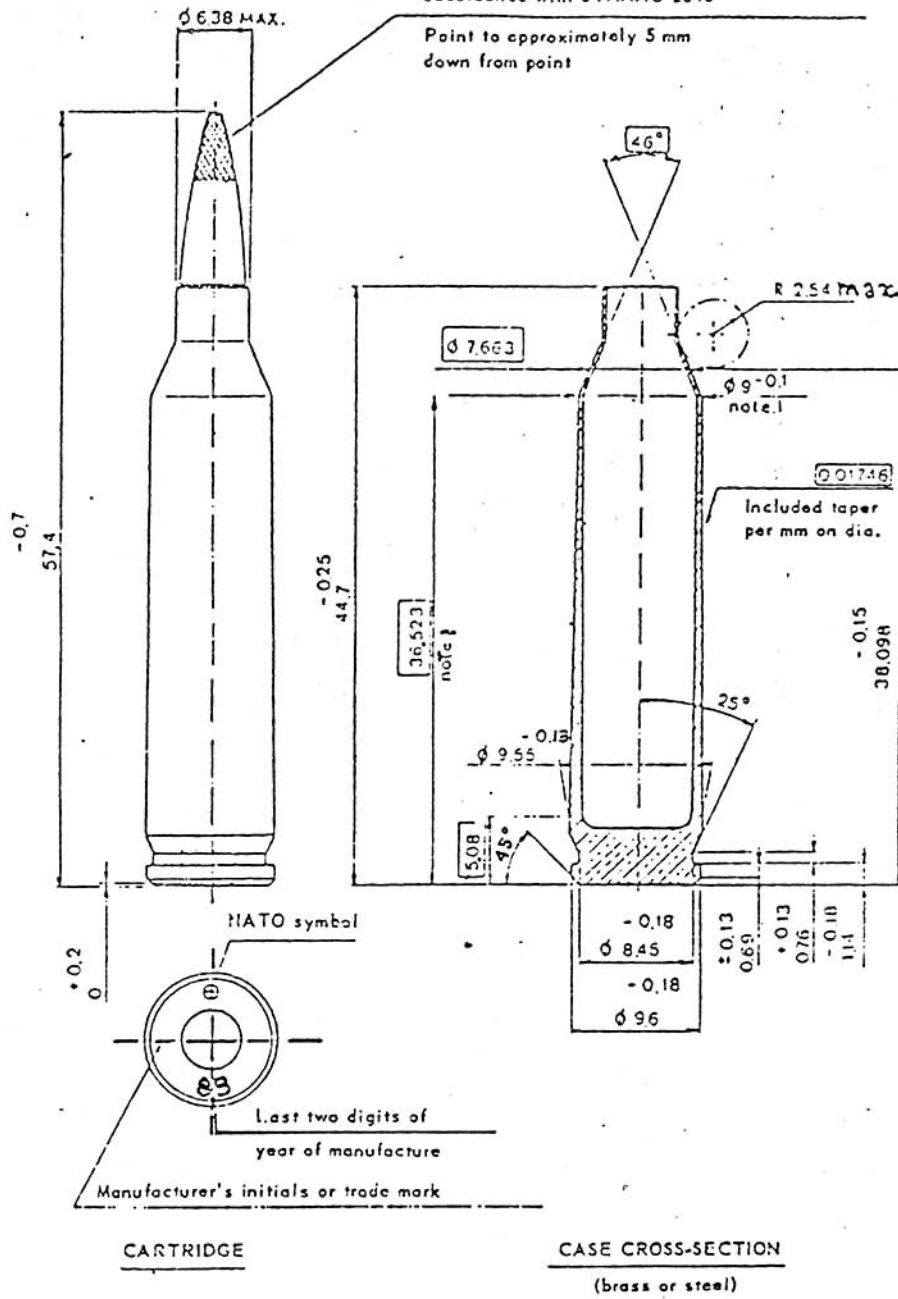
were made concerning overall condition of the barrel. This included comments on the erosion and heat checking patterns, land stripping, balloting, gas port erosion (if applicable) and bullet jacket material deposits in the bore.

- d. Barrel chamber measurements were taken using the dimensions shown in Figure 4.2-1 as a reference.
- e. A sample from the cartridge lots used in test were weighed and measured. Figure 4.2-2 (external cartridge dimensions) and Figure 4.2-3 (case hardness gradient locations) specify the location/type of measurements required. Each of the cartridges in the sample was weighed in assembly, then disassembled and its components weighted. After ammunition disassembly, the cartridge case hardness was measured. These measurements were in accordance with procedures specified in ASTM-E92 (Ref. 56).

Minimum bullet pull
 = 200 N

Point of the bullet point in accordance with STANAG 2316

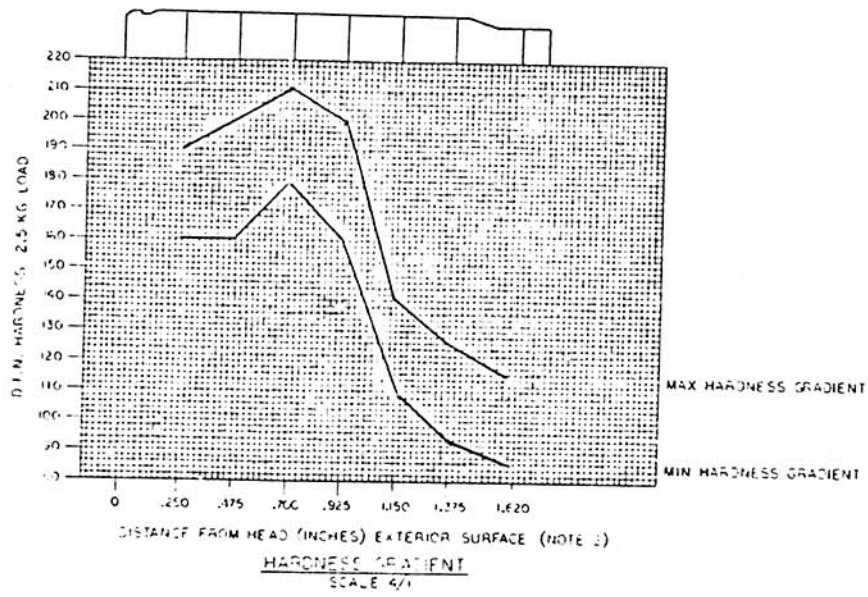
Point to approximately 5 mm down from point



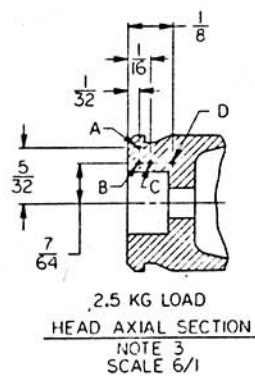
Notes:

1. Measurements given to the theoretical intersection of surfaces (maximum material condition m).
2. Included taper (due to variable rejection of material) not exceeding 0.05 is allowed at the mouth.
3. Material: brass or coated steel.
4. Minimum base marking.

Figure 4.2-2. External cartridge dimensions for 5.56 X 45 mm ammunition.



Case Sidewall Hardness



Minimum Head Hardness
 A=175 DPN C=175 DPN
 B=185 DPN D=185 DPN

Figure 4.2-3

- f. After all prefiring inspections of the test items and support material were completed and the results found to be satisfactory, testing was begun. Visual inspection of the ammunition used in firing subtests 4.3 through 4.7 was made before firing to detect defects that were listed in MIL-STD-636 (Ref. 30).

4.2.4 Test Findings

- a. The barrel and gauge inspection data are contained in Appendix B of this report. The barrels and gauges used were found to be in serviceable condition during test use.
- b. The physical characteristics of the ammunition are reported in Table 4.2-1.

TABLE 4.2-1. AMMUNITION CHARACTERISTICS

Measurement Indices	Criteria Limit		M855			M856			
	Max	Min	Max	Min	Avg	Max	Min	Avg	
a									
Case hardness, DPN									
a. location on side wall, from head (inches):	0.250	190	160	b 211	185	195	-	-	-
	.475	200	160	c 214	194	204	-	-	-
	.700	210	180	d 220	180	202	-	-	-
	.925	200	160	e 217	173	200	-	-	-
	1.150	140	110	f 149	122	134	-	-	-
	1.375	126	94	g 140	119	128	-	-	-
	1.620	114	85	b 118	90	108	-	-	-
b. location on head section:									
	A	-	175	226	183	196	-	-	-
	B	-	185	238	190	218	-	-	-
	C	-	175	223	178	198	-	-	-
	D	-	185	223	h 183	205	-	-	-

a Only 18 of the 30 samples were available for measurement of sidewall hardness.

b Four above maximum limit.

c Twelve above maximum limit.

d Five above maximum limit.

e Eight above maximum limit.

f One above maximum limit.

g Seven above maximum limit.

h Two below minimum limit.

Note: NA= Data not available.

4.2.5 Technical Assessment

All supporting equipment and test items were found to conform to their applicable specifications and drawings throughout testing. There were no indications found that the test ammunition would produce any safety hazards during its use.

The test items have performed in accordance with the criteria requirements. There was no apparent adverse effect on case casualties due to some cases being outside the required hardness gradient (Refer. to Table 4.2-1 and Table 3.2-7).

4.3 TRAJECTORY AND PROJECTILE TRACE

4.3.1 Objective and Issues

- a. Test objective. To determine if the test and control ammunition meets manufacturing specifications.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met the U.S. Safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridge, 5.56-mm, M855 Ball and M856 Tracer?
- d. Other issue. Are all of the test item's RAM requirements met?

4.3.2 Criteria

- a. Trace - M856 (night). The bullet of the tracer cartridge shall exhibit a trace below full luminosity and preferably invisible from the muzzle of the weapon for a range of at least 13 m (43 ft.). Visible trace of full luminosity should begin at a range not greater than 70 m (230 ft.) from the muzzle of the weapon and should continue to trace to a minimum range of 900 m (2950 ft.) (Para. 3.9.1 of MIL-C-63990A (Ref. 19).
- b. Trace - M196. When viewed at night from a line parallel to the plane of the trajectory at each point of observation, the bullet of the cartridge shall exhibit a visible trace from a point not greater than 68.6 m (75 yd.) from the muzzle (Para. 3.8 of MIL-C-60111B (Ref. 57).
- c. The mean point of impact of the sample test cartridges (CONUS-produced M856 Tracer) at 548.4 m (600 yd.) must not deviate above or below the mean point of impact of the control cartridge (Belgian made M855 Ball) in a vertical direction by more than 274 mm (10.8 in.) (Para. 3.11.2 of MIL-C-63990A (Ref. 19).
- d. The mean point of impact of the test cartridges at 600-yards shall not deviate above or below the mean point of impact of the reference cartridge in a vertical direction, by more than 10.8-inches. (Note: A reference round shall be in accordance with Drawing 9357841 and shall have passed the testing criteria of MIL-C-70460) (Para. 3.11.2 of MIL-C-63990A (Ref. 19). (This supersedes criterion 4.3.2c).
- e. The mean point of impact of the sample test cartridges (CONUS-produced M855 Ball) at 548.4 m (600 yd.) must not deviate above or below the mean point of impact of the control cartridge (Belgian produced M855 Ball) in a vertical direction by more than 274 mm (10.8 in.) (Para. 3.11.2 of MIL-C-63990A (Ref. 19).
- f. The mean point of impact of the test cartridges at 600-yards shall not deviate above or below the mean point of impact of the reference

cartridge in a vertical direction, by more than 10.8-inches. (Note: A reference round shall be in accordance with Drawing 9357841 and shall have passed the testing criteria of MIL-C-70460) (Para. 3.11.2 of MIL-C-63989A (Ref. 15). (This supersedes criterion 4.3.2e.)

4.3.3 Test Procedure

- a. Basic guidance for testing is given in paragraphs 28 and 29 of TOP 4-2-016 (Ref. 43). Specific guidance is given below.
- b. The projectile trace, normally fired concurrently with the trajectory test, was fired separately in order to optimize test resources. Firing was from both an M16A2 rifle and M249 SAW under conditions of daylight and darkness. Gun muzzle elevation was set at 15°. A sample of rounds for each of the test and control ammunition was fired and the trace times measured with stop watches. Trace burn characteristics were visually and photographically monitored.
- c. Trajectory firings were done with a Mann barrel held in a machine rest. The HAWK velocimeter (doppler radar) was positioned symmetrically behind the mounted weapon, with the radar antennas aligned to the line-of-fire. A complete range survey was then made of the various azimuths and elevations of the radar and gun. This survey pinpointed the relationship of the gun, radar, and range. This information was used in conjunction with the radial velocity data, recorded during firing, to construct ballistic range tables for the ammunition. The data from these tables were compared to determine the degree of ballistic match attained between rounds. Table 4.3-1 presents the firing schedule for the ballistic match test.

TABLE 4.3-1. BALLISTIC MATCH FIRING SCHEDULE

Seq. No.	Ammo Type	Mode of Fire	No. of Rd. Fired	Remarks
1	M193	SS	10	Three fouling shots fired before test, in addition to the 10 rounds. Ctg lot No. LCL-4-161.
2	M855	SS	10	Ctg lot No. LC85B300S325 (test).
3	M855	SS	10	Ctg lot No. LC85D300S339 (test).
4	M856	SS	10	Ctg lot No. FNB83G001-L002 (control).
5	M856	SS	10	Ctg lot No. LC85D300S339 (test).
6	M856	SS	10	Ctg lot No. (Olin pre-production test sample).
7	M856	SS	10	Ctg lot No. LC85D300S335
8	M196	SS	10	Ctg lot No. LC81A010G030 (control).

Seq. = Sequence.
SS = Single shot.

NOTE: All firing done in the order listed, with cooling and cleaning of the barrel after each 10-round series fired.

- d. The radial velocity, meteorological, and range-survey data recorded were used to compute the remaining velocity, maximum ordinate, time-of-flight to range and the angle of projectile fall. The tabulated data were presented at range intervals of 50 meters from the weapon muzzle to 1000 meters. Beyond that range, the interval became 100 meters.
- e. Vertical target firing at 548.4 meters range (600 yd.) was done to verify the computed results of the ballistic match data recorded during the trajectory firings. This information is contained in paragraph 4.7 of this report.

4.3.4 Test Findings

- a. The trace visibility test was observed visually during daylight hours in order to ascertain if ignition and burning of the tracer down range could be observed from the shooter's position. The M856 CONUS-produced tracer projectile provided the best results when compared with either the FN produced M856 (L110-type projectile), or the M196 Tracer round. Like all tracers which have a dim ignition range, full tracer visibility became a reality well forward of the firing position; therefore, the observer's ability to visually acquire the round in flight affected the outcome of the observation.
- b. Firing of traced ammunition at night did not have the visibility problems found during the daytime. Visual observations made at the firing site and down range, along the trajectory path of the projectile, revealed the true character of the projectile's tracer. These data are summarized in Table 4.3-2.

TABLE 4.3-2. TRACER BURNING CHARACTERISTICS VIEWED IN DARKNESS

Ammunition Type	Criterion Range(ft.)	No. of Tracer Projectiles Without Defects, by Weapon and Defect Type					
		M16A2		M249			
		Short	Dim	Short	Late	Dim	
M856 (CONUS) lot No.	a 43	100	100	100	96	100	
LC85D300S335	b 230	100	98	100	100	99	
	c 2950	100	100	100	100	100	
	M856 (L110) lot No.	a 43	100	100	100	100	100
FNB83A001-001	b 230	100	d 93	100	100	d 91	
	c 2950	100	100	100	100	100	
	M196 (CONUS) lot No.	b 150	100	100	100	100	100
LC80L010G026	c 1500	75	100	73	100	100	

- a = Minimum range for blind or dim ignition from weapon.
- b = Minimum range for start of full tracer brightness.
- c = Minimum range for end of full tracer brightness.
- d = These rounds also exhibited a tendency toward lessened brightness and intermittent burning.

NOTE: One hundred rounds were fired by each weapon with each ammunition lot.

- c. The flight characteristics of the various types of ball and tracer rounds tested were documented in Laboratory Report Number 86-BA-39 (Ref. 58). The details are excerpted and summarized in the tables and charts which follow. The data for the M193 Ball projectile were lost in the data transmission and are, therefore, not available.
- d. Graphs of the KD versus Mach number for each of the ammunition lots defined in Table 4.3-2 are displayed in Figures 4.3-1 through 4.3-7.
- e. Refinement of the data presented in the previous seven figures is shown in Figures 4.3-8 through 4.3-14.
- f. Aiming data derived from the computed trajectory data are presented in Tables 4.3-3 through 4.3-9. These velocity ranges in 100-meter increments from muzzle to 1500-meters.
- g. Data on range and maximum ordinate at the elevation required to produce that range were presented for elevations from 5° to 45° given in 5° increments. Tables 4.3-10 through 4.3-16 contain this information.
- h. The final set of figures represents the aiming data as it relates to the ballistic match of various projectiles of 5.56-mm caliber. These data are shown in Figures 4.3-15 through 4.3-18.

K_D versus Mach No
5.56-mm Ball, M855
Lot: LC 85B300S325

SUMMARY PLOT

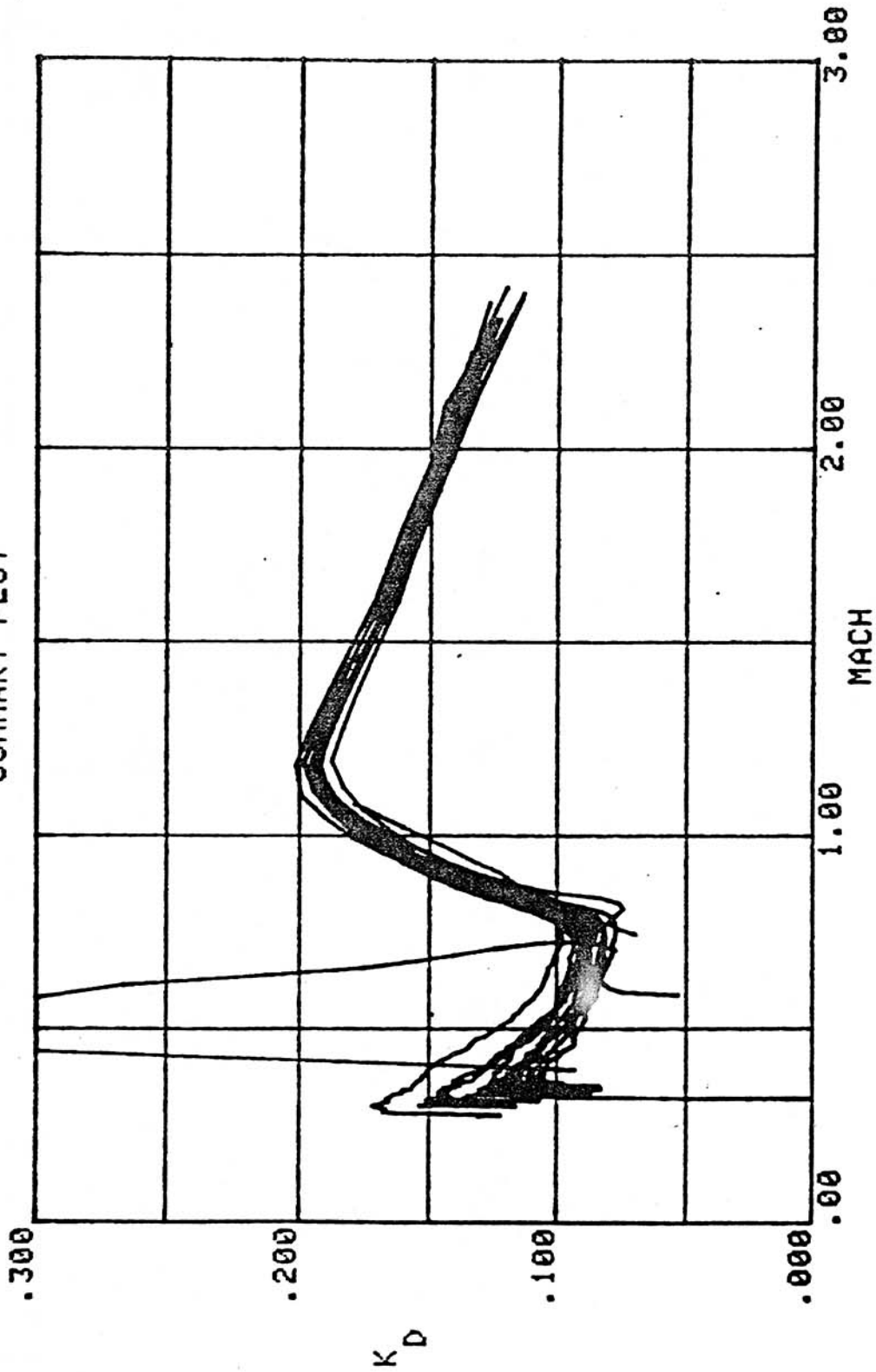


Figure 4.3-1.

K_D versus Mach No
5.56-mm Ball, M855
Lot: LC 85D300S339

SUMMARY PLOT

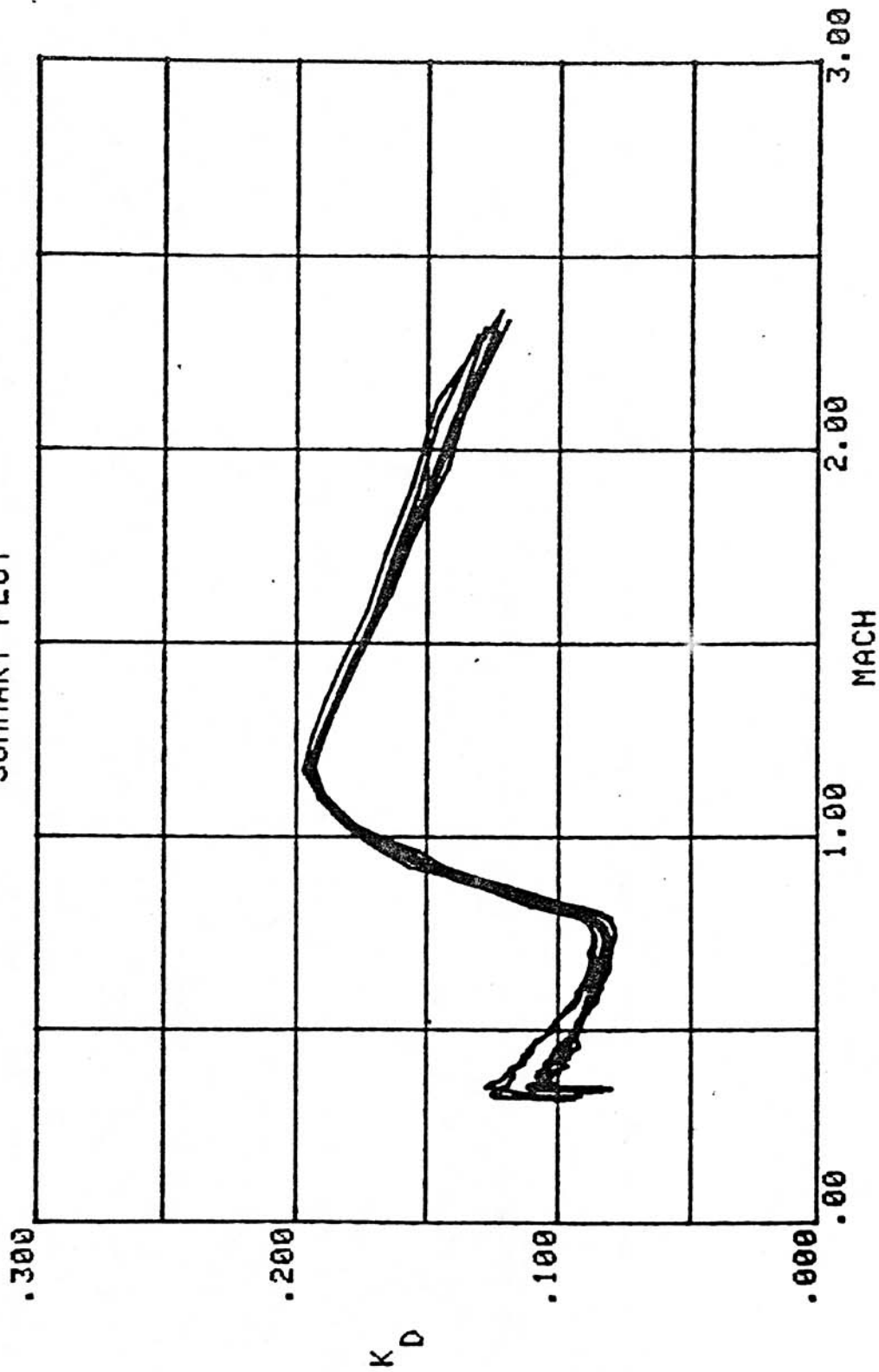


Figure 4.3-2.

K_D versus Mach No
5.56-mm Tracer, M856
Lot: FNB 83G001L002

SUMMARY PLOT

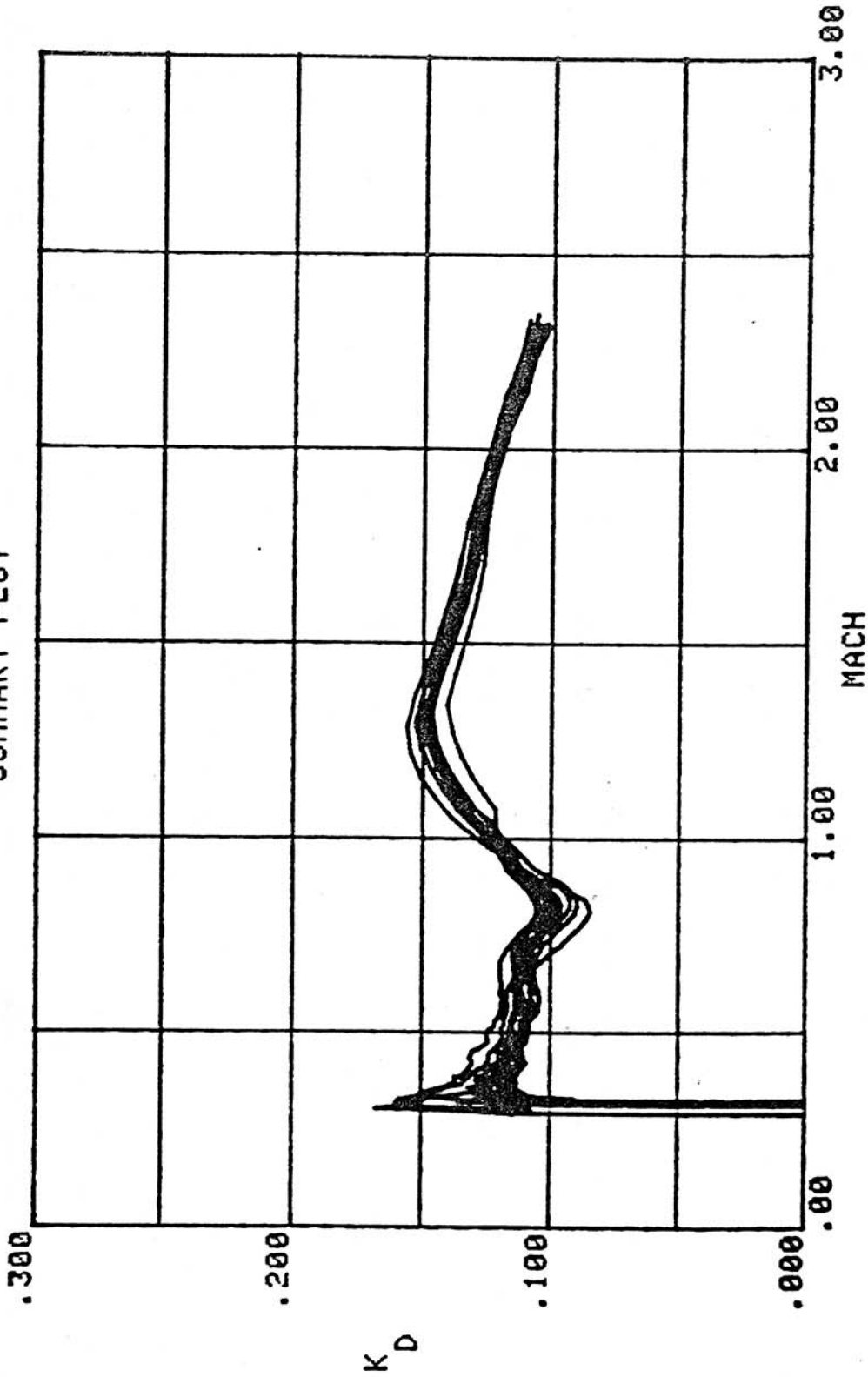


Figure 4.3-3.

K_D versus Mach No
5.56-mm Tracer, M856
Lot: LC 85D300S339

SUMMARY PLOT

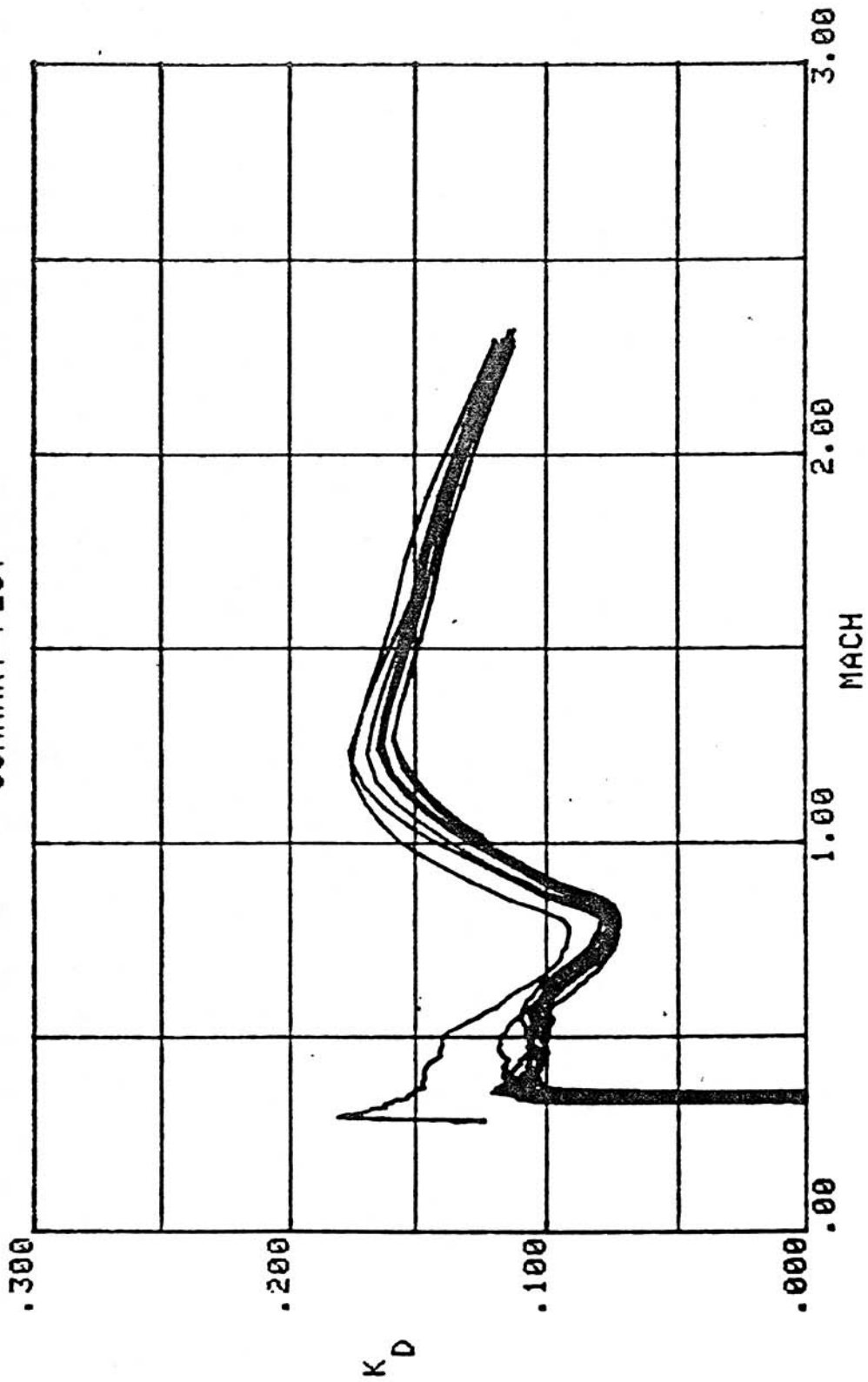


Figure 4.3-4.

K_D versus Mach No
5.56-mm Tracer, M856
Lot: LC (Olin)

SUMMARY PLOT

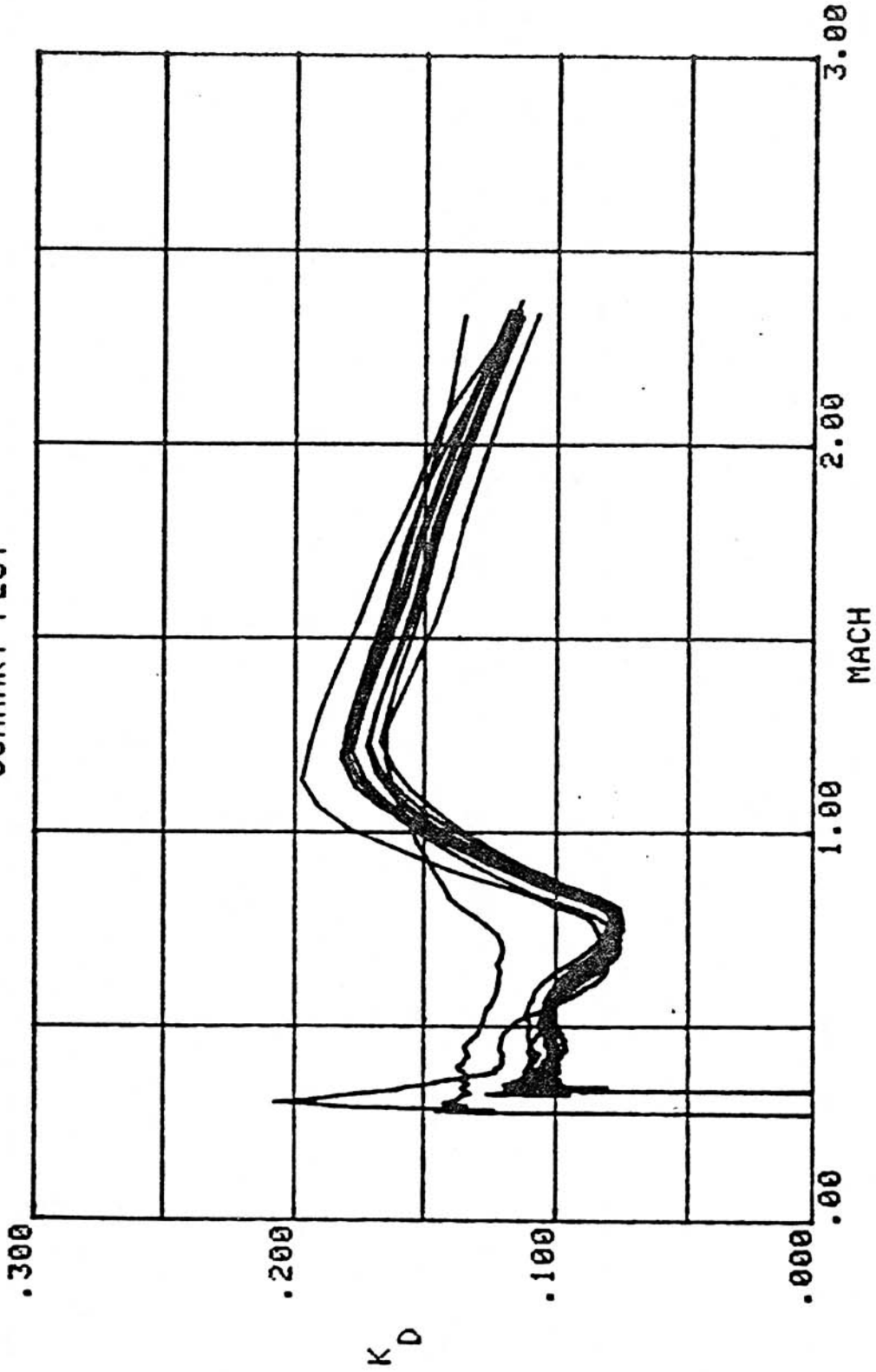


Figure 4-3.5.

K_D versus Mach No
5.56-mm Tracer, M856
Lot: IC 85D300S335

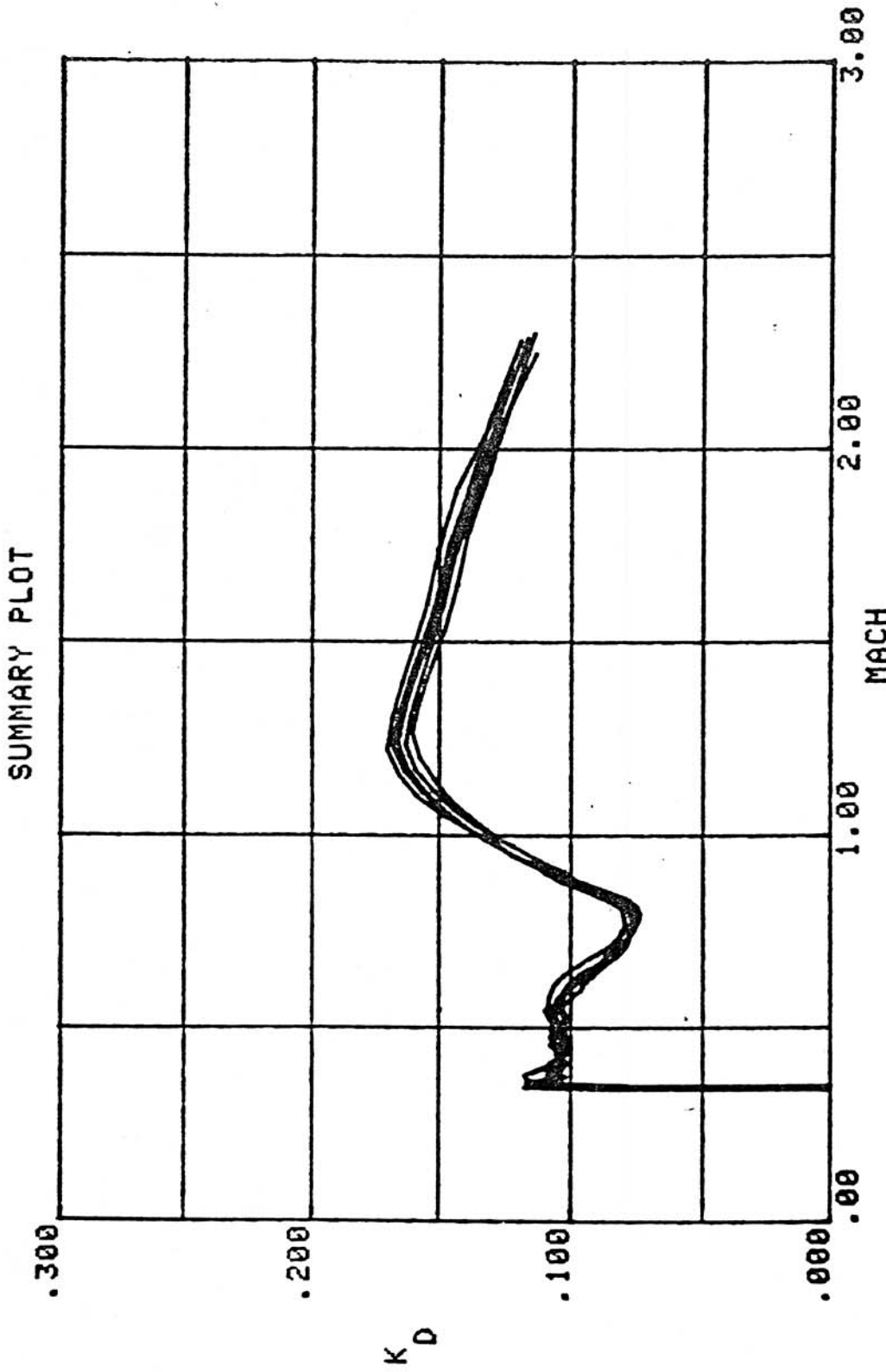


Figure 4.3-6.

K_D versus Mach No
5.56-mm Tracer, M196
Lot: LC 81A010G030

SUMMARY PLOT

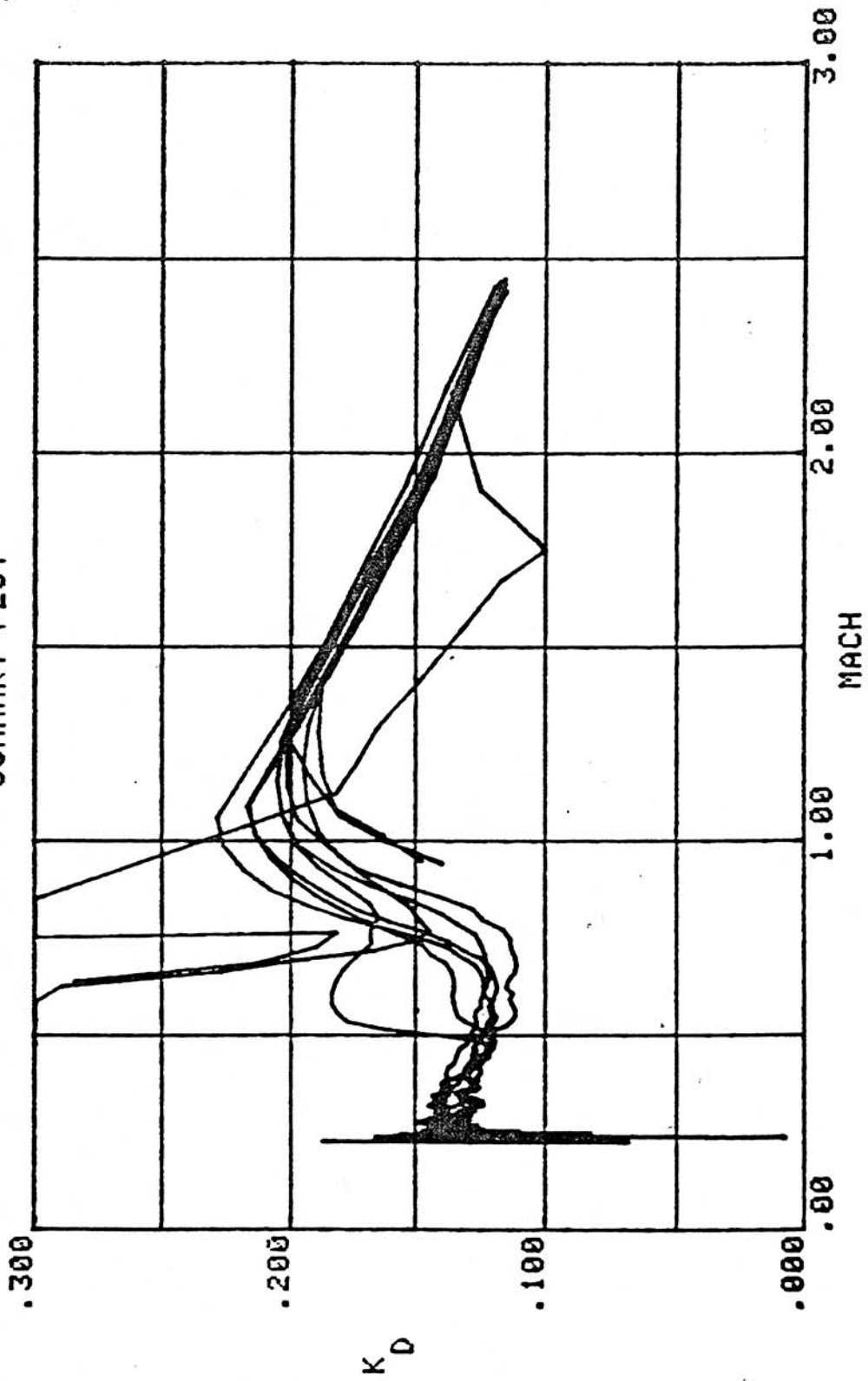


Figure 4.3-7.

M855 (BALL) LC85 B300 S325

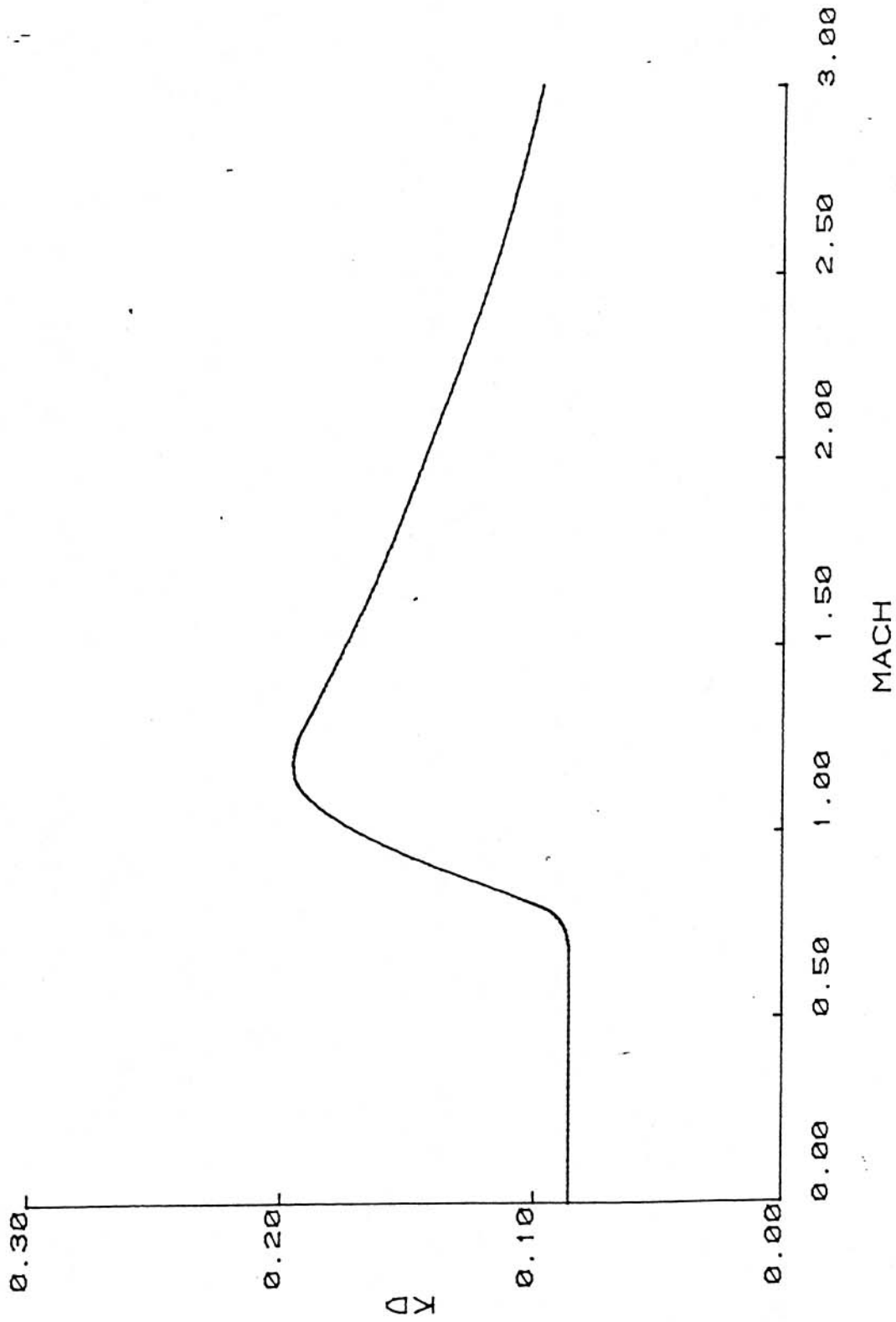
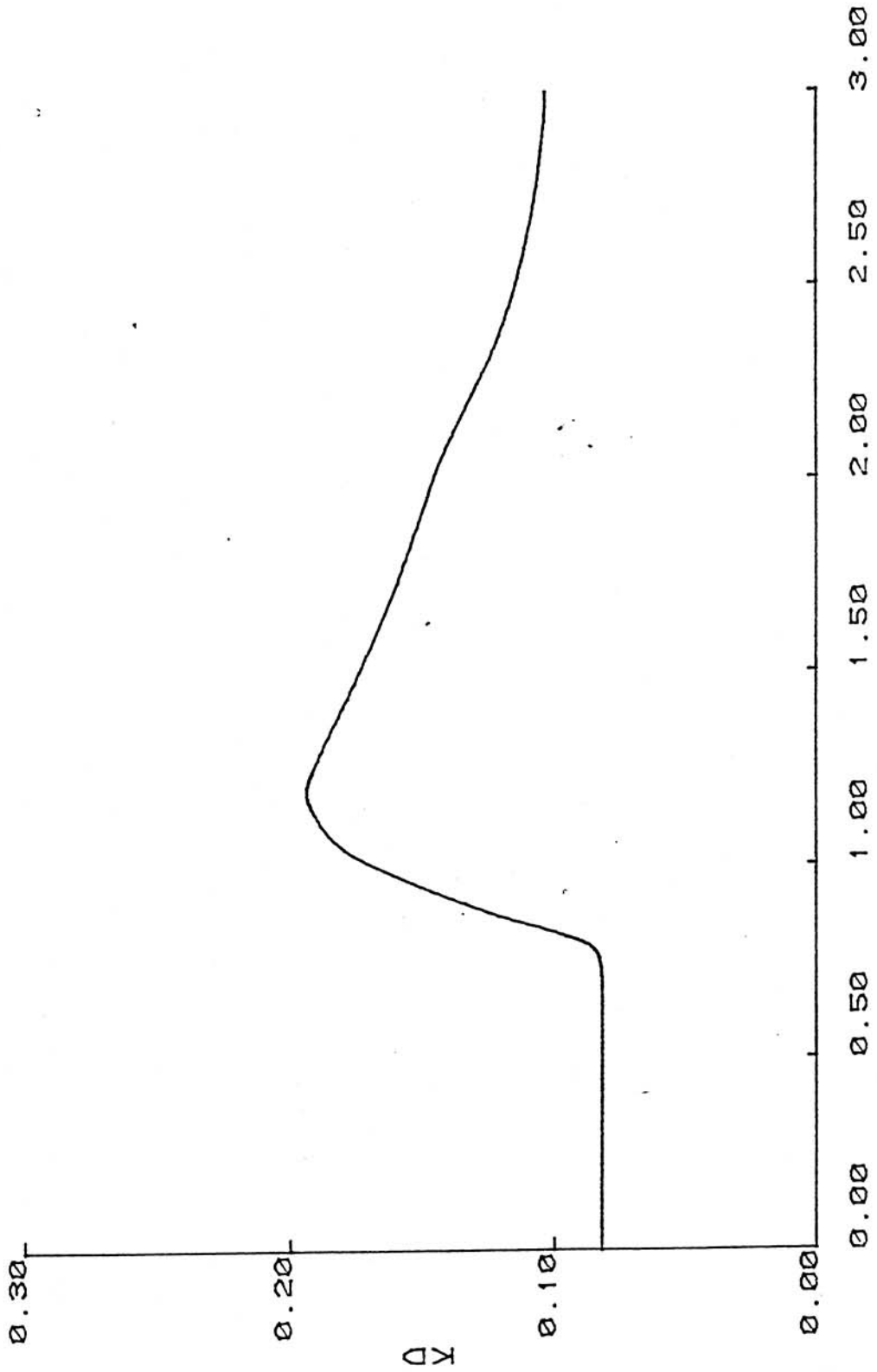


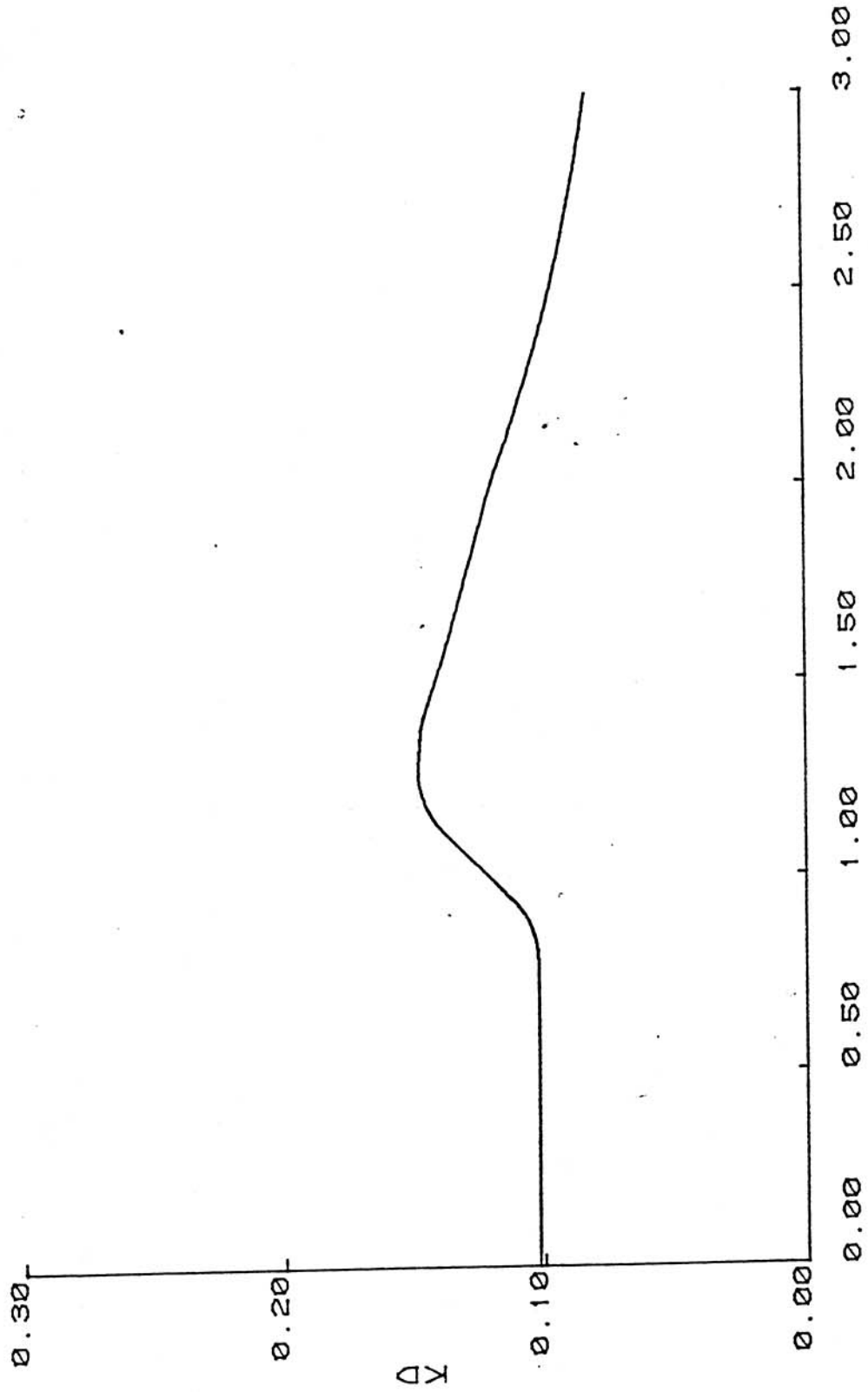
Figure 4.3-8.

M855 (BALL) LC85D300S339



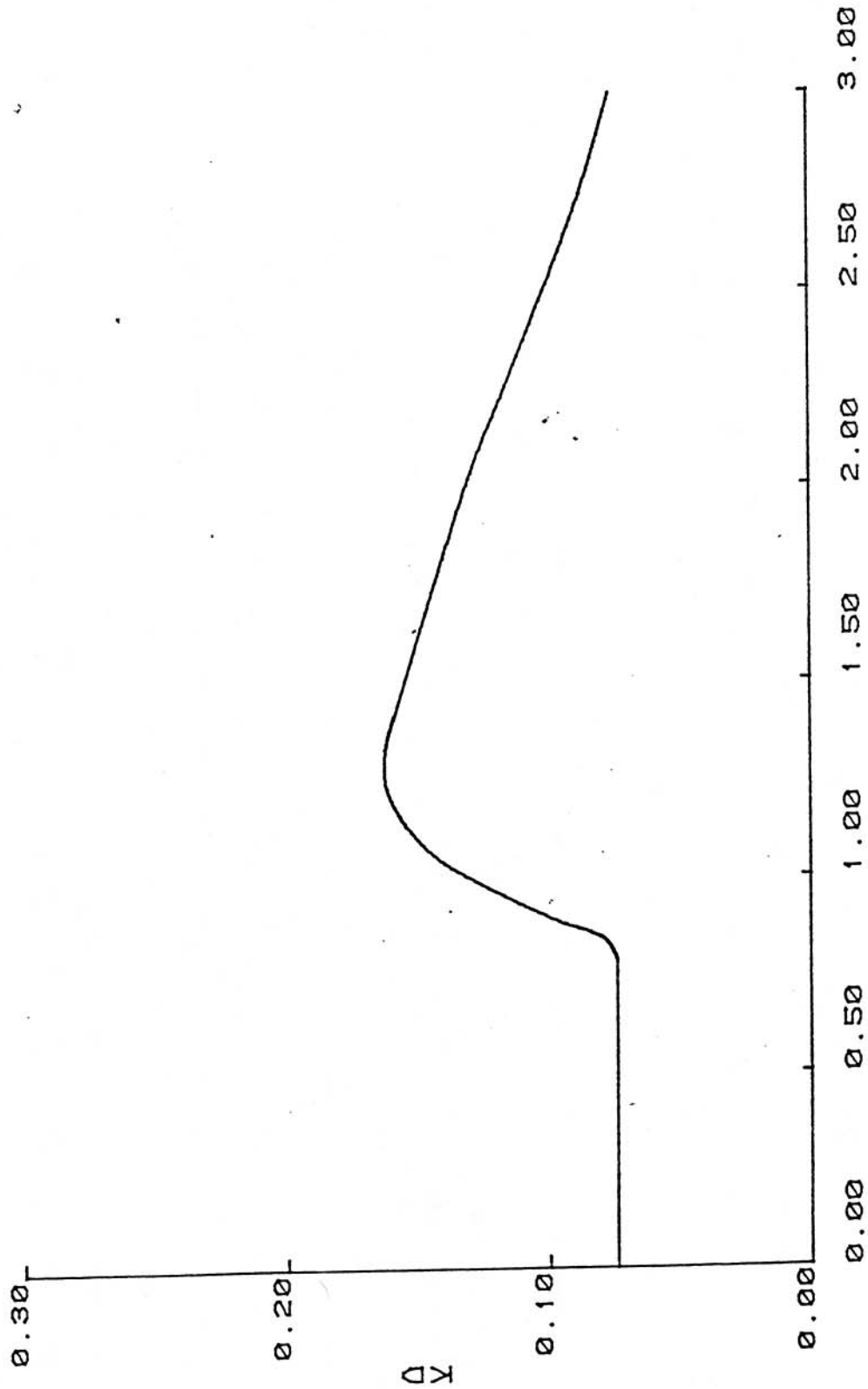
MACH
Figure 4.3-9.

M856 (TRACER) FNB83G001-L002



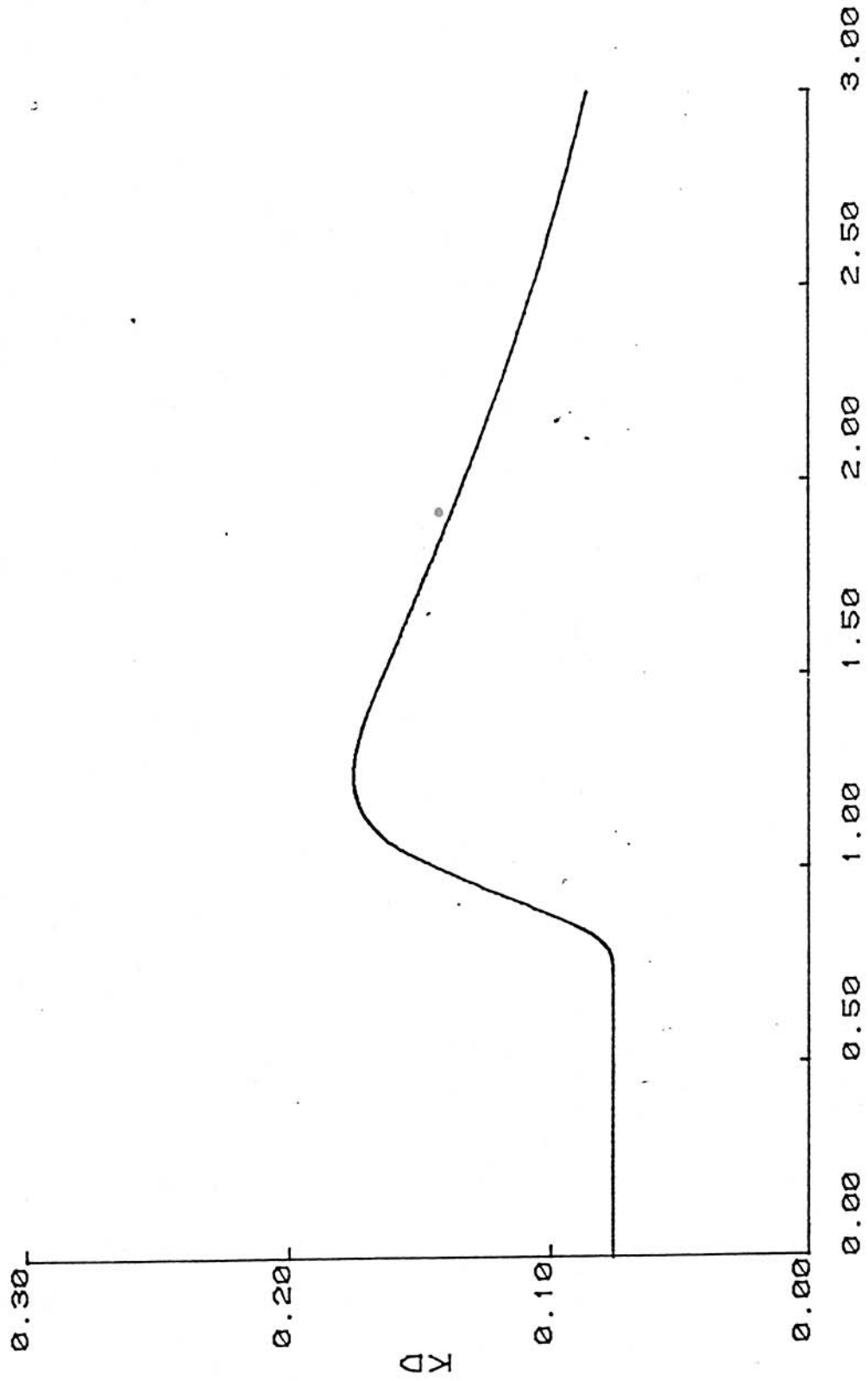
MACH
Figure 4.3-10.

M856 (TRACER) LC85D300S339



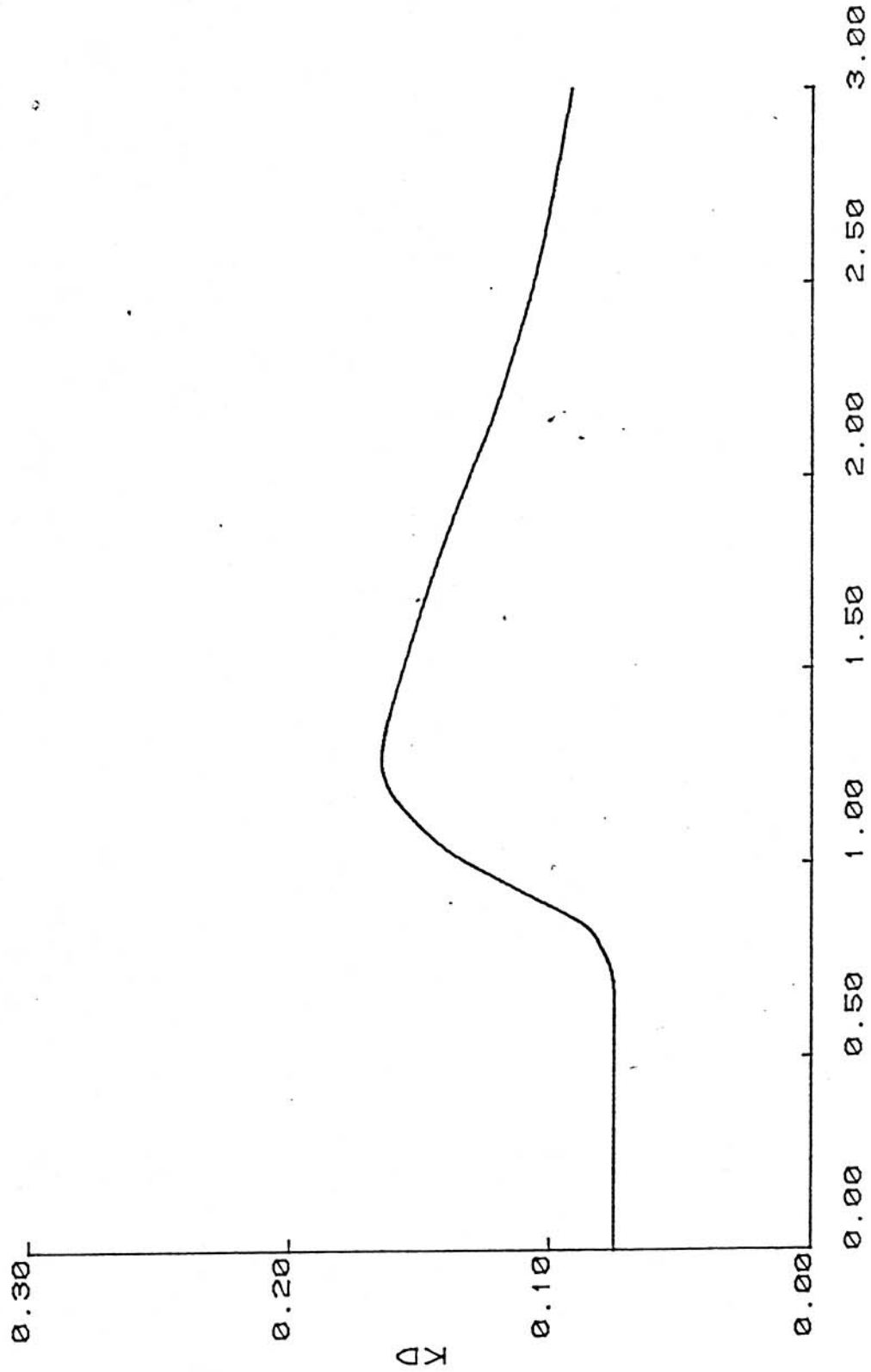
MACH
Figure 4.3-11.

M856 (TRACER) LCCOLIND



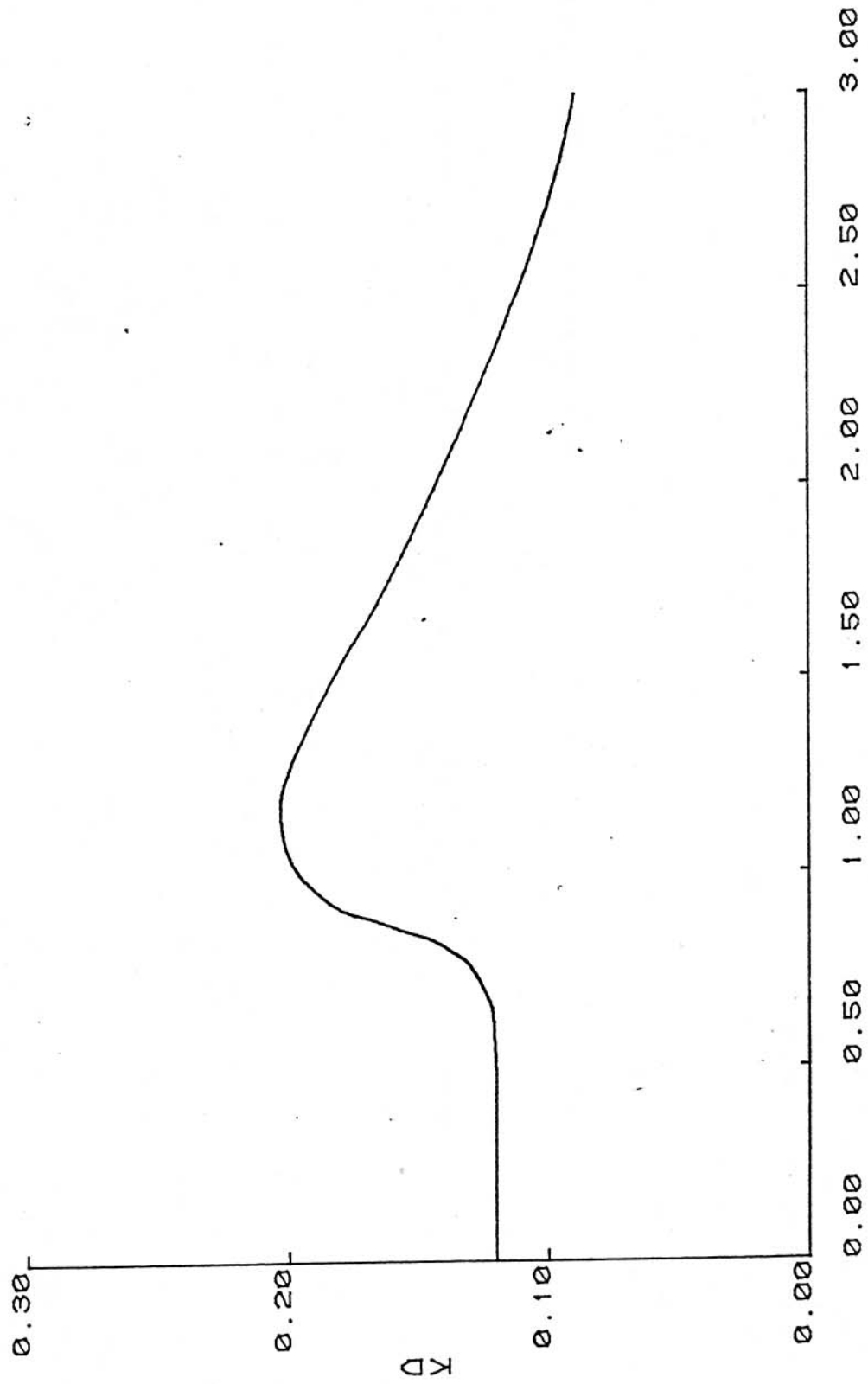
MACH
Figure 4.3-12.

M856 CTRACER LC85D300S335



MACH
Figure 4.3-13.

M196 CTRACER> LC81A010G030



MACH
Figure 4.3-14.

TABLE 4.3-3. AIMING DATA FOR 5.56-MM BALL, M855,
LOT: LC85B300S325

Range Meters	Elev, mils	Flight Time, sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	3036	925	0.00	0.00
100	0.6	0.11	2713	827	0.04	0.05
200	1.4	0.24	2391	729	0.09	0.24
300	2.3	0.39	2073	632	0.17	0.61
400	3.3	0.56	1770	539	0.27	1.27
500	4.7	0.76	1483	452	0.43	2.35
600	6.4	1.01	1225	373	0.66	4.10
700	8.7	1.30	1035	315	1.03	6.89
800	11.6	1.64	915	279	1.49	11.20
900	15.3	2.02	834	254	2.09	17.49
1000	19.9	2.43	766	233	2.78	26.11
1100	25.3	2.87	704	215	3.61	37.46
1200	31.6	3.36	648	198	4.59	51.99
1300	38.9	3.89	596	182	5.75	70.29
1400	47.4	4.47	549	167	7.10	93.10
1500	57.1	5.10	506	154	8.75	121.38

TABLE 4.3-4. AIMING DATA FOR 5.56-MM BALL, M885, LOT LC85D300S339

Range Meters	Elev, mils	Flight Time, sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	3036	925	0.00	0.00
100	0.6	0.11	2716	828	0.04	0.05
200	1.4	0.24	2396	730	0.09	0.24
300	2.2	0.39	2074	632	0.16	0.16
400	3.3	0.56	1768	539	0.27	1.27
500	4.7	0.76	1483	452	0.43	2.35
600	6.4	1.01	1227	374	0.66	4.10
700	8.7	1.30	1037	316	1.01	6.88
800	11.6	1.64	919	280	1.49	11.99
900	15.3	2.01	843	257	2.08	17.44
1000	19.8	2.42	778	237	2.74	25.96
1100	25.1	2.86	718	219	3.53	37.10
1200	31.2	3.33	664	202	4.46	51.25
1300	38.4	3.85	613	187	5.54	68.93
1400	46.5	4.41	567	173	6.82	90.81
1500	55.9	5.02	525	160	8.35	117.72

TABLE 4.3-5. AIMING DATA FOR 5.56-MM TRACER, M856,
LOT FNB83GC01L002

Range Meters	Elev, Mils	Flight Time, sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	2883	879	0.00	0.00
100	0.7	0.12	2621	799	0.04	0.06
200	1.5	0.25	2360	719	0.10	0.25
300	2.4	0.40	2102	641	0.16	6.24
400	3.5	0.56	1853	565	0.26	1.28
500	4.7	0.75	1620	494	0.39	2.29
600	6.3	0.97	1404	428	0.58	3.81
700	8.2	1.22	1222	372	0.83	6.06
800	10.5	1.51	1081	329	1.15	9.32
900	13.3	1.83	972	296	1.56	13.91
1000	16.7	2.18	880	268	2.09	20.19
1100	20.8	2.58	798	243	2.72	28.53
1200	25.6	3.01	723	220	3.50	39.42
1300	31.2	3.49	656	200	4.46	53.45
1400	37.9	4.02	595	181	5.56	71.37
1500	45.7	4.60	540	165	7.09	94.14

TABLE 4.3-6. AIMING DATA FOR 5.56-MM TRACER, M856
LOT: LC89D300S339

Range Meters	Elev, Mils	Flight Time, sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	2883	879	0.00	0.00
100	0.7	0.12	2608	795	0.04	0.06
200	1.5	0.25	2324	708	0.10	0.26
300	2.4	0.40	2041	622	0.17	0.66
400	3.6	0.58	1772	540	0.28	1.34
500	4.9	0.78	1522	464	0.43	2.43
600	6.6	1.01	1300	396	0.63	4.12
700	8.7	1.28	1126	343	0.94	6.69
800	11.4	1.59	1006	307	1.33	10.48
900	14.6	1.93	924	282	1.80	15.82
1000	18.5	2.30	860	262	2.35	22.99
1100	23.0	2.70	801	244	2.97	32.25
1200	28.1	3.12	746	227	3.71	43.87
1300	34.0	3.58	695	212	4.53	58.22
1400	40.6	4.07	648	198	5.50	75.73
1500	48.1	4.60	604	184	6.64	96.93

TABLE 4.3-7. AIMING DATA FOR 5.56-MM TRACER, M856,
LOT: LC (OLIN)

Range Meters	Elev, Mils	Flight Time, sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	2883	879	0.00	0.00
100	0.7	0.12	2589	789	0.05	0.06
200	1.5	0.26	2275	693	0.10	0.26
300	2.5	0.41	1974	602	0.18	0.68
400	3.7	0.59	1684	513	0.30	1.40
500	5.2	0.80	1415	431	0.47	2.60
600	7.1	1.06	1188	362	0.72	4.51
700	9.5	1.35	1032	315	1.09	7.52
800	12.6	1.69	932	284	1.54	12.01
900	16.4	2.06	860	262	2.09	18.31
1000	20.9	2.45	796	243	2.73	26.72
1100	26.1	2.88	738	225	3.47	37.53
1200	32.1	3.35	684	208	4.33	51.12
1300	39.0	3.85	634	193	5.34	67.97
1400	46.8	4.39	588	179	6.53	88.69
1500	55.7	4.97	546	166	7.94	114.01

TABLE 4.3-8. AIMING DATA FOR 5.56-MM TRACER, M856,
LOT: LC85D300S335

Range Meters	Elev, Mils	Flight Time sec	Remaining Velocity		Angle of fall, deg	Max Ord, ft
			f/s	m/s		
0	0.0	0.00	2883	879	0.00	0.00
100	0.7	0.12	2595	791	0.04	0.06
200	1.5	0.25	2310	704	0.10	0.26
300	2.5	0.40	2027	618	0.17	0.66
400	3.6	0.58	1757	536	0.28	1.35
500	5.0	0.78	1506	459	0.44	2.46
600	6.7	1.02	1286	392	0.65	4.18
700	8.9	1.29	1117	340	0.96	6.81
800	11.6	1.60	998	304	1.35	10.67
900	14.9	1.95	914	279	1.82	16.11
1000	18.8	2.32	846	258	2.40	23.42
1100	23.4	2.72	785	239	3.05	32.89
1200	28.7	3.16	730	223	3.80	44.84
1300	34.7	3.63	680	207	4.69	59.66
1400	41.6	4.13	633	193	5.71	77.82
1500	49.3	4.67	590	180	6.89	99.90

TABLE 4.3-9. AIMING DATA FOR 5.56-MM TRACER, M196,
 LOT: LC81A010G030

<u>Range Meters</u>	<u>Elev, Mils</u>	<u>Flight Time, sec</u>	<u>Remaining Velocity</u>		<u>Angle of fall, deg</u>	<u>Max Ord, ft</u>
			<u>f/s</u>	<u>m/s</u>		
0	0.0	0.00	3200	975	0.00	0.00
100	0.6	0.11	2847	868	0.03	0.05
200	1.2	0.23	2481	756	0.09	0.22
300	2.1	0.38	2108	643	0.15	0.57
400	3.1	0.55	1740	530	0.26	1.20
500	4.4	0.76	1392	424	0.44	2.30
600	6.3	1.02	1100	335	0.74	4.21
700	8.9	1.36	902	275	1.21	7.52
800	12.5	1.75	775	236	1.87	12.99
900	17.3	2.20	673	205	2.78	21.39
1000	23.5	2.73	585	178	3.96	33.68
1100	31.5	3.33	510	155	5.57	51.12
1200	41.7	4.02	445	136	7.67	75.48
1300	54.6	4.82	390	119	10.46	109.21
1400	71.0	5.75	343	105	14.12	155.74
1500	91.8	6.82	304	93	18.90	219.91

TABLE 4.3-10. 5.56-MM BALL, M855,
 LOT: LC25B300S325, MV= 3036 F/S

<u>Elev, Deg</u>	<u>Range, Meters</u>	<u>Max Ord, Ft</u>
5	1752	226
10	2176	588
15	2417	1019
20	2564	1494
25	2647	1998
30	2677	2520
35	2663	3049
40	2607	3576
45	2512	4092

TABLE 4.3-11. 5.56-MM BALL, M855
 LOT: LC85D300S339, MV=3036 F/S

<u>Elev, Deg</u>	<u>Range, Meters</u>	<u>Max Ord, Ft</u>
5	1774	226
10	2216	592
15	2470	1029
20	2626	1513
25	2714	2026
30	2749	2559
35	2738	3099
40	2683	3639
45	2587	4168

TABLE 4.3-12. 5.56-MM TRACER, M856,
 LOT: FNB33GC01L002, MV=2883 F/S

<u>Elev,</u> <u>Deg</u>	<u>Range,</u> <u>Meters</u>	Max Ord, <u>Ft</u>
5	1872	245
10	2266	638
15	2480	1098
20	2603	1599
25	2666	2125
30	2681	2666
35	2653	3212
40	2586	3754
45	2482	4282

TABLE 4.3-13. 5.56-MM TRACER, M856,
 LOT: LC85D300S339, MV=2883 F/S

<u>Elev,</u> <u>Deg</u>	<u>Range,</u> <u>Meters</u>	Max Ord, <u>Ft</u>
5	1903	235
10	2405	627
15	2694	1100
20	2874	1625
25	2979	2185
30	3024	2767
35	3017	3360
40	2962	3952
45	2861	4532

TABLE 4.3-14. 5.56-MM TRACER, M356,
 LOT: LC (OLIN), MV=2883 F/S

<u>Elev</u> <u>Deg</u>	<u>Range</u> <u>Meters</u>	<u>Max</u> <u>Ord</u> <u>Ft</u>
5	1790	223
10	2256	591
15	2523	1035
20	2689	1528
25	2784	2052
30	2824	2596
35	2815	3150
40	2761	3702
45	2665	4245

TABLE 4.3-15. 5.56-MM TRACER, M356,
 LOT: LC85D300S335, MV=2383 F/S

<u>Elev,</u> <u>Deg</u>	<u>Range,</u> <u>Meters</u>	<u>Max</u> <u>Ord,</u> <u>Ft</u>
5	1879	233
10	2371	621
15	2655	1087
20	2831	1605
25	2933	2156
30	2977	2730
35	2970	3313
40	2915	3897
45	2815	4470

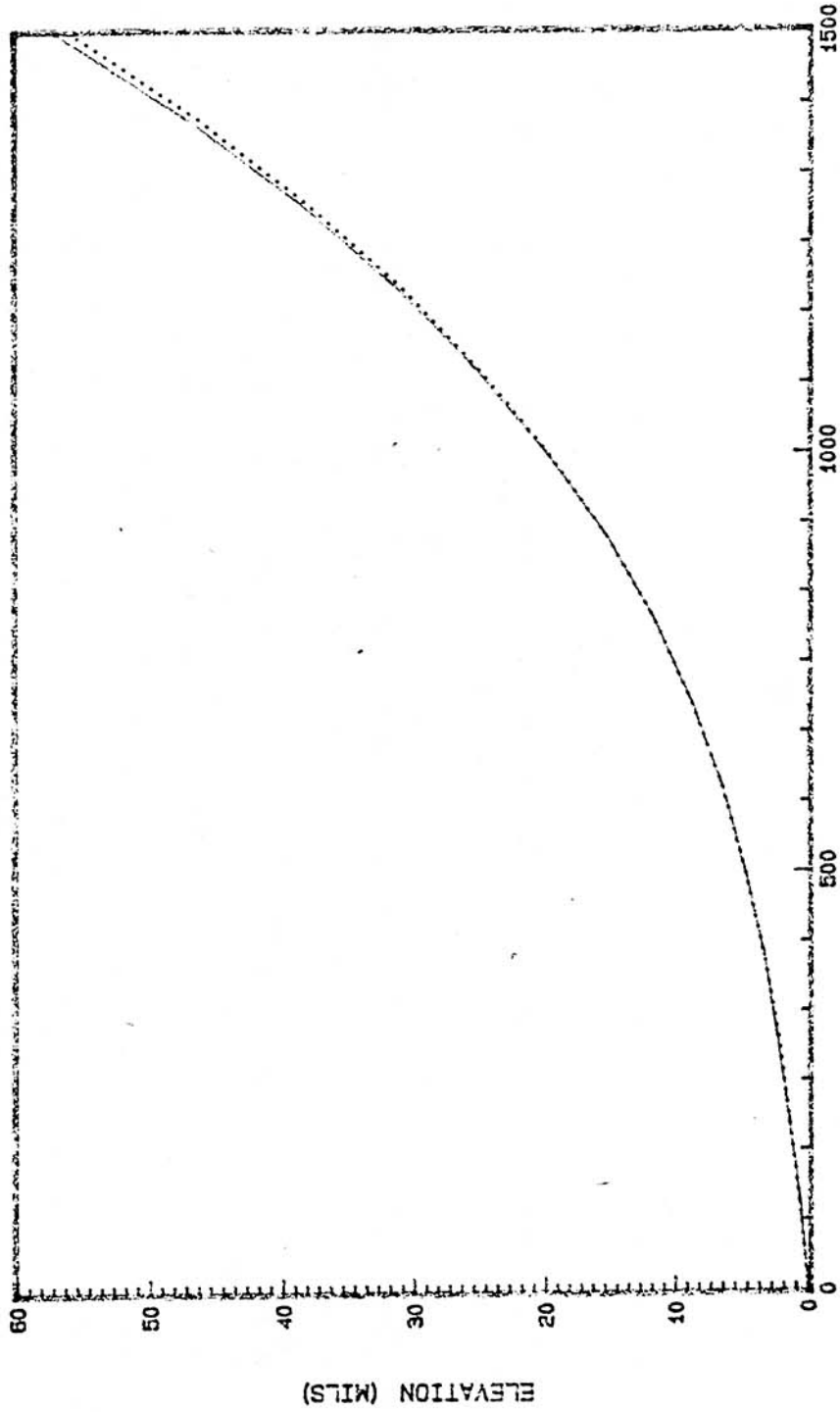
TABLE 4.3-16. 5.56-MM TRACER, M196,
LOT: LC81A010G030, MV=3200 F/S

<u>Elev,</u> <u>Deg</u>	<u>Range,</u> <u>Meters</u>	<u>Max</u> <u>Ord,</u> <u>Ft</u>
5	1488	211
10	1756	526
15	1899	886
20	1977	1275
25	2012	1679
30	2011	2092
35	1981	2506
40	1922	2914
45	1838	3311

AIMING DATA

5.56-mm BALL., M855

LOT: LC85B300S325
LOT: LC85D300S339



RANGE (METERS)

Figure 4.3-15.

AIMING DATA

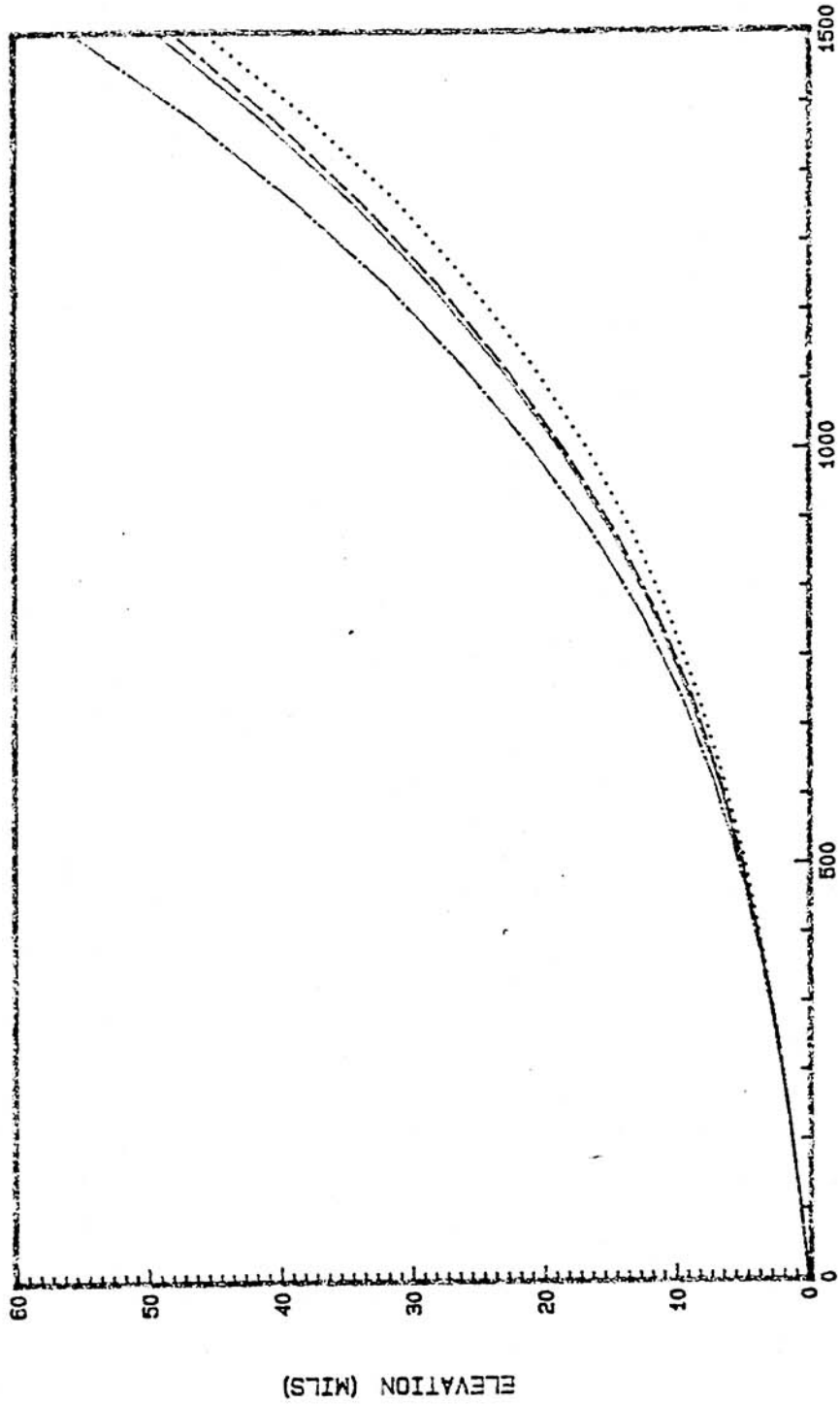
5.56-mm TRACER, M856

LOT:
LC85D300S335

LOT:
LC (OLIN)

LOT:
LC85D300S339

LOT:
FN8836001L002

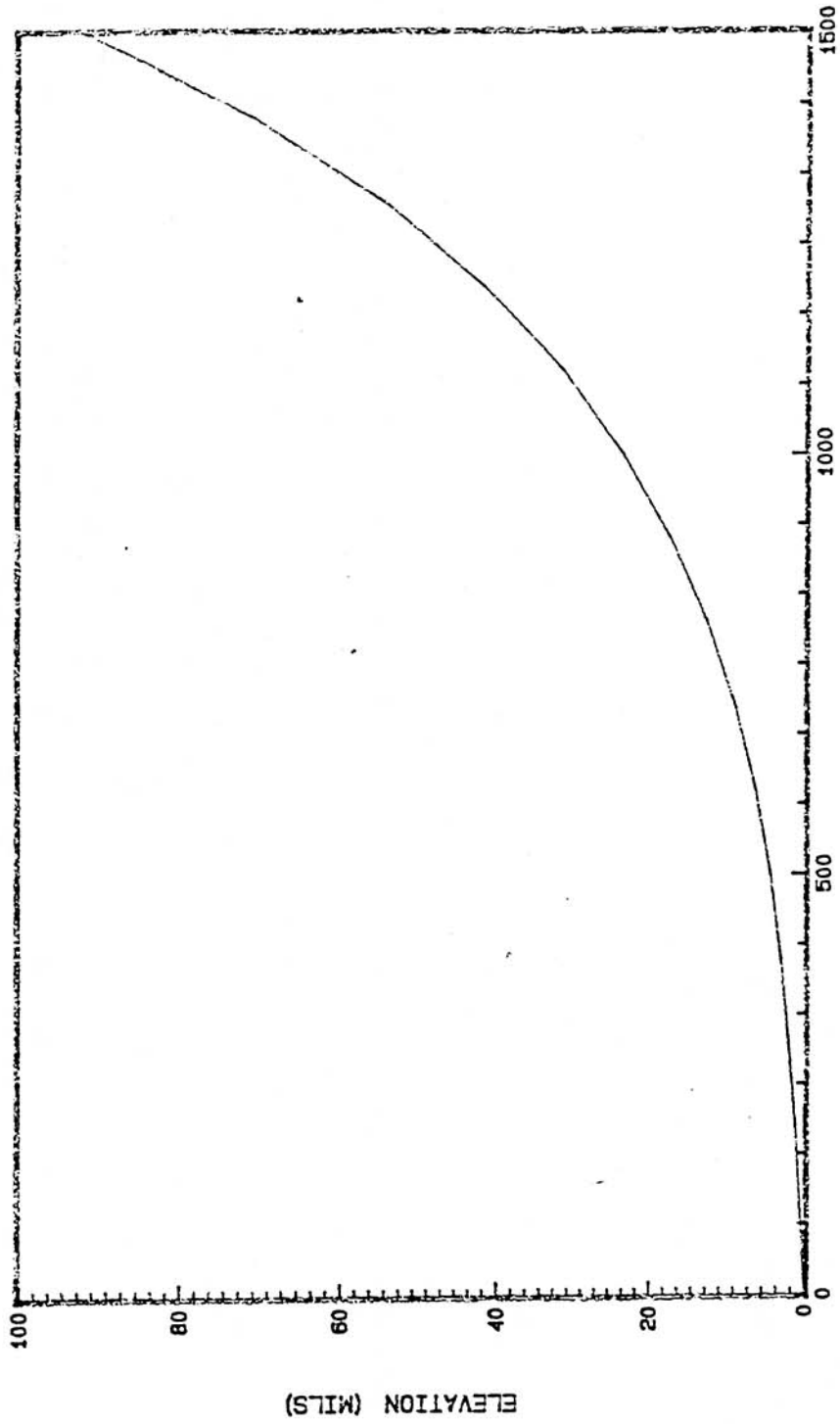


RANGE (METERS)

Figure 4.3-16.

AIMING DATA
5.56-mm TRACER

M196



RANGE (METERS)

Figure 4.3-17.

AIMING DATA

5.56-mm

M855

LOT: LC85B300S325

M855

LOT: LC85D300S339

M856

LOT: LC85D300S335

M856

LOT: LC (OLIN)

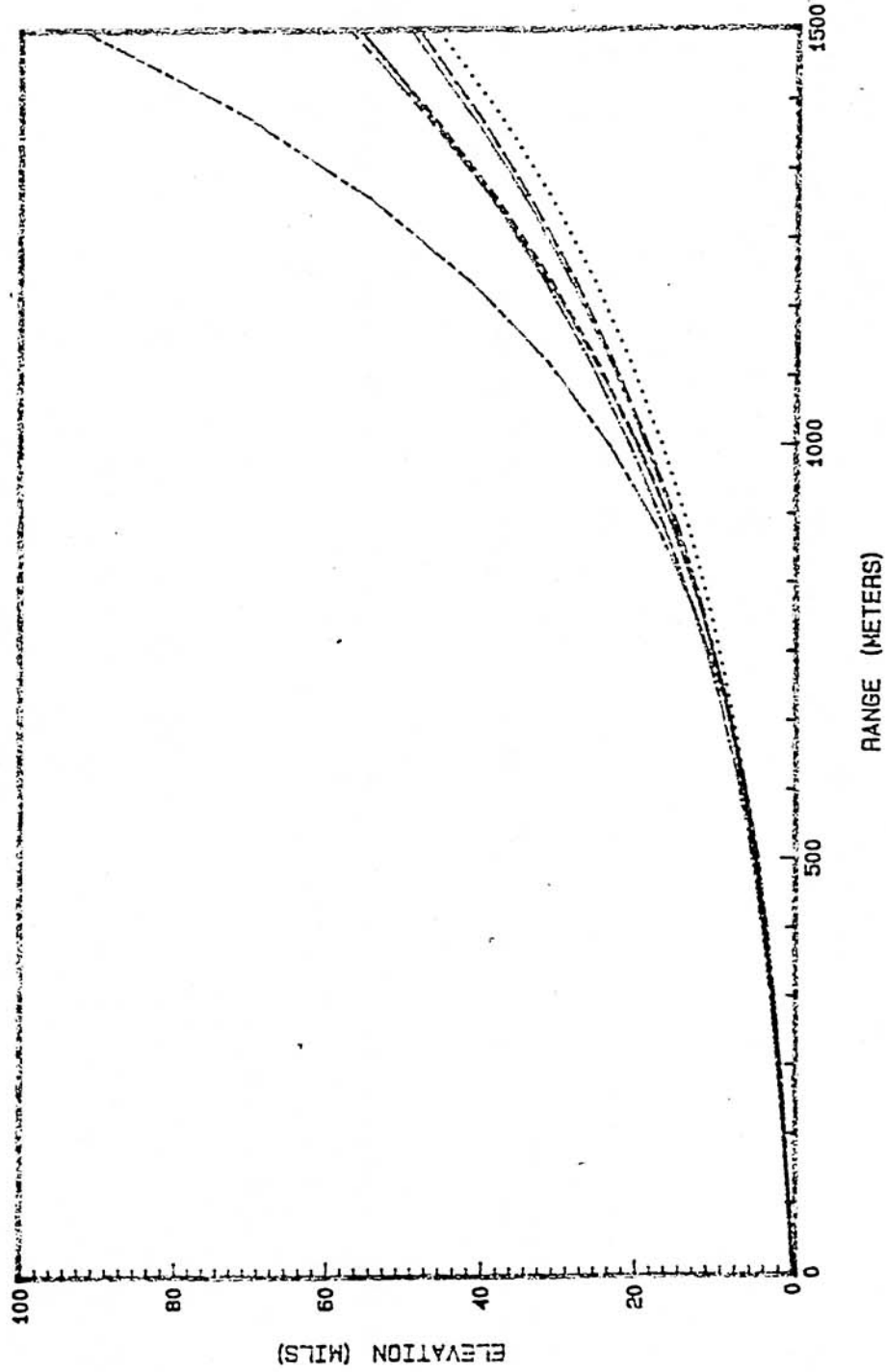
M856

LOT: LC85D300S339

M856

LOT: FNBB36001L002

M196



RANGE (METERS)

Figure 4.3-18.

4.3.5 Technical Assessment

- a. Ballistic match of the two lots of CONUS-produced M855 Ball rounds tested, produced a match throughout the 1500-meter range.
- b. The CONUS-produced M855 ball ammunition was ballistically matched with the Olin-design, CONUS-produced, M856 Tracer ammunition throughout the 1500-meter range.
- c. The CONUS-produced M855 Ball ammunition was ballistically matched to the M856 CONUS-produced ammunition (LCAAP-Remington design) out to 700-meters range.
- d. All rounds tested were ballistically matched to 700-meters range.
- e. The ballistic match of rounds, determined during vertical target firing at 457-meters (600 yd.), confirmed the validity of the HAWK trajectory determinations.
- f. There were no indications of safety hazards during this test such as erratic projectile flight. The CONUS-produced ball and tracer ammunition produced tracer and trajectory performance levels that were within specification requirements, therefore, the criteria were met.

4.4 PENETRATION

4.4.1 Objective and Issues

- a. Test objective. To determine if the test and control ammunition meets manufacturing specifications.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridges, 5.56-mm, M855 Ball and M856 Tracer?
- d. Other issue. Are all of the test item's RAM requirements met?

4.4.2 Criterion

The bullet of the sample cartridges shall demonstrate complete penetration of 10 gauge (0.34 cm (0.135 in.)) thickness AISI 1010 or 1020 steel plate target with hardness between RB-55 minimum and RB-70 maximum (NATO plate) positioned at 0°, ±5° obliquity and located 600 m (656.2 yd.) from the weapon. Additionally, an aluminum witness plate (2024T3 or equivalent nominally 0.020 inch (0.5 mm thick) shall be located 6 inches (150 mm) behind the target to determine penetration. Testing shall be performed when the air temperature is between -1 and +35°C (30°F and 95°F) (Para. 3.9 of MIL-C-63989A (Ref. 15)).

4.4.3 Test Procedure

- a. The basic test procedures are established in TOP 4-2-016, Paragraph 36 (Ref. 43) and SCATP 5.56mm (Heavy Bullet) (Ref. 59). Specific procedures are given below.
- b. All penetration test rounds were fired from a Mann barrel mounted in an accuracy test stand. Fifty rounds of each ammunition type (M855 and M856) were fired against 10-gauge thickness (NATO) target plates set vertically and perpendicular to the line-of-fire. Obliquity limits of the rigidly mounted plate, relative to the line-of-fire was 0±5° in both the horizontal and vertical axes. The range to target was 600-meters from the barrel muzzle. A witness plate was positioned 150 mm behind the target plate at the same obliquity. Paired velocity sensors were located along the line-of-fire at ranges of 15.0 and 25.0-meters and 15.1 and 25.1-meters from the barrel muzzle. The permitted ambient temperature range of testing was -1 to +35°C. Range temperature was recorded for each round fired. Wind velocity was also measured; it must not exceed 8 km/hr at the time of firing.
- c. A total of 50 good hits were required. A good hit was defined as a first strike (no ricochet) on the plate at a point not less than 25 mm from other adjacent hits, a target support, or the edge of the target plate. The Navy criterion was used to define complete penetration of the target plate. This occurred when the entire projec-

tile, or major portion thereof, passed through the plate. In order to qualify as acceptable, complete penetration of the witness plate must also occur.

- d. Testing for acceptance was done only with the ball round. The tracer round was tested only for information.

4.4.4 Test Findings

The penetration test data are tabulated in Table 4.4-1 for the M855 Ball cartridge and Table 4.4-2 for the M856 Tracer rounds.

TABLE 4.4-1 M855 BALL AMMUNITION PENETRATION DATA

Rd. No.	Avg. Vel. m/s	Amb. Temp. (F)	Wind Speed mps	Type of Pen.	Rd. No.	Avg. Vel. m/s	Amb. Temp. (F)	Wind Speed mph	Type of Pen.
1	920.8	69	5	CP	26	914.1	71	3	CP
2	928.3	69	4	CP	27	921.2	72	1	CP
3	917.2	69	4	CP	28	924.9	72	0	CP
4	923.6	69	5	CP	29	941.0	72	1	CP
5	912.0	69	4	CP	30	921.5	72	0	CP
6	911.2	69	5	CP	31	922.0	72	0	CP
7	930.0	69	4	CP	32	915.6	72	5	CP
8	912.4	69	2	CP	33	911.8	72	5	CP
9	912.3	69	0	CP	34	920.4	72	3	CP
10	912.6	69	1	CP	35	919.2	73	4	CP
11	926.0	70	0	CP	36	929.5	73	1	CP
12	920.9	70	2	CP	37	913.7	73	1	PP
13	911.9	70	2	CP	38	919.8	74	4	CP
14	912.1	70	1	CP	39	925.3	74	2	CP
15	923.4	70	4	CP	40	919.8	74	5	CP
16	920.6	70	0	CP	41	933.0	74	4	CP
17	921.0	70	5	CP	42	919.0	76	5	CP
18	925.5	70	1	CP	43	933.9	74	4	CP
19	914.0	70	5	CP	44	923.4	74	2	CP
20	928.6	70	5	CP	45	931.2	74	5	CP
21	919.9	70	5	CP	46	927.6	76	5	CP
22	923.4	71	1	CP	47	923.1	74	5	CP
23	922.3	71	1	CP	48	922.8	74	0	PP
24	921.8	71	1	CP	49	920.9	74	1	CP
25	916.4	71	1	CP	50	925.9	74	3	CP
				Total	48				CP
					2				PP
				Average		921.2	72	2	-
				ES		29.8	7	5	-
				Std. Dev.		6.6	-	-	-

CP = Complete Penetration
 ES = Extreme Spread
 Pen. = Penetration
 PP = Partial Penetration

NOTE: All projectiles that completely penetrated the target plate, also completely penetrated the witness plate.

TABLE 4.4-2. M856 TRACER AMMUNITION PENETRATION DATA

Rd. No.	Avg. Vel. m/s	Amb. Temp. (F)	Wind Speed mph	Type of Pen.	Rd. No.	Avg. Vel. m/s	Amb. Temp. (F)	Wind Speed mph	Type of Pen.
1	873.0	71	4	NP	26	878.0	70	7	NP
2	878.8	71	4	NP	27	890.2	70	7	NP
3	865.9	71	3	NP	28	879.9	70	8	NP
4	884.0	71	3	NP	29	877.6	70	6	NP
5	880.0	71	4	NP	30	878.9	70	6	NP
6	879.2	71	5	NP	31	882.8	70	4	NP
7	884.8	71	5	NP	32	881.0	70	2	NP
8	880.2	71	6	NP	33	887.1	70	2	NP
9	885.1	71	7	NP	34	879.2	70	2	NP
10	875.0	71	7	NP	35	887.4	70	1	NP
11	871.0	71	7	NP	36	879.2	70	1	NP
12	848.2	71	6	NP	37	875.9	70	2	NP
13	880.2	71	6	NP	38	878.6	70	2	NP
14	874.0	71	4	NP	39	883.9	70	1	NP
15	879.1	71	1	NP	40	874.4	70	2	NP
16	880.4	71	2	NP	41	886.8	70	1	NP
17	881.2	71	2	NP	42	880.9	70	2	NP
18	880.0	71	4	NP	43	883.6	70	2	NP
19	879.4	71	3	NP	44	887.0	70	3	NP
20	883.4	70	3	NP	45	881.6	70	3	NP
21	898.2	70	6	NP	46	887.6	70	2	NP
22	882.2	70	6	NP	47	885.2	70	1	NP
23	875.6	70	5	NP	48	872.2	70	1	NP
24	879.8	70	6	NP	49	883.0	70	3	NP
25	883.2	70	7	NP	50	888.0	70	3	NP
				Total	50	-	-	-	NP
				Average	-	880.8	70	3	-
				ES	-	32.3	1	7	-
				Std.Dev.	-	5.6	-	-	-

ES = Extreme Spread

NOTE: NP = No penetration of either the target or witness plate; however, the projectiles did bulge the rear of the target plate.

4.4.5 Technical Assessment

- a. The first sample accept/reject criterion allows no more than two failures in 50 rounds. The CONUS-produced M855 Ball ammunition demonstrated that it could meet that level of performance. The M856 Tracer ammunition performed as expected, (i.e., non-penetrating) since it does not contain a steel nose filler like that of the ball projectile.

The testing in this portion of the program was completed without any safety incidents occurring or any indication that the ammunition created any additional RAM requirements. The test criterion, which is applicable to only the M855 Ball, was met.

4.5 WATERPROOFNESS

4.5.1 Objective and Issues

- a. Test objective. To determine if the test and control ammunition meets manufacturing specifications for waterproofness.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridges, 5.56-mm, M855 Ball and M856 Tracer?
- d. Other issue. Are all of the test item's RAM requirements met?

4.5.2 Criterion

The cartridge shall not release more than one bubble of air when subjected to a positive internal pressure of 51.710 kPa (7.5 psi) for 30 seconds (Para. 3.5 of MIL-C-63989A and MIL-C-63990A for M855 Ball and M856 Tracer, respectively (Ref. 15 and 19).

4.5.3 Test Procedure

The test procedures specified in Paragraph 17 of SCATP 5.56-mm (Heavy bullet) (Ref. 59) provided guidance for this test. A 50-round sample of each cartridge type was tested in 5-round increments. Each grouping of rounds was placed in a water-filled glass tank. The tank was then subjected to a vacuum pressure of 52 kPa (7.5 psi) for 30 seconds. The number and location of any escaping bubbles were noted for each cartridge. The cartridges were disassembled and inspected for internal leaking after immersion.

4.5.4 Test Findings

The results of testing the M855 Ball cartridge, Lot Number LC84E300S286 and M856 Tracer cartridge, Lot Number LC85D300S335, are reported in Table 4.5-1.

TABLE 4.5-1. RESULTS OF WATERPROOFNESS TEST

<u>Ammunition Type</u>	<u>No. Rd.</u>	<u>Temperature</u>				<u>No. of Rd. With Leaks</u>
		<u>Air</u>		<u>Water</u>		
		<u>°C</u>	<u>°F</u>	<u>°C</u>	<u>°F</u>	
M855 Ball	50	20.6	69	15.0	59	0
M856 Tracer	50	21.1	70	16.7	62	0

4.5.5 Technical Assessment

All test ammunition produced results that were within the criterion limits.

4.5.6 Conclusions

The test ammunition was safe to fire after immersion in water and met the Military Specification requirements for waterproofness; therefore, the criterion was met.

4.6 VELOCITY, PRESSURE AND ACTION TIME

4.6.1 Objective and Issues

- a. Test objective. To determine if the test and control ammunition meets manufacturing specifications.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met the U.S. safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military specification for Cartridge, 5.56-mm M855 Ball and M856 Tracer?
- d. Other issue. Are all of the test item's RAM requirements met?

4.6.2 Criteria

- a. Velocity. The average velocity of the M855 cartridge, conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$ shall be 3000 fps \pm 40 fps at 78 feet from the muzzle of the weapon. The standard deviation of the velocities shall not exceed 40 fps (Para. 3.6 of MIL-C-63989A (Ref. 15)).
- b. Velocity. The average velocity of the M856 cartridge, conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$ shall be 2860 \pm 40 fps at 78 feet from the muzzle of the weapon. The standard deviation of the velocities shall not exceed 40 fps (Para. 3.6 of MIL-C-63990A (Ref. 19)).
- c. Chamber pressure measurement by piezoelectric transducer. The average chamber pressure of the sample M855 and M856 cartridge, conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$ shall not exceed 55,000 psi. Neither the chamber pressure of an individual sample test cartridge or the average chamber pressure plus three standard deviations of chamber pressure shall exceed 61,000 psi (Para. 3.7 of MIL-C-63989A and MIL-C-63990A (Ref. 15 and 19, respectively)).
- d. Port pressure measurement by piezoelectric transducer. The mean port pressure minus three standard deviations shall be equal to or greater than 13,000 psi for the sample M855 Ball cartridges, conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$ (Para. 3.8 of MIL-C-63990A (Ref. 19)).
- f. Velocity (temperature stability). When conditioned at either $125^{\circ} \pm 2^{\circ}\text{F}$ or $-65^{\circ} \pm 5^{\circ}\text{F}$ for not less than one hour and then fired at that temperature, the average velocity shall not decrease by more than 250 fps with respect to the average velocity of the sample M855 or M856 cartridges of the sample lot, conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$. Any increase in velocity is acceptable (Para. 3.10 of MIL-C-63989A and MIL-C-63990A (Ref. 15 and 19, respectively)).
- g. Chamber pressure (temperature stability). When conditioned at either $125^{\circ} \pm 2^{\circ}\text{F}$ or $-65^{\circ} \pm 5^{\circ}\text{F}$ for not less than one hour and then fired at that temperature, the average chamber pressure shall not exceed 61,000 psi nor vary for the average chamber pressure of the

sample M855 and M856 test cartridge $70^{\circ} \pm 2^{\circ}\text{F}$ by more than 5,000 psi. Any decrease in chamber pressure is acceptable (Para. 3.10 of MIL-C-63989 and MIL-C-63990 (Ref. 14 and 18, respectively).

- h. Chamber pressure (temperature stability). The average chamber pressure shall not vary from the average chamber pressure of the sample test cartridges conditioned to $70^{\circ} \pm 2^{\circ}\text{F}$ by more than 5,000 psi. Any decrease in chamber pressure is acceptable (Para. 3.10.2 of MIL-C-63989A and MIL-C-63990A (Ref. 15 and 19, respectively). (This supersedes criterion 4.6.2g).
- i. Port pressure (temperature stability). When conditioned at either $125^{\circ} \pm 2^{\circ}\text{F}$ or $-65^{\circ} \pm 5^{\circ}\text{F}$ for not less than one hour and then fired at that temperature, the average port pressure shall not vary by more than 2000 psi from the average port pressure of the sample M855 cartridges of the sample lot conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$, but not to be less than 12,000 psi (Para. 3.10.3 of MIL-C-63989A (Ref. 15)).
- j. Port pressure (temperature stability). When conditioned at either $125^{\circ} \pm 2^{\circ}\text{F}$ or $-65^{\circ} \pm 5^{\circ}\text{F}$ for not less than one hour and then fired at that temperature, the average port pressure shall not vary by more than 1500 psi from the average port pressure sample test M856 cartridge of the sample lot conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$ (Para. 3.10.3 of MIL-C-63990 (Ref. 18)).
- k. Port pressure (temperature stability). The average port pressure shall not vary by more than 15000 psi from the average port pressure of the sample test cartridges of the same lot conditioned at $70^{\circ} \pm 2^{\circ}\text{F}$, but not to be less than 11,400 psi (Para. 3.10.3 of MIL-C-63990A (Ref. 19). (This supersedes criterion 4.6.2j).
- l. Action time. The mean action time plus five standard deviations of the sample M855 and M856 test cartridges shall not exceed 3 milliseconds. Action time is defined as the sum of primer ignition time, propellant burning time and the time taken by the bullet to reach the gas port (Para. 3.10.4 of MIL-C-63989A and MIL-C-63990A (Ref. 15 and 19, respectively).

4.6.3 Test Procedure

- a. The acquisition of velocity, pressure and action time data was initially done by review of all information provided by the developer's acceptance test report on the ammunition delivered for test.
- b. The velocity, pressure and action time retest was done at ARDEC Test Site, Fort Dix, New Jersey. The test methods specified in Section 7 of SCATP 5.56-mm (Heavy Bullet) (Ref. 59) were used. Referenced M855 cartridges shall conform to MIL-C-070460A (Ref. 17).

(1) Velocity sensors (lumiline screens) were placed at 16.2 and 31.4 meters from the Mann barrel muzzle. This established the instrumental point at 23.8-meters (78-feet) which is consistent with the NATO test procedures for 5.56-mm ammunition. A total

of 30-rounds of each lot of ammunition was tested at each of the following temperatures: 70, 125, and -65°F, in accordance with paragraph 3 of MIL-C-63989A and MIL-C-63990A (Ref. 15 and 19, respectively).

- (2) The use of piezoelectric transducers (KIAG 6203) replaced the copper crusher cylinder method of determining pressure. A Mann barrel, appropriately machined for pressure stations was used. This electronic pressure, velocity, and action time (EPVAT) barrel was mounted in the normal manner.
- (3) The EPVAT barrel and basic set-up for pressure testing was used in concurrently determining action-time. The breaching components were fitted with a device that allowed signal transmission of the firing pin/primer contact to start the action time counter. The pressure transducer at the gas port location was used to stop the action time counter.

4.6.4 Test Findings

Tabulated results of the velocity, pressure, and action time tests are presented in Table 4.6-1 (M855 Ball ammunition) and Table 4.6-2 (M856 Tracer ammunition).

TABLE 4.6-1 EPVAT DATA, M855 BALL CARTRIDGE FROM MANN BARREL
NUMBER KSA 012

<u>Test Indices</u>	<u>Parameters</u>	<u>Meas. Units</u>	<u>Data by Temperature and Ammo Type</u>			
			<u>70°F Reference</u>	<u>70°F Test</u>	<u>125°F Test</u>	<u>-65°F Test</u>
Velocity	Mean	fps	2,987	2,969	3,020	2,915
	Std. Dev.		16	15	15	29
	Ext. Var.		56	62	62	127
	Corr. Mean		2,990	2,972	3,023	2,918
Pressure:						
(1) Chamber	Mean	psi	49,300	50,400	53,600	47,400
	Std. Dev.		1,000	700	900	1,500
	Ext. Var.		3,500	2,700	3,800	6,100
	Corr. Mean		49,869	51,000	54,200	48,000
(2) Port	Mean	psi	14,140	14,300	14,300	14,150
	Std. Dev.		90	110	100	110
	Ext. Var.		370	480	440	480
	Corr. Mean		13,492	13,650	13,650	13,500
Action Time	Mean	ms	0.83	0.92	0.93	0.95
	Std. Dev.		0.03	0.02	0.03	0.03
	Ext. Var.		0.14	0.09	0.16	0.18

TABLE 4.6-2. EPVAT DATA, M855 BALL CARTRIDGE FROM MANN BARREL
NUMBER KSA 013

<u>Test Indices</u>	<u>Parameters</u>	Meas. <u>Units</u>	<u>Data by Temperature and Ammo Type</u>			
			70°F <u>Reference</u>	70°F <u>Test</u>	125°F <u>Test</u>	-65°F <u>Test</u>
Velocity	Mean	fps	2,988	2,980	3,040	2,924
	Std.Dev.		15	14	19	18
	Ext. Var.		57	66	71	62
	Corr. Mean		2,990	2,982	3,042	2,926
Pressure:						
(1) Chamber	Mean	psi	49,700	50,300	54,400	47,700
	Std.Dev.		600	800	1,200	900
	Ext. Var.		2,100	3,100	5,100	3,000
	Corr. Mean		49,869	50,500	54,600	47,900
(2) Port	Mean	psi	13,490	13,560	14,230	13,680
	Std.Dev.		110	120	130	140
	Ext. Var.		420	450	450	660
	Corr. Mean		13,492	13,560	14,230	13,680
Action Time	Mean	ms	0.83	0.90	0.92	0.92
	Std.Dev.		0.01	0.05	0.03	0.03
	Ext. Var.		0.05	0.28	0.12	0.13

TABLE 4.6-3 EPVAT DATA, M855 BALL CARTRIDGES FROM MANN BARREL
NUMBER KSA 017

<u>Test Indices</u>	<u>Parameters</u>	Meas. <u>Units</u>	<u>Data by Temperature and Ammo Type</u>			
			70°F <u>Reference</u>	70°F <u>Test</u>	125°F <u>Test</u>	-65°F <u>Test</u>
Velocity	Mean	fps	2,990	2,966	3,034	2,912
	Std. Dev.		16	14	18	25
	Ext. Var.		63	58	66	125
	Corr. Mean		2,990	2,966	3,034	2,912
Pressure:						
(1) Chamber	Mean	psi	49,300	49,200	53,300	46,200
	Std. Dev.		800	800	1,200	1,300
	Ext. Var.		2,900	3,400	4,800	5,700
	Corr. Mean		49,869	49,800	53,900	46,800
(2) Port	Mean	psi	13,560	14,020	14,440	14,020
	Std. Dev.		160	110	120	110
	Ext. Var.		590	450	440	510
	Corr. Mean		13,492	13,950	14,370	13,950
Action Time	Mean	ms	0.82	0.92	0.94	0.94
	Std Dev.		0.01	0.02	0.03	0.05
	Ext. Var.		0.05	0.11	0.17	0.20

NOTE: Reference M855 Ball cartridge, Lot Number FNB83A001-001. Test M855 Ball cartridge, Lot Number LC84E300S286.

TABLE 4.6-4 EPVAT DATA, M856 TRACER CARTRIDGES FROM MANN BARREL
NUMBER V041

Test Indices	Parameters	Meas. Units	Data by Temperature and Ammo Type			
			70°F Reference	70°F Test	125°F Test	-65°F Test
Velocity	Mean	fps	2,992	2,856	2,902	2,784
	Std. Dev.		12	19	23	24
	Ext. Var.		48	78	114	95
	Corr. Mean		2,990	2,856	2,900	2,782
Pressure:						
(1) Chamber	Mean	psi	50,200	46,500	48,800	43,200
	Std. Dev.		800	1,100	1,400	1,200
	Ext. Var.		3,100	4,600	6,300	5,000
	Corr. Mean		49,869	46,169	48,469	42,869
(2) Port	Mean	psi	14,050	14,410	14,410	14,170
	Std. Dev.		110	110	110	130
	Ext. Var.		340	460	430	530
	Corr. Mean		13,492	13,852	13,852	13,612
Action Time	Mean	ms	0.83	0.86	0.85	0.87
	Std. Dev.		0.04	0.02	0.03	0.03
	Ext. Var.		0.19	0.10	0.14	0.14

NOTE: Reference M855 Ball, Lot number FNB83A001-001. Test M856 Tracer, Lot Number LC855300S335.

4.6.5 Technical Assessment

Comparison of the exhibited ammunition performance with the test criteria revealed that both the M855 Ball and M856 Tracer CONUS-produced ammunition fall within the specified limits for velocity, pressure (both chamber and port) and action time, as shown in the accompanying tables.

TABLE 4.6-5 ANALYSIS OF EPVAT CASE-MOUTH PRESSURE

Item Number	Indices Pressure	Criterion Values psi	Actual Values, psi, by Ammo/Barrel			
			M855			M856
			KSA-012	KSA-013	KSA-017	V-041
1	Average at +70°F	≤ 55,000	51,000	50,500	49,800	46,200
2	Maximum at +70°F	≤ 61,000	52,000	51,900	51,300	49,100
3	Average +3 σ @ +70°F	≤ 61,000	53,100	52,900	52,200	49,500
4a	Average at +125°F	≤ 60,000	54,200	54,600	53,900	48,500
4b	Variation from Item No.1	± 5,000	+3,200	+4,100	+4,100	+4,100
5a	Average at -65°F	≤ 60,000	48,000	47,900	46,800	42,900
5b	Variation from Item No.1	± 5,000	-3,000	-2,600	-3,000	-3,300

NOTE: All pressure values are rounded to the nearest 100 psi. Criterion values apply to both M855 and M856 cartridges. Item No. 2 is for an individual round. Item 4a and 5a criterion changed from ≤ 61,000 psi (Ref. 18).

TABLE 4.6-6 ANALYSIS OF EPVAT PORT PRESSURE

Item Number	Indices, Pressure	Criterion		Actual Values, psi, by Ammo Type			
		Values, psi		M855			M856
		M855	M856	KSA-012	KSA-013	KSA-107	V-041
1	Average at +70°F	-	-	13,650	13,560	13,950	13,850
2	Average -3 α @+70°F	>13,000	>12,400	13,320	13,200	13,620	13,520
3a	Average at +125°F	<12,000	<11,400	13,650	14,230	14,370	13,850
3b	Variation from Item No. 1 test at +125°F	+ 2,000	+ 1,500	0	+ 670	+ 420	0
4a	Average at -65°F	<12,000	<11,400	13,500	13,680	13,950	13,610
4b	Variation from Item No. 1 test at -65°F	+2,000	+1,500	- 500	+ 120	0	- 240

NOTE: Items 3a and 4a from M856 Tracer criterion changed from no value (Ref. 18).

TABLE 4.6-7 ANALYSIS OF EPVAT VELOCITY

Item Number	Indices, Velocity	Criterion		Actual Values, psi, by Ammo/Barrel			
		Values, psi		M855			M856
		M855	M856	KSA-012	KSA-013	KSA-017	V-041
1	Range at 70°F: Max. Min.	2960- 3040	2820- 2900	2972	2982	2996	2854
2	Std.Dev. at +70°F	≤ 40	≤ 40	15	14	14	19
3	Decrease from Item No. 1 tested at +125°F	≤ -250	≤ -250	+ 51	+ 60	+ 54	- 72
4	Decrease from Item No. 1 tested at -65°F	≤ -250	≤ -250	- 54	- 56	- 54	- 72

NOTE: In Item Number 3, any increase above the velocity obtained at +70°F is permitted. All rounds showed this characteristic.

TABLE 4.6-8. ANALYSIS OF EPVAT ACTION TIME

Item Number	Indices, Time	Criterion Values, ms	Actual Values, ms, by Ammo/Barrel			
			M855			M856
			KSA-012	KSA-013	KSA-017	V-014
1	Average +5 α @+70°F	3	1.02	1.15	1.02	0.96
2	Average +5 α @+125°F	3	1.08	1.07	1.09	1.00
3	Average +5 α @-65°F	3	1.10	1.07	1.19	1.02

The ammunition was safe to fire as evidenced by the EPVAT data being within specification limits; therefore, the criteria are met.

4.7 DISPERSION AND ACCURACY

4.7.1 Objectives and Issues

- a. Test objective. To determine if the test and control ammunition meets manufacturing specifications.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridges, 5.56-mm, M855 Ball and M856 Tracer?
- d. Other issue. Are all of the item's RAM requirements met?

4.7.2 Criteria

- a. The average horizontal and vertical linear standard deviations of the sample targets fired with M855 ammunition shall not exceed 6-inches when fired at a range of 600-yards. No individual targets shall exhibit horizontal or vertical linear standard deviations greater than 7.8-inches (Para. 3.11.1 of MIL-C-63989 (Ref. 14).
- b. No individual target shall exhibit horizontal or vertical linear standard deviations greater than 7.8-inches at 600-yards (Para. 3.11.1 of MIL-C-63989A (Ref. 15). (This supersedes criterion 4.7.2-a.)
- c. The mean point of impact of the sample M855 test cartridges fired at 600-yards must not deviate above or below the mean point of impact of the control cartridges (M855 reference) in a vertical direction by more than 10.8-inches (Para. 3.11.2 of MIL-C-63989 (Ref.14)
- d. The mean point of impact of the test cartridge at 600-yards shall not deviate above or below the mean point of impact of the reference cartridge in a vertical direction, by more than 10.8-inches. (Note: A reference round shall be in accordance with Dwg. 9357841 and shall have passed the testing criteria of MIL-C-70460) (Para. 3.11.2 of MIL-C-63989A (Ref. 15). (This supersedes criterion 4.7.2c.)
- e. The horizontal and vertical standard deviation of the sample M856 test cartridges shall not exceed 11.8-inches at 600-yards (Para. 3.11.1 of MIL-C-63990 (Ref.18).
- f. No individual target shall exhibit horizontal or vertical linear standard deviations greater than 11.8-inches at 600-yards (Para. 3.11.1 of MIL-C-63990A (Ref. 19). (This supersedes criterion 4.7.2e.)
- g. The mean point of impact of the sample M856 test cartridge at 600-

yards must not deviate above or below the mean point of impact of the control cartridge (CONUS-produced M855 Ball) in a vertical direction by more than 10.8-inches. (Note: The ball round shall have been accepted in accordance with MIL-C-63989) (Para. 3.11.2 of MIL-C-63990 (Ref. 18).

- h. The mean point of impact of the cartridge at 600-yards shall not deviate above or below the mean point of impact of the reference cartridge in a vertical direction, by more than 10.8-inches. (Note: A reference round shall be in accordance with Dwg. 9357841 and shall have passed the testing criteria of MIL-C-70460 (Ref. 19). (This supersedes criterion 4.7 2g.)

4.7.3 Test Procedure

- a. Basic test procedures are given in SCATP 5.56-mm (Heavy Bullet), section 11 (Ref.59). Specific procedures applicable to this test are given below.
- b. Dispersion and accuracy test data were initially obtained from the acceptance test report on the ammunition.
- c. The retest was fired at the ARDEC Test Site, Fort Dix, New Jersey. Procedures are described in the following paragraphs.
- d. The dispersion testing was done at a range of 600-yards. The belgian manufactured M855 reference ammunition, CONUS-produced M855 Ball, and M856 Tracer rounds were each fired for three 30-round targets. The cartesian coordinate measurements were taken from the boresight aiming point so that accuracy could also be determined. The Mann barrels used were cooled to ambient range temperature after each 30 rounds fired.
- e. Accuracy testing was a nonfired computational exercise which used the 600-yard dispersion data as its base. The purpose was to compare relative bullet strikes on the target for the different types of rounds fired.
- f. At no time during the firing were surface winds in excess of 5 mph.

4.7.4 Test Findings

The dispersion and accuracy data are reported in four tables, corresponding to the four separate tests conducted by ARDEC. Table 4.7-1 covers firing of M855 Ball reference and test rounds. Table 4.7-2 contains information on the firing of M855 reference and test rounds, and M856 Tracer test ammunition. Another test of M855 reference and M856 test cartridge is reported in Table 4.7-3. The final table in this data series (Table 4.7-4) presents information on the dispersion characteristics of the Belgian produced M856 Tracer cartridge (L110 type).

TABLE 4.7-1 MANN BARREL FIRED 600-YARD DISPERSION AND ACCURACY
TEST OF M855 BALL AMMUNITION

Data Indices	M855 Reference				M855 Test			
	1	2	3	Avg.	1	2	3	Avg.
Velocity, fps, at 78 ft:								
Maximum	3066	3059	3060	-	3027	3036	3011	-
Minimum	3006	3003	2995	-	2949	2946	2946	-
Average	3032	3031	3031	-	2991	2994	2983	-
Extreme variation	60	56	65	-	78	90	65	-
Standard deviation	15	16	17	-	19	20	16	-
Meteorological data:								
Temperature, °F	77	74	73	-	75	74	72	-
Relative humidity, %	48	58	61	-	51	58	61	-
Barometric pressure in. of mercury	29.9	29.9	29.9	-	29.9	29.9	29.9	-
Wind speed, mph	0	0-5	0-5	-	0	0-5	0-5	-
Dispersion data, ("):								
Extreme horizontal spread	14.7	12.2	15.4	-	15.7	18.0	16.8	-
Extreme vertical spread	18.6	16.7	15.8	-	24.0	17.6	22.3	-
Extreme spread	18.9	17.5	19.1	-	27.2	17.5	23.8	-
Horizontal standard deviation	3.5	2.6	3.5	3.2	4.3	4.6	3.6	4.2
Vertical standard deviation	3.8	4.2	3.8	3.9	5.5	3.7	4.8	4.7
Accuracy data, ("):								
Vertical difference between centers-of-impact	-	-	-	-	7.1	6.3	6.7	6.7

Notes: M855 reference, lot No. FN583A001-001.
M855 test, lot No. LC84E300S286.

Three Mann barrels, designated 1, 2, and 3 were used in this test.

TABLE 4.7-2 MANN BARREL FIRED 600-YARD DISPERSION AND ACCURACY
TEST OF M855 BALL AND M856 TRACER AMMUNITION

Data Indices	M855 Reference				M855 Test				M856 Test			
	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
Velocity, fps, at 78 ft:												
Maximum	3049	3037	3048	-	3055	3026	3006	-	2924	2898	2918	-
Minimum	2997	2980	2977	-	2935	2938	2941	-	2810	2830	2832	-
Average	3022	3014	3019	-	2977	2976	2972	-	2858	2866	2871	-
Extreme variation	52	57	71	-	120	88	65	-	114	68	95	-
Standard deviation	13	16	17	-	25	18	18	-	25	16	21	-
Meteorological data:												
Temperature, °F	70	68	65	-	70	67	64	-	69	67	62	-
Barometric pressure in of mercury	29.8	29.8	29.8	-	29.8	29.8	29.8	-	29.8	29.8	29.8	-
Wind speed, mph	0	0	0	-	0	0	0	-	0	0	0	-
Dispersion data (inches):												
Extreme hor. spread	9.0	12.4	9.5	-	17.8	20.6	14.9	-	48.1	44.1	41.5	-
Extreme vert. spread	13.8	13.4	14.6	-	13.0	15.1	19.2	-	42.8	41.9	48.2	-
Horizontal standard dev.	2.5	3.2	2.6	2.8	4.1	4.6	3.8	4.2	^a 13.1	9.2 ^a	12.2	11.5
Vertical standard dev.	3.4	3.2	3.2	3.3	3.9	4.4	4.5	4.3	10.5	9.5 ^a	12.2	10.7
Accuracy data (inches):												
Vertical diff. between C.I., between M855(ref) and test ammo	-	-	-	-	-5.6	-7.5	-10.0	-7.8	-12.3	-8.9	-11.5	^b 10.9

^a Does not satisfy requirements of criterion 4.7.2f (11.8 in. maximum).

^b Does not satisfy requirements of criterion 4.7.2h (10.8 in. maximum).

Notes: M855 Reference, lot No. FNB83A001-001.
M855 test, lot No. LC84E300S286.
M856 test, lot No. LC85D300S335.

Three Mann barrels, designated 1, 2, and 3 were used in this test.

TABLE 4.7-3. MANN BARREL FIRED 600-YARD DISPERSION AND ACCURACY TEST OF THE M855 AND M856 TRACER AMMUNITION

Data Indices	M855 Reference				M856 Test			
	1	2	3	Avg.	1	2	3	Avg.
Velocity, fps, at 78 ft:								
Maximum	3039	3025	3038	-	2926	2948	2924	-
Minimum	2981	2967	2981	-	2806	2807	2831	-
Average	3002	3001	3013	-	2855	2852	2870	-
Extreme variation	58	58	57	-	120	141	93	-
Standard Deviation	14	14	15	-	26	18	21	-
Meteorological data:								
Temperature, °F	64	65	66	-	64	65	66	-
Barometric pressure, in. of mercury	29.8	29.8	29.8	-	29.8	29.8	29.8	-
Wind speed, mph	5	2	5	-	5	1	4	-
Dispersion data, (in.):								
Extreme horizontal spread	9.6	13.4	12.4	-	28.6	32.5	39.1	-
Extreme vertical spread	10.0	15.5	15.7	-	44.2	37.9	31.7	-
Horizontal standard deviation	2.7	3.2	3.2	3.0	7.1	7.8	8.7	7.9
Vertical standard deviation	2.8	4.1	4.0	3.6	10.4	9.5	7.5	9.1
Accuracy data, (in.):								
Vertical difference between centers-of-impact	-	-	-	0	-8.8	-5.8	^a 0.0	2.9

Notes: Target no. 1 fired from barrel no. K5A044.
 Target no. 2 fired from barrel no. K5A043.
 Target no. 3 fired from barrel no. K5A040.
 M855 reference, lot No. FNB83A001-001; M856 test, lot No. LC85D300-S335.

Three Mann barrels, designated 1, 2, and 3 were used in this test.

^aSatisfies requirements of criterion 4.7.2h (10.8-inches, maximum) during this retest.

TABLE 4.7-4. MANN BARREL FIRED 600-YARD DISPERSION TEST OF M856 TRACER AMMUNITION (FN TYPE L110)

<u>Data Indices</u>	<u>M856, Control</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>Avg.</u>
Velocity, fps, at 78 ft.:				
Maximum	2982	2974	2952	-
Minimum	2919	2910	2895	-
Average	2949	2938	2917	-
Extreme variation	63	64	57	-
Standard variation	15	14	15	-
Meteorological data:				
Temperature. °F	75	76	77	-
Barometric pressure, in. of mercury	29.7	29.7	29.7	-
Wind speed, mph	0	0	0	-
Dispersion data, (in.):				
Extreme horizontal spread	25.4	22.0	19.2	-
Extreme vertical spread	22.6	18.6	24.2	-
Horizontal standard deviation	6.1	4.7	4.9	5.2
Vertical standard deviation	6.1	4.5	5.7	5.4

Notes: Target No. 1 fired from Barrel No. K5A040.
 Target No. 2 fired from Barrel No. K5A043.
 Target No. 3 fired from Barrel No. K5A044.
 M856 Tracer (L110 type-Belgian Manufacturer), Lot No. FNB83A001-001.

Three Mann barrels, designated 1, 2, and 3 were used in this test.

4.7.5 Technical Assessment

The CONUS-produced M855 Ball ammunition satisfied the criteria throughout all firings. The CONUS-produced M856 Tracer rounds produced mixed results, indicative of a round that was experiencing projectile quality control of problems during manufacture. Compounding this problem was the change in specification requirements which is now in effect, but was not when the test samples were produced. The change from using average values to using the values produced by the firing of each target in a series of targets, tightened the dispersion requirement. Retest of the tracer ammunition after initial failures, resulted in satisfying both the old as well as the revised criteria. A tabulation of the assessed results is given in Table 4.7-5.

TABLE 4.7-5. ASSESSMENT OF MANN BARREL FIRED M855 BALL AND M856 TRACER AMMUNITION FOR ACCURACY AND DISPERSION AT 600-YARDS

Criterion Reference			Test Meas. In., by Ammo/Trial				
			M855 Ref.		M855 Test		
Para. No.	Values, (in.)	Indices	1	2	1	2	
4.7.2a	6.0	Avg. HSD	3.2	2.8	4.2	4.2	
		Avg. VSD	3.9	3.3	4.7	4.3	
	7.8	Max Ind. HSD	3.5	3.2	4.6	4.6	
		Max Ind. VSD	4.2	3.4	5.5	4.5	
4.7.2c	10.8	Avg. Vert CI	-	-	-6.7	-7.8	
		Max Ind. CI	-	-	-7.1	-10.2	
			M855 Ref.	M856 Test	M856 Ctrl		
			2	3	2	3	4
4.7.2e	11.8	Avg. HSD	2.8	3.0	11.5	7.9	5.2
		Avg. VSD	3.3	3.6	10.2	9.1	5.4
4.7.2f	11.8	Max Ind. HSD	3.2	3.2	^a 13.1	8.7	6.1
		Max Ind. VSD	3.4	4.1	^a 12.1	^a 10.4	6.1
4.7.2g,h	+10.8	Avg. Vert CI	-	-	-10.9	-2.9	-
		Vertical CI ^b Max Ind. CI	-	-	-12.3	-8.8	-

^aFails to satisfy criterion limits.

^bValues given only for information.

CI = Center of impact

HSD = Horizontal standard deviation

Ind = Individual

Vert = Vertical

VSD = Vertical standard deviation

- b. The CONUS-produced ball and tracer ammunition were safe to fire, there being no signs of erratic flight which could endanger personnel. The use of tracer ammunition produced under the LCAAP (Remington Arms Corp.) projectile design (used in SAW ammunition assessment) was no longer applicable. Stocks of this item will eventually be superseded by the slightly shorter M856 Tracer projectile produced under LCAAP (Olin) projectile design. Provisional firings of this ammunition was done during the trajectory test. Results from that test showed no degradation in ballistic match. Dispersion of the new tracer projectile is supposed to be improved, due to improvements in quality control and changes in design. Failure of the tracer ammunition to satisfy requirements not in force at the time of manufacture and acceptance test (i.e., Criterion 4.7.2f) can not be charged against that ammunition.

4.8 BULLET PULL

4.8.1 Objective and Issues

- a. Test objective. To determine if the CONUS-produced M855 and M856 cartridges meet the requirement for minimum bullet extraction force.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Is the CONUS-produced M855 and M856 ammunition compatible with the SAW and M16A2 rifle?
- d. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridge, 5.56-mm, M855 Ball and M856 Tracer?
- e. Other issue. Are all of the test item's RAM requirements set?

4.8.2 Criterion

The force required to extract the bullet from the cartridge case shall not be less than 200N (45 lb) (Para. 3.3 of MIL-C-63989A and MIL-C-63990A) (Ref. 15 and 19, respectively).

4.8.3 Test Procedure

Testing was conducted in accordance with the procedures given in SCATP 5.56mm (Heavy Bullet), Section 5 (Ref. 59). The test sample consisted of 25 rounds of each cartridge type (CONUS-produced M855 Ball and M856 Tracer). The rate of pull was 3.5-inches per minute.

4.8.4 Test Findings

The results of the bullet-pull test are presented in Table 4.8-1 for 25-round samples of M855 Ball, lot No. LC83E300S286, and M856 Tracer, lot No. LC85D300S335.

TABLE 4.8-1 BULLET PULL TEST RESULTS

<u>Rd. No.</u>	<u>Force, lb.</u>	<u>Rd No.</u>	<u>Force, lb.</u>	<u>Rd No.</u>	<u>Force, lb.</u>	<u>Rd No.</u>	<u>Force, lb.</u>	<u>Rd No.</u>	<u>Force, lb.</u>	<u>Summary</u>
M855 Ball										
1	58.5	6	71.5	11	65.5	16	83.0	21	67.0	Mean= 68.2
2	75.0	7	65.0	12	65.0	17	68.5	22	60.0	Max.= 83.0
3	65.0	8	71.5	13	74.0	18	65.5	23	68.5	Min.= 57.6
4	66.0	9	77.0	14	60.5	19	70.5	24	72.0	ES = 26.0
5	77.0	10	60.5	15	65.0	20	57.0	25	76.5	
M856 Tracer										
1	78.5	6	93.0	11	85.0	16	63.0	21	68.0	Mean= 77.3
2	83.5	7	78.5	12	72.5	17	54.5	22	97.5	Max.= 97.5
3	55.5	8	72.5	13	90.5	18	91.5	23	83.0	Min.= 54.5
4	58.5	9	64.5	14	83.0	19	90.5	24	72.0	ES = 43.0
5	77.0	10	71.5	15	83.5	20	87.5	25	76.5	

4.8.5 Technical Assessment

- a. The minimum demonstrated bullet extraction force exhibited by the test ammunition (M855 Ball= 57.6 lb, M856 Tracer= 54.5 lb.) was above the minimum specified by the criterion (45 lb).
- b. The CONUS-produced ball and tracer cartridges did not debullet during handling/transporting of the ammunition or cycling through either the M16A2 Rifle or M249 SAW because of adequate projectile retention in the cartridge case. The test criterion was met.

4.9 RESIDUAL STRESS

4.9.1 Objective

Test objective. To determine if the case of the M855 and M856 cartridge is free from residual stress that could cause cracks or splits during storage or service use.

4.9.2 Criterion

The cartridge case shall not split when subjected to a one percent mercurous nitrate solution for 15 minutes (Para. 3.4 of MIL-C-63989A and MIL-C-63990A) (Ref. 15 and 19, respectively).

4.9.3 Test Procedure

Testing was conducted in accordance with the procedures of SCATP-5.56-mm (Heavy Bullet), Section 12 (Ref. 59). An initial sample of 50-rounds of each cartridge type was tested.

4.9.4. Test Findings

Twenty-five complete test cartridges and 25 empty but primed cartridge cases were subject to the Mercurous Nitrate Test. The test samples were from ammunition Lot No. LC84E300S286 (M855 Ball cartridge). There were no occurrences of cracks or splits in either of the two 25-item samples tested.

4.9.5 Technical Assessment

Comparison of the criterion with that of the test results showed that the test item conformed to its performance requirement.

5.1 TEST PART III- INTRODUCTION

This part of the test program assessed ammunition performance, including M27 links, as it related to operation and reliability of the M249 SAW. Subtests used in this assessment are listed in Table 5.1-1. Assessment of tracer performance was integrated into each of the subtests where that type of round was fired.

TABLE 5.1-1. INDEX OF SUBTESTS

<u>Para. No.</u>	<u>Subtest Description</u>	<u>Page No.</u>
5.2	Inspections.....	5-2
5.3	Endurance and Reliability.....	5-15
5.4	High Temperature (+155°F).....	5-40
5.5	Low Temperature (-65 °F).....	5-52
5.6	Temperature/Humidity.....	5-58
5.7	Smoke and Flash.....	5-61
5.8	Cook-off.....	5-79
5.9	Salt-Fog.....	5-82
5.10	Metal Parts Integrity.....	5-84
5.11	Secured Cargo and Rough Handling....	5-89
5.12	Noise.....	5-95
5.13	Water Spray.....	5-97

5.2 INSPECTIONS

5.2.1 Objectives and Issues

- a. Test objective. The overall objective was to determine if the observed performance of the test ammunition, when fired in the M249 SAW, demonstrated compatibility with the weapon to the extent that all test criteria were met.
- b. Critical issue. Has the CONUS-produced M855 and M856 ammunition met U.S. safety requirements?
- c. Critical issue. Is the CONUS-produced M855 and M856 ammunition compatible with the SAW?
- d. Critical issue. Does the CONUS-produced M855 and M856 ammunition meet the requirements set forth in the Military Specification for Cartridge, 5.56-mm Ball M855, and Tracer, M856?
- e. Other issue. Are all of the test item's RAM requirements met?

5.2.2 Criterion

The condition of all M249 SAW before test use must conform to applicable drawings and specifications for the manufacture and acceptance of those weapons (Test Agency devised, TECOM approved).

5.2.3 Test Procedure

- a. Inspection of the weapons was done using TOP 3-2-045 (Ref. 36) as a guide.
- b. Barrel land and groove diameter measurements were taken at 1 inch intervals, starting at the commencement of rifling and ending at the muzzle at the point of full rifling.
- c. Barrel chamber measurements were obtained from precision casts of the chamber. Measurements were made with an optical comparator to confirm that the dimensions of the chamber conform to those given in Figure 4.2-1.
- d. Firing pin protrusion measurements were made with a dial-indicating height gauge.
- e. Headspace measurements were taken with GO and NO-GO plug gauges.
- f. Extractor protrusion and clearance were checked with GO/NO-GO type gauges.

- g. Firing pin indent in copper cylinders was obtained by placing the cylinder and its holding fixture in the weapon chamber. The barrel muzzle was placed on a flat, hard surface (weapon in a vertical, butt-plate-up position). The bolt was released from the sear-up position. The copper cylinder was then carefully removed from the holder and the indent measured. This was done by taking the before-test length of the cylinder and subtracting the after-test length measured to the bottom of the indent. Three trials were made.
- h. Magnetic particle inspection was made of all gun components subjected to high pressure and/or extreme wear during firing.
- i. After completion of the initial measurements and visual inspections, each M249 was fired to check functioning and establish baseline velocity and dispersion data. All firing was from the weapon mounted in a test stand. Velocity sensors were located 16 and 31-meters forward of the gun muzzle. A dispersion target was located at 50-meters.
- j. Dispersion firing consisted of three 10-round targets per barrel for each weapon. Firing was in the automatic mode. Each barrel was boresighted on target to establish a reference point. All target measurements were then taken from that reference point so that accuracy as well as dispersion could be determined. The velocity of each round was recorded. Only CONUS-produced M855 Ball cartridges were fired in this portion of the test. The range was 50-meters. Velocity sensors were positioned at 16 and 31-meters.
- k. Belt-pull force was determined for each weapon for all gas regulator settings and barrels assigned to the weapon. Testing was in accordance with paragraph 6.2.20 of TOP 3-2-045 (Ref. 36). Three trials for each test condition were required. Only CONUS-produced M855 Ball ammunition was used for this portion of the test.
- l. The final inspection firing was the function check. Each weapon was fired in accordance with paragraph 4.5.6 of PD-QAF-1 (Ref. 28). Cyclic rate was recorded for each burst fired. Only CONUS-produced M855 Ball ammunition was used for this portion of the test.

5.2.4 Test Findings

Eight M249 SAW's were inspected for conformance to manufacturing specifications. The detailed barrel bore measurement data are located in Appendix B. The identification of barrels as to whether or not they were "plugged" not was resolved through conversations with the weapon manufacturer's representatives. The term "plugged" refers to the manufacturing process which was used to prevent damage to the bore plating during phosphate coating of the barrel exterior. The bore was plated, then "plugged" before being immersed in the phosphate solution. The plugs prevented the solution from entering the bore and undermining the plating (this could cause a reduction in barrel life due to plating break up under firing pressure). Figure 5.2-1 shows the numerical markings which designated "plugged". None of the barrels used during the test of CONUS produced ammunition were of the "plugged" variety. The marking was found on the under side of the barrel, to the rear of the gas piston.

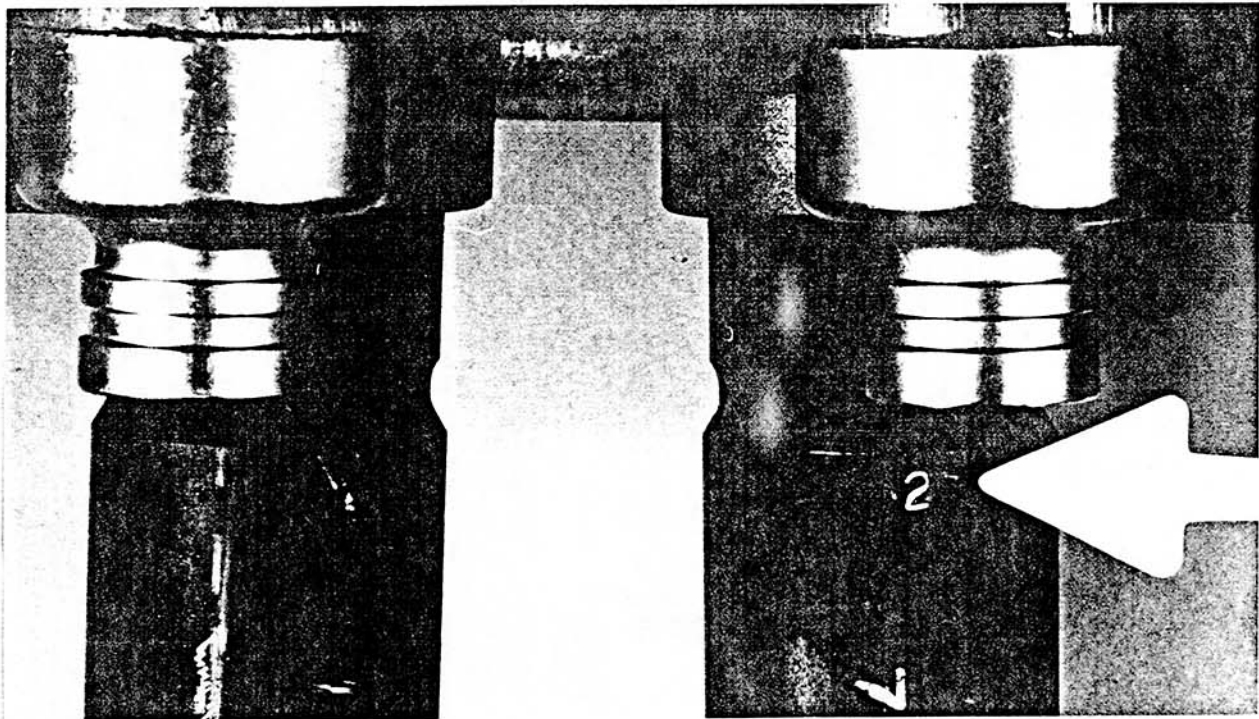


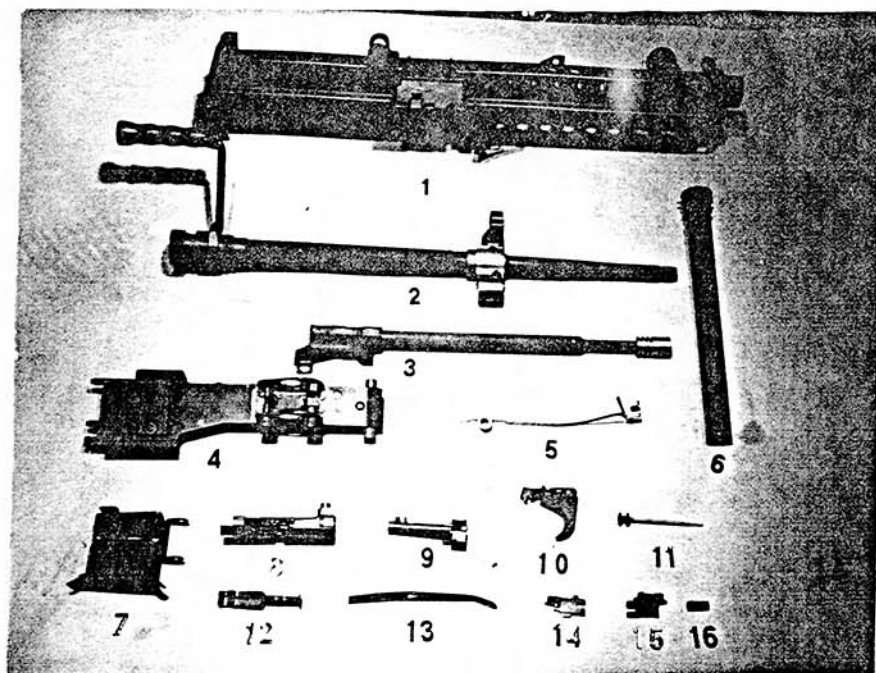
Figure 5.2-1. "Plugged"-barrel marking, indicated by the No. 2 (arrow).

Inspection of the receiver rails of the eight weapons was made to determine if the blind welds of the left and right bolt guide rails were all intact. Table 5.2-1 presents the results of this inspection.

TABLE 5.2-1. M249 SAW RECEIVER INSPECTION

<u>Wpn Identification</u>		<u>Rail Loose</u>		<u>Remarks</u>
<u>Serial No.</u>	<u>Test No.</u>	<u>Right</u>	<u>Left</u>	
001240	1	N	N	Heavy burr at top, front edge of left rail.
002279	2	N	Y	No burr at top, front edge of left rail.
002305	3	N	Y	Moderate burr at top, front edge of left rail.
002437	4	N	N	Same as No. 3.
002594	5	N	N	Same as No. 1.
014229	6	N	N	Same as No. 3.
014230	7	N	N	Slight burr at top, front edge of left rail.
014231	8	N	N	Same as No. 2.

Magnetic particle inspection found minor cracking in the welds of the receiver. None were in critical locations. Figure 5.2-2 shows the parts that were inspected and Figures 5.2-3 and 5.2-4 shows the crack locations on the receivers.



<u>Test No.</u>	<u>Description</u>	<u>Item No.</u>	<u>Description</u>
1	Receiver assembly	9	Bolt
2	Barrel assembly	10	Trigger assembly
3	Piston assembly	11	Firing pin
4	Cover assembly	12	Sear
5	Feed lever	13	Ejector
6	Gas cylinder assembly	14	Rear cartridge guide
7	Feed tray assembly	15	Front cartridge guide
8	Slide assembly	16	Extractor

Figure 5.2-2. Machine gun, 5.56-mm, M249: referenced components No. 1 through 3, 5 through 9, and 11 through 16 were inspected by the magnetic- particle method and Components No. 4 and 10 by the liquid penetrant method.

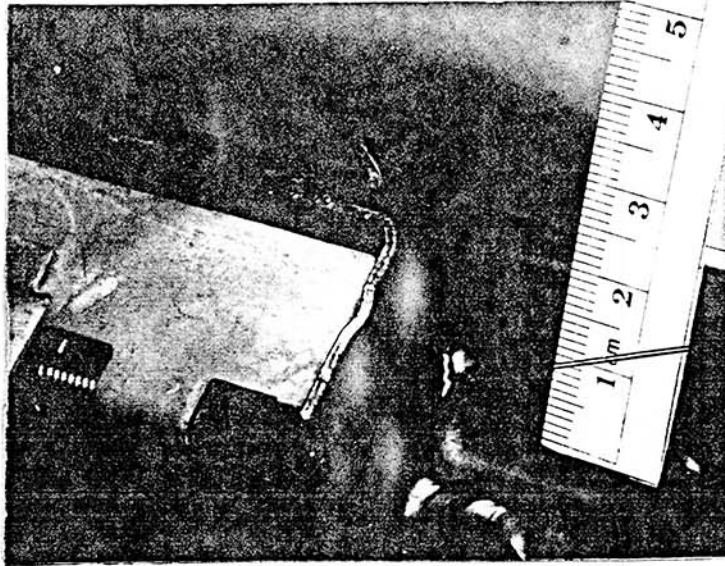


Figure 5.2-3. Receiver (referenced Component No. 1), machine gun 5.56-mm, M249, SN 002437: magnetic particle crack pattern noted before firing showing a 0.6-cm crack in bottom front magazine well weld (arrow).

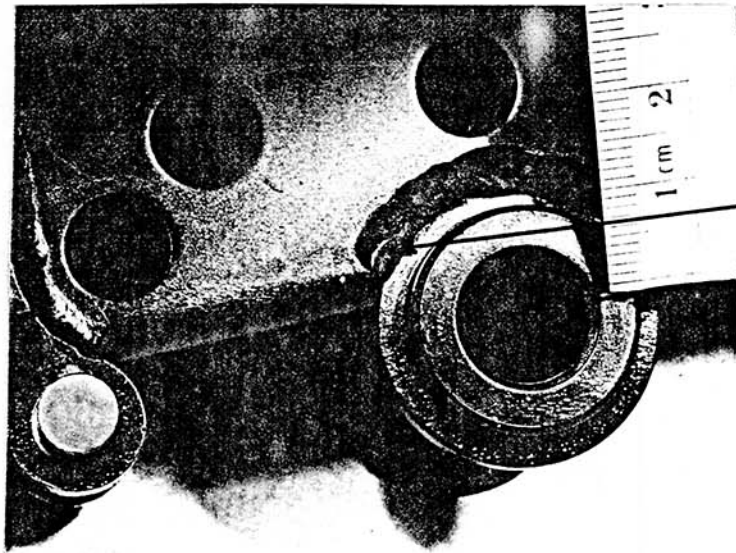


Figure 5.2-4. Receiver (reference Component No. 1), machine gun 5.56-mm, M249, SN 002305: magnetic particle crack pattern noted before firing showing 0.4-cm crack in weld (arrow) on M249, SN 002305, in the area of tripod mounting boss (left side).

The results of the belt-pull test were documented in Laboratory Report No. 85-DF-(F)-37 (Ref. 47). The information contained in that report is summarized in Table 5.2-2. M855 Ball test ammunition from functional Lot No. LC850D300S339 was used in this test.

TABLE 5.2-2. INITIAL BELT PULL INFORMATION

Wpn		Belt Pull, N, by Gas Regulator Setting and Trial No.								
Identification		Bbl	Normal Setting				High Setting			
Serial No.	Test No.		1	2	3	Avg.	1	2	3	Avg.
001240	1	1	87.1	96.6	79.6	87.8	81.4	74.5	67.8	74.6
		S1	82.2	93.8	81.7	85.9	115.1	95.3	81.4	97.3
002279	2	2	83.0	88.0	85.8	85.6	91.7	102.6	87.1	^a 93.8
		S2	89.5	93.5	96.5	93.2	88.5	67.2	50.0	68.6
002305	3	3	75.6	82.6	96.0	84.7	^b -	81.6	93.3	^c 87.4
		S3	90.3	90.4	89.4	90.0	97.0	72.5	78.4	82.6
002437	4	4	98.3	95.8	91.7	95.3	116.1	121.0	122.5	^a 119.9
		S4	108.8	101.5	103.8	104.7	100.0	130.7	102.5	111.1
002594	5	5	68.0	67.8	67.8	67.9	74.2	100.4	87.2	87.3
		S5	53.7	67.5	54.1	58.4	101.0	94.4	93.6	96.3
014229	6	6	95.3	103.5	107.5	102.1	99.3	103.9	115.0	^d 106.1
		S6	104.0	95.8	104.7	101.4	126.2	126.2	126.0	126.1
014230	7	7	95.0	87.6	94.6	92.4	112.1	78.9	80.6	^c 90.5
		S7	101.3	101.3	95.4	99.3	119.7	70.6	93.5	^c 94.6
014231	8	8	89.2	89.4	100.0	92.9	118.6	107.8	109.3	^c 111.9
		S8	102.1	102.6	102.9	102.5	120.9	102.9	102.6	108.7

^a One belt separation occurred on each of the three trials.

^b Low value of 46.0 N not counted due to belt separation.

^c Belt separation occurred on one of the three trials.

^d Belt separation occurred on two of the three trials.

S - Spare (barrel).

Note: To convert belt pull force from N to lb-f, divide by 4.448. The minimum acceptable belt pull is 61 N (13.71 lb-f).