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APPENDIX 2

REPORT
OF THE
M16 RIFLE REVIEW PANEL

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1 JUNE 1968

AUDIT TRAIL AND ANALYSIS OF M16A1
WEAPON AND AMMUNITION SYSTEM TESTS

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DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF
FOR RESEARCH, DEVELOPMENT, AND ACQUISITION
WASHINGTON, DC 20310

REPLY TO
ATTENTION OF

DAMA-WSW

1 FEB 1991

MEMORANDUM FOR THE RECORD

SUBJECT: Declassification Action - Report of the M16 Rifle Review Panel (C) dated 1 June 1968. [redacted]

1. The Report on the M16 Rifle Review Panel dated 1 June 1968 was prepared for the Office of the Chief of Staff of the Army, by the Office of the Director of Weapons System Analysis. The Ground Combat Systems Division, Office of the Director of Weapons Systems, Office of the Deputy Chief of Staff for Research, Development and Acquisition, is the successor to the originator of the report.

2. This office has completed a review of subject report and appendices 1 through 11 and has determined classification of Confidential is no longer needed. The report is now Unclassified. Selected extracts of the report are at Enclosure 1.

3. Notification of this declassification will be forwarded to all distribution addressees and a declassified copy will be forwarded to the Defense Technical Information Center, Cameron Station, for file.

WILLIAM G. COOMER
Colonel, GS
Chief, Ground Combat Systems
Division

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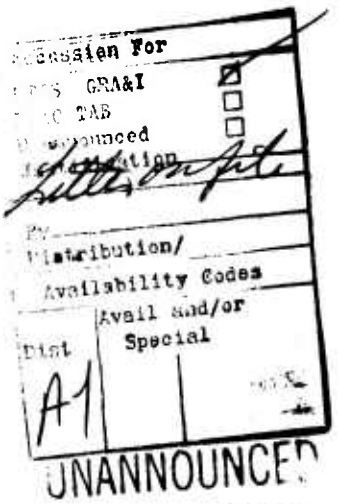
APPENDIX 2

AUDIT TRAIL AND ANALYSIS OF M16A1

WEAPON AND AMMUNITION SYSTEM TESTS



1 June 1968

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Appendix 2

Audit Trail and Analysis
of M16A1
Weapon and Ammunition System Tests

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Appendix 2

AUDIT TRAIL AND ANALYSIS OF M16A1

WEAPON AND AMMUNITION SYSTEM TESTS

A. Introduction

The M16A1 weapon and ammunition system did not follow the traditional cycle of research, development, testing, and evaluation. The initial exploratory efforts of the 1950's led to the development of the caliber .22 lightweight rifle cartridge, and two companion rifles by Armalite and Winchester. Subsequent to comparative tests in 1958, developmental effort focused on the Armalite AR15 caliber .223 light weight rifle, with the final engineering test being completed in November 1960. The AR15 was adopted by the U.S. Air Force in 1961 as its standard replacement for the M1 and M2 carbines. At the same time, the Army dropped developmental and testing activity, when the Ordnance Corps directed its institutional attention to producing satisfactory M14 rifles and to initiating development of the all-purpose handheld weapon (APHHW) system, which in 1962 became known as the Special Purpose Individual Weapon (SPIW). In 1962 the Office of the Secretary of Defense (OSD) directed field testing of the AR15 in Vietnam. The enthusiastic reception accorded the AR15 by the Vietnamese and American soldiers who tested it, together with the fact that the Air Force had adopted it, OSD was interested, and the President had given it his attention, led to a worldwide comparative evaluation of the AR15 with

the then issued M14, and the Soviet AK47 assault rifle.

As a result of the comparative evaluation the Secretary of the Army asked the Secretary of Defense in January 1963 for authority to procure 50,000 to 100,000 AR15's and the Secretary approved the request. The Army plan was to procure the AR15 for airborne, air assault, and special forces units only; the light weight of the AR15 made it especially suitable for these units. The M14 was to remain the standard arm of the mainline Army divisions.

During 1963 and 1964 there was only limited formal testing on the AR15, designated by then the XM16E1, because it was a special purpose, limited production item and was carried as excess to the Army's rifle requirements. The expanding commitment in Vietnam altered the Army's position, especially when U.S. troops undertook combat missions and requested large issues of the XM16E1. By 1965, the demand for increased firepower left insufficient time to conduct a thorough testing and evaluation program, with the result that the XM16E1 joined the Vietnam war as the basic infantry rifle with few improvements on the 1960 and 1963 prototype versions. On 23 February 1967 the Army classified the XM16E1 Standard A and changed its designation to M16A1. The engineering test basis for this action was the series of tests conducted during the 1965-1966 Army Small Arms Weapons Systems (SAWS) Study at Development and Proof Services

(D&PS) at Aberdeen Proving Ground and at other U.S. Army Test and Evaluation Command (USATECOM) installations.

Since production began in March 1964 at Colt's, the developmental and testing history of the M16A1 has consisted of a series of product improvement actions. As a consequence of being a limited production item for several years, and having modifications always tested as product improvements, the M16A1 has had a confused history of test and evaluation. Over 250 tests have been conducted, some related, others independent or with conflicting results. The objectives and methods of the tests and the validity of test data and conclusions vary widely among these tests because the M16 received scant attention for much of the period, and there was insufficient time to make up for neglected developmental activity after it was accepted as the United States' rifle for the Vietnam war.

The main body of the appendix analyzes the tests and evaluations of the M16A1 to determine the thoroughness and validity of test procedures and results. The principal purpose of this analysis is to determine how these test and evaluation practices may be strengthened for application to future weapon systems. Since it would be difficult and unprofitable to attempt an analysis of all M16 tests, only tests that were especially significant have been chosen for analysis. These include the SAWS tests, for example, which

are significant because they are recent, extensive, and served as the basis of the M16A1 type classification action and the series of tests on buffer designs. The analysis concludes by focusing on particular aspects of the testing program in order to identify, where possible, gaps in the test data collected, and to discuss the validity of the statistical design of tests, the test criteria, the significance of test results, the adequacy of follow-on weapon design and reliability data analysis, and the consistency of follow-on actions with test results.

At Inclosure 2-1, beginning on page 2-91, is a chronological display of 270 tests and evaluations of the M16A1 system, together with indications of subsequent tests, actions, evaluations, and decisions associtated with each test. This audit trail analysis of tests also includes the evaluations by senior headquarters of the major series of tests and correlates tests and evaluations with subsequent decisions. For convenience, the audit trail is divided into five time periods:

The early M16A1 developmental period prior to 1962.

The 1962-1963 worldwide comparative evaluation of the AR15, M14, and AK47 rifles, directed by the Secretary of Defense.

The period between the 1962-1963 comparative evaluation and the 1965-1966 Army Small Arms Weapons Systems (SAWS) Study.

The 1965-1966 Saws Study.

The period of test and evaluation since the 1965-1966 SAWS Study.

B. Analysis of the SAWS Study Tests

The Chief of Staff directed on 12 November 1964 that the Army Staff initiate a review and evaluation of the Army Small Arms Weapons Systems (SAWS), to include a study of doctrine, desired characteristics, and test and evaluation of existing weapon systems. The object was to develop the necessary analytical background upon which to base a program for replacing existing stocks of small arms (as the inventory dropped below requirements), or for replacing the inventory with weapon families of demonstrated superiority with respect to cost effectiveness.

While only portions of the SAWS Study dealt with the XM16E1 system, the SAWS tests did include major evaluations of the XM16E1 rifle and the associated 5.56mm M193 ball and M196 tracer cartridges. The SAWS Study formed the basis for the 7 November 1966 Chief of Staff decision to seek a one-rifle Army inventory based upon the XM16E1 rifle. Further, the SAWS tests formed the engineering basis for the 23 February 1967 classification of the XM16E1 as the Standard A M16A1 rifle.

In the following analysis of the SAWS Engineering and Service Tests, the discussion is in terms of both the M14 and the XM16E1 rifles. Other systems - notably the Stoner - were evaluated as well, but the M14 and XM16E1 were tested as standard items, and discussion of their tests demonstrates the general validity and significance of the

tests of other systems conducted at the same time. On the other hand, to put the discussion in terms of the XM16E1 alone would suggest that the critical comments have only narrow applicability, when indeed they pertain to the tests in general. Also, presentation of data for both the then-limited production XM16E1 and the Standard A M14 provides a basis for evaluation of the analytical comments.

The SAWS Engineering Test

In the SAWS tests the test details did not clearly support the objectives. USATECOM was directed by the U.S. Army Combat Developments Command (USACDC) to determine the functioning of test systems under all adverse conditions, including rain, snow, salt water, dust, and mud after submersion and at extreme temperatures, as stated in AR 705-15, Operation of Materiel Under Extreme Conditions of Environment.[1/]

The mud subtest was conducted in such a way that the functioning of test systems could not be determined. Two rifles of each type fired one magazine each with the results given below.

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1 USACDCIA Ltr to CG, USACDCCAG, 11 Mar 65, Characteristics and Standards Against Which to Conduct Engineering-Service Type Tests for Small Arms Weapons Systems (SAWS) Program, p. 8.

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Table 2-1 — XM16E1 and M14 MALFUNCTIONS in the SAWS ENGINEERING MUD SUBTEST

20 Rounds Fired per Weapon

XM16E1	No. 1	2 failures to eject 3 failures to fire
	No. 2	no malfunctions
M14	No. 1	3 failures of the bolt to close 15 failures to fire 1 failure of the bolt to remain to the rear[a]
	No. 2	16 failures of the bolt to close 14 failures to fire 1 failure of the bolt to remain to the rear[a] 4 failures to eject

[a] Did not cause a stoppage.

When one rifle has 5 stoppages in 20 rounds, and another rifle of the same type has none; or when one has 34 stoppages in attempting to fire 20 rounds, while another of the same type has only 18 stoppages in 20 rounds, the possibility of an interaction between the environmental condition and the individual weapon is evident.

When test items give results with the variability between rifles of the same type as great as that indicated above, it is misleading and statistically impossible to apply the results obtained from the test sample to the entire population of rifles represented in the tests. The results obtained are very likely

peculiar to a single weapon. Determination of a true XM16E1 performance level applicable to the population of XM16E1's and the true M14 performance level is impossible under such conditions. Furthermore, one has been unable to determine the validity of the criteria. It is possible that the mud was so dense as to mask significant differences between systems, or that the differences between individual weapons masked important effects of the mud environment, or that 20 rounds were insufficient to prove the relative merits of competing systems.

The only conclusion drawn from the mud subtest in the SAWS Engineering Test report was that the dust cover on the XM16E1 was a feature "desirable beyond the nice-to-have category."[2/] USATECOM reached this conclusion evaluating the XM16E1 dust cover, even though the test data are not statistically convincing. No comment was made of the performance of other systems under the same environmental conditions.[3/]

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2 USATECOM, Engineering Test of Small Arms Weapons Systems (SAWS) Partial Report (DPS-1851), December 1965, Vol. I, p. 137. Hereafter cited as the SAWS Engineering Test, Partial Report.

3 Little could be said of the results of the mud test of the Stoner 5.56mm rifle, which was tested at the same time. One Stoner rifle had three failures to eject in firing 30 rounds. The second had 24 failures of the bolt to close and 21 failures to fire in firing 30 rounds.

Because of the small sample sizes and the variability between individual weapons, the results of the engineering environmental subtests, such as the mud subtest, can give only an indication of weapon performance, and even then without great assurance. This fact is amplified in Table 2-2 which presents, for comparison, data on the variability between test items for the XM16E1 and M14. Note that in several instances the stoppages of one of the two XM16E1's were attributed to the weapon, and not the environmental condition in which the weapons were tested. In particular, one XM16E1 which was prone to failures to eject was used as one half of the XM16E1 sample in four of the nine environmental subtests. (See Table 2-2, especially footnotes a-d.) Its malfunctions were reported against the XM16E1 in evaluation of the environmental test results.

TABLE 2-2 — SAWS ENGINEERING ADVERSE CONDITIONS TEST DATA

Subtest	Weapon	Number of Stoppages Reported By Weapon Number 1	2	Rounds Fired per Weapon
Sand	XM16E1	13[a]	0	100
	M14	16	9	100
Salt water	XM16E1	8[b]	0	100
	M14	1	0	100
Temperature - humidity	XM16E1	4[c]	0	100
	M14	1	0	100
Water spray	XM16E1	31[d]	5	600
	M14	3	6	600
Dust	XM16E1	1	4	20
	M14	3	23	20
Mud	XM16E1	5	0	20
	M14	18	34	20
Extreme high temperature	XM16E1	26[e]	13[f]	1,200
	M14	4	1	1,200
Extreme low temperature	XM16E1	222	29	3,000
	M14	5	4	3,000
Unlubricated	XM16E1	59[g]	2	3,000
	M14	14[h]	3	3,000

[a] An explanatory note in the test report states that these 13 failures to eject in XM16E1 Number 136623 were not attributed to the deleterious effects of sand. The suggestion is that they were peculiar to the weapon. Nonetheless, they are counted in all tabulations of malfunctions.

[b] These malfunctions were failures to eject in the same rifle that had 13 failures to eject in the sand subtest. (See a, above.) They were not attributed to the environmental conditions.

[c] These stoppages were failures to eject with XM16E1 Number 136623.

[d] Of these stoppages, 29 were failures to eject. This was XM16E1 Number 136623.

[e] The same weapon, Number 137291, was used for the extreme low-temperature test.

[f] The same weapon 137658, was used for the extreme low temperature te

[g] Fired only 1,000 rounds.

[h] Fired only 1,500 rounds.

weapon-peculiar malfunctions (with incidence
ıll but obliterates any useful output from the
nditions. See Tables 2-3 and 2-4 which cite
ineering Test. The differences in the total
r the entire test sample,[4/] total stoppages
ing rifle for the XM16E1 and M14 respectively,
e in the sample are dramatic. The average stop-
btests were:

All But Worst Rifle	Worst Rifle	Entire Sample
10	44	22
3	16	7

s that the M14 is 22/7 = 3 times as reliable as
id be that the better XM16E1's in the test sample
he population of XM16E1's and that the typical
M14 did in these tests. The comparative
be then that the XM16E1 rifle is 16/10 =
the M14. There is no answer with such a

st used a rifle sample size of 3. The
n, smoke, and flash subtests had a sample
ests had a sample size of 2.

TABLE 2-3 — SAWS ENGINEERING TEST RESULTS, XM16E1 RIFLE

Subtest	Entire Sample Less the Worst Weapon			Worst Weapon			Stoppage Rate for Entire Sample
	Stoppages	Rounds Fired	Stoppage Rate	Stoppages	Rounds Fired	Stoppage Rate	
Accuracy	10	956	10	-	0	-	10
Sand	0	100	0	13[c]	100	130	65
Salt water	0	100	0	8[c]	100	80	40
Temperature - humidity	0	100	0	4[c]	100	40	20
Water spray	5	600	8	31[c]	600	52	26
Dust	1	20	50	4	20	200	125
Mud	0	20	0	5	20	250	125
Extreme high temperature	13	1,200	11	26	1,200	22	16
Extreme low temperature	29	3,000	10	222	3,000	74	42
Gas contamination	9[a]	409	22	-	-	-	22
Smoke	15[b]	575	26	-	-	-	26
Flash	1	700	2	-	-	-	2
Unlubricated	2	3,000	1	59	1,000	59	15
Reliability	275	23,988	11	403	8,987	45	21
Sustained fire	50	4,403	11	111	4,868	23	17
Total	410	39,171	10	886	19,995	44	22

[a] This was weapon 136623 and 6 of these stoppages were failures to eject. See Table 2-2, especially footnotes a-d.

[b] This was weapon 136623 and 10 of these stoppages were failures to eject

[c] This was weapon 136623.

TABLE 2-4 — SAWS ENGINEERING TEST RESULTS, M14 RIFLE

Subtest	Entire Sample Less the Worst Weapon			Worst Weapon			Stoppage Rate for Entire Sample
	Stoppages	Rounds Fired	Stoppage Rate	Stoppages	Rounds Fired	Stoppage Rate	
Accuracy	4	1,262	3	-	0	-	3
Sand	9	100	90	16	100	160	125
Salt water	0	100	0	1	100	10	5
Temperature - humidity	0	100	0	1	100	10	5
Water spray	3	600	5	6	600	10	8
Dust	3	20	150	23	20	1,150	650
Mud	18	20	900	34	20	1,700	1,300
Extreme high temperature	1	1,200	1	4	1,200	3	2
Extreme low temperature	4	3,000	1	5	3,000	2	2
Gas contamination	1	673	1	-	-	-	1
Smoke	0	360	0	-	-	-	0
Flash	0	430	0	-	-	-	0
Unlubricated	3	3,000	1	14	3,000	5	3
Reliability	50	24,130	2	111	9,686	11	5
Sustained fire	27	4,599	6	76	4,407	17	11
Total	123	39,594	3	291	22,233	13	7

Results of the SAWS Engineering Tests

The data gathered in the adverse conditions subtests described above were utilized in two ways to determine the results of the SAWS Engineering Test. First they were the basis for the USATECOM evaluation of the test weapons against the USACDC prescribed performance characteristics and standards. These characteristics and standards are cited in Table 2-5, together with test results for the XM16E1 and M14 and analytical comments. In general, the criteria are based on comparative data, for example: dispersion with the bipod shall be less than that measured without the bipod, or reliability at extreme temperatures should not be less than reliability at ambient temperature. Because of the small sample sizes these criteria cannot be applied meaningfully. The data basis for these comparisons is frequently distorted by poor performance of one weapon in the sample, thereby invalidating the comparison itself.

The second utilization of the SAWS Engineering Test data was to provide a statement of weapon system reliability. The data obtained in the reliability subtest were the basis for the USATECOM limited evaluation on weapon mechanism performance. The three M14E2 automatic rifles had .88 stoppages per 1,000 rounds fired, thereby establishing the reliability of the basic M14-M14E2 design. The less reliable M14 performance, 4.76 stoppages per 1,000 rounds, was attributed to poor quality control. On the other hand, while the

TABLE 2-5 — SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a/] XM16E1	Results[a/] M14	Analytical Comment
Simplicity of design and construction; weight; and length.	Be comparable to the M14 and commensurate with the intended tactical role.	M	M	The significance of being commensurate with the intended tactical role is not well defined, but as this is a general performance statement, it need not be well defined.
Easily identifiable, positive safety		M	M	None.
Capability of firing safely with bayonet attached.		M	M	None.
Capability of firing area munitions safely.	Fire standard rifle grenades in hand-held position.	F	M	Area fire munitions were taken to be the standard rifle grenades. No consideration was given to firing 40mm grenades from the muzzle, although such grenades exist. The report is not clear on how many broken stocks occurred when the rifles were supported on soft-ground and how many broke when the rifles were concrete-supported.
Sound and blast.	Have as maximum, 140 decibels.	F	F	The Human Engineering Laboratory (HEL) has reported that all current rifle systems have associated noise levels above the threshold of possible ear damage.
Capability of delivering selectively semiautomatic, full automatic, and controlled burst automatic fire.		M	M	Among all the SAWS Engineering Test weapons, only the Colt weapons (XM16E1, automatic rifle, and sumachine gun) had burst control capability. Therefore, the statement that the M14 met the criteria is not obvious.
Semiautomatic fire accuracy.	Average extreme spread not to exceed 9 inches at 100 meters.	S	F	Average extreme spread data are: XM16E1 at 100 meters 4.3 inches M14 at 100 meters 10.4 inches

Source: These results were extracted from USATECOM, Engineering Test of Small Arms Weapons Systems(SAWS) Partial Report (DPS-1851), December 1965, Vol I, and Final Report (DPS-1970), March 1966, Vol I.

a/ Footnotes on page 2-21.

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a] XM16E1	Results[a] M14	Analytical Comment
Resistance to deleterious effects of sand.	Average stoppage rate for each weapon tested not to exceed 5 per 100 rounds.	F	F	One XM16E1 had no malfunctions. The other had 13 failures to eject, none attributed to the effects of sand. Yet, the XM16E1 failed to meet the standard. The two M14's had 16 and 9 stoppages, respectively.
Resistance to deleterious effects of salt water	Average stoppage rate for each weapon tested not to exceed 5 per 100 rounds.	M	S	One XM16E1 had no malfunctions. The other (the same weapon that had stoppages in the sand test) had 8 failures to eject, none attributed to the effects of salt water. Yet the XM16E1 failed to meet the standard. The two M14's had 1 and 0 stoppages, respectively.
Resistance to rust and corrosion during use and storage.	Average stoppage rate for each weapon tested not to exceed 1 per 100 rounds.	F	S	One XM16E1 had no malfunctions. The other (the same weapon that encountered stoppages in the sand test) had 4 failures to eject. Despite the demonstrated susceptibility of this weapon to ejection failures, it was used in this test. As a result the XM16E1 failed to meet the performance standard. The two M14's had 1 and 0 stoppages, respectively.
Functioning under adverse rain conditions.	Average stoppage rate for each weapon tested not to exceed 1 per 100.	F	S	One XM16E1 had 5 stoppages. The other (again the malfunctioning weapon used in the sand test) had 29 failures to eject, and only 2 other stoppages in 600 rounds. With the repeated failures to eject, the XM16E1 failed the test standard. The two M14's had 3 and 6 stoppages in the 600 rounds, respectively.
Functioning under adverse dust conditions.	Average stoppage rate for each weapon tested not to exceed 2 per magazine.	M	F	Both the XM16E1 and the M14 fell below the standard, although the XM16E1 was significantly better (5 as compared to 26 stoppages in 40 rounds).
Functioning under adverse mud conditions.	Average stoppage rate for each weapon tested not to exceed 2 per magazine.	M	F	Both the XM16E1 and the M14 fell below the standard, although the XM16E1 was significantly better (5 as compared to 52 stoppages in 40 rounds).

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a/] XM16E1	Results[a/] M14	Analysis of Comment
Functioning under high temperature extremes.	Not to be less reliable at high temperatures than at ambient temperatures.	M	M	The performance standard was not valid. The two XM16E1's had 11 and 22 stoppages per 1,000 rounds but met the standard, since in the ambient temperature reliability firings two XM16E1's had a combined stoppage rate of 11, while an errant XM16E1 stopped 45 times per 1,000 rounds. Therefore, the XM16E1 sample tested at high temperature performed better than the sample at ambient temperatures.
Functioning under low temperature extremes.	Not to be significantly less reliable at low temperatures than at ambient temperatures.	F	M	Again, the performance standard was not valid. One XM16E1 had 10 stoppages per 1,000 rounds, surpassing the XM16E1 ambient temperature average of 16 stoppages per 1,000 rounds. However, the second XM16E1 had 74 stoppages per 1,000 rounds.
Signature effects of flash	Not to exceed that of the M14.	M	M	This is not a quantified criterion.
Performance after use of improper cleaning materials.	Tested components not to be totally unserviceable.	M	M	The test found that many plastics were resistant to the corrosive effects of gasoline, bore cleaner, carbon cleaner, and dry cleaning solvent.
Penetration at representative ranges between 25 and 1,000 meters of body armor, helmets with liners, steel, wood, sandbags, aluminium armor, and logs.	Comparable to the M14.	F	M	This is not a quantified criterion. The 7.62mm cartridge fired in the M14 is designed also for the M60 machinegun, and accordingly is required to have effective penetration capabilities at ranges of machine gun interest, beyond ranges of rifle interest. The 5.56mm cartridge should be judged for penetration characteristics against the requirements for rifle projectile, not machine gun projectile penetration.

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a/] XM16E1	Results[a/] M14	Analytical Comment
Functioning without cleaning or lubrication.	Stoppage rate not to exceed the stoppage when rifles are lubricated by more than 30 percent.	F	M	Just as in the case of firings at extreme temperatures, this performance standard was made meaningless by the observed variation of stoppages for the XM16E1. But even then each of the two XM16E1's would have met the standard if the comparison had been made with data from the reliability subtest. However the comparison was made with data from the sustained fire subtest, and one XM16E1 failed. The failure was due to one of the two weapons which had 59 stoppages in 1,000 rounds. The second XM16E1 had only 0.7 stoppages per 1,000 rounds. But the average was 15 stoppages per 1,000 rounds, which is less than the average of 21 in the reliability subtest, or 17 in the sustained fire subtest. The M14 met the standard, and in fact surpassed it, having only one-fourth the stoppage rate of the sustained fire subtest used in the comparison, when fired unlubricated.
Capability of barrel life without accuracy degradation of more than 10 percent.	-	-	-	Barrel life was judged acceptable for all weapons tested.
Cook off safety.	To have no cook offs within 120 rounds.	M	S	Conclusions were based on unspecified previous tests.
Reliability.	To be comparable with the M14.	F	M	The XM16E1 was supposed to meet the 4.5 stoppages per 1,000 rounds rate of the M14, and did not. Two XM16E1's averaged 11 stoppages per 1,000 rounds, while the third had 45 stoppages per 1,000 rounds.
Maximum rate and duration of fire.	No unsafe conditions to be induced by sustained fire.	M	M	None.
	Dispersion and projectile velocity not to be degraded by more than 10 percent.	M	M	None.

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a] XM16E1	Results[a] M14	Analytical Comment
Maximum rate and duration of fire.	No unsafe conditions to be induced by sustained fire.	M	M	None.
	Dispersion and projectile velocity not to be degraded by more than 10 percent.	M	M	None.
	Stoppage rate to be comparable to that of the M14.	F	M	Again, the XM16E1 variance in performance with the sample of two determined the outcome. One XM16E1 equalled the M14 average stoppage rate of 11 per 1,000 rounds, while the second XM16E1 had 23 stoppages per 1,000 rounds.
Dispersion when fired semiautomatically from the prone position.	Average mean radius at 600 meters not to exceed that when firings are from benchrest.	F	(Not reported)	From benchrest at 600 meters, the 3 XM16E1's had an average mean radius of 7.8 inches. From the prone position, the average was 10.5 inches, and therefore the XM16E1 failed the comparison standard. In the case of the M14, benchrest accuracy at 600 meters was reported for only one of the three M14's tested, because two shots missed the target. Examination of the individual target data revealed that M14 benchrest accuracy (for those rounds striking the target) was 18.5 inches mean radius at 600 meters. From the prone position, the average was 15.3 inches.
Dispersion when fired semiautomatically from the prone position employing the bipod.	*To be less than when firing without the bipod at 100 meters.	F	M	The mean radii at 100 meters were for the XM16E1, 2.2 inches without bipod, and 2.3 inches with bipod. Therefore the XM16E1 failed to meet the performance standard. However, the M14 met the standard, despite its greater dispersion, because the mean radii were 2.7 inches without bipod, 2.5 inches with bipod.

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a] XM16E1	Results[a] M14	Analytical Comment
Dispersion when fired automatically (3-round bursts) from the prone position employing the bipod.	The number of hits on a 42x60-inch area not to be greater than the number of hits obtained without the bipod.	S	S	The criteria have meaning only with respect to the efficacy of the bipod. In firing 90 rounds at 100 meters, the XM16E1 scored 84 hits using the bipod, compared to 34 without; the M14 scored 70 hits using the bipod, compared to 33 without.
Dispersion when fired automatically (3-round bursts) from the standing position.	More than 10 hits in each 30 rounds to impact within a 30x40-inch target at 25 meters.	F	F	Data are not given for the number of hits. The only comment is that both the M14 and XM16E1 had fewer than 30 hits in firing 90 rounds. Examination of individual target data reveals average extreme spreads of 9.8 inches for the XM16E1 and 20.0 inches for the M14.
Ballistic match of the tracer projectile.	The tracer projectile to impact sufficiently near the expected impact of ball projectiles to be useful as a target designator throughout the range of visible trace.	M	M	"Increased tracer dispersion (by a factor of two) in this test appeared to mask any consistent relationship between the centers of impact of the various SAWS weapons when comparing ball with tracer results."[b]
Recoil.	Not to be excessive.	M	M	Evaluation of data against the stated criteria must rely on value judgment. The kinetic energy recoil data were: XM16E1, 3.3 ft-lbs.; M14, 10.2 ft.-lbs.
Gas effects.	Gas contamination level not to exceed that of the M14.	S	M	None.
Smoke effects.	Target observation not to be greater than that of the M14.	M	M	None.

TABLE 2-5 cont'd

SAWS ENGINEERING TEST
CHARACTERISTICS AND STANDARDS

Weapon to be Evaluated With Respect to:	Performance Standard	Results[a] XM16E1	Results[a] M14	Analytical Comment
Smoke effects. (cont'd)	Position disclosing effects of smoke not to be more revealing than that of the M14.	M	M	None.
Assembly-disassembly and maintenance techniques.	Not to be more difficult or complex than with the M14.	M	M	None.
Tracer penetration effects.	Defeat standard helmets at 600 meters.	F [b]	M	The XM196 tracer projectile penetrated helmet and liner at 550 meters, but not at 600 meters. Terminal effects are not usually specified for tracer projectiles, as the dominant requirement is for a ballistic flight match with ball projectiles.

a. S = Surpassed the standard.
M = Met or closely approached the standard.
F = Fell below the standard.

b. USATECOM, SAWS Engineering Test, Final Report, Vol I, March 1966, p. 45. In this test, it was noted that many of the 5.56mm tracer projectiles were yawing on impact at 800 meters, and failed to penetrate the ¼-inch plywood target. Some projectiles failed to penetrate even the paper target placed over the plywood. As a consequence of these observations, a special test for tracer penetration effects was conducted (see below).

Colt automatic rifle had 1.38 stoppages per 1,000 rounds, USATECOM did not conclude in its discussion of the reliability test that the poorer XM16E1 performance (20.56 stoppages per 1,000 rounds) was due to poor quality control.[5]

The number of stoppages in the engineering subtests were combined with reliability data from SAWS Service Test to yield the following figures:

	Stoppages per 1,000 Rounds	Rounds Fired
M14	1.17	490,046
XM16E1	11.15	139,756

These figures are commonly cited as indicative of the comparative reliability of the XM16E1 and the M14 and provided the data for stoppage rate statements in the USATECOM Analysis of Results of SAWS Engineering and Service Test[6] and in the U.S. Army Infantry Agency SAWS reports. However, no criteria were presented to support the reasonableness of this summation.

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5 However, USATECOM wrote "ther does appear to be a reasonable amount of data to support the contention that the performance level of the XM16E1 weapon in the SAWS test may have been primarily a function of the quality of the production total of weapons tested." SAWS Engineering Test, Partial Report, Vol. I, p. 44. The Colt automatic rifle was basically the same as the XM16E1.

6 USATECOM, Analysis of Results of SAWS Engineering and Service Tests Jan 66, Chart 9.

There is no evidence that any meaningful criteria were employed in deciding that the dust subtest should consist of 20 rounds for each of two rifles, while the extreme high temperature subtest consisted of 1,200 rounds for each of two rifles and the extreme low temperature subtest consisted of 3,000 rounds for each of two rifles.

No comment is made on the two different citations of reliability. The disparity between the reliability subtest data and that for all SAWS Engineering and Service Tests is highlighted, in terms of stoppages per 1,000 rounds fired, in the figures below.

Table 2-6 — SAWS Engineering and Service Test Reliability Data In Terms of Stoppages per 1,000 Rounds Fired

	All Tests	Engineering Reliability Subtest
XM16E1	11.15	20.56
M14	1.17	4.76
Ratio of XM16E1 to M14	9.5 to 1	4.3 to 1

Again, there is the question of criteria - which set of data best represents typical XM16E1 and M14 performance. Even the relative reliability of the XM16E1 and the M14 differ by a factor of two between the two sets of data. This illustrates two problems: first, the data base is insufficient to account for observed differences; and second, care must be exercised in the drawing of conclusions from the data collected. Unfortunately, USATECOM's careful

account of the sample size and data variances, as cited in its report of the SAWS Engineering Test, has been lost in successive extracts from the report, with the result that the data are treated with an absoluteness of finality not intended by the original testing agency.

Follow-up Actions on Engineering Test Results

The SAWS Engineering Test contained an appendix devoted to the deficiencies and shortcomings noted in the test weapons on the basis of all firings conducted during the Engineering Test. The following paragraphs present extracts from this portion of the SAWS Engineering Test report,[7] together with a comment on the extent to which suggested corrective action by USATECOM was in fact followed by U.S. Army Weapons Command (USAWECOM), U.S. Army Munitions Command (USAMUCOM), and other responsible agencies.

> 1. Deficiency: Unreliable functioning. The exact cause of the unreliable performance of the XM16E1 rifle was not identified. An intensive study should be undertaken to evaluate the effects of the use of ball and CR-type (IMR 8136) propellants; to evaluate standard and experimental buffer systems in this rifle; and to determine if certain lots of rifles exhibit substandard performance.

Both Frankford Arsenal (at the direction of the Project Manager, Rifles) and Colt's studied the effects of alternate ball and extruded grain (IMR or CR) propellants on the XM16E1 and found significantly more malfunctions, greater visible fouling, and higher

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7 USATECOM, Appendix III, Deficiencies and Shortcomings, SAWS Engineering Test, Final Report, Volume II, March 1966, D&PS Report 1970, pp III-1 through III-7.

cyclic rates (commonly exceeding the design unit with the standard buffer assembly) associated with the use of WC 846 (ball) propellant. Springfield Armory evaluated Colt's experimental buffer system in April and May 1966, and USAWECOM approved a modified buffer design in July 1966. No available data indicate any effort in 1966 to determine whether certain lots of rifles exhibited substandard performance. It was supposed at the time that the new buffer would eliminate substandard performance when ball propellant loaded ammunition was used. As long as rifles were being procured with the original buffer, Colt's utilized for acceptance testing only ammunition loaded with IMR 8136 propellant shipped by direction of the Project Manager to Colt's. Therefore, the quality assurance tests were less likely to reveal substandard performance.

2. Severely limited grenade launch capability. The emphasis on light weight construction of (the XM16E1 and other) 5.56mm weapons, which usually includes stamped metal components and plastic stocks, appears to inherently rule out unrestricted and safe launching of rifle grenades.

A commercially developed family of 40mm grenades designed for launching from the end-of-the-muzzle is compatible with the stock and material strengths of lightweight 5.56mm rifles. Their evaluation was directed by the Chief of Staff in November 1966.[8/]

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[8] CSM 66-485, 7 Nov 66, sub: Army Small Arms Weapon Systems.

3. Shortcoming: Obstructed bore hazard due to rain accumulation. Training manuals should emphasize that weapons of this caliber (5.56mm) should always be made bore-safe after exposure to rain by depressing the muzzle and opening the bolt prior to firing.

This precautionary step was taken for all rifles prior to firing in each phase of the water spray test that involved pointing the muzzle vertically, up or down. With regard to the water hazard problem, the XM16E1 outperformed the M14 in the water spray subtest. Training materials currently do include the caution to drain the bore by opening the bolt after exposure to water.

4. Shortcoming: Charging handle becoming unlatched. Relocate the pivot point of the latch or employ a stronger latch spring. The psychological effect of continued failure of the charging handle to remain latched could be sufficiently serious to warrant assessing this as a deficiency instead of a shortcoming.

On 18 March 1966, Colt's submitted a request for technical action (RTA), calling for dimensional modification of the charging handle latch to insure a more positive locking of the charging handle latch during firing. Final approval was granted 9 August 1966.[9/]

5. Shortcoming: Bolt breakage. Specific identity of the material should be made available to the . . . contractor for his consideration.

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[9] See Appendix 11 for a complete chronological listing of all RTA's, which reflect modifications made to the XM16E1 rifle.

Nine damaged or broken XM16E1 bolts were encountered in the SAWS Engineering Test. In June 1966 Colt's resubmitted a January 1966 RTA proposing to steel shot peen the bolt in order to increase fatigue life. Government approval was granted on 13 September 1966.

6. Shortcoming: Extractor spring failure. Consideration should be given to redesign of the bolt to permit a longer spring to be employed.

Sixteen damaged or broken extractor springs were encountered in the SAWS Engineering Test. While the small size of the bolt has precluded introduction of a longer extractor spring, chrome plated chambers were introduced in September 1967 to lessen frictional resistance in the extraction cycle. No formal reports exist on follow-up action on this reported shortcoming.

The SAWS Engineering Test report,[10] in the section on findings contains the following statements suggesting areas for weapon system improvement, to which comments have been added.

1. The present 5.56mm (55-grain) ball projectile is not optimum in over-all effectiveness, particularly at extreme ranges; an experimental 68-grain projectile appeared superior.

No published work was done on bullet design in 1966. On 16 May 1967 the Chief of Staff directed that the Commanding General, U.S. Army Materiel Command, conduct studies to determine the optimum

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10 SAWS Engineering Test, Final Report (DPS-1970) March 1966, Vol. I, p. 18.

5.56mm projectile design for the M16A1 system. The Ballistic Research Laboratories was to have reported on this by 31 January 1968, but the date has been extended to December 1968.

> 2. High-speed film results indicated that the charging handle on the XM16E1 rifle occasionally unlatches and moves rearward with significant velocity during firing.

As discussed above, a 1966 modification to the charging handle corrected this deficiency.

> 3. The 5.56mm tracer cartridge was totally ineffective in penetration tests at ranges beyond 700 meters.

It is generally agreed that 700 meters is beyond the range of interest for rifles. Therefore, this conclusion reflects not a shortcoming in the M16A1 system, but rather a problem for the continued development of a 5.56mm machine gun system. The conclusion, however, is related to the tracer bullet break-up deficiencies reported in the second half of 1967, in Vietnam and at Development and Proof Services. USAMUCOM initiated no action in response to this SAWS Engineering Test conclusion.

The SAWS Service Test

The objective of the SAWS Service Test, conducted between July and November 1965, was to determine the operational suitability of candidate weapons. To accomplish this purpose, the overall test was divided into 20 subtests: preoperational inspection and physical

characteristics, training, rate of fire, sights, magazines, ammunition and packaging, day and night tactical defense exercises, day and night tactical assault exercises, mounts, record and transition fire, signature characteristics, pointed fire accuracy, portability and aerial delivery, accessories and training aids, maintenance, durability and reliability, versatility of weapon design, safety, human factors engineering, and value analysis. The analysis in this appendix is restricted to those aspects of the service test associated with XM16E1 development and improvement, as opposed to those associated with its effectiveness as a combat rifle. While the Service Test conducted by the U.S. Army Infantry Board (USAIB) at Fort Benning did not have as its primary mission development of data for engineering analysis, it did record data on twice as many rounds (95,720 as opposed to 44,036) as did the SAWS Engineering Test, fired by 20 different XM16E1's. Only 10 different XM16E1's were considered in the Engineering Test. In particular, this analysis is concerned with the results of the magazine, maintenance, and durability and reliability subtests, and the USAIB listing of deficiencies and shortcomings.

Magazines. All candidate weapons were faulted for not having a 50-round capacity magazine, which had been stated as an objective criterion by USACDC. The XM16E1 was faulted for not having a

multiround magazine charging device. Several months after the completion of the SAWS Service Test, Frankford Arsenal completed development of a 10-round ammunition clip and magazine charging device, which is now used in the tactical packaging of all 5.56mm ammunition.

A high incidence of bolt overrides and double feeds was experienced with the XM16E1.

> The magazine follower does not rise evenly within the magazine because the magazine spring slides on the magazine base, occasionally causing the round to be improperly indexed at the time the bolt begins its forward movement. . . . It was discovered during testing that 21 rounds could be charged into M14, XM16E1 (and other) . . . magazines. . . . No apparent adverse effects resulted from overcharging the magazines. However, throughout all testing, test soldiers were cautioned against charging extra rounds into all magazines.[11]

The comment on overloading magazines is at variance with Vietnam reports, but this variance may be due to environmental and propellant effects on typical operating energy levels. Under non-adverse conditions at the USAIB with clean rifles and with ball propellant and the old buffer, there may typically have been sufficient energy available to feed the first of 21 rounds without failure.

Maintenance. "The carbon build-up in the XM16E1 . . . (and other 5.56mm rifles) was excessive in the operating groups and in the bore. The removal of this carbon was difficult and took an excessive amount of time."[12] The 5.56mm ammunition used

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11 USAIB, SAWS Service Test, December 1965, p. 87.

12 Ibid, p. 172.

contained WC 846 (ball) propellant. The statement on fouling was later substantiated for WC 846 propellant by Frankford Arsenal in a test directed by the Project Manager, Rifles.[13/] USAIB received XM16E1's with M11 cleaning rods but without bore cleaning brushes. The 3-piece M11 cleaning rods were found unsuitable, because they mushroomed and flared at the joints, breaking frequently. They have since been replaced by a new 4-piece cleaning rod. The USAIB also identified[14/] the need for a chamber cleaning brush, which subsequently was first fielded in May 1966. No comment was made as to the desirability of in-stock stowage of cleaning equipment for the XM16E1. The report noted simply that cleaning equipment was carried in the bipod case and that this method was judged adequate.

Durability and Reliability. Using observations and data collected on the 20 XM16E1's firing a total of 95,720 rounds in the SAWS Service Test as a basis, the USAIB stated the following were significant with respect to durability (1-4) and reliability (5-11):

1. Four incidents of bolts being cracked or broken. (As noted above in the discussion of follow-on actions to the SAWS Engineering Test, approval was granted on 13 September 1966 to steel shot peen the bolts in order to increase fatigue life.)

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13 Frankford Arsenal, Feb 66, A Test of Cartridge, 5.56mm, Ball M193, Lots RA5074 and WCC 6089 in Rifles, 5.56mm XM16E1 and AR15.

14 The need for a chamber cleaning brush had previously been identified in 1964.

2. Four incidents of the bolt carrier keys, having to be retorqued. (On 16 February 1966, government approval was granted Colt's to change the bolt carrier key surface roughness requirement so as to specify a standard grind finish in order to control flatness more closely. While the Service Test was in progress, the bolt carrier key was modified to chrome-plate the interior and parco-lubrite the exterior.)

3. Five incidents of the buffer assembly roll pins being separated or deformed. (These pins were eliminated by adoption of a redesigned buffer in 1966. However, the deficiencies encountered in the roll pins of the original design were never cited in the justification for the redesigned buffer.)

4. 24 incidents of the firing pin retaining pin being cracked during firing.[15] (In January 1966 an RTA was submitted and approved requesting changes in the material and hardness specification in order to improve quality and reliability.)

5. 532 failures of the bolt to remain to the rear after the last round of a magazine had been fired. (These occurred on average with every ninth magazine fired. The association of this malfunction with cyclic rate was confirmed in the Frankford Arsenal test of SAWS ammunition lots mentioned previously.)

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[15] This same deficiency had been reported in the series of tests comprising the 1962-1963 comparative evaluation of the AR15, M14, and AK47.

6. 188 incidents of the bolt overriding the base of the round in feeding from the magazine.

7. 251 failures to eject. (This was the second most common malfunction - after failure of the bolt to remain to the rear. As evidenced by the January 1968 Weapons Systems Evaluation Group's test of the operational reliability of the M16A1 in Panama, failure to eject, associated with the use of ball propellant, continues to be a common and serious cause of malfunction.)

8. 1,242 malfunctions of various kinds, or one per four magazines. (The Frankford Arsenal post-SAWS test of 5.56mm ammunition identified excessive cyclic rate with ball propellant as the cause of many of those malfunctions. The buffer modification has resulted in lower cyclic and malfunction rates.)

9. One incident of the selector switch being inoperative. Selector switches are checked on a 100 percent basis in the quality assurance examination at Colt's. Inoperative selector switches have been reported by other agencies.

10. One incident of the front sight post being frozen. None of the 20 XM16E1's tested had fewer than 4 malfunctions per 1,000 rounds and none had more than 22, with individual rifle malfunction rates reasonably distributed between these limits. Thus, the data are not biased by typically good or bad rifles. It

is interesting to note that 100 M14's were used in the SAWS Service Test, which yielded a significantly larger and more meaningful data base -- 100 M14's and 445,265 rounds fired.

Shortcomings: Appendix IV of the SAWS Service Test lists XM16E1 shortcomings:

1. Sight did not have a visual scale for determining zero. (The M16-XM16E1 Rifle Technical Coordinating Committee approved a new design for the rear sight correcting this shortcoming on 13 April 1966.)

2. Front sight required a tool or cartridge for adjustment. (No change has been made.)

3. Front sight was not operable with minimum motion. (The firer took too long in adjusting elevation.)

4. Bipod legs were not adjustable. (No change has been made, and bipods are no longer issued with each rifle.)

5. Weapon fired with the safety-selector switch between the safe and semiautomatic positions. (The report did not say how many of the 20 XM16E1's had this shortcoming. No changes have been made.)

6. Rapid build-up and transfer of heat in sustained automatic fire caused difficulty in handling the weapon. (This shortcoming was reported for all automatic rifles. In fact, six M14 forestocks caught on fire during long burst, sustained automatic fire testing.)[16/]

7. Pointing characteristics were poor.

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16 USAIB, SAWS Service Test, p. 231.

C. M16 Buffer Development

Background

The most significant modification made to the M16A1 rifle was the change in December 1966 of the buffer (action spring guide assembly), because of its demonstrated effect on cyclic and malfunction rates and its sensitivity to propellant energy levels. The importance of the modification and the ensuing debate of buffer and propellants makes the buffer test program especially worthy of analysis. During the SAWS tests, the XM16E1 was reported to have excessive cyclic rates up to 960 rounds per minute as compared with the design or specification upper limit of 850 as well as an excessive number of malfunctions. At the same time, the nearly identical Colt automatic rifle, using a buffer of a new design, was significantly more reliable: 3.02 stoppages per 1,000 rounds, compared with 11.15 for the XM16E1. The new buffer design had increased mass and utilized sliding steel weights, rubber discs, and a polyurethane bumper in lieu of nested springs to cushion recoil forces. Colt's proposed such a buffer for the XM16E1 in January 1966, at which time Frankford Arsenal had just completed test firings of 12,000 rounds in each of four XM16E1's and two AR15's.[17] using the original design buffer. The Frankford tests confirmed the higher cyclic and

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[17] Frankford Arsenal, Feb 66, A Test of Cartridge, 5.56mm, Ball, M193, Lots RA5074 and WCC 6089 in Rifles, 5.56mm, XM16E1 and AR15.

malfunction rates for ball (WC 846) propellant, as compared with IMR (8136) propellant, that had been reported in the SAWS tests. In particular, failure of the bolt to remain to the rear after the last round of the magazine had been fired increased dramatically as a function of cyclic rates in excess of 850 rounds per minute. Colt's tests had shown reduced cyclic rates with its new buffer design. At the 12-13 January 1966 meeting of the inter-service XM16E1 Rifle Technical Coordinating Committee, the responsibility for test and evaluation of Colt's proposed buffers was assigned to Springfield Armory. As a result in July 1966 USAWECOM adopted the new buffer design, and in December 1966 the new buffer entered production. Headquarters, USATECOM, directed on 26 June 1967 that a product improvement test of the redesigned buffer be conducted, using the old and new buffers with the objectives of comparing cyclic rates of fire and of comparing the bolt rebound upon closing (bolt carrier bounce). The test, conducted between 7 September 1967 and 15 January 1968 was the most thorough study of buffers for the M16A1, although it came 17 months after the decision to modify the buffer.

Springfield Buffer Test

Between 6 April and 13 May 1966, Springfield Armory evaluated four types of buffers, proposed by Colt's for the XM16E1.[18/]

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18 Springfield Armory, 20 Dec 66, Internal Work Report on Buffer for 5.56mm, XM16E1 Rifle.

Basically all of the same design, these buffers contained sliding steel weights separated by rubber discs and had a polyurethane bumper at the rear end. The differences between them were use of Buna N rubber or polyurethane for the discs and a cup or truncated cone shaped bumper. Three of each buffer type were available for test. (For the Springfield buffer test firing schedules, see Table 2-7.)

TABLE 2-7 — DESIGN OF SPRINGFIELD ARMORY BUFFER TEST FIRINGS

1,000 Rounds per Trial at -65°F and 155°F
600 Rounds per Trial at Ambient Temperatures

Weapon Number	Number of Trials[a] For Each Type of Ammunition			For Each Type of Buffer			
	WC 846	IMR 8136	Tracer	1	2	3	4
At -65 F							
1	2	2	2	3	3	-	-
2	2	2	2	3	3	-	-
3	2	2	2	3	3	-	-
4	2	2	2	-	-	3	3
5	2	2	2	-	-	3	3
6	2	2	2	-	-	3	3
At 155°F and ambient temperatures							
1	1	1	-	-	2	-	-
2	1	1	-	-	2	-	-
3	1	1	-	-	2	-	-
4	1	1	-	-	-	2	-
5	1	1	-	-	-	2	-
6	1	1	-	-	-	2	-

[a] For a given trial, the same rifle-buffer combination was used with a given type of ammunition.

The first phase of the buffer evaluation was conducted at -65° Fahrenheit (F) using two different types of buffers in each of six XM16E1's. Nine lots of ammunition were used, 3 ball and 2 tracer lots with WC 846 propellant, and 3 ball and 1 tracer lots with IMR 8136 propellant. Each rifle-buffer combination fired 1,000 rounds with each of three kinds of ammunition — ball with WC 846 propellant, ball with IMR 8136 propellant, and tracer, with the following results:

1. Buffers 1 and 2 were tested in the same 3 rifles. Buffer 2 had, with each type of ammuntion, associated cyclic rates closer to 750 rounds per minute and fewer malfunctions than buffer 1.[19/] Buffer 1 was eliminated from further consideration.

2. Buffers 3 and 4 were tested in the same 3 rifles. This set of 3 rifles was different from the set in which buffers 1 and 2 had been tested. Buffer 3 had, with WC 846 propellant, an associated cyclic rate closer to 750 rounds per minute and fewer malfunctions than buffer 4. By the same criteria, buffer 4 was better than buffer 3 with IMR 8136 propellant and tracer ammunition. Buffer 4 was eliminated from further consideration.

With three types of ammunition, one should conduct 216 firing cycles, which at 1,000 rounds each (or even with a smaller number

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19 750 rounds per minute is the nominal XM16E1 cyclic rate. The permissable range is 650-850 rounds per minute.

of rounds) would provide sufficient data to permit an analysis of variance or correlation analysis. Such analysis could prove with statistical confidence the association or nonassociation of differences in cyclic or malfunction rates between different types of buffers. However, the sample as tested was too small to permit statistical analysis, (36 firing cycles with 12 variables tested in 6 rifles) and the results were sufficiently varied, especially with respect to buffers 3 and 4, to inhibit obvious conclusions. Yet choices had to be and were made. Two types of buffers were eliminated from further testing at ambient and +155°F temperature on the basis of a small data base collected at -65°F. If the objective of the elimination of two types of buffers was to reduce the test matrix, a more accurate criterion would have been performance at ambient, rather than -65°F temperature.

At -65°F a total of 36,000 rounds was fired, with the majority of malfunctions being the bolt's overriding the base of the cartridge, and the bolt's failing to remain to the rear after the last round had been fired. No analysis was made of these or other malfunctions with a view to improving the design of the XM16E1 or its magazine.

The second phase of the buffer evaluation was conducted at +155°F, using buffer 2 in each of 3 rifles and buffer 3 in each of another set of 3 rifles. Preliminary firings had shown significant differences in average cyclic rates and numbers of malfunctions for these rifles at ambient temperatures with the standard buffer. (See Table 2-8.) The comparative evaluation of buffers 2 and 3 at

TABLE 2-8 — CYCLIC AND MALFUNCTION RATES FOR TEST RIFLES

	Average Cyclic Rate		Number of Malfunctions in 600 Rounds per Rifle	
	WC 846	IMR 8136	WC 846	IMR 8136
Ambient Temperature, Standard Buffer				
Set of 3 rifles using buffer 2	894	802	118	5
Set of 3 rifles using buffer 3	962	848	165	7
155°F, Standard Buffer				
Set of 3 rifles using buffer 2	958	b/	196[a]/	b/
Set of 3 rifles using buffer 3	985	b/	222[a]/	b/

a Number of malfunctions in 1,000 rounds per rifle.

b Not fired.

155°F and ambient temperatures in no way accounted for the demonstrated performance difference between these sets of rifles.

Comparative evaluation of buffer 2 and 3 showed, for an average of three rifles per buffer type at 155°F, that with both ball and IMR propellant buffer 3 had an associated cyclic rate closer to 750 rounds per minute and fewer malfunctions than buffer 2. However, from these results, based on 12,000 rounds, it is not possible to determine statistically significant differences between buffer types. No firin

were conducted with tracer ammunition because tracer cartridges were in short supply.

The third and final phase of the buffer evaluation was a repeat of the second phase at ambient temperatures, except that only 600 rounds were fired from each rifle-buffer-ammunition combination for a total of 7,200 rounds. No tracer ammunition was used. Statistically there were no significant differences in observed results between buffers 2 and 3. Further, such results were influenced by the demonstrated differences in the performance of the individual rifles.

The Springfield report summarized its conclusions:

> As intended, the proposed buffers produce a reduction of cyclic rate and a corresponding reduction of malfunction rate when firing ammunition loaded with ball (WC 846) propellant, however the improvement has not reduced the malfunction rate to an entirely acceptable level.[20]

Detailed conclusions were that:

1. The performance with the proposed buffers and WC 846 propellant was not as good as previous XM16E1 performance with standard buffers and with IMR 8136 propellant.

2. With IMR 8136 propellant, XM16E1 performance with the proposed buffers was not much changed from previous XM16E1 performance with standard buffers.

3. The average cyclic rates of fire at -65°F with WC 846 propellant and the proposed buffers were within the range considered

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[20] Springfield Armory, 20 Dec 66, Internal Work Report on Buffer for 5.56mm, XM16E1 Rifle, p. 2.

desirable for good weapon function. At 155°F the cyclic rate was higher than desired but lower than with the standard buffer.

4. Buffer 2 had a more simplified design than buffer 3.

The decision, based on the test data described above and on engineering judgment, was made in July 1966 to adopt buffer 2. It was introduced into production rifles in December 1966.

The Springfield Armory test of buffers was faulty or incomplete as indicated below:

1. Two buffer types were eliminated from consideration after testing only at -65°F. A more meaningful criterion would have been performance at ambient temperatures.

2. Firings of 12,000 rounds with tracer ammunition were made only at -65°F, because of a shortage of ammunition. If additional tracer ammunition were not available for the buffer test, the test results would have been more significant if the tracer ammunition had been used only after elimination of two buffer types and at ambient temperatures.

3. Tracer results were not presented by propellant types.

4. More rounds (1,000) were fired for each rifle-buffer-ammunition combination at extreme (-65°F and 155°F) temperatures than were fired at the more common ambient temperatures (600 rounds).

5. In the firings at -65°F only 2 buffers were used per rifle. No consideration was given to the statistical significance of the observed differences. There is a strong possibility that these differences were due to chance.

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6. In the firings at 155°F and ambient temperatures, only one buffer was used per rifle. The two buffer types were evaluated in two different sets of rifles, with demonstrated performance differences.

7. The data obtained at 155°F and ambient temperatures are inconclusive.

8. The test data and report do not demonstrate that the best buffer design was selected.

USATECOM Product Improvement Buffer Test

Between December 1966 and June 1967 data on the redesigned M16A1 buffers were collected in the Colt's quality assurance firings for acceptance of rifle production lots. These data indicated the compatibility of the new buffer with the M16A1 weapon and ammunition system, but were not comparable with similar data derived from tests with the previous standard buffer because Colt's changed from IMR 8136 to WC 846 (ball) propellant-loaded ammunition for its acceptance testing when the new buffer design was introduced into production. Then, on 26 June 1967, USATECOM initiated comparative tests of buffers and propellants to confirm the compatibility of the newly adopted buffer design with the M16A1 rifle system using both ball and IMR type propellants and to provide a comprehensive evaluation of the old and new buffers in the M16A1 rifle.[21/]

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21 USATECOM, Jan 68, Product Improvement Test of the Redesigned Buffer for M16A1 Rifles, (DPS Report 2662).
See Table 2-9 for the subtests conducted, together with the objectives, evaluation criteria, and comments on the test design.

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TABLE 2-9 —— PRODUCT IMPROVEMENT TEST OF REDESIGNED M16A1 BUFFERS CHARACTERISTICS AND STANDARDS

Subtest	Objective	Criteria	Test Design
Cyclic rate of fire	To measure the cyclic rate of fire of the test weapons under normal ambient conditions.	Cyclic rate for each 20 round burst to be between 650 and 850 rounds per minute.	A total of 160 rounds per weapon was fired, according to the design in Table 2-10.
High humidity	To evaluate M16A1 performance with the redesigned buffer under high humidity conditions and to compare with the standard buffer.	Total number of malfunctions and unserviceable parts not to exceed those prescribed in the quality assurance specifications for Colt's 6,000-round reliability test.a/	The cyclic rate of fire subtest was repeated, followed by the environmental firing according to the design in Table 2-11. The test concluded with repetition of the cyclic rate of fire test under environmental conditions, weapon cleaning, and a second repetition of the cyclic rate of fire subtest. A total of 1120 rounds were fired from each of the 12 weapons. (560 for each rifle-buffer combination).
High temperature (+155°F)	To evaluate M16A1 performance with the redesigned buffer under high temperature conditions and to compare with the standard buffer.	Same as for the high humidity subtest above.	Same as for the high humidity subtest above.
Fouling	To evaluate M16A1 performance with the redesigned buffer with various types of ammunition under conditions presumed to result in increased propellant fouling.	Same as for the high humidity subtest above.	Firings were at 20°F since at this temperature fouling was thought to affect most severely the rifle's functioning. MIL-L-14107A oil was used as a lubricant because the standard MIL-L-46000A was not recommended at temperatures below 32°F. The cyclic rate of fire subtest was repeated, followed by half the trials reflected in Table 2-11, the cyclic rate of fire subtest again, and the second half of the trials reflected in Table 2-11. At the end of the test the cyclic rate of

TABLE 2-9 —— PRODUCT IMPROVEMENT TEST OF REDESIGNED M16A1 BUFFERS CHARACTERISTICS AND STANDARDS

Subtest	Objective	Criteria	Test Design
Fouling (cont'd)			fire subtest was repeated twice - once at 20°F, and after cleaning again at ambient temperatures. A total of 1500 rounds was fired from each of the 12 weapons.
Low temperature (-65°F)	To evaluate M16A1 performance with the redesigned buffer under low temperature conditions and to compare with the standard buffer.	Same as for the high humidity subtest above.	Firings followed the same schedule as for the fouling test above.
Extreme altitude functioning	To evaluate M16A performance with the redesigned buffer when firing semiautomatically and automatically, hand-held at 80° elevation and -80° depression.	Same as for the high humidity subtest above.	The firing consisted of four cycles, according to the design in Table 2-12 followed by the cyclic rate of fire subte A total of 2080 rounds was fired from eac of 6 weapons.
Accelerated Rate	To determine the effect on the M16A1 on cyclic rate of fire as a result of firing 140 rounds as rapidly as possible.	Same as for the cyclic rate of fire subtest above.	See Table 2-13. A total of 560 rounds was fired from each of 6 weapons.
Dynamic Dust	To evaluate M16A1 performance with the redesigned buffer when firing in a severe dust environment.[b]	Weapons with redesigned buffers to perform as well or better than those with standard buffers.[c]	See Table 2-13. A total of 560 rounds wa fired from each of 6 weapons.

TABLE 2-9 —— PRODUCT IMPROVEMENT TEST OF REDESIGNED M16A1 BUFFERS
CHARACTERISTICS AND STANDARDS

Subtest	Objective	Criteria	Test Design
Salt water immersion	To evaluate M16A1 performance with a redesigned buffer when firing under high temperature, high humidity conditions after immersion in salt water.	Same as for the dynamic dust subtest above.[c] Footnote c applies	See Table 2-14. The standard buffer was not tested, since this test was considered sufficiently severe enough to destroy the weapons. Rather than use half the weapons for each buffer, only the redesigned buffer, was tested, using 3 weapons for each projectile-propellant combination. A total of 300 rounds was fired from each of 12 weapons.

a. See Inclosure 2 to Appendix 5, page 5-82.
b. Unlike the SAWS Engineering Test dust subtest, in this subtest the dust was blown into the chamber housing the test weapon during the firings.
c. The criteria which appear in the July 1967 test plan were "No stoppages are permitted during firing except stoppages which may be immediately cleared by use of the charging handle, bolt closure device, or by the removal and insertion of a magazine. No more than one permitted stoppage, as defined above, shall occur during the firing of each full magazine. The criterion applies individually to each 20-round magazine complement irrespective of the ratio of total stoppages to total rounds fired in the test. This was changed to read as given above in USATECOM's approval of the test plan on 29 August 1967.

Table 2-10 - DESIGN OF CYCLIC RATE OF FIRE SUBTEST

(one 20-round continuous burst per trial)

Weapon Number	Number of Trials					
	For Each Projectile-Propellant Combination				For Each Buffer	
	Ball-Ball	Ball-IMR	Tracer-Ball	Tracer-IMR	Standard	Redesigned
1	2	2	2	2	4	4
2	2	2	2	2	4	4
3	2	2	2	2	4	4
4	2	2	2	2	4	4
5	2	2	2	2	4	4
6	2	2	2	2	4	4
7	4	4	-	-	4	4
8	4	4	-	-	4	4
9	4	4	-	-	4	4
10	-	-	4	4	4	4
11	-	-	4	4	4	4
12	-	-	4	4	4	4

USATECOM BUFFER TEST

Table 2-11 - DESIGN OF ENVIRONMENTAL SUBTESTS

80 rounds per trial for the high humidity and high temperature subtests
140 rounds per trial for the fouling subtest
200 rounds per trial for the low temperature subtests

Weapon Number	Number of Trials					
	For Each Projectile-Propellant Combination				For Each Buffer	
	Ball-Ball	Ball-IMR	Tracer-Ball	Tracer-IMR	Standard	Redesigned
1	2	2	2	2	4	4
2	2	2	2	2	4	4
3	2	2	2	2	4	4
4	2	2	2	2	4	4
5	2	2	2	2	4	4
6	2	2	2	2	4	4
7	4	4	-	-	4	4
8	4	4	-	-	4	4
9	4	4	-	-	4	4
10	-	-	4	4	4	4
11	-	-	4	4	4	4
12	-	-	4	4	4	4

USATECOM BUFFER TEST

Table 2-12 - DESIGN OF EXTREME-ATTITUDE FUNCTIONING SUBTEST

40 rounds per trial

Weapon Number	Number of Trials[a/] For Each Projectile-Propellant Combination				For Each Buffer	
	Ball-Ball	Ball-IMR	Tracer-Ball	Tracer-IMR	Standard	Redesigned
1	8	8	8	8	16	16
2	8	8	8	8	16	16
3	8	8	8	8	16	16
4	8	8	8	8	16	16
5	8	8	8	8	16	16
6	8	8	8	8	16	16

[a/] One-fourth of the trials for each combination of projectile-propellant and for each buffer was fired in each of the following attitudes; all hand-held:

[a] +80° elevation, semiautomatic.

[b] +80° elevation, automatic.

[c] -80° depression, semiautomatic.

[d] -80° depression, automatic.

USATECOM BUFFER TEST

Table 2-13 - DESIGN OF ACCELERATED RATE AND DYNAMIC DUST SUBTESTS

140 rounds per trial

Weapon Number	Number of Trials For Each Projectile-Propellant Combination				For Each Buffer	
	Ball-Ball	Ball-IMR	Tracer-Ball	Tracer-IMR	Standard	Redesigned
7	2	2	-	-	2	2
8	2	2	-	-	2	2
9	2	2	-	-	2	2
10	-	-	2	2	2	2
11	-	-	2	2	2	2
12	-	-	2	2	2	2

USATECOM BUFFER TEST

Table 2-14 - DESIGN OF SALTWATER IMMERSION SUBTEST

300 rounds per trial

Weapon Number	Number of Trials					
	For Each Projectile-Propellant Combination				For Each Buffer	
	Ball-Ball	Ball-INR	Tracer-Ball	Tracer-INR	Standard[a/]	Redesign
1	1	-	-	-	-	1
2	1	-	-	-	-	1
3	1	-	-	-	-	1
4	-	1	-	-	-	1
5	-	1	-	-	-	1
6	-	1	-	-	-	1
7	-	-	1	-	-	1
8	-	-	1	-	-	1
9	-	-	1	-	-	1
10	-	-	-	1	-	1
11	-	-	-	1		1
12	-	-	-	1	-	1

[a/] The standard buffer was not tested because the test was considered severe enough to destroy the weapons. Rather than use half the weapons for each buffer, only the redesigned buffer was tested, using 3 weapons for each projectile-propellant combination.

The test matrices for this USATECOM test (Tables 2-10 through 2-14) prescribe a dramatically more valid test, than did the thin, incomplete matrix used in the Springfield Armory buffer firings (Table 2-7 above).

The USATECOM buffer test presents two types of data for each subtest — cyclic rate and reliability. On the basis of these data the two buffer designs can be compared meaningfully. The sample size of rifles (12) was sufficiently large to compensate for individual rifles which happened to be bad performers. The importance of this is demonstrated in the fouling subtest in which 12 rifles fired an average of 1,820 rounds each with an average of 18 malfunctions per rifle. (See Table 2-15.)

Table 2-15 — MALFUNCTION INCIDENCE IN THE FOULING SUBTEST (1,820 ROUNDS PER RIFLE)

Rifle Number	Number of Malfunctions
1	4
2	21
3	2
4	28
5	2
6	57
7	22
8	1
9	16
10	6
11	30
12	28

Note that rifle number 6 had 3 times the average number of malfunctions; 47 of these 57 were failures to feed the first round in the magazine. These failures were almost uniformly distributed over ammunition type (13, 13, 11, 10 for the four types, respectively); and over mode of fire attempted (automatic or semiautomatic) for each buffer type, although of course, all first rounds in the magazine are actually fired semiautomatically. Furthermore, for each of the 16 possible combinations of ammunition, buffer, and mode of fire attempted, there were between 2 and 4 failures, which demonstrates the uniformity of the distribution. This uniformity means that the high malfunction incidence did not distort the comparative results for buffers, with any ammunition type.

Similarly, Table 2-16 displays the malfunction incidence in the extreme low temperature subtest.

Table 2-16 — MALFUNCTION INCIDENCE IN THE EXTREME LOW TEMPERATURE SUBTEST (2,235 ROUNDS PER WEAPON)

Rifle Number	Number of Malfunctions[a]	
1	36	
2	32	
3	80	
4	61	
5	74	
6	55	
7	53	(These rifles fired
8	36	only ball ammuni-
9	107	tion.)
10	48[b]	(These rifles fired
11	180	only tracer ammuni-
12	54	tion.)

[a] The average number of malfunctions per weapon was 68.

[b] This rifle had 22 percent (3 times the average for all 12 rifles) of the malfunctions in this subtest and 76 percent (38 out of 49) of the malfunctions in the high humidity subtest. In the saltwater immersion subtest, this rifle had 17 percent of the total malfunctions while firing only 9 percent of the total number of rounds fired.

Rifles firing tracer ammunition exclusively had 86 (44 percent) more malfunctions than those firing ball ammunition exclusively. As each rifle was fired with both the standard and the redesigned buffer, and as there were 12 rifles and 12 buffers of each design in the test matrix, characteristicly poor performance, in comparison with the other rifles, in one or two rifles did not distort the results. In the SAWS Engineering Test the data were not significant because they had been collected only on two XM16E1's and then frequently with great variance.

Cyclic rate in the USATECOM buffer test data are sufficient to be meaningful. Cyclic rate was measured at least twice under the conditions of each subtest, and again at the end of each subtest at ambient temperatures after cleaning and lubrication. The test matrix for cyclic rate determination was sufficiently large to provide valid data. Anamalous results are infrequent and are compensated for by the test matrix.

The one question raised by a review of the January 1968 USATECOM buffer test report was whether or not the ammunition used met the specifications with respect to port pressure, a matter of critical importance because of the association of port pressure with operating energy levels and cyclic rate, and hence with malfunction rates. The buffers were being compared on the basis of cyclic and

malfunction rates, and such comparisons would be largely or totally invalidated if the ammunition lots used did not produce typical operating energy levels, as indicated by port pressures — that is, did not meet the port pressure specification. Acceptance data from Twin Cities and Lake City Army Ammunition Plants showed that all four of the lots used by USATECOM met the port pressure specification. However, USATECOM conducted port and chamber pressure verification tests for the four lots, and found that for three lots the port pressures were below the specifications. There are several explanations, the most likely being calibration differences, or possibly chance factors in selection of the sample. The Project Manager, Rifles has directed that Frankford Arsenal resolve the differences in the reported port pressures.[22] In the meantime, it is unlikely that the lots used at USATECOM were not substantially equivalent in terms of port pressure to lots being produced and issued for use in Vietnam. Consequently, it is unlikely that the ammunition characteristics of the lots used at USATECOM have invalidated the results of the buffer test.[23]

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22 No estimated completion date was available as of 1 May 1968.

23 This judgment is based on the fact that the lots at Twin Cities and Lake City meet the specifications in government tests at those installations, and therefore correspond in port pressure to other ammunition lots being produced.

D. Analysis of M16A1 System Tests

This section analyzes M16A1 system tests, seeking in particular weaknesses in past test policies and procedures as they were applied to the M16 and areas which need be given careful consideration in view of present and future policies and procedures. The intent is to identify, where possible, gaps in the test data collected, and to discuss the validity of the statistical design of tests, the test criteria, the significance of test results, the adequacy of the follow-on weapon design and reliability data analysis, and the consistency of follow-on actions with the test results. In each instance the shortcomings fall into two categories —the tests did not include all that might appropriately have been done, and the agencies did not make the best use of what was done.

Gaps in Test Data Previously Collected

With the aid of hindsight, reinforced by reports of malfunction problems encountered in Vietnam, it is now easy to see the faults in the testing cycle for the M16. A major weakness was in the lack of kinematic[24] analysis of M16 weapon functioning, although kinematic analyses were conducted on other small arms systems. In 1964 the U.S. Army Weapons Command requested that the Ballistic Research Laboratories (BRL) make a kinematic evaluation of the 5.56mm Armalite AR18 rifle to determine the soundness of the design because adverse results had been obtained in tests of the AR18 at Fort Benning,

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[24] i.e., a time-motion-displacement study of the weapon's operating parts.

Georgia, and Aberdeen Proving Ground, Maryland.[25] Also in 1964, three prototype weapons from each of the four contractors for the Special Purpose Individual Weapon system (SPIW) were delivered to BRL for kinematic analysis and evaluation to furnish data for selecting the prototype which could be best developed to meet the requirements for the SPIW system.[26] At the same time, first deliveries of M16's and XM16E1's were being received from Colt's who had requested waivers (granted between April and June 1964) to permit acceptance of rifles with cyclic rates up to 900 rounds per minute. In September 1965 Colt's proposed permanent relaxation of the upper limit for cyclic rate from 850 to 900 rounds per minute when WC 846 (ball) propellant was used. In November 1965 there were numerous reports of excessive XM16E1 malfunctions from the Small Arms Weapons Systems (SAWS) Study test sites. However, the Weapons Command did not request and the Ballistic Research Laboratories did not conduct a kinematic evaluation of the XM16E1, although reasons for such evaluation were at least as cogent as for the kinematic evaluations conducted on the AR18 and SPIW systems.[27] Colt's did

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25 BRL Memo Rpt 1635, Feb 65, A Kinematic Evaluation of the AR18 Rifle, Cal. 0.223.

The AR18 was described as a revision of the AR15 rifle, designed to eliminate the difficulty in accurate aiming caused by the straight stock and high sights of the AR15. Another feature was improved portability by use of a folding stock.

26 BRL Technical Note 1541, Aug 64, Kinematic Evaluation of the Special Purpose Individual Weapon Prototypes.

The four contractors were Aircraft Armaments, Inc., Harrington and Richardson, Springfield Armory, and Winchester Arms.

27 D&PS did conduct a special high-speed film evaluation of the charging handle latch operation in the SAWS Engineering Test, but this was in no way a kinematic design analysis.

some kinematic work to support the proposed new buffer design in December 1965 and January 1966, but it was limited in scope.

While kinematic analysis should be an integral part of the development and introduction of an automatic weapon system, characterized by close tolerances and sensitivity to operating energy levels, a thorough kinematic analysis of the M16A1 was not directed until January 1968, at which time it was treated as an item of highest priority within the U.S. Army Materiel Command.

A second weakness in the testing of the M16 was that no formal or informal laboratory work was done to conduct engineering analysis to improve the design and functioning of selected components.

The M16 test program not only failed to include some important tests but also left a number of tests incomplete in terms of the stated test purpose. The most notable example was the omission of cyclic rate measurements in the 17 March to 10 April 1964 firings for the engineer design test of alternate propellants for use in the 5.56mm M193 cartridge.[28/] This test resulted in approval of WC 846 (ball) propellant for loading in 5.56mm ammunition, although it was later demonstrated that the use of WC 846 propellant in place

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28 Development and Proof Services, APG, Firing Record S46440, Engineer Design Test of Alternate Propellants for Use in Cartridge, 5.56mm, Ball, M193, 17 Mar - 10 Apr 64.

of IMR 4475 or 8136 propellants had a significant effect on the functioning of the M16. Experience has proven the seriousness of the omission of cyclic rate measurements in this engineer design test of propellants.[28]

Experience has also proven the inadequacy of the M16 test program with respect to environmental testing. No tests other than the SAWS troop tests and limited user evaluation in 1962 have been conducted by the U. S. Army under tropic conditions. In January 1968, however, the Weapons Systems Evaluation Group (WSEG) conducted an operational reliability test of the M16A1 system in Panama. On the other hand, since its production began in March 1964, the M16 has been used in almost exclusively in a tropic environment. This shortcoming in the M16 test program is obvious in hindsight, but also results from inadequate foresight. The M16 was initially adopted, in January 1963, for use by the airborne, air assault, and special forces units. In December 1965 it was adopted as the standard rifle for the Vietnam war, and in November 1966 it became a standard Army rifle. Yet in 1966, modification of the action spring guide assembly (buffer) was delayed while buna rubber discs were developed to pass a 2,000-round test at -65°F, and no tests were undertaken at the Tropic Test Center. In June 1967 Rock Island Arsenal completed a comprehensive evaluation of lubricants for use

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28 Colt's had measured M16 cyclic rates as part of their acceptance procedure since production began in March 1964. D&PS had measured cyclic rates with other rifles, most recently in the 7.62mm M14 Comparison Test, D&PS Report 1175, February 1964. Thus, cyclic rate measurements for rifles was a common procedure.

with the M16. This test was to be supplemented by an evaluation under Arctic winter (1967-68) conditions. No supplement provided for environmental consideration by the Tropic Test Center.[29] Similarly, USATECOM completed an evaluation of the new buffer design in January 1968 and has in process (as of May 1968) an evaluation of the chrome plated chambers introduced into production in September 1967, without any follow-up or supporting test data from the Tropic Test Center.

Another gap in M16 test data is the failure to consider tracer cartridges in lethality evaluations. Historically, tracer rounds have been used to designate, not defeat targets. Accordingly, the primary emphasis has been on developing a round to match the ballistic flight characteristics of the ball ammunition, and properly so. However, with an automatic rifle in the hands of each infantryman, the employment of tracer is of necessity modified. With the common 4-ball-to-1-tracer ratio, 20 percent of a squad's ammunition is tracer. This 20 percent must be used to defeat as well as to designate targets, lest the

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29 Arthur D. Little, under contract to DDR&E, now has the mission of evaluating Army and DOD policies and procedures for lubricant evaluation.

squad's firepower be severely curtailed. Not until the summer of 1967, when the 9th Infantry Division reported an observed lack of lethal effects for the 5.56mm M196 tracer projectile, was tracer lethality for the M16 a subject of investigation or even of consideration.[30] Then, in November 1967, in tests of the XM177E2 submachine gun, USATECOM observed tracer projectile breakup within the first 50 yards from the muzzle when M196 tracer cartridges loaded with WC 846 propellant were fired at temperatures ambient in Vietnam (90°F to 125°F).

Statistical Design of Tests

The problem of statistical design for tests of a rifle and ammunition system is essentially two-dimensional. For each individual characteristic to be tested, whether a product improved component or an environmental factor, there are the two questions of the breadth of the rifle sample, the number of rifles, and the depth of the firing, the number of rounds fired per rifle. Sample sizes must be statistically adequate with respect to both the number of rifles and the number of rounds fired per rifle. Yet in engineering tests, sample sizes that are too small to provide results with statistical significance are prevalent. A dramatic example is the unlubricated subtest of the SAWS Engineering Test.

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30 Lack of tracer penetration was noted in the SAWS Engineering Test (see page 2-28 above).

Two XM16E1's were supposed to fire 3,000 rounds each. The first had two stoppages in the 3,000-round schedule of alternating automatic and semiautomatic fire. The second had 59 stoppages after just 1,000 rounds,[31] at which time the test was terminated because of excessive malfunctioning. The probability that the two rifles tested represent the same population of XM16E1 rifles is virtually zero. No further testing was conducted, however, and the results from the sample of two were averaged together to yield 15.3 malfunctions per 1,000 rounds. For all tests, the the statistical levels of confidence in the results obtained should be reported.

The statistical design of tests could be improved by developing and analyzing models of malfunction incidence with the object of determining the mean number of rounds between the occurrence of a given type of malfunction in rifles suffering the malfunction. Review of past M16 tests clearly demonstrates that some rifles are more prone to certain malfunctions than are other rifles tested under the same conditions. Knowing the frequency with which malfunctions of a given kind can be expected, it is possible to estimate the number of rounds that should be fired per rifle to yield a reasonable degree of confidence that malfunction properties

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31 USATECOM distinguished between malfunctions which caused stoppages and those that did not. Only malfunctions causing stoppages are cited here and elsewhere in this discussion.

will be observed. At present, the reasons for the varying number of rounds fired in environmental tests cannot be determined, as in the SAWS Engineering Test: 20 rounds per rifle for the mud and dust subtests; 100 for sand; 1,200 for the extreme high temperature; and 3,000 for the extreme low temperature.

Often the sample size is too small to permit statistical analysis, or even to compensate in a gross way for random variability in rifles and ammunition. Statistical procedures are necessary to permit extension of the data from the relatively few items actually tested to the population of rifles and ammunition represented in the tests. The statistically predicted description of the population is the end object of the test program; the observation of phenomena in the test sample is not.

Another aspect of test design, conduct, and analysis is highlighted by comparing any Army test with the Weapons Systems Evaluation Group's (WSEG) test of M16A1 operational reliability, conducted for the Director of Defense Research and Engineering in Panama in January 1968. WSEG, with the support of the Institute for Defense Analyses, had a carefully developed test design, utilizing 192 M16A1's in four combinations - chromed and unchromed chambers, and ball and IMR propellants - with controlled cleaning, firing, exposure, and magazine loading schedules. Between 5,000 and 6,000 rounds were fired from each rifle, with detailed data recorded on

environmental conditions and functioning properties. The purpose of the test was to assess operational reliability, but in accomplishing this purpose, WSEG compiled a record of M16A1 malfunctions and possible causes more comprehensive than that contained in any Army report. The size of the sample of rifles and the number of rounds fired under each condition were sufficiently large to obtain enough malfunctions to permit statistical analysis. Thus, the WSEG test lends itself to engineering analysis of the weapon system.[32]

Variability of performance between lots of ammunition has been demonstrated in Army tests. Yet test designs have not, and perhaps cannot, effectively randomize this variability because of the extensive matrix that would be required to sample typical ammunition lots, in addition to sampling rifles and firing an appreciable number of rounds from each ammunition lot. The 1967 Ballistic Research Laboratories' evaluation of barrel twist effects on accuracy handled the problem of variability among ammunition lots well. The main body of the test firings for accuracy with 1,000 barrels with the standard 1-in-12-inch twist rate and 1,000 with a 1-in-14-inch twist were made using ammunition with average accuracy characteristics. Recognizing that not all ammunition in the field has "average" accuracy characteristics, BRL fired from each of the 2,000 rifles one 10-round shot group using ammunition with acceptable

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32 The WSEG data are discussed in detail in Appendix 6.

but marginal accuracy characteristics. Statistically valid statements could be and were made about bullet dispersion based on these firings, because the results considered variations in performance that one expects to encounter in the system as issued to the field. On the other hand, USATECOM in its engineering tests had greater difficulty in compensating for variations in the pressure-time curves between ammunition lots and the consequent effects on weapon functioning. In practice USATECOM typically utilized one lot of ammunition in its engineering and service tests, thus not accounting for variability of ammunition, but at the same time not allowing the results to be distorted by a chance variation not randomized.

Test Criteria

Individual test criteria and procedures with respect to the M16 warrant examination, beginning with the question of what type of results were soughts and going on to assess the validity of the way the test was administered. In the engineering tests conducted at Aberdeen Proving Ground, the basic objective is to determine the technical properties, performance, capabilities, limitations, reliability, maintainability, endurance, and safety characteristics of an item or system and its associated tools and test equipment as described in the Qualitative Military Requirements (QMR's) or the Technical Characteristics (TC's).

The basic objective of the service tests is to determine, under simulated or actual field conditions, to what degree the item or system and its maintenance package meet the characteristics described in the QMR and to determine the suitability of the item or system and its maintenance package for use by the Army.

Questions of the efficacy of criteria are intertwined with statistical design and validity, as demonstrated in the SAWS Engineering Tests. Commonly, rifle bipods are justified because they improve accuracy. Therefore, the criterion chosen was that dispersion should be less with the bipod than without. While the criterion was reasonable, evaluation against it was not, because the results with and without the bipod were only slightly different, and there was a reasonable probability that this difference was due to chance. Any criteria based on comparison of results with a given data base can be evaluated with validity only if the comparison data base is statistically significant.

Other tests like the Springfield Armory test of buffers did not specify any evaluation criteria; or like SAWS Service Test have unreasonable criteria — such as a 50-round magazine capacity for all rifle systems. Army test criteria frequently specify that the test item should be at least as good as the standard for which it is proposed as a replacement. Uncritical acceptance of such criteria can be troublesome, as any test system need possess

only the characteristics required to fulfill its intended role, regardless of the characteristics of the standard item. This fact emerges when the 5.56mm M196 and the 7.62mm M62 tracer cartridges are compared. The 5.56mm cartridge is intended only for the rifle, at present, whereas the 7.62mm cartridge is used in both rifles and machine guns. Clearly, the 7.62mm M62 cartridge has trace and penetration requirements at ranges beyond those of rifle interest, and it is not necessary that the M196 tracer cartridge for the M16A1 rifle match the characteristics of the M62 tracer cartridge for the M60 machine gun, yet such a criterion was applied in the SAWS Engineering Test.

Special problems arise with environmental test criteria. Obviously such criteria need to be sufficiently stringent so as to differentiate between weapon types under adverse environmental conditions and so that the weapon's performance reflects the presence of adverse conditions. On the other hand, such criteria must not be so severe as to induce a nearly 100 percent malfunction rate, thereby masking differences between weapon designs. Some tests utilize very severe adverse conditions, others test the rifle under moderate conditions. The SAWS Engineering Test mud subtest bordered on extreme severity, and was clearly too severe a test for the M14. 52 stoppages resulted in an attempt to fire 40 rounds. A part of the

severity criteria is the duration of the test. In SAWS, the tests were of extremely short duration, but the more recent USATECOM buffer test had extensive environmental firings, which resulted in significant data.

It has been suggested that the engineering test criteria are not realistic, in that rifles are subjected to only one adverse condition at a time. The current engineering test approach is correct. The WSEG Panama test was a test of operational reliability, and had the mission of testing under conditions like those in Viethan. However, engineering tests are for weapon design and analysis evaluation. To run a mix of adverse conditions would limit the engineering control of test variables, and would risk the masking of certain effects by more dominant ones. Yet an engineering test should determine all effects of environment, and these environments should be chosen so as to be demanding of the test rifle and representative of the worldwide range of environmental conditions.

Tests should be conducted under conditions that place great but tolerable stress on the system under test. Since the SAWS Study, USATECOM has sought to determine temperature-humidity conditions under which propellant residue fouling most severely inhibits reliable weapon functioning. This work resulted in the decision to conduct the 1967 buffer test fouling subtest at 20°F. At other

temperatures, fouling, while readily apparent, does not manifest itself as severely in malfunctions. Continued evaluation of conditions under which functioning is most critically affected is required, so that the M16A1 or any future system can be tested under the most severe conditions. Such tests, with subsequent applied engineering analysis, could then provide an improvement in the system.

Another area in which M16 test criteria were deficient was the lack of standardization in testing procedures with respect to tests with the same objectives. It would seem reasonable that two tests with the same purpose should follow the same procedures.[33] In order for the results of any test to be considered reliable, they should be statistically reproducible. That is, if the same test procedures are repeated, the results of the two trials should be statistically equivalent. This would not be the case, of course, if the test procedures were not standard. Furthermore, it is often desirable to compare results of tests performed at different times or places or with different weapons. It is not at all clear how to compensate for different test procedures, assuming that standard procedures do not exist, and thus at best the desired comparisons would be extremely difficult.

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[33] These comments are for tests conducted within the same time frame. Improvement (and hence alteration) of test procedures is expected and necessary over a period of time.

This lack of standardization during tests of the M16 system is illustrated by service tests of the XM196 5.56mm tracer cartridge. The temperate climate condition test was conducted by the U.S. Army Infantry Board (USAIB) and the test under arctic winter conditions by the U.S. Army Arctic Test Center (USAATC). The objective of each of these service tests was to determine the suitability of the subject cartridge under the respective climatic conditions. However, the subtests and procedures differed. The arctic phase consisted of seven subtests, while the temperate phase consisted of these seven with two additional subtests, compatibility in automatic fire and human factors engineering.

The objective of the accuracy subtest was in each case to determine the accuracy, at various ranges, of the test cartridge and control cartridges for comparison purposes. In the arctic, type B targets were fired upon at ranges of 200, 300, 400, and 500 meters. At the USAIB, type A targets were fired on from ranges of 50, 100, 200, and 300 meters and type B targets were fired on from ranges of 400, 500, and 600 meters. In the arctic only semiautomatic mode was considered, while the USAIB also fired in the automatic mode. In the arctic test the rifles were zeroed at 200 meters using control cartridges. In the USAIB test they were zeroed at 50 meters using test cartridges. The object of the position-disclosing effects subtest was in each case

to determine the position-disclosing effects of the test cartridge. In the arctic, observers were placed downrange at 100 meter intervals out to 900 meters, as well as behind each firer. In the USAIB test, observers were positioned downrange at 100-meter intervals out to 600 meters. The Arctic Test Center considered only conditions of daylight and darkness, whereas the USAIB also considered twilight conditions. Many more differences in procedures can be shown with respect to these two subtests, as well as some of the other subtests among the common seven.

A second example of nonstandardized procedures is evident in the M16 product improvement tests of bolt assist devices. The purpose of these tests was to determine the suitability of the particular bolt assist device being tested. Examination of three such tests performed by the USAIB on three separate occasions in 1963 revealed the following differences:

1. Each used a different number of test weapons (3, 4, 9).

2. The earliest test consisted of four subtests, the last three of which involved treating the weapons in some way, firing them, noting the malfunctions and noting whether or not they were cleared by using the test device. The two other USAIB tests involved only three subtests, because two treatments (liberal coating of oil and submergence in water) were combined into one test.

3. A different total number of rounds was fired in each test (2,465, 2,886, 7,200).

Examination of two tests conducted by D&PS on separate occasions revealed the following differences:

1. A different number of test weapons was used in each (5,7).

2. Different subtests from the ones performed by USAIB were performed by D&PS. The two D&PS tests did not consist of the same set of subtests because items other than just the bolt closure device were tested.

3. In the dust subtest of one of these the barrel muzzle was taped to prevent dust from entering the bore. In the other, it was not.

Malfunction Criteria

The earlier discussion of the SAWS Engineering Test found fault with the summation of malfunctions and stoppages across all adverse condition tests and for all types of malfunctions. It would be useful to have a descriptive model of malfunction behavior under adverse conditions, so that malfunctions could be totaled in a reasonable proportion according to the test environment and could be totaled with account given to their relative severity. Such a model would provide an index of the loss of rifle effectiveness in combat situations due to weapon malfunction.

The questionable validity of mere tabulations of malfunctions is generally recognized. Throughout the M16 test period, some reports have split malfunctions into categories, according to their severity. Most successful of such classification of malfunctions was the WSEG Panama test, in which there were three categories:

1. Malfunctions readily clearable by the firer, without assistance.

2. Malfunctions clearable by the firer, using only tools normally available (cleaning rod, cartridge, and the like).

3. Malfunctions that required attention by an armorer or the use of an armorer's tools.

The categories were reasonable, and throughout the WSEG test report, malfunction data are presented by category of severity, as well as totaled for all malfunctions. There is, of course, the problem of consistent and correct classification of malfunctions by category of severity.

When all data in a report are consistent for all environments and for all types of malfunctions, there is no need to combine or to choose between data in order to arrive at determination of the better system. On the other hand, when a proposed product improved component is associated with fewer malfunctions of one type than the standard component, but more malfunctions of another type, a choice must be made as to whether the proposed component

really improves overall system performance. Such was the case with the January 1968 USATECOM product improvement test of the redesigned buffer. An interesting and valuable analytical method for grouping malfunctions is given in that report. All readily clearable malfunctions were assigned a numerical value of one. No value was assigned severe malfunctions. Rather, calculations were made to determine what value would have to be assigned to the more severe malfunctions in order to reverse the preference between buffer designs. Military and engineering judgment could then be applied to decide whether the weighting factor thus obtained was reasonable, and which design would yield the better performance results. In the USATECOM buffer test report, such a procedure yielded a weighting factor of 5.3 required to reverse results for all test conditions other than saltwater immersion and -65°F. If military or engineering judgment should determine that difficult-to-clear malfunctions should not be valued as much as 5.3 times the value of easy-to-clear serious malfunctions, then the redesigned buffer would be preferred on the basis of weighted malfunction experience. If the difficult-to-clear malfunctions should be so valued, then the standard buffer would be preferred. This analytical model offers a method of combining different types of malfunctions. It would be useful as well to develop a model for the combination of different environmental malfunction rates, when there is a performance difference between candidate components under various environments.

Validity of Test Results

Examination of M16 test reports to determine how the test data were used to derive conclusions has shown that one of three statements can be made about most reports.

1. The report consisted only of tabulated data on which apparently no analysis was performed and on the basis of which no conclusions were drawn and presented in the report.

2. The conclusions were limited to statements describing the trends implied by the data, and were generally weak enough not to raise questions as to their validity.

3. The conclusions were strong statements with respect to the significance of test results, and the implication is made that they have been drawn on the basis of some kind of analysis of the data.

While the test reports in the first two categories failed to deal with data that could have been statistically analyzed with profit, it was most important to examine the reports in the third category to see how well the conclusions were supported by the data. It was found that the criteria used in drawing the conclusions commonly were not stated and that the statistical tests, if any, performed on the data were not specified. In some cases, by emphasizing selected portions of the data, conflicting conclusions can be drawn. In others conclusions can actually be refuted by performing a statistical test on the data.

In the 1966-67 Arctic Test Center engineer design test of preservative lubricants, five lubricants were tested for effectiveness under arctic winter and spring breakup conditions. It was concluded that experimental lubricants A and B were best suited for U.S. Army use on small arms weapons under these conditions. Six firing tests (one test for each of 3 temperature ranges and 2 lubrication methods) were conducted on four different type of weapons for each of the 2 modes of fire. In addition, a series of tests for several consecutive days of fire was performed. Although the basis for drawing the conclusion was not explicitly stated, it might have been the total number of malfunctions when they were summed over the entire series of tests. This sum was, in fact, smallest for A and second smallest for B. Summing the number of malfunctions over all tests performed obscured any effect that the four variables (weapon, mode of fire, temperature, and lubrication method) might have had on the lubricant. One can select subsets of the set of all tests performed for which the total number of the malfunctions would result in a different ranking of the lubricants. Based upon consideration of the total number of malfunctions as a function of type of weapon, lubricant A was <u>not</u> best for either the XM16E1 or the M14. Viewing the data in this way raises a question as to the influence

of the mode of fire, temperature, method of lubrication, and the type of weapon on the effectiveness of a lubricant and makes questionable the criteria on which the conclusion of this test apparently was based.

In January 1966 Colt's performed a test on the effect of the position of the powder in the cartridge on chamber pressure, port pressure and short-piston velocity. Two lots of ammunition, one containing WC 846 propellant, and one containing CR 8136 propellant, were tested, with 20 rounds fired from each lot. The position of the powder in the cartridge case (forward or rearward) was alternated with each round. The following observation was made: "The data show no significant dependence of velocity, or of port pressure, upon powder position, with either of the ammunition lots tested."[34] There is no evidence that any statistical analysis has been made on the test data. In inspecting the port pressure data for the WC 846 propellant, a difference of 300 p.s.i. was observed in the average port pressures recorded for the two positions of the powder. A one-way analysis of variance test on the data indicated, in fact, that a significant difference did exist in the mean values of the port pressure because of the position of the powder, in contradiction to the implication in the report that powder position did not affect port pressure.

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[34] Colt's Inc., Effect of Ammunition Variables on Acceptance Testing of XM16E1 Rifles, 17 Jan 66.

The report, Evaluation Test of the Rate of Rifling Twist in AR15, by D&PS in January 1963 concluded "long range accuracy and bullet stability of the AR15 rifle with a rate of twist of one turn in 12 inches were superior to those of the rifle with one turn in 14 inches." The use of the term "long range accuracy" in the above conclusion is at least misleading, since the test was conducted at two ranges - 100 yards and 500 yards. Since there might be some question as to whether a single test at 500 yards is sufficient basis for generalization as "long range," it would have been more precise to refer to 500-yard accuracy. The report did not indicate specifically how the conclusion was supported by the data, nor do the data support the conclusion of superiority for the 1-in-12-inch twist rate. Statistical analysis of variance has shown that there is no statistically significant difference in the mean radius data at 500 yards between the two rates of twist.

The 1963 USAIB evaluation of forward assist assemblies stated conclusions for which either no supporting data were presented or for which the criteria were so obscure that it is impossible to determine whether supporting data exist. For example, the following partial conclusion was stated: "the bolt assist device did not significantly reduce the time required

to reduce chambering or feeding stoppages after the first round was fired."[35] No quantitative data supported this contention. Also, "The bolt assist device used in this test provides an adequate but not an optimum means of closing the bolt of the AR15 in event of a stoppage."[36] It is not at all clear how this statement can be supported without first defining "adequate" and "optimum" in terms of some quantified criteria. A recent example of inadequate sample size and conclusions not supported by the data was provided by a 20 December 1967 test report on M16A1 Chrome Plated Chambers. "Chrome plated chambers are superior to non-plated chambers in avoiding failures to extract under dust and saltwater environments."[37] The report supported this conclusion with the following data:

Failures to Extract

	Chrome Chamber		Nonchrome Chamber	
	Weapon 1	Weapon 2	Weapon 1	Weapon 2
Static dust test 500 rounds fired per rifle	0	0	0	0
Dynamic dust test 1,820 rounds fired per rifle[a]	0	0	1	1
Saltwater immersion 180 rounds fired per rifle	0	0	1	1

[a] The two nonchrome chambered rifles fired 1701 and 1760 rounds, respectively. Reason not given.

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35 Page 4, USAIB, Product Improvement Test of Armalite AR15, Rifle, 30 Aug 63.

36 Page 5, USAIB, Product Improvement Test of Armalite AR15 Rifle, 14 Oct 63.

37 Page 9, APG Letter Report on Initial Production Test of Chrome Plated Chambers for M16A1 Rifles, 20 Dec 67.

There were not enough failures to extract to make a valid judgement that the four that did occur could be associated with the fact that the chambers were not chromed.

Weapon Design Analysis

Small arms system tests must be more than data gathering activities. They should, especially the engineering tests, maintain the flexibility to pursue questions that arise in the conduct of the originally scheduled test series. A good example of such flexibility is the SAWS Engineering Test. After encountering frequent incidences of the charging latch handles moving rearward while the rifle was firing, D&PS took high-speed movies to analyze the malfunction. Its analysis led to a solution to the rifle design shortcomings and the introduction of a corrective modification. Yet in the same test series, when one rifle had a demonstrated tendency to ejection failures, not only was no analysis to determine the cause reported, but also the rifle was continued in use. The engineering tests should be dynamic and lead directly to engineering analysis, so that the cause of malfunctions can be identified, and not merely their existence or frequency.

The Army and other Defense agencies have conducted large-scale tests of the M16A1 in recent years. All of these tests have recorded reliability data. Of course, there were differences in the data due to variances in judgment as to the type and

severity of a given malfunction and to limitations in some tests to observe each round fired, because of the operational nature of the test. This was particularly true in the field experimentation trials at the USACDC Experimentation Command at Fort Ord, California, where test monitors could not interfere with the natural flow of the test runs lest the evaluation results be distorted. (Table 2-17 lists some of these tests to show the large number of rounds and weapons involved.)

Table 2-17 — MAJOR M16A1 TEST FIRINGS

TEST	NUMBER OF M16A1's	NUMBER OF ROUNDS FIRED	
		Total	Average per Weapon
SAWS Engineering Test	10	59,845	5984
SAWS Service Test	20	95,720	4786
SAWS Troop Acceptability Test	about 100	215,020	2150
SAWS Field Experimentation	120	437,692	3647
USATECOM 1967 Lubricants Test	120	294,353	2453
USATECOM 1967 Buffer Test	12	99,891	8324
1967 IRUS Field Experimentation[a]	120	508,882	4241
1968 WSEG Operational Reliability Test	192	1,088,135	5667
1964-68 Colt's Quality Assurance Reliability Test[b]	139	780,662	5616
Total	833	3,580,200	4298

[a] Infantry Rifle Unit Study (IRUS) conducted by USACDCEC, Fort Ord, California.

[b] Through February 1968.

These data and those developed in detail in analysis of M16A1 reliability testing in Appendix 6 should be subjected to engineering analysis. The answers to questions similar to what types of malfunctions are most likely under certain conditions and what are the causes of the malfunctions experienced are required to provide further refinement and improvement in weapon design. There are isolated incidences where such analyses have been conducted. However, lethargy is typical of this kind of engineering analysis activity. Rock Island Arsenal took more than six months to measure chamber dimensions on the rifles in the June 1967 lubricants test that were prone to failures to extract, in an effort to determine whether there was a difference in chamber dimensions between rifles prone and those not prone to extraction failures.

Steps should be taken to increase the usefulness of field experimentation and troop test data in answering questions of engineering design. While USACDC's mission was not engineering testing, the rifle samples were typically large. Malfunction data have already been recorded as a byproduct of the combat evaluation mission. These same tests could serve a vital second purpose if their data collection permitted engineering analysis. Such data would be much like data obtained in the recent WSEG Panama test. Engineering tests at D&PS, which subject weapons to adverse conditions in detail, cannot have the relatively huge samples used

in the field tests. Both types of data are necessary for engineering analysis. A sense of urgency about improving weapon design is also required. The Army invests considerable time and resources in accumulation of test data. However, all too often the necessary follow-on activity of analysis is neglected, although engineering analysis and not firing data will provide the significant return on the investment in test programs.

E. Conclusions

1. The conclusions drawn in testing of the M16 system were often not clearly supported by the test data.

2. Because of the small size of the sample and the variability between weapons, the results of the engineering environmental subtests could give only an indication of weapon performance, and even then without great assurance.

a. In several instances in the engineering tests, the stoppages of one of the two XM16E1's used were attributed to the weapon and not to the environmental condition in which the weapon was tested. Despite this fact the rifle continued in use, and the malfunctions were reported against the XM16E1 in an evaluation of the environmental test results.

b. The dominance of weapon-peculiar malfunctions (with incidence up to 1-in-8 rounds) all but obliterates any useful output from the SAWS tests under environmental conditions.

c. There is no evidence that any valid criteria were employed in deciding that the SAWS Engineering Test dust subtest should consist of 20 rounds for each of two rifles, while the extreme high temperature consisted of 1,200 rounds for each of two rifles.

3. The summation of Engineering and Service Test malfunctions provided the data on which stoppage rate statements in the USATECOM

Analysis of Results of SAWS Engineering and Service Test and in the Infantry Agency's SAWS reports were based. However, no criteria were presented to support the reasonableness of this summation.

4. The Springfield Armory test of buffers was deficient as follows:

a. Two buffer types were eliminated from consideration after testing only at -65°F. A better criterion would have been performance at ambient temperatures.

b. Firings (12,000 rounds) with tracer ammunition were made only at -65°F because of a shortage of ammunition. If additional tracer ammunition could not be made available for the buffer test, tracer ammunition should have been used only after elimination of two buffer types and at ambient temperatures.

c. More rounds (1,000) were fired for each rifle-buffer-ammunition combination at extreme (-65°F and 155°F) temperatures than were fired at the more common ambient temperatures (600 rounds).

d. In the firings at -65°F on 2 buffers were used per rifle. No consideration was given to the statistical significance of the observed differences.

e. In the firings at 155°F and ambient temperatures, only one buffer was used per rifle. The two types of buffer were evaluated in two different sets of rifles, with demonstrated performance differences.

f. The test data and report do not demonstrate that the best buffer design was selected.

5. The 26 June 1967 USATECOM comprehensive evaluation of the old and new buffers in the M16A1 rifle utilized test matrices which prescribed a dramatically more valid test, than did the thin, incomplete matrix used in the Springfield Armory buffer firings.

6. In the case of the M16 there was no kinematic analysis of M16 weapon functioning, although kinematic analyses were conducted on other small arms systems. While kinematic analysis should be an integral part of the development and introduction of an automatic weapon system, characterized by close tolerances and sensitivity to operating energy levels, a thorough kinematic analysis of the M16A1 was not directed until January 1968.

7. The most notable example of incomplete testing was the omission of cyclic rate measurements in the 17 March to 10 April 1964 firings for the engineer design test of alternate propellants for use in the 5.56mm M193 cartridge. This test resulted in the

approval of WC 846 (ball) propellant for loading in 5.56mm ammunition, although it was subsequently demonstrated that the use of WC 846 propellant in place of IMR 4475 or 8136 propellants had a significant effect on the functioning of the M16.

8. Experience has proven the inadequacy of the M16 test program with respect to environmental testing. No tests, other than the SAWS troop tests and limited user evaluation in 1962, have been conducted by the U.S. Army Tropic Test Center. On the other hand since production began in March 1964 the M16 has been used in combat exclusively in a tropic environment.

9. A significant gap in M16 test data is the failure to consider tracer cartridges in lethality evaluations.

10. The statistical design of tests could be improved by developing and analyzing models of malfunction incidence with the object of determining the mean number of rounds between occurrence of a given type of malfunction in rifles displaying the malfunction.

11. The statistically predicted description of the population is the end object of the test program; the observation of phenomena in the test sample is not.

12. It would seem reasonable that two tests, in the same time frame, with the same purposes or objectives, should follow the same procedures.

13. Small arms system tests must do more than gather data.

a. These tests, especially the engineering tests, should be flexible enough to pursue questions that arise in the conduct of the originally scheduled test series.

b. The Army and other Defense agencies have conducted large-scale tests of the M16A1 in recent years. All of these tests have recorded reliability data. These data and those developed in detail in an analysis of M16A1 reliability testing (Appendix 6) should be subjected to engineering analysis.

c. Steps should be taken to increase the usefulness of field experimentation and troop test data to answer questions of engineering design. While USACDC's mission is not engineering testing, the rifle samples are typically large. These same tests could serve a vital second purpose, if their data collectio permitted engineering analysis.

d. The Army invests considerable time and resources in the accumulation of test data, but all too often the necessary follow-on analysis is neglected. Yet engineering analysis and not firing data will provide the significant return on the investment in test programs.

14. In the December 1967 Initial Production Test of Chrome Plated Chambers for M16A1 Rifles, there were not enough failures to extract to make a valid judgment that the four that did occur could be associated with the fact that the chambers were not chromed.

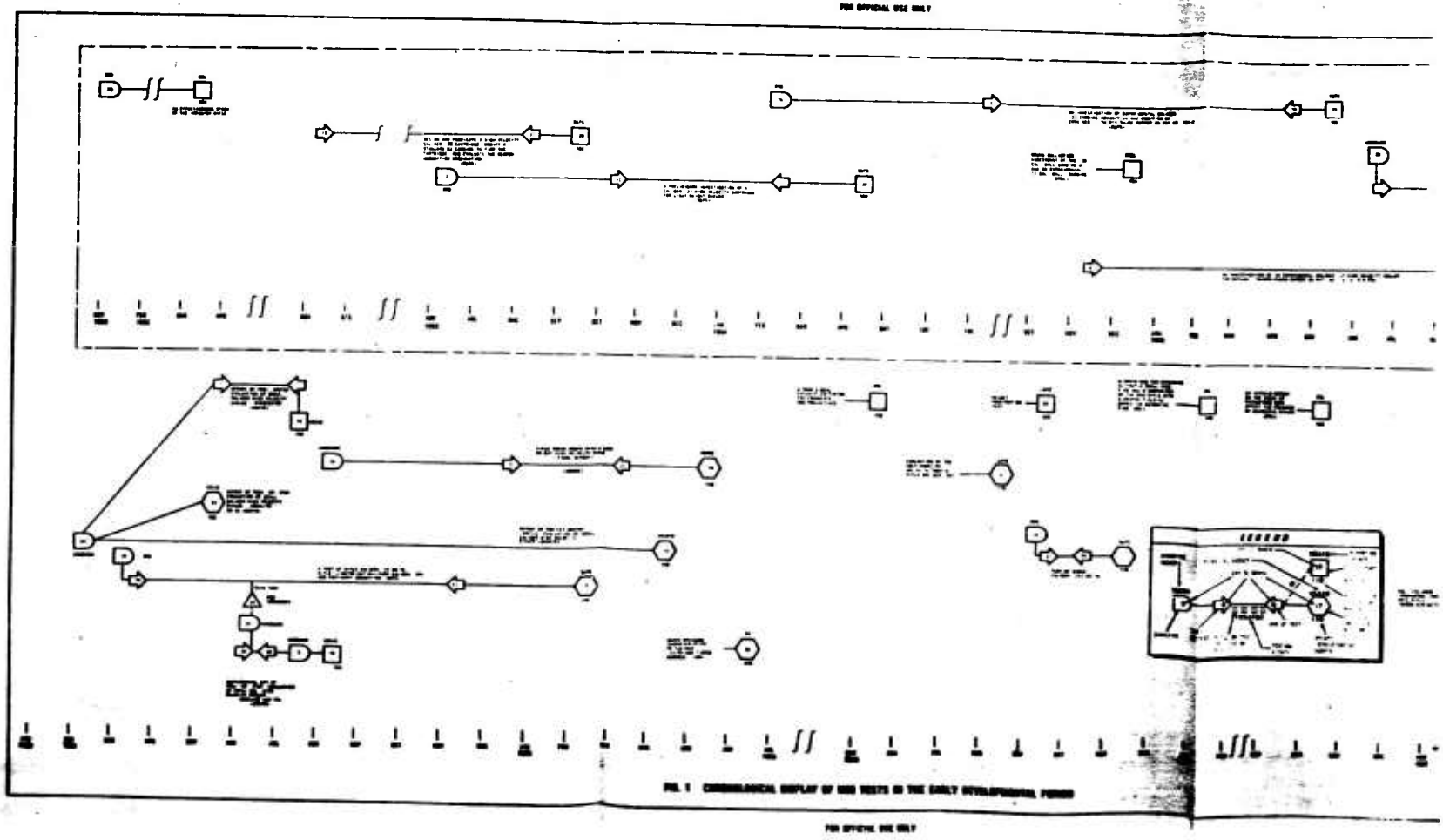
15. Test reports have not included statements of the statistical level of confidence in the validity of the results obtained and reported.

Audit trail analysis of M16 Tests and Evaluations

The collection of 270 tests and evaluations of the M16A1 rifle and ammunition system are analyzed chronologically in this inclosure. The chronological analysis indicates subsequent tests, actions taken, evaluations and decisions made with regard to each test. The evaluations of the major series of tests presented by senior headquarters are correlated with subsequent decisions.

The audit trail is divided into time periods. The first treats tests in the early developmental period of the M16A1, prior to the 1962-63 comparative evaluation; the second deals with tests and evaluations resulting from the worldwide comparative evaluation of the AR15, M14, and AK47 rifles directed by the Secretary of Defense; the third describes M16A1 tests between the 1962-63 comparative evaluation and the 1965-1966 Army Small Arms Weapons Systems (SAWS) Study, and treats the more and the less significant tests separately. The fifth is the SAWS Study and its consequent evaluations and decisions. Tests and evaluations since the SAWS Study are divided into two categories - significant and less significant. Evaluations and studies are treated under the heading of tests, and wherever possible, the initiator of a test is given, together with the date the test was directed. Only

The principal findings, conclusions, or recommendations are cited. The test dates column indicates where possible the time period of the actual testing (or evaluation). The report date would then be sometime after the test dates. When the test dates were not available, a single date is given, which is the report date.



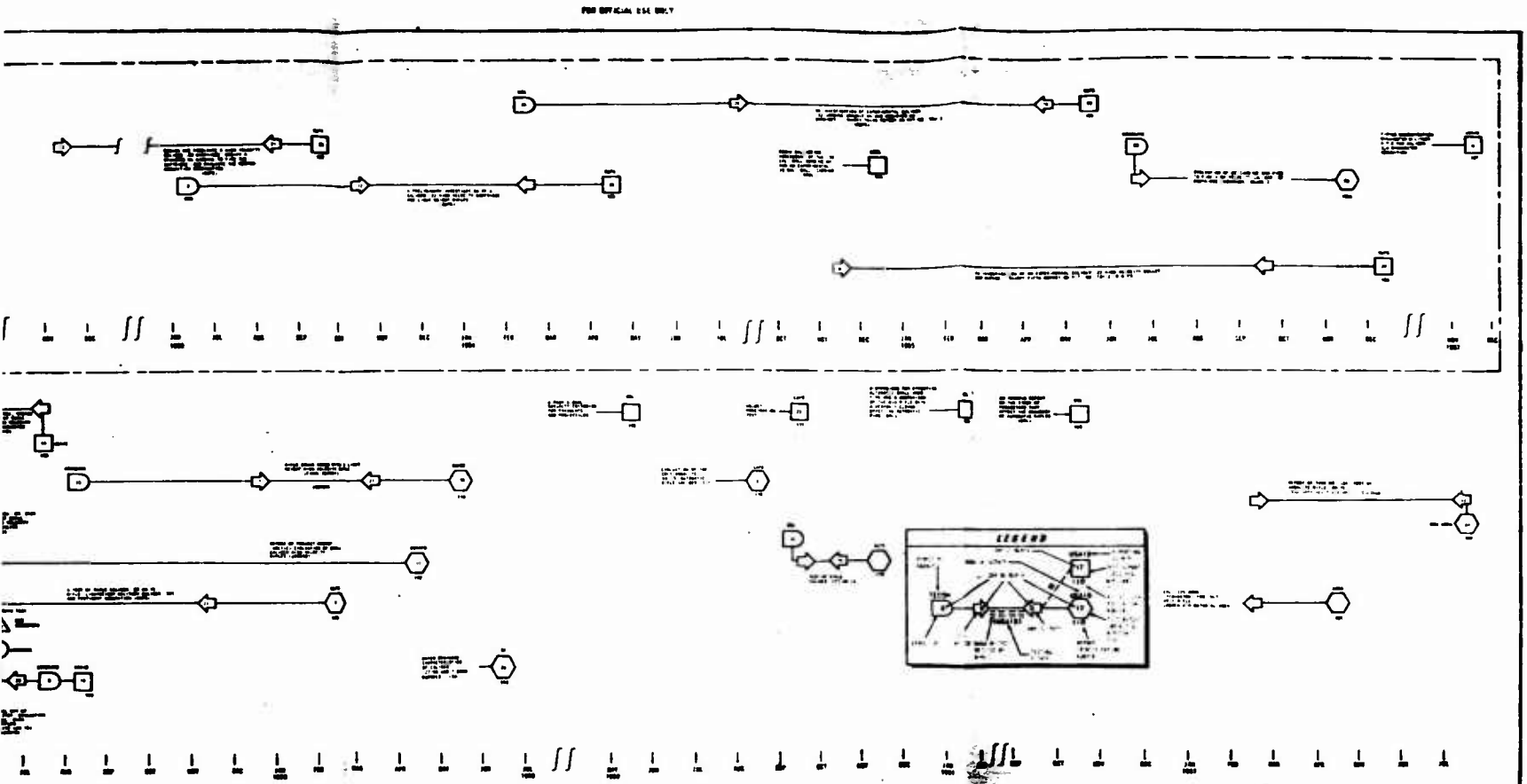


FIG. 1 CHRONOLOGICAL DISPLAY OF WIG TESTS IN THE EARLY DEVELOPMENTAL PERIOD

TABLE 2 - 18

CHRONOLOGICAL DISPLAY OF M16 TESTS IN THE EARLY DEVELOPMENTAL PERIOD

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NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST [illegible]	SUB[illegible]
	INITIATOR	DATE	PURPOSE					
101	Ordnance Corps	28 Nov 50	To provide basic data to assist in developing future rifle requirements.	BRL	Effectiveness Study of the Infantry Rifle	[illegible]	[illegible] for a family [illegible] the M2 caliber .30 carbine. [illegible] data on caliber [illegible] rifles [illegible] included. A smaller [illegible] velocity [illegible] was found to be more effective than the caliber .30 M1 rifle.	Further [illegible] testing [illegible] and Proof [illegible] in 1952-53, (Item 102) and in 1953-54 (Item 103).
102	Ordnance Corps	2 Jun 53	To increase the effectiveness of the M2 carbine, in both semi- and full-automatic fire, by adapting it to a high velocity, small caliber cartridge.	D&PS	Design and Fabricate a High Velocity Caliber .22 Cartridge; Modify a Standard M2 Carbine to Fire the Cartridge; and Evaluate the Weapon Ammunition Combination	13 Nov 52 to 21 Aug 53	The M2 type carbine was capable of good performance when modified to fire 41 grain caliber .22 bullets at velocities in excess of 3,000 fps. The caliber .22 bullet had less striking energy than the caliber .30 carbine bullets, but more than enough energy to satisfy lethality criteria to at least 400 yards. The caliber .22 compared favorably with the M1 rifle in firing against standard targets at ranges up to 300 yards.	Continued testing (Item 103).
103	Ordnance Corps	2 Jun 53	To design a high velocity caliber .22 rifle cartridge, fabricate proof weapons and equipment for producing and testing the ammunition, adapt a lightweight automatic rifle to the caliber .22; make a preliminary investigation of interior, exterior, and terminal ballistics of the cartridge; and evaluate briefly the performance of the ammunition in the light weight automatic rifle.	D&PS	Preliminary Investigation of a Caliber .22 High Velocity Cartridge for Light Weight Rifles	12 Oct 53 to 1 Feb 54	The experimental caliber .22 ammunition was superior to the caliber .30 carbine ammunition with respect to weight, recoil, accuracy, trajectory, and ½ inch armor plate penetration, but less good with respect to penetration of helmets and body armor.	Continued testing (Item 105).
104	Ordnance Corps			CRDL	Wound Ballistics Assessment of the Caliber .30 Ball Carbine and an Experimental Caliber .22 Ball Carbine Cartridges	Dec 54	At ranges up to 300 yards, the caliber .22 projectile was superior in wounding power to the caliber .30 bullet in gelatin tissue models and in animals. Beyond 300 yards differences were probably not significant. The accuracy of the caliber .22 was markedly superior to that of the caliber .30. Recommendations: (1) From a wound ballistics viewpoint, the experimental caliber .22 carbine ball round should replace the caliber .30 ball carbine round for use in the military carbine. (2) Studies on the basic phenomena of bullet tumbling in tissue targets should be continued and extended.	Continued Ordnance Corps development of small caliber, high velocity rifle or carbine system (Item 105).
105	Ordnance Corps	26 Feb 54	To design a suitable military bullet for employment in an experimental caliber .22 carbine cartridge, procure ammunition employing the bullet designed, evaluate performance of the ammunition, and assemble and test modified M2 carbine adapted to the experimental cartridge.	D&PS	Investigation of Experimental Caliber .22 Carbine Ammunition and Modified M2 Carbine	20 Jul 54 to 18 Apr 55	The caliber .30 M2 could be adapted to the experimental caliber .22 carbine cartridge employing a bullet of acceptable military characteristics, with a resulting improvement in lethality, semi-automatic and burst fire accuracy, flatness of trajectory, and penetration of some types of targets.	Continued testing (Item 106).
106	Ordnance Corps	7 Jan 55	To investigate some interior, exterior, and terminal ballistic properties of ammunition employing an experimental caliber .22 rifle bullet designed by D&PS.	D&PS	Investigation of Experimental Caliber .22 High Velocity Bullet for Rifles	8 Nov 54 to 22 Sep 55	The experimental high velocity caliber .22 rifle bullet was superior in terminal ballistics and equal in wound ballistics to the caliber .30 M2 bullets. Fouling with X487.2 ball propellant was reported as a problem.	Development of small caliber, high velocity rifles and evaluations in 1958, (Items 108 and 109).

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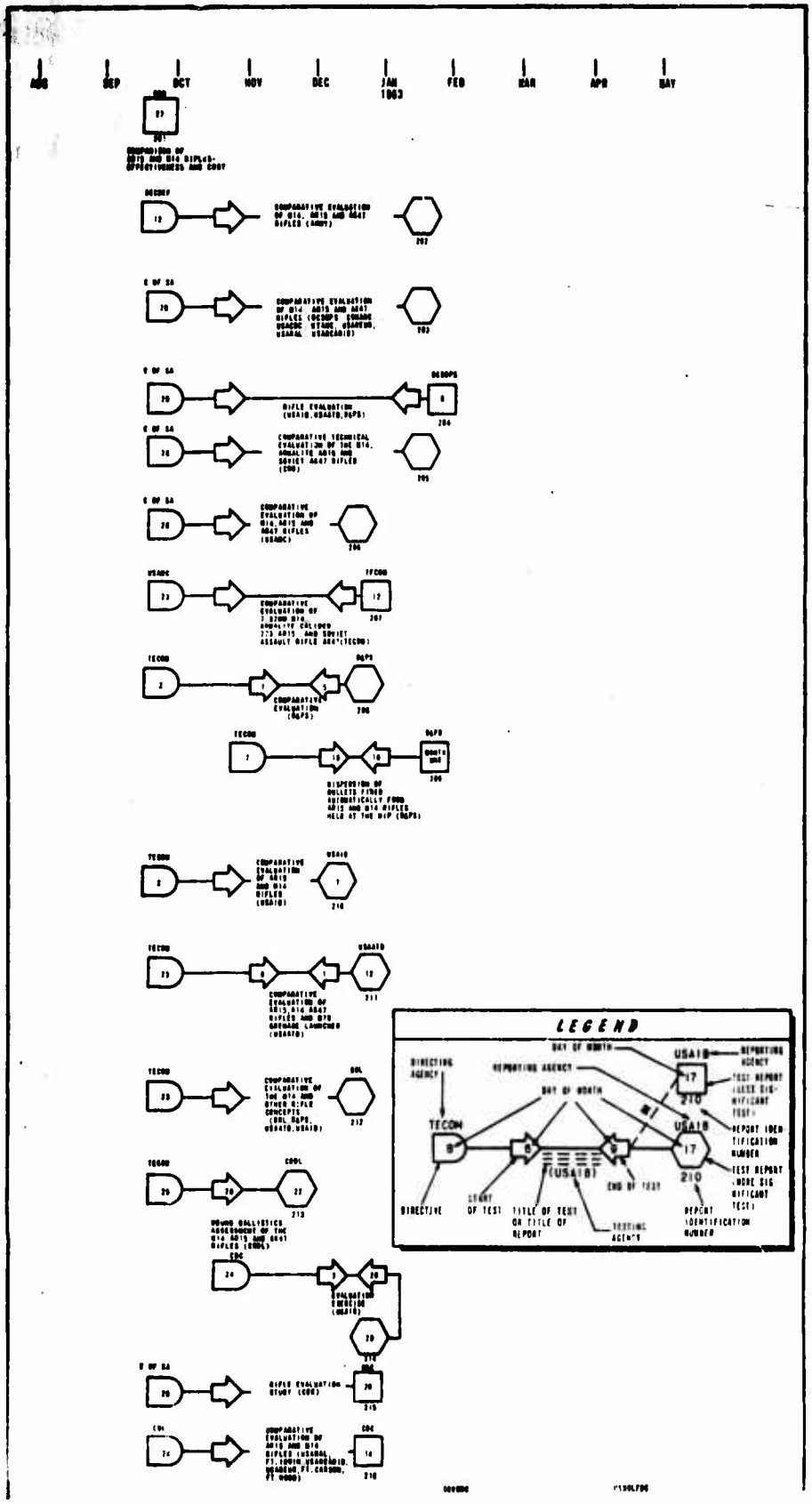
NO	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
106a	USCONARC	20 Jun 55	To determine if the high velocity caliber .22, fired in the modified M2 carbine, has sufficient military value to warrant further development.	USCONARC Board 3	Evaluation of M2 Carbine Modified to Fire High Velocity Caliber .22 Cartridge	Jun 55 to 28 Nov 55	Recommendations: (1) No further development of the test high velocity caliber .22 cartridge for use in a modified carbine be undertaken. (2) Investigation of the small caliber, high velocity principle be given a high priority. (3) A lightweight rifle utilizing the high velocity, small caliber principle be developed at the earliest practical date.	Continued development, culminating in USAIB 1958 tests of AR15 and Winchester rifles (Items 108 and 109).
107			To observe an experimental light weight rifle developed by Winchester for military use.	USAIB	Firing Demonstration Winchester Military Rifle for Caliber .224 Winchester Ammunition	6 Nov 57	The rifle functioned well during all firing (approximately 500 rounds). Personnel firing the rifle were greatly impressed with its handiness, light weight, and reduced recoil. Apparent deficiencies were: improperly calibrated sights; omission of a device to hold the bolt open after the last round has been fired; unsatisfactory magazine release; and unsatisfactory safety. Recommendation: Immediate action be taken to investigate the subject rifle for military use.	Military potential evaluation directed on 24 Feb 58, (Item 109).
108	USCONARC	24 Feb 58	To determine the potential of the AR15 small caliber high velocity rifle to replace the M14 and M15 rifles.	USAIB	Evaluation of Small Caliber High Velocity Rifles - Armalite (AR15)	Feb 58 to 27 May 58	The AR15 and M14 were comparable in organizational maintenance, accuracy, and performance under adverse conditions. The AR15 was superior in lightness of weight, ease of assembly and disassembly, reliability under simulated combat conditions, and ease of handling. The AR15 was inferior in penetration and flash suppression. Recommendations: (1) The AR15 be considered a potential replacement for the M14 and M15. (2) Development be expedited to provide a round for the AR15 that has greater resistance to bullet disintegration and better penetration characteristics.	Standard engineering test (Item 110) and arctic test (Item 112).
109	USCONARC	24 Feb 58	To determine the potential of Winchester small caliber velocity rifle to replace the M14 and M15 rifles.	USAIB	Evaluation of Small Caliber High Velocity Rifles - Winchester	May 58 to Jul 58	The Winchester and M14 were comparable in organization maintenance, accuracy, reliability under simulated combat conditions, and adverse conditions. Winchester was superior in lightness of weight and ease of handling. Winchester was inferior in penetration, sights, and position disclosing effects. Recommendations: (1) The Winchester be considered a potential replacement for the M14 and M15. (2) Development be expedited to provide a round for the Winchester that has greater resistance to bullet disintegration and better penetrating characteristics.	Standard engineering test (Item 110) and arctic test (Item 112).
110	Ordnance Corps	17 Mar 58	To subject the test weapons to the appropriate standard engineering test. To subject the ammunition to appropriate tests to determine military performance under normal and adverse conditions including extremes of temperature.	D&PS	Test of Caliber .22, AR 15; Lightweight Military Caliber .224 Rifle; and Pertinent Ammunition	20 Mar 58 to 21 Nov 58	Advantages of AR15: light weight, light recoil, favorable handling qualities, convenient assembly and disassembly, good endurance; of Lightweight military rifle: light weight, light recoil, favorable handling qualities, and convenient assembly and disassembly; and of Ammunition: light weight, light recoil. Disadvantages of AR15: high malfunction rate when magazine was loaded to 30-round capacity, and poor accuracy characteristics; of Light weight military rifle: poor accuracy, function and endurance characteristics; and of Ammunition: high level of case casualties. Recommendation: Further development be conducted to correct deficiencies observed.	Re-fire rain portion of test for AR15 (Item 111). Conduct field experimentation trials (Item 113). Conduct further engineering tests (Items 114 and 115).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
111	USCONARC	17 Jun 58	To duplicate the rain test originally performed during Item 110 above.	USAIB	Evaluation of Small Caliber High Velocity Rifles - Armalite (AR15) Supplement	30 Jul 58	Results of this test were similar to the original one. A combination of surface tension and capillary action of the water within the bore prevented complete drainage, resulting in excess overpressure when the weapon was fired. Recommendations: (1) The development of a high velocity small caliber rifle be continued despite the results of the rain test. (2) At this stage of development, the AR15 still continue to be considered as a potential replacement for the M14 and M15. (3) The deficiency resulting from the rain test be corrected.	Item 114.
112	USCONARC	26 Feb 58	To determine the potential of the small caliber high velocity rifles to replace the M14 and M15 rifles under arctic winter conditions.	USAAIB	Evaluation of Small Caliber High Velocity Rifles	19 Sep 58 to 17 Apr 59	The AR15 when modified to correct deficiencies was a potential replacement. The caliber .224 cartridge was unsuitable.	Final [illegible] firing test (Item 116).
113	USCONARC	29 Aug 58	To compare the relative effectiveness of variously organized rifle squads armed with M14 rifles and the Winchester and Armalite lightweight, high velocity rifles. To determine the impact of the lightweight high velocity rifles on squad organization, techniques, and logistics.	CDCEC	Rifle Squad Armed with a Lightweight High Velocity Rifle	1 Dec 58 to 22 Mar 59	The attributes demonstrated by the prototype test weapons indicated an overall combat potential superior to that of the M14. Advantages included lightweight of weapon and ammunition, ease of handling, and superior full automatic firing capability. Recommendations: (1) Emphasis be placed on the development of a lightweight high velocity rifle combining the accuracy characteristics of the Winchester with the reliability characteristics of the Armalite, and not exceeding the weapon and ammunition weight of either. (2) Concurrent with the adoption of such a weapon, serious consideration be given to reduction in size of the present squad.	Squad size recommendation subsequently addressed in 1962-63 AR15 and M14 comparative evaluation (Item 204).
114	Ordnance Corps		To evaluate the drainage characteristics of the caliber .22/06 and 7.62mm barrels and determine the effect of temperature, metal finish, and supplementary finish.	Springfield Armory	Water Drainage Characteristics of Caliber .22/06 and 7.62mm Barrels	29 Jun 59	7.62mm barrels drained more efficiently than caliber .22/06 with the cartridge in the chamber and no external force applied. It was more difficult to fill the barrel of a caliber .22/06 when inversed in water. There was no indication of capillarity with the caliber .22/06 for any barrel condition or temperature. Recommendations: (1) Investigate firing of caliber .22/06 and 7.62mm weapons with different amounts of water in the barrel to determine the critical water volume causing bulging and splitting. (2) Conduct an investigation with a given amount of water placed in different areas of the caliber .22/06 barrel to ascertain the effect of firing on the physical characteristics of the barrel.	
115	Ordnance Corps		To estimate the incapacitating effectiveness of single missiles at various ranges.	CWL	Provisional Casualty Criterion for Fragments and Projectiles.	1952 to 1959	Theoretical and experimental studies were conducted to provide casualty criteria.	
116	[illegible], USAF		To conduct a comprehensive evaluation of the AR15 for USAF suitability.	Lackland AFB	Evaluation of the Colt - Armalite AR15 Automatic Rifle Caliber .223	18 Jul 60 to 22 Sep 60	(Detailed data not available.) Both Remington and Norma 5.56mm ammunition was utilized.	Determine penetration characteristics (Item 117). Evaluate caliber .223. Remington ammunition (Item 121).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
117	HQ, USAF		To determine the penetration ability of caliber .223 cartridge fired from the AR15 at steel helmets.	Lackland AFB	Helmet Penetration Test	12 Sep 60 to 16 Sep 60	Penetration of one side of the helmet achieved at range out to and including 600 yards.	Item 404 and 425.
118	Ordnance Corps	12 Sep 60	To subject the rifle to a final engineering test (Standard Light Automatic Rifle Test).	D&FS	Test of Rifle, Caliber .223 AR15	21 Sep 60 to 20 Oct 60	The AR15 gave near normal performance in the unlubricated, dust, extreme cold and (modified) rain tests. It completed the mud test.	USAF adoption in 1961. Vietnam [illegible] [illegible]
119			To present the combinations of aiming errors and projectile dispersions that are required to yield given levels of hit probability.	BRL	Dispersions for Effective Automatic Small Arms Fire and a Comparison of the M14 Rifle with a Weapon Yielding Effective Automatic Fire	Jan 61	Aiming errors of 2.5 and .8 mils would be required at ranges of 100m and 300m, respectively, to obtain a hit probability of .8 or higher with a 3-round burst. Such hit probabilities were unlikely with conventional weapons. Thus, the caliber .22 flechette weapon was of interest.	Item [illegible]
120			To summarize the work being done at BRL to improve the accuracy of automatic fire for the all purpose hand-held weapon (APHHW).	BRL	Study of Parameters that Affect the Accuracy of Automatic Rifles	Oct 61	Recommendations: In view of stringent limitation on the dispersion of the all purpose hand held weapon (APHHW): (1) multiple projectiles and multiple barrel weapons be given consideration, (2) any mechanical device for improving the accuracy should be evaluated and should show promise before an extensive test program is initiated, (3) target firings of weapons like the expected APHHW be carried out at much higher rates to check the model over a wider range.	
121			To evaluate the effectiveness of the caliber .223 round developed by Remington Arms Company when used in the Colt AR15 Rifle. Criteria for evaluation were taken from AFMPP-BQ-2 dated 22 May 1961.	Hill AFB	Caliber .223 Ammunition (Remington) for Colt AR 15 Rifle	23 Feb 62	The cartridge tested appeared to have the qualities desired. Killing and wounding power of the cartridge was excellant at ranges of at least 500 yards. The bullet traveled a flatter trajectory than slower bullets giving less vertical error with a fixed iron sight. Recommendations: (1) A large sample of the ammunition tested be acquired to complete the testing required before adopting the round as a USAF item. (2) Investigate the possibility of a suitable round being manufactured by other than Remington Arms, to provide alternate sources of procurement.	
122	SECDEF		To determine if the AR15 is compatible with the small stature, body configuration, and light weight of the Vietnamese soldier and to evaluate the weapon under actual combat conditions in South Vietnam. The scope was expanded to include a comparison between the AR15 and the M2 carbine.	ARPA	Test of Armalite AR15 Rifle	1 Feb 62 to 15 Jul 62	The AR15 was capable of replacing any or all of the shoulder weapons currently being used by the Republic of Vietnam Armed Forces. Recommendations: (1) The AR 15 be considered for adoption as the basic weapon for all RVNAF with a view toward improving effectiveness and simplifying training, weapons, and logistics systems. (2) Priority for adoption of the AR15 be given to those units which frequently operate in jungle environment for extended periods. (3) The M1 or M2 carbine continue to be issued only to those individuals who can function effectively with a weapon best suited for defensive role.	Office, Secretary of Defense evaluation of the AR15 rifle. The 1962-63 comparative evaluation of the AR15, M14, and AK47 rifles. (Items 202 through 213.)



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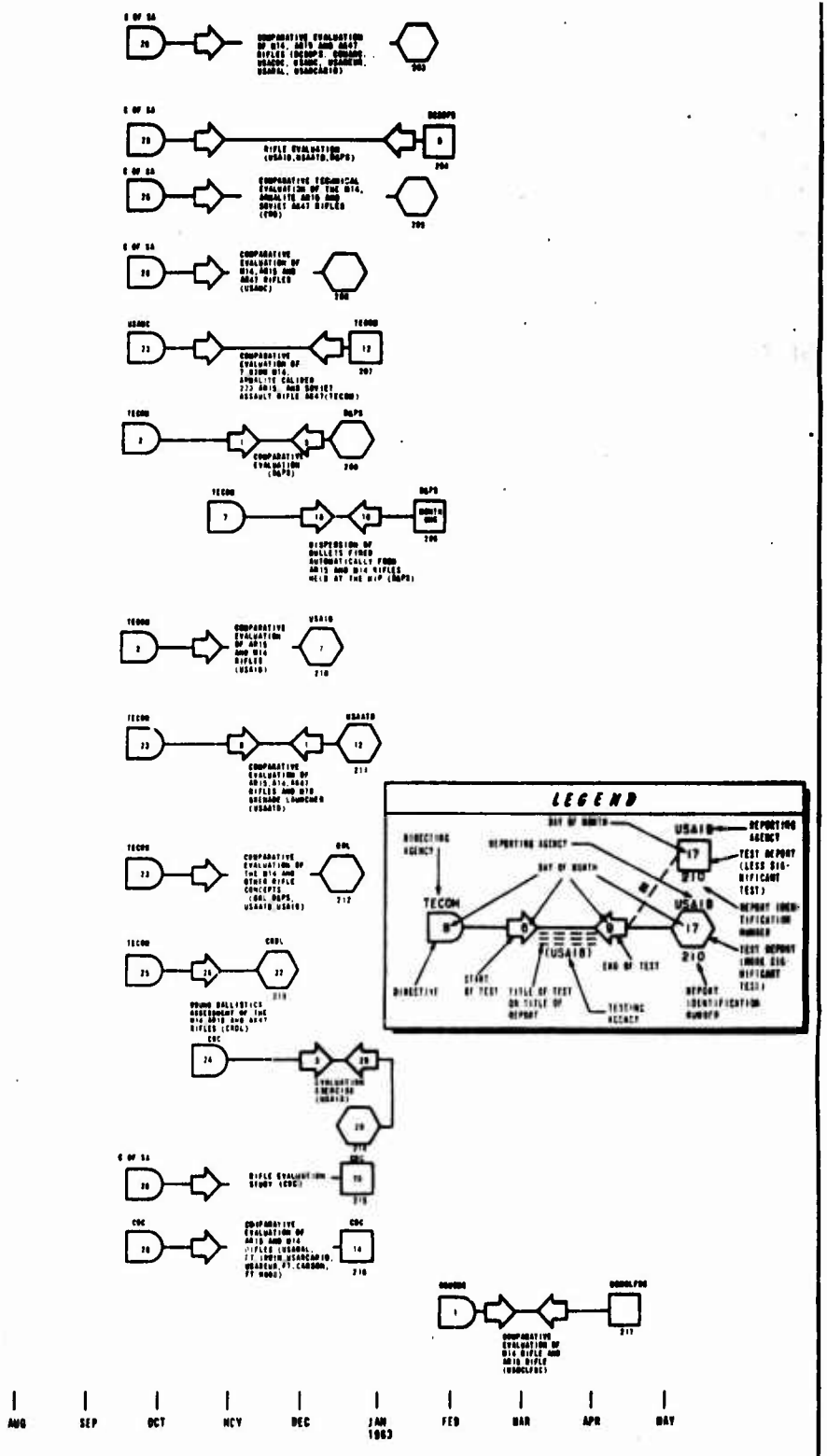

FIG. 2 CHRONOLOGICAL DISPLAY OF M16 TESTS DURING THE 1962-1963 COMPARATIVE EVALUATION

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CHRONOLOGICAL DISPLAY OF M16 TESTS DURING THE 1962-1963 COMPARATIVE EVALUATION

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NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
201	OSD (Comptroller)		This is a cost-effectiveness comparison of the M14 and AR15. The comparison is relative to general combat use of the AR15 by Army units in normal and special combat situations. It analyzes previous Army tests and the ARPA Vietnam evaluation.	OSD	Comparison of AR15 and M14 Rifles - Effectiveness and Cost	27 Sep 62	The study indicated that the AR15 was decidedly superior in many of the factors considered. In none of them was the M14 superior. It was, therefore, concluded that in combat the AR15 was a superior weapon. Cost data indicated that it was a less expensive weapon. The M14 rifle appeared somewhat inferior to the M1, and decidedly inferior to the Soviet AK47 rifle.	This analysis, together with the ARPA Vietnam evaluation, led to the SECDEF decision (Item 202) for a thorough, comparative evaluation of the M14, AR15, and AK47.
202	SECDEF	12 Oct 62	To obtain the Army views on the relative effectiveness of the M14, AR15, and Soviet AK47 rifles. To obtain the Army recommendation should either the AR15 or AK47 prove superior to the M14. The SECDEF memorandum was a consequence of evidence to the effect that the M14 was definitely inferior in firepower and combat effectiveness to the Soviet AK47 assault rifle and that the AR15 was markedly superior to the M14 in every respect of importance to military operations.	Army	Comparative Evaluation of M14, AR15, and AK47 Rifles	Oct 62 to Jan 63	The detailed results are cited under Items 205 through 216. On 15 Jan 63, the SA made the following recommendations: (1) procurement of 50,000 to 100,000 AR15's from fiscal year 1964 funds; (2) continued procurement of limited quantities of M14's; and (3) expedited research and development of the special purpose individual weapon (SPIW) which was considered to have capabilities exceeding those of either the M14 or AR15.	This directive initiated the worldwide 1962-63 comparative evaluation. (Items 203 through 216.)
203	CofSA	26 Oct 62	To conduct an impartial and objective comparative evaluation of the relative effectiveness of the M14, AR15, and Soviet AK47 assault rifles.	DCSOPS CONARC USACDC USAMC USAREUR USARAL USARCARIB	Comparative Evaluation of M14, AR15, and AK47 Rifles	Oct 62 to Jan 63	On 14 Jan 63, the CofSA made the following recommendations to the SA: (1) procurement of 50,000 to 100,000 AR15's from fiscal year 1964 funds for issue in order of priority, to Air Assault, Special Forces, and Airborne units; (2) procurement of sufficient modified M14(M)'s from fiscal year 1964 funds to provide automatic rifle capability for all infantry squads armed with the M14.	SA report to the SECDEF on 15 Jan 63 cited in Item 202 above.
204	CofSA	26 Oct 62	To report the Army findings and to recommend an appropriate Army position on the Army rifle program based upon an assessment of the future needs and the recent objective analysis and comparative tests of the merits of the M14, AR15, and AK47 rifles.	DCSOPS	Rifle Evaluation	Oct 62 to Jan 63	Only the M14 was acceptable for general use in the US Army. The AR15 was unsuitable as a replacement for the M14 because of poor reliability, night firing, and penetration characteristics and because adoption would violate NATO standardization agreements. Its lighter weight, although, desirable, was not a dominant factor. The AK47 was unsuitable as a replacement for the M14 because it was optimized for the submachine gun role. No basis existed for reducing the size of an infantry squad whether armed with M14 or AR15. Recommendation: continue production of the M14 as the basic Army rifle until a radically improved shoulder weapon can be procured which meets or exceeds the approved characteristics of SPIW. The target date for initial procurement of this follow-on weapon under an accelerated research and development program would be 1 Jan 67. This would not be to prejudice product improvements such as are offered by the M14 (USAIB).	CofSA report to the SA on 14 Jan 63 cited in Item 203 above.

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NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
205	CofSA	26 Oct 62	To evaluate comparison of technical characteristics as evidenced in engineering and service tests and evaluations conducted prior to October 1962; a subjective estimate of the impact on NATO standardization of the unilateral adoption by the United States of the AR15 caliber .223 round; and the current development program for the next generation hand held weapon system.	CRD	Comparative Technical Evaluation of the M14, Armalite AR15, and Soviet AK47 Rifles	Oct 62 to Jan 63	The CRD evaluation was part of the DCSOPS report (Item 204). CRD Recommendations: (1) The AR15 not be adopted as an Army-wide replacement for the M14. (2) If tests now in progress prove it to be acceptable, the AR15 be procured for Special Forces and Airborne Units to exploit the weight advantage and gain experience with the system. (3) The SPIW development program be continued on an expedited basis. (4) Complete replacement of the M14 by the AR15 be considered incompatible with the expedited continuation of the SPIW program. The Army cannot afford or justify an expensive program to develop a new weapon (SPIW) intended to replace a weapon (AR15) which would have been in the Army inventory only two years. (5) The AR15 be considered as a substitute for the SPIW if for any reason the SPIW is unreasonably delayed or early prototypes indicate that only marginal improvement over the AR15 can be anticipated.	DCSOPS Jan 63 report to the CofSA (Item 204).
206	CofSA	26 Oct 62	To conduct an impartial and objective comparative evaluation of the relative effectiveness of the M14, AR15, and Soviet AK47 assault rifles.	USAMC	Comparative Evaluation of M14, AR15, and AK47 Rifles	Oct 62 to Dec 62	On 24 Dec 62, the CG, USAMC, on the basis of TECOM's report (Item 207) made the following recommendations to the CofSA: (1) The AR15, with appropriate product improvements, be adopted as the standard Army rifle unless weight saving is not a dominant feature and standardization problems are insurmountable. (2) A phased plan for introduction of the AR15 be developed emphasizing the equipping of units most likely to be committed in undeveloped areas of the world. (3) The flechette research and development program be reviewed and reoriented as necessary. (4) No consideration be given to adopting a weapon comparable to the Soviet AK47 assault rifle.	Led, in part, to the CofSA report to the SA on 14 Jan 63 cited in Item 203 above.
207	USAMC	23 Oct 62	The present test series was directed because earlier tests were not necessarily representative of current production, capabilities, and requirements, and were not always conducted concurrently with tests of the M14 rifle.	USATECOM	Comparative Evaluation of 7.62mm, M14; Armalite Caliber .223 AR15; and Soviet Assault Rifle AK47	Oct 62 to Dec 62	The detailed results are cited under Item 208 through 213. On 12 Dec 62 TECOM reported to USAMC that although some areas of the AR15 require improvement, it was an effective military weapon. Effectiveness studies predicted significant advantages of a flechette weapon over other weapons. The AK47 was substantially inferior to both the AR15 and M14. Recommendations: (1) The AR15 not replace the M14 unless the weight of the AR15 is a dominant factor. (2) Development of a flechette weapon be expedited. (3) Consideration of an AK47 type rifle as a replacement for the M14 be dropped.	CG, USAMC report to the CofSA on 24 Dec 62 (Item 206). Discussion problem areas observed in the TECOM tests (Item 401).
208	USATECOM	23 Oct 62	To perform concurrently an overall evaluation of the subject weapons, which would be representative of current production, capabilities, and requirements.	D&PS	Comparative Evaluation	1 Nov 62 to 5 Dec 62	Major differences in characteristics between the AR15 and M14 systems were the result of differences in the cartridges used. Under favorable conditions, the AR15 was comparable or superior to the M14 when firing automatic. Both rifles were capable of high level performance. The AR15 had a high stoppage rate in the rain test because of primer separation.	The reported primer problem was subsequently investigated further in January 1963 (Item 401).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DA	[illegible]	[illegible] ACTION
	INITIATOR	DATE	PURPOSE					
209	USATECOM	7 Nov 62	To fire ten 3-round groups from the AR15 and M14 rifles at a range of 25 yards with the rifle held at the hip.	BRL	Dispersion of Bullets Fired Automatically from AR15 and M14 Rifles Held at the Hip	18 Dec 62	[illegible] from each [illegible] of the 30 [illegible] fired by [illegible] and one M14 [illegible] rounds in a 3-shot burst.	
210	USATECOM	23 Oct 62	To perform concurrently an overall evaluation of the subject weapons, which would be representative of current production, capabilities, and requirements.	USAIS	Comparative Evaluation of AR15 and M14 Rifles	Oct 62 to 7 Dec 62	The AR15 and M14 were compared under temperate environmental conditions in the rifle, automatic rifle and submachine gun roles. Conclusions: (1) The M14 should be retained as basic weapon with no current consideration of adopting the AR15. (2) The AR15 could be employed in a submachine gun role. (3) A modified M14 should be adopted to fulfill the automatic rifle role.	TECOM 12 Dec 62 report to USAMC, cited in Item 207.
211	USATECOM	23 Oct 62	To evaluate and compare the AR15 and M14 rifles under arctic conditions. The M79 grenade launcher and the Soviet AK47 rifle were also evaluated.	USAATB	Comparative Evaluation of AR15, M14, and AK47 Rifles and M79 Grenade Launcher	6 Nov 62 to 1 Dec 62	The M14 and AR15 were equal with respect to ease of disassembly and assembly, known distance semiautomatic fire accuracy, field firing, penetration of armored vests, adverse conditions, position disclosure, reliability, and maintenance. The M14 was superior to the AR15 with respect to penetration of wood panels, and steel helmets and liners; rifle grenade accuracy; and durability. The AR15 was superior to the M14 with respect to weight and known distance automatic fire accuracy. Conclusions: (1) The AR15 compares favorably with the M14 for Army use under arctic winter conditions. (2) The caliber .223 cartridge, of the type and lot tested is unsuitable for Army use under arctic winter conditions.	TECOM 12 Dec 62 report to USAMC, cited in Item 207.
212	USATECOM	23 Oct 62	To provide a comparative evaluation of the M14, AR15, and the Soviet AK47 rifles. Data for the M2 carbine and caliber .22 flechette has also been established in order to provide a basis for decisions.	BRL	Comparative Evaluation of the M14 and Other Rifle Concepts	Oct 62 to Dec 62	Weapons were ranked on an effectiveness basis relative to the M14. Extremes of temperature caused relatively small differences in effectiveness. Generally the P_{hit}'s of the M14 and AR15 bullets were equal out to 300 yards. At longer ranges, the P_{hit} for the M14 increased. The M14 was competitive or superior to the other weapons for all aiming errors. The only weapon to demonstrate effective automatic fire without use of a bipod was the flechette-firing weapon.	TECOM 12 Dec 62 report to USAMC, cited in Item 207.
213	USATECOM	25 Oct 62		CRDL	Wound Ballistics Assessment of the M14, AR15, and AK47 Rifles	25 Oct 62 to 22 Nov 62	Close agreement between theoretical effects based on the methods used and the actual effects occurring from accidents with weapons indicated validity of the procedures. Based on consideration of the reactions of the goats, tissue and bone damage, survival and incapacitation time, and blood losses, the comparative effectiveness on goats of the bullets indicated equivalence of the M14 and AR15 at 50m and 100m; M14 superiority at 25m, 300m, and 500m; and AK47 inferiority at all ranges out to 300m. The AK47 was better than the AR15 and equivalent with the M14 at 500m. Modified hallow point bullets for the AR15 were more effective than the standard ones.	Wound ballistics evaluation of the AR15 with a 1-in-12 inch barrel twist rate in Jun 63 (Item 317) Wound ballistics assessment of AR15, M14, and AK47 published in March 1964.

NO	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATE	TEST [illegible]	[illegible]
	INITIATOR	DATE	PURPOSE					
214	USCONARC	21 Nov 62	To compare the hit distribution and hit capabilities of platoons armed with the AR15's and M14's as a function of squad size.	USAIS	Evaluation Exercise	3 Dec 62 to 20 Dec 62	Platoons [illegible] ability or better [illegible] armed with the M14. [illegible] hit probability. [illegible] reliable as the M14 [illegible] and should not be adopted as a replacement for the M14 [illegible] of weapons.	[illegible]
215	CofSA	26 Oct 62	To evaluate the employment of small arms to determine the desired military characteristics of a rifle.	USACDC	Rifle Evaluation Study	Oct 62 to Dec 62	The M14, AR15, AK47, and SPIW were compared to determine which met the desired military characteristics. The AR15 represented an improvement over the M14 and except for the SPIW came closest to meeting the desired characteristics. The AK47 was inferior. Recommendations: (1) Continue use of the M14 in Europe. (2) Correct deficiencies of AR15. (3) Equip Air Assault, Airborne, and Special Forces units with the AR15. (4) Continue the SPIW program.	DCSOPS Jan 63 (Item 204) report to the CofSA. CofSA Jan 63 (Item 203) report to the SA.
216	USACDC	26 Oct 62	To assist the Army Staff in an impartial and objective evaluation of the relative effectiveness of the M14 and the AR15 by conducting tactical evaluation and troop tests including an evaluation of the ARPA Vietnam test of the AR15 rifle.	USARAL Ft Irwin USARCARIB USAREUR Ft Carson Ft Hood	Comparative Evaluation of AR15 and M14 Rifles	Oct 62 to Dec 62	Neither the M14 nor the AR15 were found to be a superior weapon for the purposes of the test. Except for reliability deficiencies, the AR15 was operationally equivalent to the M14 for infantry use. No basis existed for taking exception to the broad conclusions contained in the ARPA report as to the suitability of the AR15 for use by Vietnamese Armed Forces.	Conduct engineering evaluation of AR15 to examine reported deficiencies (Item 303).
217	USMC		To determine which rifle best suits the Marine Corps requirement for a standard rifle.	USMC	Comparative Evaluation of M14 Rifle and AR15 Rifle	Feb 63 to Mar 63	With respect to training, the AR15 was easier to teach and learn than the M14, and was equal in known distance marksmanship. With respect to combat effectiveness, the AR15 and M14 were equal in hit probability, automatic fire, both approximately equal, and night quick fire. The AR15 and M14 were equal in reliability and maintenance.	USMC interest in development of the Stoner 63 Weapon System.

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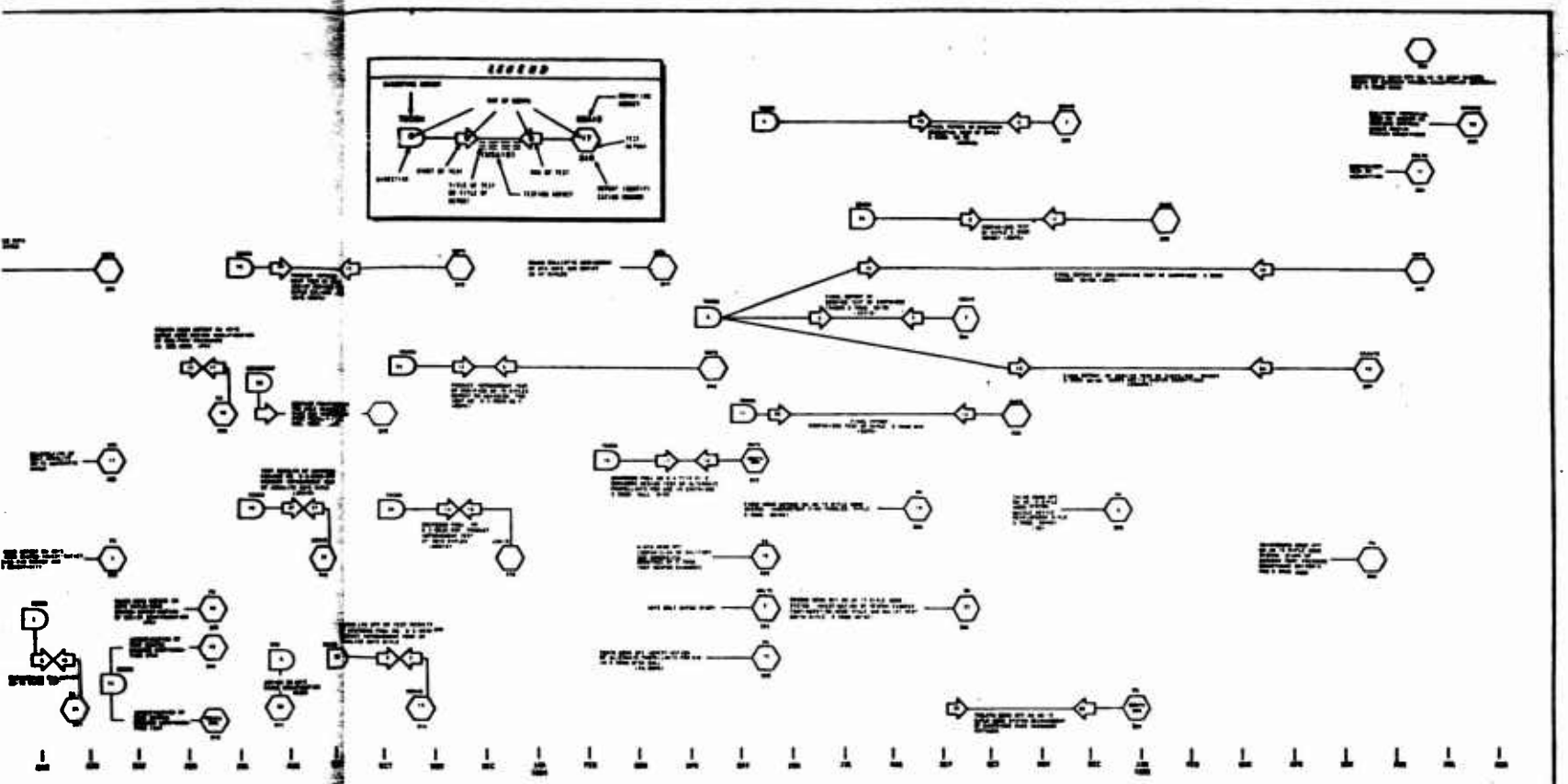


FIG. 3 CHRONOLOGICAL DISPLAY OF TJC MORE SIGNIFICANT M16 TESTS IN THE 1963-1965 TIME PERIOD

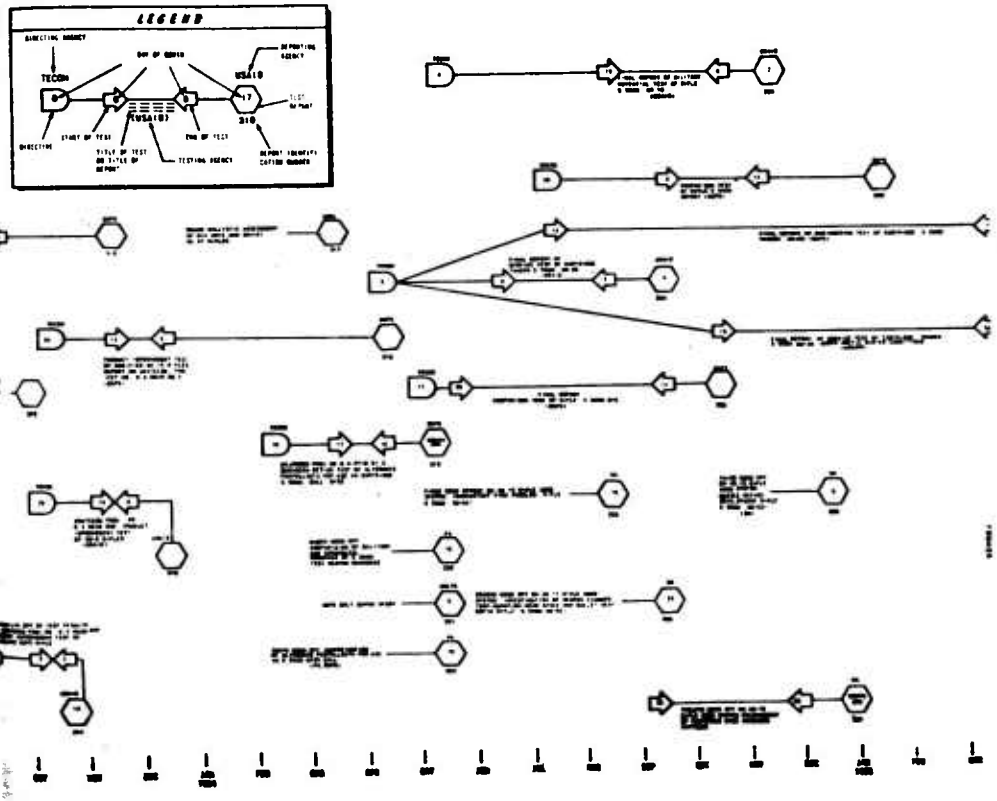


FIG. 3 CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT USIG TESTS IN THE 1963-1965 TIME PERIOD

TABLE 2 - 20

CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT M16 TESTS IN THE 1963-1965 TIME PERIOD

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATE	[illegible]	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
301	USATECOM		To record mean radius and shot group data as a function of range at ambient firing temperatures 90 to 120F and 210 to 310F.	USAATC	Evaluation of Bullet Stability in the AR15	29 Jun [illegible]	[illegible] Caliber .223 [illegible] to cold [illegible] for the XM [illegible] At all temperatures, [illegible] standard AR15 with [illegible]	[illegible] Arsenal (Item 307).
302	USAF		To provide a basis for design decisions involving AR15.	Eglin AFB	Exterior Ballistics of the AR15	Jan 63	Remington caliber .223 bullets fired in 1-in-14 inch twist barrels were unstable and a cold weather combat conditions. Changing to 1-in-12 inch twist stabilized Remington caliber .223 bullets under all expected combat situations without reducing lethality. Using flatbase instead of boattail bullets provided stable projectiles in 1-in-14 inch twist barrels, but an unacceptable degradation in exterior ballistics resulted. Caliber .223 bullets penetrated and killed various soft material targets. There were no severe deflection or breakup problems when firing through brush.	Item 311.
303	USAMECOM	1 Mar 63	To confirm malfunctions observed in certain test board reports.	Springfield Armory	Engineering Evaluation AR15	6 Mar 63 to 15 Mar 63	Malfunctions encountered during test confirmed worldwide evaluation test results. The majority of malfunctions were attributed to the magazine. Failures were predominently failu to feed, bolt override, and failure of the bolt to remain to the rear after the last round had been fired. Conclusion: Design studies and product improvement were needed in several areas.	Item 321.
304	USATECOM	14 Dec 62	To determine differences in stability and accuracy of AR15 with 1-in-12 and 1-in-14 inch twist.	[illegible]	Evaluation Test of the Rate of Rifling Twist in AR15, Caliber .223	10 Jan 63 to 29 Jan 63	Long range accuracy and bullet stability of AR15 with 1-in-12 twist were superior to those with 1-in-14 twist.	Item 311.
305	USN		To evaluate the AR15 for SEAL Team use.	USN	Malfunctions of Colt Armalite AR15	Aug 62 to Aug 63	46 AR15's were evaluated on rifle ranges and under simulated combat conditions. Common malfunctions were failure to feed, the bolt overriding the base of the top cartridge, and primer detonation without igniting the propellant. The scope mount was found to be unsatisfactory.	
306			To investigate certain malfunctions which have occurred occasionally in various trials by using forces.	Frankford Arsenal	Investigation of Firing Pin Energy and Primer Sensitivity	4 Apr 63	Based on measurements of indent depth, firing pin energy and hammer blow energy, supplemented by kinematic data supplied by Springfied Armory, recommendations were made for trial criteria to be used in manufacturing AR15's and caliber .223 ammunition primers.	Item 311.
307			To establish the relative merits of two types of bullets and observe effects of shape on exterior ballistic properties.	Frankford Arsenal	Investigation of Bullet Configuration	18 Jun 63	Remington .223 bullets were compared with Sierra bullets when fired for accuracy and velocity in 1-in-12 and 1-in-14 inch twist barrels. Sierra bullets had better exterior ballistics. Use of this type was expected to allow lower muzzle velocity while providing higher impact velocity beyond 100 yards. Accuracy was significantly lower with 1-in-14 inch twist barrels.	(See Item 440).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
308			To examine the question of lot to lot variability in port pressure of ammunition in available samples.	Frankford Arsenal	Investigation of Gas Port Pressures in .223 Ammunition	11 Jun 63	Tests using a new gage provided chamber and gas port pressure test data. Port pressure was found to be remarkably uniform, both lot to lot and round to round. Recommendations: (1) Further testing be conducted to establish port pressure specifications. (2) Adopt arbitrary tentative specifications until more data can be obtained.	Item 332.
309	USAMECOM	11 Apr 63	To evaluate and compare the configurations of the chamber designed for the AR15 rifle and the chamber of the test weapon used for ammunition evaluation.	Frankford Arsenal	Investigation of Test Weapon Chamber Configuration	17 Jun 63	Test firings were conducted, both at FA and Remington, of two throat cone chamber configurations. The two test configurations were satisfactory, and the original configuration used in AR15's was less satisfactory than either experimental chamber. Recommendation: "Shape B" be tentatively adopted for ammunition testing and considered for development as standard for AR15.	Decision at 25-26 Jun 63 Joint Service Technical Committee Meeting to approve FA recommendation. Item 325.
310	USAMECOM	11 Arp 63	To determine, through a coordinated effort with Frankford Arsenal, the XM16E1 chamber configuration which will result in average chamber pressures of not more than 52,000 psi and average muzzle velocities of not less than 3200 ft/sec.	Springfield Armory	Investigation of Test Weapon Chamber Configuration		In view of the limited scope of the tests conducted, no firm conclusions could be drawn. Increase of the bullet seat cone depth appeared acceptable up to a point where approximately 0.096" free run to a 5° cone or where approximately 0.075" free run to a 2°27' cone is reached. Beyond these limits a degradation in weapon accuracy could be expected.	Decision at 25-26 Jun 63 Joint Service Technical Committee Meeting to approve FA recommendation. Items 320 and 325.
311	OSD	9 Jul 63	To evaluate modifications to the AR15, concurred in by all Services, as submitted by the Secretary of the Army on 9 Jul 63.	OSD	Action on AR15 Rifle Modification	26 Jul 63	On 26 Jul 63 the DEPSECDEF announced the following decisions and instructions: (1) Bolt closure device. Concurred in Army plan to continue to seek technical improvement without delaying production. Testing to be conducted by the four Services. (2) Barrel twist. Approved 1-in-12 inch barrel twist rate. Reconduct lethality test to provide a more reliable data base for future technical decisions. (3) Primer sensitivity. Cautioned against decreasing primer sensitivity too much. (4) Other cartridge types. Provide a schedule for development and procurement of blank and grenade launching cartridges.	Item 312. Requirement for further test cancelled on 10 Sep 63. Barrel twist re-evaluated in 1967. Items 614 and 630. Item 312.
312	DEPSECDEF	26 Jul 63	To evaluate the AR15 bolt closure and the AR15 inadvertent fire problem and to provide the SECDEF with the position of all Services.	USA USN USMC USAF	Service Positions on the Bolt Closure Device and Inadvertent Fire Problem	Jul 63 to Oct 63	On 12 Oct 63, the SA reported to the SECDEF: (1) The Army believes a manual bolt closure capability is mandatory. The USN and USMC believe it desirable, but not mandatory. The USAF believe it neither necessar or desirable. (2) All four Services agree that the present design of the firing pin and bolt assembly introduces an unacceptable safety hazard. More development and testing is required.	Items 313-316, 318, and 321. Plunger type bolt closure device was adopted. Further primer sensitivity investigation. (Items 318, 429, 431, 434, and 435).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
313	USATECOM	19 Jul 63	To evaluate a proposed bolt closure assist device.	USAIB	Product Improvement Test of Armalite AR15	30 Aug 63	Three AR15's modified to include a bolt assist device were tested. In some cases the charging handle did not provide enough leverage to open the bolt. The bolt assist device did not significantly reduce the time to clear chambering and feeding stoppages. The modified AR15 did not show significant improvement in reliability.	Item 314
314	USATECOM	19 Jul 63	To test the suitability of the side mounted bolt assist device on the AR15.	USAIB	Product Improvement Test of Armalite AR15		Eleven AR15's modified with a side mounted bolt assist were tested, as before. This device provided an adequate but not optimum means of closing the bolt. The left mounted device was not acceptable. Eight other previously reported deficiencies were not corrected. Further improvement was recommended.	Item 316
315	USATECOM	19 Jul 63	To test the bolt assist device under the most severe test practicable to determine if the device will overcome any malfunction consisting of the bolt failing to close, and determine if any undue safety hazards exist.	DuPS	Product Improvement Test of Bolt Assist Device for AR15	23 Jul 63 to 15 Sep 63	Three models of charging handle bolt assist devices and a plunger type bolt closure device were tested for operation under various adverse conditions. Only the plunger type bolt closure device provided an effective means for closing the bolt under adverse conditions. The modified charging handle did not provide adequate means for extraction operations under adverse conditions. Recommendation: The charging handle bolt assist device tested not be adopted.	Item 318
316	USATECOM	29 Oct 63	To determine the suitability of AR15 modifications (side mounted bolt assist device, larger charging handle, and a modified firing pin designed to prevent inadvertent fire).	USAIB	Product Improvement Test of XM16E1's	14 Nov 63 to 18 Nov 63	Nine XM16E1's equipped with a side mounted bolt assist device similar to one previously tested, but with an enlarged striking surface on the plunger cap, were tested under a variety of conditions, as before. The new plunger cap was adequate for closing the bolt. The modified charging handle increased the capability to apply leverage for opening the bolt and was adequate. The spring cushioned firing pin was adequate to perform its task. Recommendation: The modifications be adopted.	Bolt closure device adopted. Spring cushioned firing pin not adopted. Item 318.
317	USAMC		To assess the wound ballistics of the AR15 with a 1-in-12 inch rifling twist and to compare these data with those for the AR15 with 1-in-14 inch rifling twist.	CRDL	Wound Ballistics Assessment of the M14, AR15, and AK47 Rifles: Supplement, the AR15 with 1-in-12 Inch Rifling Twist	Jan 63	Goats and gelatin tissue models were used as targets at real ranges of from 10m to 500m. Based on considerations of the reactions of the goats, the tissue and bone damage, the survival and incapacitation times, and the blood losses, the comparative effectiveness results were the equivalence of the 1-in-14 and 1-in-12 inch twists at 25m and 500m, and the superiority of the 1-in-14 inch twist at 50m, 100m, and 300m. The P_{HK} values for the AR15 with the 1-in-12 inch twist were significantly lower than those for the 1-in-14 inch twist at all ranges, except 500m where the differences were not significant.	Formal report issued March 64.

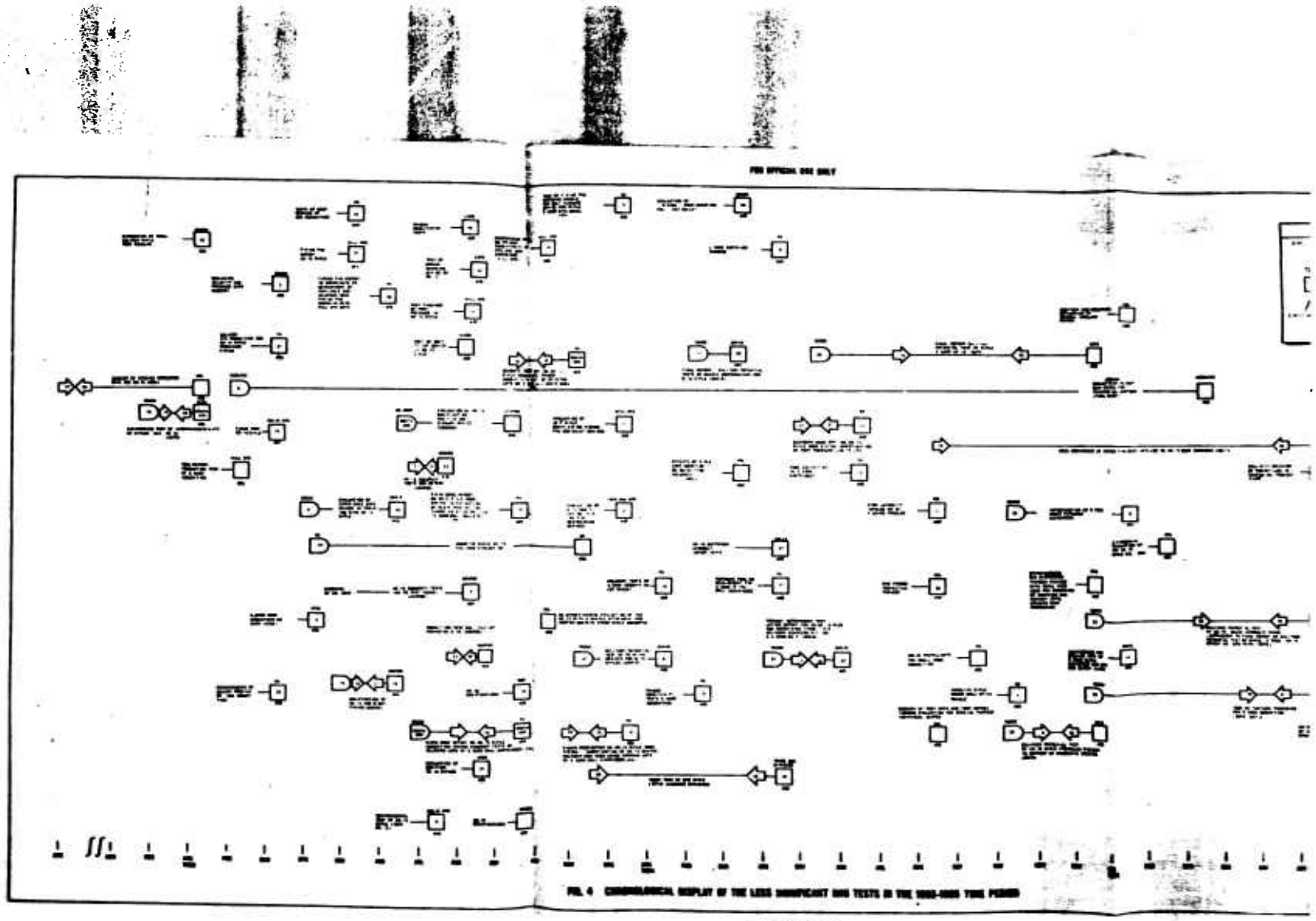
NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST	RESULTS/REMARKS	ACTION TAKEN
	INITIATOR	DATE	PURPOSE					
318	USATECOM	24 Oct 63	To test product improvement modifications to the AR15, including the bolt closure device and the charging handle.	D&PS	Product Improvement Test of Modified AR15's	[illegible]	[illegible]	Item 588
319	USATECOM	18 Feb 64	To conduct a series of ballistics tests of four types of propellants as part of ammunition evaluation program at Frankford Arsenal.	D&PS	Engineering Design Test of Alternate Propellants for Use in 5.56mm, M193 Cartridge	17 Mar 64 to 10 Apr 64	Four types of propellants (IMR4475, IMR (CR) 8136, WC846, and HPC 10) were tested in twelve AR15's for smoke, flash, fouling, and erosion. The fouling test indicated little or no decrease in accuracy. Due to relatively mild firing schedule employed, there was no significant variation in barrel wear, projectile velocity, or accuracy performance from any of the four lots of ammunition or respective weapons. Sparklers were observed in all firings. An endurance firing schedule was used in lieu of an erosion schedule because, to date, there was no known firing schedule for erosion evaluation of ammunition in rifles.	Item 322
320	USAWECOM		To record and explain the differences which are apparent in comparison of Army drawings depicting the 5.56mm test weapon chamber and the commercial counterpart drawings for caliber .223 test weapons.	Frankford Arsenal	Comparison of Military and Commercial Drawings of 5.56mm Test Weapon Chambers	19 May 64	The chambers depicted in the Army drawing and the commercial drawing (S.A.A.M.I. manual) were substantially the same. The differences in appearance were largely due to conversion of the commercial drawing to conform to standard military practices. The military drawing was consistent with the 5.56mm cartridge dimensions and described a test weapon chamber considered to be functionally equivalent to the commercial counterpart depicted in the S.A.A.M.I. manual.	
321			To investigate recent problems with bolt catch failure during endurance tests.	Colt's	AR15 Bolt Catch Study	5 May 64	High speed movie films made at Springfield Armory of a cut away AR15 were analyzed. Time available for bolt catch engagement seemed rather close. Recommendation: Machine the action spring guide assembly to a slightly smaller dimension.	Action spring guide assembly (buffer) completely changed in 1966. (Items 605, 606, 608, and 611).
322	USAMUCOM	14 Feb 64	To find a propellant which will allow achievement of the required nominal velocity (3250 ft/sec) at a chamber pressure substantially less than that produced with IMR 4475 and not significantly inferior in other characteristics.	Frankford Arsenal	Investigation of Alternate Propellants for Use in 5.56mm M193 Ball Ammunition	17 Mar 64 to 10 Apr 64	Cartridge samples representing IMR (CR) 8136 and WC846 propellants indicated that propellants of these types were satisfactory, and could afford substantial advantage over IMR4475 with regard to velocity - pressure relationships. The cartridge sample representing HPC10 propellant was not suitable because the chamber pressures developed, especially at cold temperatures, were excessive. Recommendation: Approve the use of IMR8136 and WC846 as permissible alternatives to IMR4475.	IMR 8136 and WC 846 approved for loading in 5.56mm ball and tracer cartridges. Item 612.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST [illegible]	[illegible]	[illegible]
	INITIATOR	DATE	PURPOSE					
323	USAWECOM		To determine the practicability of providing a linear compression firing pin spring as a means of reducing the risk of inadvertent fire during bolt closure.	Spring-field Armory	Inadvertent Fire Problem in XM16E1 Rifle	19 Aug [illegible]	[illegible] cause of [illegible] firing pin spring.	Item 443.
324	USATECOM	3 Apr 64	To determine the suitability of tracer cartridge XM196 for use with XM16E1 rifles under temperate climatic conditions.	USAIB	Service Test of Cartridge, Tracer, M196	9 Jun 64 to 3 Aug 64	XM196 tracer cartridges were found satisfactory with respect to: physical characteristics, accuracy, suitability of tracer element, position discarding effects, reliability, durability, and effect on weapon performance, maintenance, safety, and human factors engineering. Conclusions: (1) XM196 cartridges were suitable for use with M16 type rifles under temperate climatic conditions. (2) The XM196 compared favorably with M62 and M80 cartridges in ballistic compatibility and in overall suitability despite the shorter burnout range of the tracer element. Recommendation: Adopt the 5.56mm, XM196 tracer cartridge for use with the M16.	Arctic Test (Item 331). XM196 5.56mm tracer cartridge adopted.
325	USAWECOM	26 Jun 63	To investigate the effects on weapon performance of the AR15 chamber throat cone modification, approved at the 25-26 Jun 63 Joint Service Technical Committee Meeting.	Spring-field Armory	System Investigation of Weapon Chamber Configuration, Head Space, and Bullet Seat Depth	22 Sep 64	Six M16's were tested for cyclic rate, velocity, and accuracy. Two values of head space were considered. Bullet seat was advanced in three increments. No degradation in accuracy was noted in any of the rifles tested. Projectile velocity decreased as free run was increased. Cyclic rate increased with the number of rounds fired. The effect of head space on projectile velocity was inconclusive due to small sample size and large random variations between rifles.	
326	USAWECOM	11 May 64	To determine whether M16 production rifles conform to the performance specification. To serve as a quality assurance measure to detect any design, manufacturing, or inspection deficiencies that would adversely affect the operation of the rifles.	DCPS	Comparison Test of Rifle, M16	26 May 64 to 14 Sep 64	Five rifles were tested for accuracy and reliability, under unlubricated and adverse conditions. Four of the five rifles tested met the performance requirements. No significant design or operational deficiencies were encountered. Recommendations: (1) Adequate cleaning equipment accompany the rifles. (2) Consideration be given to incorporating lubrication requirements into the purchase description specifications.	Similar Item 330 tests the XM16E1 rifle.
327			To provide interim standardization of equipment and procedures for hardness measurements. To begin acquisition of some data to provide a background and basis of comparison for case hardness measurements for 5.56mm ammunition.	Frankford Arsenal	Measurement of Cartridge Case Hardness Patterns	25 Sep 64 to 29 Oct 64	A ten-round sample of M193 cartridge cases from three manufacturers were tested using methods employed for 7.62mm cartridges. No casualties or stoppages ascribable to the cartridge cases occurred during the firing tests with any of the samples. Recommendations: (1) The procedures and equipment described be utilized for the making of hardness measurements wherever required. (2) Comparable data be acquired from various experiments. (3) The experimental procedures be refined.	Case hardness standards introduced in the second quarter of FY 1968. Item 443.

NO	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS-RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
328	USATECOM	4 May 64	To determine the military potential of the AR18 rifle using the XM16E1 rifle as control.	USAIB	Military Potential Test of AR18 Rifle	19 Aug 64 to 6 Oct 64	The AR18 was found more suitable than the XM16E1 with respect to transportability, pointed fire accuracy, night fire accuracy, and delivery by individual parachutists. The XM16E1 was found to be more suitable than the AR18 with respect to reliability, durability, automatic fire accuracy, and bayonet employment. The two rifles were comparable with respect to physical characteristics, ease of maintenance, and semiautomatic fire accuracy.	Item 459, AR18 [illegible] test [illegible] file [illegible].
329	USAWECOM	18 Mar 63	To develop a muzzle device for improved weapon controllability in automatic and burst fire from certain (or as preferred, from all) firing positions.	Springfield Armory	Muzzle Device Development for XM16E1 Rifle	8 Dec 64	Seven experimental compensators and three flash suppressors were tested on three rifles for accuracy, sound level, flash, and blast. Based on the tests, five devices were selected for further testing. Of the designs tested, those with high braking and compensating capacity had an unacceptable high noise level. None provided sufficient stabilization to meet the five military accuracy requirement. It was not considered possible to optimize all functions in a single device.	Item 641.
330	USAWECOM	28 Jul 64	To conduct an evaluation of production XM16E1 rifles to assure conformance with technical requirements and to detect and design, manufacturing, or inspection deficiency that would adversely affect operation, and to determine the effectiveness and handiness of forward bolt assist device in reducing malfunctions.	DuPS	Comparison Tests of XM16E1 Rifle	8 Sep 64 to 13 Nov 64	Five rifles were subjected to a variety of environmental and accuracy tests. One of the five rifles failed to meet the performance specifications. Under adverse conditions no significant design or operational deficiencies were encountered. Use of the bayonet did not change the center of impact. The bolt assist assembly provided a ready means of clearing failure to lock and failure to strip malfunctions and was not detrimental in any way to the use and operation of the rifle. Recommendation: Adequate cleaning equipment be designed and issued.	Chamber cleaning brush issued in May 1966. Continuing evaluation of means to carry cleaning equipment.
331	USATECOM	3 Apr 64	To determine the suitability of XM196 tracer cartridge for use under arctic winter conditions.	USAATC	Service Test of Cartridge, Tracer, 5.56mm, XM196, Under Arctic Winter Conditions	15 Oct 64 to 23 Mar 65	Reliability of tracer ignition was found to decrease as the temperature decreased. The XM196 tracer cartridge was unsuitable for use with the XM16E1 under arctic winter conditions. The XM196 cartridge would compare favorably with control cartridge when the deficiency has been corrected.	Item 607.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
332			To evaluate the meaningfulness of the current port pressure requirements.	Frankford Arsenal	Study of Current Port Pressure Acceptance Criteria for 5.56mm Ammunition	17 May 65 to 27 May 65	Port pressure data from 140 lots of M193 ball and 15 lot of M196 tracer ammunition were analyzed. Conclusions: (1) Current port pressure requirements are reasonable in that they are compatible with cartridge designs and other interior ballistic parameters. (2) The current requirements are reasonably and meaningfully restrictive. (3) Compliance with these requirements is associated with a high probability of satisfactory function of the rifle system and precludes, in large measure, acceptance of ammunition which will not provide satisfactory weapon function. (4) A major change in port pressure level of M196 and M193 ammunition cannot be achieved without extensive redesign of the cartridge or significant compromise of performance. (5) It is feasible to design new weapons to accommodate port pressure levels of current ammunition. Recommendations: (1) The current port pressure requirements be maintained and considered firm. (2) Tests are recommended for establishing pressure limits under fielding conditions. (3) Future weapon designs should consider the range of port pressure provided by standard 5.56mm ammunition.	Item 732.
333			To evaluate the acceptance criteria for testing the primer sensitivity of 5.56mm ammunition.	Frankford Arsenal	Study of Current Primer-Sensitivity Criteria for 5.56mm Ammunition	Jun 65	Primer sensitivity data from 155 lots of M193 and M196 ammunition into which a total of 38.9 primer lots had been assembled, were analyzed. Conclusions: (1) The current sensitivity requirements present an unreasonable burden to manufacturers because of their narrow range, and because they can be achieved only with a loss of some fraction of production. (2) Primers complying with current requirements are necessarily insensitive and would consequently yield a high rate of misfires when fired in weapons with conventional bolt and firing pin dynamics. Recommendation: Consideration be given to modification of the rifle, thereby permitting relaxation of the primer sensitivity requirements.	Item 733.
334			To establish the cyclic rates for two lots of Remington ammunition containing ball propellant compared with one lot of Remington ammunition containing DuPont propellant.	Colt's	Comparison Test of Ammunition for Cyclic Rate	11 Jun 65	Cyclic rate data were taken for 50 rifles. Each fired a sample from each of three lots. Lots RA5118 and 5119 were loaded with Western ball (WC846) powder. Lot RA5120 was loaded with DuPont (IMR 8136) powder. The cyclic rate with the Western powder averaged 80 rounds per minute higher than for the DuPont powder.	Item 601.
335	USATECOM	3 Apr 64	To determine the suitability of the XM196 tracer 5.56 cartridge for use with the M16 and XM16E1 rifles.	LnPS	Engineering Test of the XM196 Tracer Cartridge	15 Jul 64 to 16 Mar 65	Engineering tests conducted to determine the physical and ballistic characteristics included safety; cook-off; functioning; ballistic properties; and initiation, termination, intensity, and visibility of tracer element. The physical and tracer characteristics, and the accuracy of the test cartridge complied with specifications. A cook-off could be expected with either tracer or ball ammunition when more than 120 rounds are fired rapidly. Vibration of the tracer cartridge caused delays in the trace. The erosion characteristics of the tracer cartridge were comparable to those of the ball cartridge. Attitude of the weapon did not affect functioning. Recommendation: XM196 tracer ammunition be considered suitable for use with M16's.	XM196 5.56mm tracer cartridge adopted. Metal fouling with tracer cartridges reported and evaluated in 1967 (Item 628).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST [illegible]	[illegible]	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
336	USATECOM	8 Apr 64	To determine the performance, accuracy, dispersion, reliability, penetration, and ease of maintenance of the Stoner rifle using M14 and XM16E1 rifles as control weapons.	USATC	Military Potential Test of the Stoner 63 Weapon System Under Arctic Winter Conditions	15 D[illegible] 64 to 15 Apr 65	[illegible] accuracy of the Stoner rifle compared favorably with that of the XM16E1 and M14. The reliability of this test weapon was significantly inferior to that of the control weapons. The stoppage rate of the Stoner was four times that of the XM16E1 and 25 times that of the M14. The Stoner did not perform satisfactorily when fired lubricated or unlubricated at the test temperatures (-10°F to -56°F). The control M14 and XM16E1 performed satisfactorily when fired unlubricated.	The Stoner system was evaluated again in the SAWS Study (Items 503-513_).



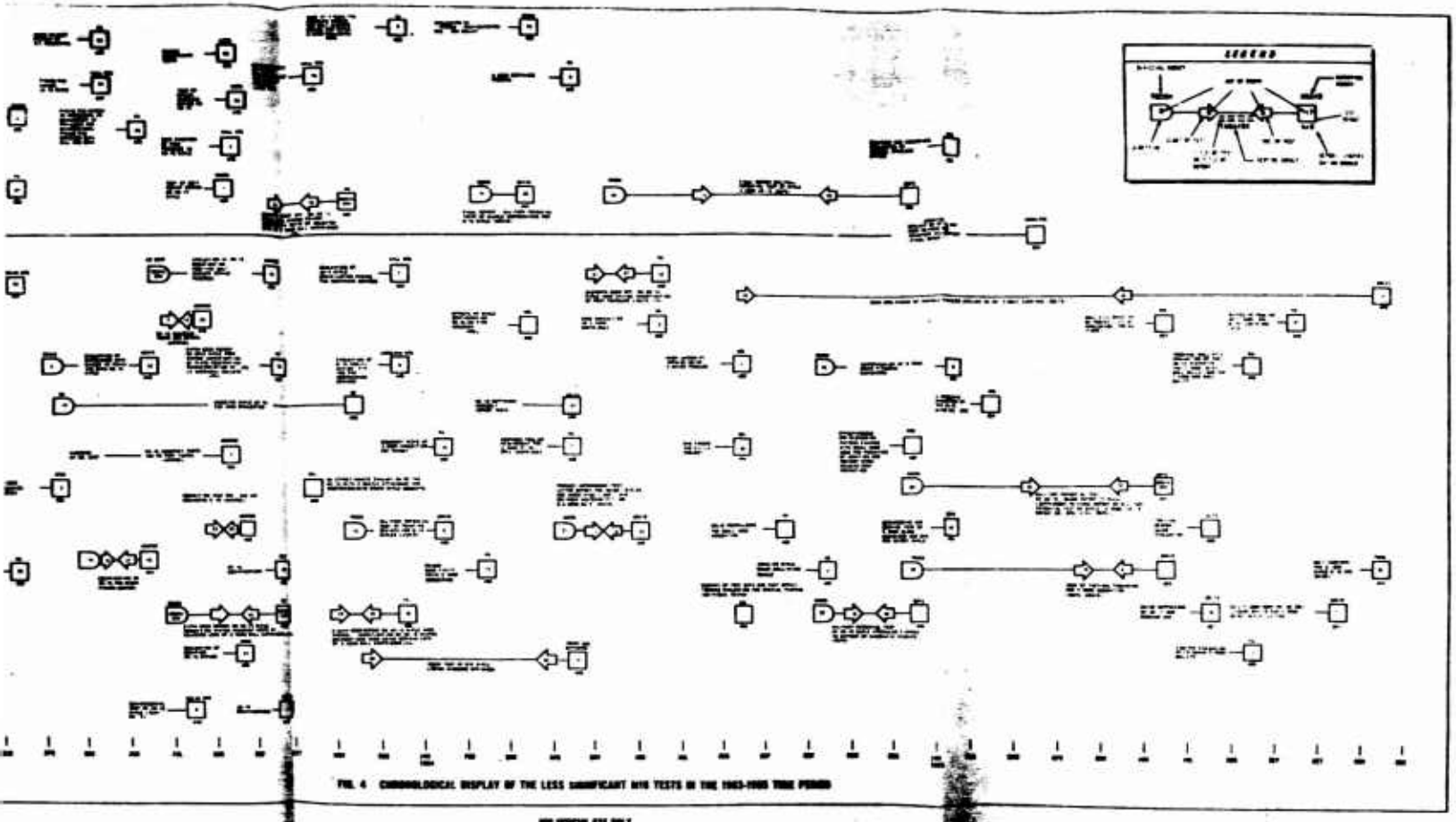


FIG. 4 CHRONOLOGICAL DISPLAY OF THE LESS SIGNIFICANT HYD TESTS IN THE 1963-1968 TIME PERIOD

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TABLE 2 - 21

CHRONOLOGICAL DISPLAY OF THE LESS SIGNIFICANT M16 TESTS IN THE 1963-1965 TIME PERIOD

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
401	USAMUCOM	7 Jan 63	To take action on major deficiencies in small caliber rifle evaluation tests, in particular blown primers when moisture is in the bore and debulleting.	USATECOM	Discussion of Small Caliber Rifle Test Results	16 Jan 63	In a meeting on 16 Jan 63, USATECOM orally released test data on the AR15 system to USAMUCOM. No reports could be released per USAMC restrictions. The tests were in no sense engineering tests of the ammunition. Durability, reliability and terminal effectiveness of the system were the main points tested. Chamber and port pressures, action times, waterproofing, and climatic storage data were not taken. Reported problems were debulleting and blown primers. Conclusion: The USATECOM test data confirmed the suspicion that the USAF proposed chamber pressure and muzzle velocity requirements are not realistic in terms of the present commercial cartridge performance.	Items 404 and 405.
402	HEL		To establish relationships between three-round dispersion and rifle design parameters, and to determine what combination of rifle design parameters would meet the requirements specified for the SPIW Program.	HEL	Summary of Studies Conducted with the AR15	Jan 63	The evaluation presents a summary of firings conducted with the AR15 using several muzzle brake deflectors and other means to reduce automatic fire dispersion.	Item 430
403	USATECOM	19 Dec 62	To conduct interchangeability tests with the AR15 to include limited firing tests.	D&PS	Engineering Test on Interchangeability of AR15	18 Dec 62 to 20 Dec 62	Five rifles were fired 100 rounds, disassembled and reassembled with interchanged parts, and then fired 100 rounds each. No malfunction occurred which could be attributed to the interchange.	
404			To conduct various tests on 5.64mm ammunition in accordance with specification MIL-C-9963 (USAF).	Hill AFB	Preliminary Production Test of 5.64mm Ammunition	Feb 63	Data collected for the development of a technical data package.	Item 410.
405	USAMUCOM		To correct interior ballistic data on test variables with the S.A.A.M.I. chamber, the Colt AR15 rifle chamber, and a modified Colt AR15 chamber.		Remington Velocity and Pressure Data Summary	28 Feb 63 to 2 Mar 63	Three lots of ammunition were tested in three test barrels. Differences in velocity and pressure were noted.	Items 306 and 410.
406			To evaluate an experimental sample lot of less sensitive primers.	Frankford Arsenal	Caliber .223 Ammunition and AR15 Rifle - Premature Firing	21 Mar 63	USMC firings of 5000 rounds of selected ammunition were observed by FA. The fact that premature firings still occurred was taken as indicating that high firing pin inertia was the cause. Further testing was recommended.	Item 306.
407	Eglin AFB		To pinpoint any malfunctions of the AR15 under normal training situations and to determine the cause.	Hurlburt AFB	Field Test AR15 Rifle.	8 Feb 63 to 15 Mar 63	Range firing tests were conducted using marksmanship trainees. Failures to feed were observed; some due to faulty magazines. Rifle modifications recommended were: (1) Conduct closer quality control inspection. (2) Replace present type charging handle. (3) Develop an ammunition strip clip to facilitate magazine loading.	Item 414.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
408	USAMUCOM	25 Mar 63	To obtain data required in connection with study of dimensional compatibility of caliber .223 ammunition and AR15 rifle chambers.	Frankford Arsenal	Measurements of Bullet Profile of Caliber .223 Ammunition	Mar 63	(Data not available).	Items 309 and 310.
409	Hill AFB		To investigate the problems associated with reduced loads of powder in the caliber .223 ammunition.	Eglin AFB	5.64mm Ammunition Specification Data	3 Apr 63	Test rounds were hand loaded with 0, 5, and 10 grains of IMR 4475 propellant to test for bullets remaining in the bore. Conclusions: (1) A load of 10 grains will clear the bullet from the bore; (2) 5 grains may clear the bullet from the bore in most cases, but in cold weather this load may present a hazardous condition; (3) No powder in the case will cause a stoppage, but does not present a hazardous condition; none of the reduced charges cycled the rifle.	Item 425.
410	USAMUCOM		To collect velocity and chamber pressure data on 5.56mm ammunition samples obtained from USAF.	Frankford Arsenal	Tests of USAF Samples of Caliber .223 Ammunition	21 May 63	Chamber pressure mean and extreme variation data were presented for 8 test lots and a reference lot. Instrumental velocity at 15 feet for 8 test lots and 1 reference lot were also presented.	
411			To determine firing pin energies when the rifles were cleaned and test conditions maximized available energy.	Hill AFB	Firing Pin Energy, AR15, Rifle.	31 May 63	Data at variance with similar Frankford Arsenal tests were obtained. Revised specifications were recommended.	Item 412.
412	USAMUCOM	28 Jun 63	To resolve differences between Air Force and Frankford Arsenal firing pin energy measurements. (Items 411 and 306).	Frankford Arsenal, Lackland AFB	Firing Pin Energy to Coordinate FA Measurement of Available and Unintentional Firing Pin Energies With Hill AFB Data	10 Jul 63 to 12 Jul 63	The test used test fixtures and copper cylinders from both Frankford Arsenal (FA) and Hill AFB in an effort to resolve differences between measurements. Statistical analysis for each of four sets of primer sensitivity limits provided the probability of misfires, muzzle up and muzzle down, and the probability of unintentional fire.	Item 312. Further FA and USAF tests (Items 429 and 431).
413	USA Infantry Center	3 Apr 63	To conduct marksmanship training and parachute jump training with the AR15, and to check maintenance problems.	USATS	Evaluation of Experience Data Gained in Training With AR15 Rifle	30 Jun 63	M14 marksmanship training can be adopted for use with AR15 with only minor modifications. The AR15 can be jumped without a weapons container without undue risk. No serious maintenance problems were associated with such training. Recommendation: TM-57-220 be modified and approved for publication.	Item 446.
414		14 May 63	To evaluate the possible advantages of modification of the rear sight base (carrying handle) to provide a flat ramp to facilitate night firing.	Lackland AFB	Modification of AR15 for Night Firing	19 Jun 63	2000 rounds were fired in tests against pop up silhouette targets. It was found that the flat ramp in front of the peep sight did not aid in sighting the weapon under light conditions where the peep sight was ineffective. Recommendations: (1) The carrying handle remain in its present configuration, (2) Serious consideration be given to procuring three-power scopes to aid in both daylight and night firing.	USMC evaluation (Item 423).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST D[illegible]	[illegible]	[illegible]
	INITIATOR	DATE	PURPOSE					
415	BRL	13 Jun 63	To conduct firing tests at temperatures of +125°, 0°, and -65°F to determine maximum yaw as a function of range, temperature (air density), and twist rate.	Eglin AFB	Environmental Test of AR15 Rifle	9 Jul [illegible]	[illegible] tests at [illegible] conducted in [illegible] facilities [illegible] stability as a function of [illegible]	
416			To evaluate the accuracy potential of the AR15 with present lots of ammunition.	Lackland AFB	AR15 Accuracy Tests - 300 Meters	23 Jul 63	Firing tests were conducted with two 1-in-12 inch barrel and eight 1-in-14 inch barrel twist rifles. Three to four lots were fired through each rifle. The AR15 was inherently accurate; accuracy of the test weapons exceeded that of a match M1 and an M14. Recommendations: (1) The accuracy criteria for procuring ammunition be set at twelve inches extreme spread at 300 yards fired from machine rest. (2) 90% of the groups fired from each rifle be required to fall within this specified extreme spread.	Item 421.
417			To report on accidental firing rates with selected lots of Remington ammunition.	Lackland AFB	Primer Sensitivity Tests	19 Aug 63	(Data not available).	Item 429.
418			To compare AR15 functioning with and without the manual charging device.	Lackland AFB	Test of Manual Charging Device on AR15	23 Aug 63	During the first phase of the endurance test, using four standard AR15's and two modified with manual charging device, malfunctions were noted in the modified weapons which were hazardous to personnel. One AR15 blew up due to cook off occurring when the charging device failed to close the bolt fully.	Item 424.
419			To determine the port pressure of the AR15 in order that it may be specified in the ammunition contract.	Hill AFB	Test Finding of Port Pressure in AR15 Rifle	7 Aug 63	Tests were conducted using standard equipment modified to meet S.A.A.M.I. standards. Two types of seals were used. Average pressure using metal cup seals was 14,400 psi, while with neoprene seals the average was 14,800 psi. The grand mean was 14,500 psi with a variation range of 15,000 ± 2000 psi.	Item 332.
420	USATECOM		To conduct a static evaluation of the modified charging handle using dummy ammunition.	USAIB	Test of Bolt Assist Device on AR15 Rifle	1 Aug 63	A static evaluation was conducted. However, USAIB could not conduct the engineering tests needed to complete the analysis. Recommended these tests be conducted by D&PS.	D&PS test (Item 318).
421	USAF		To record firing data on the AR15 rifle for the use of the inter-service committee in determining accuracy specifications for ammunition and weapon systems.	Lackland AFB	AR15 Accuracy Tests - 100 Yard Test Tunnel	Jul 63 to Aug 63	Accuracy tests were conducted with eight AR15's with 1-in-12 twist; two AR15's with 1-in-12 twist rechambered to new specifications; and thirty AR15's with 1-in-14 twist rechambered to new chamber configurations. The AR15 was capable of producing excellent accuracy with existing ammunition. The new chamber configuration contributed to lower chamber pressures. The current 1-in-12 inch twist barrels produced marked improvement in accuracy compared with previous 1-in-14 twist barrels. Selected AR15's had an accuracy capability equal to the USAF premium grade M1 and National Match M14 with match grade ammunition. Recommendations: (1) Accuracy specifications for weapon and ammunition be based on the data obtained from 1-in-12 inch twist weapons. (2) The accuracy specification be the average extreme spread and the range of extreme spreads of any group of ten consecutive rifles shall be less than three and four inches respectively at 100 yards machine rest. (This differs from the Army specification which states a figure of 16.8 inch extreme spread at [illegible] yards).	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
422	OSD, DOD		To evaluate ammunition lot, Remington B10, to determine the incidence rate of dropped primers, partially blown primers, and leaky primers.	Lackland AFB	Test of Remington Lot B10 5.56mm Ammunition	27 Aug 63	Two AR15's with 1-in-12 twist were fired 1,000 rounds each. The primer and lot B10 failed to effectively contain gas pressure; dropped primers occurred more frequently at higher temperatures; leaky primers occurred more frequently at lower temperatures. Recommendations: (1) Remington Lot B-10 be rejected for USAF use. (2) Future lots be thoroughly tested to insure that this deficiency is corrected.	
423	USAMECOM		To evaluate modified AR15 rifles to determine if any improvement was made in their night fighting and pointing characteristics.	USMC	Evaluation of Modified AR15 Rifles	21 Aug 63	Test firings were conducted at various ranges under varying light conditions. Results achieved during this firing indicated no difference in the hitting capabilities of each type weapon. Recommendation: No further consideration be given to these particular modifications.	
424	USAF		To evaluate modifications to the AR15 rifle incorporating a "positive" bolt closure device.	Lackland AFB	Evaluation of AR15 Modification - Positive Bolt Closure Devices	13 Sep 63	Six standard AR15's and three modified rifles were fired 2,000 rounds without cleaning to induce malfunctions. The Colt modification did not satisfactorily achieve its intended function; the Springfield modification was unsatisfactory in that it did not perform its intended function in all instances and created a safety hazard. Recommendations: (1) The modifications be dropped from consideration. (2) Procurement be based on the present configuration.	USAF position (Item 312).
425			To determine the practicality of the military specification requirement for plate penetration.	Frankford Arsenal	Investigation of Plate-Penetration Characteristics of Caliber .223 Ball Bullets	16 Sep 63	Test firings were conducted against ten gauge mild steel plate at ranges from 425 to 500 yards. The M193 cartridge could be expected to perforate ten gauge mild steel plate quite consistently at 450 yards but may fail to perforate completely at 500 yards. Recommendations: (1) Using forces determine if this penetration capability meets field requirements. (2) The plate penetration requirement and test be deleted from the specifications for manufacture and acceptance of M193 ammunition.	
426	USACDC		To establish a USACDC position regarding bolt closure device and reduction of inadvertent firing modifications to the M16.		AR15 Modifications	Sep 63	A bolt closure device for the AR15 is not required. Inadvertent firing of the AR15 is not acceptable.	Army position (Item 312).
427	USAMC		To establish a USAMC position regarding bolt closure device and reduction of inadvertent firing modifications to the M16.		AR15 Modifications	Sep 63	CG, USAMC said to accept the AR15 without a manual bolt closure device and to accumulate data as rapidly as possible to support a reasoned rather than opinionated decision.	Army position (Item 312).

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS	SUBSEQUENT ACTION
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428	USAWECOM		To test samples of ammunition from USAF stock to determine which lots are suitable for rifle acceptance testing.	Frankford Arsenal		29 Sep 63	Sixteen lots of M193 [illegible] to test fired from two 1-in-12 twist rifles in machine rest on a 200 yard indoor range. Five lots had excessive accuracy, the wing [illegible] radius between 1.1 and 1.3 inches. Other lots were just outside these limits.	Item 437.
429			To report on the maximum energy delivered to the primer by the "floating" firing pin of the AR15.	Hill AFB	Primer Sensitivity of Caliber .223 Cartridge	15 Oct 63	Data was presented giving the probability of an unintentional fire occurring for primers of different sensitivity limits. FY 63 Air Force ammunition should result in complete elimination of the problem of unintentional fire. An increased rate of failure to fire could be expected unless the rifles are cleaned more frequently. Recommendations: (1) No changes of primer sensitivity limits should be considered until pending Air Force preproduction tests are completed. (2) No changes to the rifle which will decrease the available firing pin energy by more than 5% should be approved.	
430			To determine the anti-personnel effectiveness of a muzzle brake compensator attachment for the AR15 rifle.	BRL	Effectiveness Evaluation of the AR15 Rifle with a Muzzle Attachment and Comparison with Other Rifle Concepts.	Oct 63	Test firings were conducted to determine drag and velocity. There was little difference in hit probability with or without battle sight range setting except for small aiming errors and long ranges. Temperature had a negligible effect on hit probability. An analysis of wound ballistics tests was made. Projectile lethality of the AR15 with 1-in-12 twist was 10 to 25% less than with a 1-in-14 twist at 70°F. Semiautomatic and automatic fire effectiveness was also evaluated. The AR15 yields higher semiautomatic effectiveness than the other rifles in terms of kills per unit time. The muzzle brake compensator (MBC) on the AR15 generally decreased the extreme spread of two-round burst but not of three-round bursts. The MBC must be tuned for particular conditions to be effective. Accuracy improvements with the MBC varied from firer to firer. An overall effectiveness comparison was obtained by averaging and weighting effectiveness data equally for all aiming errors, casualty criteria, measures of effectiveness and fire roles. Compared to the M14, the AR15 (with 1-in-14 twist) is 1.62 times as effective and the AR15 (with 1-in-12 twist) is 1.42 times as effective.	Item 441. Item 333.
431			To evaluate the sensitivity of several lots of commercial caliber .223 ammunition which have been reported by the Air Force as having inadvertent fire problems.	Frankford Arsenal	Primer Sensitivity Tests of Selected Lots of 5.56mm Ball Cartridges	Oct 63	Tests were conducted for 5 lots of ammunition. Although not manufactured to the present criteria, the primers used in previous Remington production appeared to meet, or nearly meet the primer sensitivity limits established by the technical committee at the August 1963 meeting. To the extent that these lots were representative of previous productions, it appeared that the producer could in fact meet the current primer requirements, with adjustment to the process. The predicted accidental fire rate based on a statistical model was fairly consistent with the actual rate reported by the Air Force.	

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NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
432	United Kingdom	17 Apr 63	To evaluate the Colt AR15 rifle.	United Kingdom	Armalite Rifle AR15 Evaluation	Nov 63	The AR15 was a generally well-designed weapon suited for large scale production. Its outstanding features were light weight and low recoil.	Item 455. Item 31*.
433			To evaluate 3 firing pin devices designed to prevent primer contact during bolt closure, a T-type charging handle assembly, and a Colt-designed bolt closure device.	Springfield Armory	Test of Firing Pin, Charging Handle and Bolt Closure Device for AR15 Rifle	9 Dec 63	Recommendations on the Colt firing pin device were deferred until it was determined if primer sensitivity could be reduced. No further consideration should be given to the Springfield ball lock firing pin. Recommendations: (1) The bolt closure device be adopted as standard after deficiencies are corrected. (2) The T-type charging handle assembly be adopted as standard when deficiencies are corrected.	
434			To test rifle modifications designed to overcome the unintentional firing problem.	Hill AFB	Evaluation of AR15 Rifle Modification Firing Pin Restraint Devices	5 Dec 63	Hammer blow and bolt closure data were taken on 8 rifles firing 20,000 rounds. Firing pin spring modifications resulted in a decrease in the available firing pin energy level. WC 846 propellant substantially reduced fouling as compared to IMR 4475. Defective magazines resulted in frequent failures.	Item 435.
435	USAF		To evaluate two mechanical designs developed by Colt to reduce firing pin energy on bolt closure.	Lackland AFB	Evaluation of M16 Modification - Firing Pin Restraining Devices	Dec 63	Modifications were tested on five M16's. 10,000 rounds were fired through each weapon and malfunctions noted. Both devices tested effectively reduced firing pin energy and both were found to introduce a higher probability of misfire than of inadvertent fire. Recommendation: The firing pin restraining devices tested are not recommended because they greatly increase the probability of misfire, while adversely affecting the reliability of the weapon.	Item 318.
436	USAMUCOM		To determine the extent (if any) to which sluggish bolt operation and failures to feed and eject are attributable to the ammunition used.	Frankford Arsenal	Investigation of AR15 Weapon Malfunctions When Using Lots of 5.56mm Ball Cartridges	10 Dec 63	Ammunition lots were compared during a 6,000 round endurance test. The primer and propellant used met the requirements for 5.56mm ball cartridges. Differences in primer composition may have been a factor in the excessive fouling previously observed. Colt's previous data were not conclusive, since each test employed a new weapon. Recommendation: A satisfactorily discriminating fouling test be required as a criteria for 5.56mm cartridge acceptance.	Item 445.

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437	USAMUCOM	3 Jan 64	To establish the typical accuracy of subject ammunition lot.	Frankford Arsenal	Accuracy Tests of 5.56mm Ammunition Lot RA 5027	15 Jan 64	The grand average mean radius was found to be very slightly below the range specified for use in accuracy acceptance testing of AR15's. However, the difference was so small as to be of no statistical or practical significance.	Lot RA5027 used at Colt's for M16 acceptance testing.
438	USATECOM	13 Nov 63	To determine the military potential of pointing devices for the M16.	USAIB	Military Potential Test of Pointing Devices for M16 Rifles	6 Jan 64	Two types of pointing devices for attachment to the carrying handle of the M16 rifle were evaluated. Type 2 devices offered some military potential but the Type 1 devices offered more potential for improving pointing characteristics. Recommendation: Type 1 pointing device be considered for adoption.	
439			To determine the firing pin energy of the caliber .30 carbine M1.	Frankford Arsenal	Primer Sensitivity Tests for 5.56mm Ammunition	12 Feb 64	Ten trials to determine the firing pin energy on bolt closure were conducted for each of six M1 carbines. In 16 of these 60 trials, the firing pin made no measurable indent. The greatest observed hammer blow energy was 33 inch-ounces, and the least observed was 23 inch-ounces. The mean of all the trials was 29 inch-ounces.	Continued M16 primer sensitivity and inadvertent fire investigation.
440			To determine the stability factor of Sierra bullets fired from the AR15 rifle with twist rates of 1-in-14 and 1-in-12 inches.	Frankford Arsenal	Evaluation of Sierra Configuration Caliber .223 Bullet	12 Feb 64	Results of test firings (Item 307) indicating Sierra superiority to standard bullets were communicated to the PM-RS. BRL's position was that a 1-in-10 twist would be needed for stability of Sierra. Request PM-RS to advise on subsequent action.	
441	USATECOM	11 Feb 64	To determine the military potential of muzzle brake compensators fabricated by Springfield Armory to provide a basis for selection of a single type muzzle brake compensator for use with the M16 rifle.	USAIB	Military Potential Tests of Muzzle Compensators for M16 Rifle	26 Mar 64	Five M16's were each fitted with a different muzzle brake compensator (MBC) and one standard M16 served as a control weapon. One weapon - MBC combination was the best for prone, unsupported and prone, biped-supported fire. Another was the best for quick fire. The latter was the best for overall firing, both prone firing and quick fire.	Item 705.
442			To show the effects of differences in configuration, weight, and weight distribution of the AR15, the caliber .30 carbine, and the modified carbine when employed against short-range (20m to 60m) targets which were exposed for short durations (about 2 seconds).	HEL	Effects of Rifle Configuration on Quick Fire Accuracy	Mar 64	The overall effects of configuration were profound under quick fire conditions. It was possible to improve the effectiveness of some existing small arms without a complete weapon redesign. Recommendations: (1) The utility and feasibility of providing a modification for the M14 should be investigated. This kit should provide a sighting rib, sighted in at 50m; no projections above the rib, except a front post and a rear peep sight with an outside diameter of about .3 inch and an inside diameter of .1 inch; a drop at the comb adjustable in .25 inch increments between 1.25 and 1.75 inches; and a set of shims to adjust a stock length in .5 inch increments between 13 and 14.5 inches. (2) If at all possible, future rifles should be designed to meet the above criteria. (3) A study should be conducted to investigate weapon shooter behavior under quick-fire conditions when automatic fire is used.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
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443			To establish and record the sidewall hardness and structure of current 5.56mm cartridge production.	Frankford Arsenal	5.56mm Cartridge Program	6 Apr 64	While sidewall hardness and grain size will not be specified as a condition of ammunition acceptance, it would be desirable for future reference to establish and record these data for 5.56mm cartridge production.	Case hardness standards introduced in second quarter of FY 1968.
444			To evaluate the impact strength of butt stock assemblies in which the butt material was a phenolic resin reinforced with glass fiber.	Colt's	AR15 Butt Stock Assembly-Impact Tests	17 Apr 64	The glass filled material was superior to the standard material. However, a change was not recommended, since the cost of the test material was about twice that of the standard material. The study of the effect of increased foam density should be accomplished before any change is recommended, since this may provide increased strength at a much lower cost level.	
445	USAWECOM		To establish a proposed fouling requirement as part of the ammunition specification.	Frankford Arsenal	Proposed Fouling Requirement for 5.56mm M193 Ball Cartridges		It would appear advisable to defer any action to implement the fouling requirement on a mandatory basis pending completion of initial production sample testing. This was because the offending compounds in the primer composition were no longer being used.	Fouling requirement established for pre-production sample. Item 421.
446				101st Airborne Division	Troop Test of M16 Rifle	25 Nov 63 to 15 Mar 64	Report provides data on XM16E1's issued to 101st Airborne Division on weapon jumps, zero and record fire, penetration tests, bayonet and infiltration courses, and a major training exercise. The XM16E1 had 45 per cent fewer malfunctions than a comparable number of M14's in the record firing. There were fewer malfunctions under all operating conditions than with the M14.	Items 447 and 467.
447	USATECOM	27 Apr 64	To determine suitable means for attachment of the XM16E1 to a parachutist.	USAIB	XM16E1 Rifles and Associated Items - Air Delivery	1 May 64 to 18 May 64	Recommendations: (1) The tested method of padding a side mounted bolt assist device on the XM16E1 be adopted as normal procedure. (2) The tested method of attaching the XM16E1 to the parachutists be adopted as normal procedure.	
448			To develop a number of special ammunition samples, which will be suitable for use in tests to investigate the tolerable port pressure limits of AR15 service rifle.	Frankford Arsenal		27 May 64	Recommendations: (1) Weapon tests be designed and executed to investigate the adequacy of the present port pressure criteria for 5.56 ammunition using special ammunition samples such as those used in this test. (2) As a longer range program, consideration should be given to establishing more exactly the port pressure levels which the M16 type weapon can tolerate. (3) The cyclic rate criteria applied to the acceptance of the M16 type weapons be re-examined in the light of the data developed in this test.	Item 332.
449	Eglin AFB	4 Jan 64	To assemble data regarding Army experience with the AR15 Rifle as regards case casualties.	Frankford Arsenal	Case Casualties in 5.56mm Cartridges	12 Jun 64	At request of the USAF, data on Army experience with cartridge case casualties were assembled. Relatively few case casualties were observed in the subject lots.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
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450			To describe the impulse sound pressure problem created by modern fire power and to present techniques for partially attenuating these levels at crew positions. To discuss the effect of high intensity noise on hearing.	HEL	High Intensity Impulse Noise; a Major Problem	Aug 64	There were very large individual differences in susceptibility to impulse sound-pressure effects, both in the Army population and in the population of Americans in general. Other conditions being equal, it appeared that the higher the peak sound pressure level, the greater the resulting temporary threshold shift will be. The rate of exposure had been shown to be an important variable.	Item 459. Tracer lethality investigation (Item 700).
451			To determine the stability characteristics of the M16 tracer projectile by firing two rounds in the BRL small free flight range and analyzing the yawing motion.	BRL	M16 Tracer Projectile Project	24 Aug 64	The stability values obtained were slightly higher than those for the standard ball projectile.	
452			To present summaries of the SPIW test data and the analyses of these data to determine the effectiveness achieved with both the SPIW competitors and the control weapons, and to determine the relative tactical effectiveness of each weapon system considered.	BRL	Summary of Test Data and Effectiveness Evaluation for the Special Purpose Individual Weapon	Aug 64	The SPIW concept, which specified that multiple projectiles per trigger pull be delivered with small dispersion, was verified in that a significant increase, relative to the M14, M16, and M16M (with muzzle brake compensator) in hit and incapacitation probabilities was achieved for both aimed and pointed fire. The agreement between field test data and theoretical estimates of the effectiveness demonstrated the validity of the mathematical analysis used in previous BRL studies pertaining to SPIW and the XM16E1.	
453	USATECOM	3 Apr 64	To determine the suitability of the cartridge, tracer, 5.56mm, XM196, for use with the XM16E1 rifle.	D&PS	Engineering Test of Cartridge, 5.56mm, Tracer, XM196		Recommendation: The XM196 tracer cartridge should be considered suitable for service use with the M16 and XM16E1.	
454	USAMUCOM	16 Oct 64	To make a preliminary investigation of the feasibility of developing a 5.56mm cartridge optimized for penetration characteristics.		Investigation of 5.56mm Armor Piercing Cartridges	5 Jan 65	A proposal for developing an multi-purpose 5.56mm cartridge with improved penetration capability was submitted.	
455			To examine the wounding effects of the Armalite rifle in comparison with those of the Fabrique Nationale rifle under controlled laboratory conditions at 15 and 100 yard ranges using gelatin tissue models in a standard wound path anesthesized sheep.	United Kingdom	Armalite Rifle Wound Ballistics Trials	7 Oct 64	Results confirmed U.S. test findings that AR15 was capable of inflicting very severe wounds at short ranges (up to 100 yards). There were indications that 1-in-14 twist was slightly superior to 1-in-12 twist, the difference being very small with the Remington 5.56mm round, but more marked with the Norma 5.56mm round.	Item 737.

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	INITIATOR	DATE	PURPOSE					
456	USAWECOM	Apr 64	To subject the AR18 rifle to a military potential test.	D&PS	Military Potential Test of Rifle, 5.56mm, AR18	15 Jul 64 to 20 Oct 64	Based on a comparison of overall performance of the AR18 and XM16E1, the AR18 had military potential, but would require improvement before it could be considered an acceptable military rifle.	Items 459, 461, and 464. AR18 not further tested until 68.
457			To compare the performance of the U.S. 5.56mm cartridge with the IMK 5.56mm cartridge (77 grain) and the NATO 7.62mm cartridge.		Effectiveness and Dispersion Pattern Firings with Small Arms Ammunition for Formation of Cavities and Against Steel Helmets, Body Protections	16 Dec 64	Comparative data were gathered on the M193 Remington, 55 grain and the IMK 5.56mm 77 grain cartridges, and on the NATO 7.62mm cartridge with respect to accuracy and to penetration of moist clay, moist clay and steel plate, moist clay and hardwood boards, steel helmets, nylon body armor, and body protection with overlapping steel plates. Data were taken on depth of penetration, length of bullet track until the beginning of the cavity, and length and largest diameter of the cavity.	
458	USATECOM	30 Oct 64	To evaluate the AR18 weapon mechanism.	D&PS	Military Potential Test of the AR18 Rifle (Pendulum Firings in Support of Kinematic Studies)	6 Nov 64 to 10 Nov 64	Impulse values were determined in pendulum firings using M193 ball and XM196 tracer cartridges. All of the primers and some of the cartridge cases of the ball rounds fired appeared to show signs of high pressure. Eight primers were punctured. The fired cases from the tracer rounds appeared normal.	Item 461.
459			To present the results of the acoustical measurements in auditory tests made for the small arms program. To analyze the auditory data in terms of damage risk to hearing from exposure to the various weapons. To relate the acoustical measurements of weapon noise to the results of the auditory tests. To discuss using ear plugs for ear muffs to reduce hearing loss from gun noise exposure. To examine auditory problems that persons with and without noise induced hearing loss have when communicating while wearing ear protection devices.	HEL	Auditory and Acoustical Evaluation of Several Shoulder-Rifles	Jan 65	Repeatedly firing as many as 100 trigger pulls per day with the AR18 would probably cause, in about 25% of the firers, significant permanent hearing loss at frequencies of 4,000 cycles per second and up, but not at frequencies of 3,000 cycles per second and below. Ear plugs or ear muffs would protect the hearing adequately during exposure to gun noise--but, particularly for people with hearing loss, would reduce the ability to perceive speech or other weak auditory signals, except in the presence of rather intense masking noise.	
460	USATECOM	14 Jan 65	To determine the suitability of the 5.56mm blank and blank firing attachment (BFA) for the XM16E1 rifle.	D&PS	Engineering and Service Test of 5.56mm Blank Cartridge, and BFA for XM16E1 Rifle		Testing of the 5.56mm blank cartridge and blank firing attachment (BFA) has been delayed. The engineering test was completed in Jan 68, and the service is scheduled for Apr 68.	Service test scheduled for April 1968.
461	USAWECOM		To subject the AR18 rifle to a kinematic evaluation.	BRL	A Kinematic Evaluation of the AR18 Rifle, Caliber .223	Feb 65	The basic design of the AR18 was good. However, because of the failure to provide a positive feeding system and positive locking devices for some subassemblies, the weapon's present state of design was unsatisfactory and in some conditions was unsafe. The rifle was in an unfinished state of design but could become both satisfactory and safe without major revisions.	

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462	USMC	8 Feb 63	To conduct an evaluation of the mounted M60 machinegun; Stoner 63 Weapon System; and M14, M14E1 and M16 rifles on a comparison basis to determine the suitability for adoption as armament for helicopter crew.	USMC	Evaluation of Flight Crew Weapons for Transport Helicopters	8 Mar 65	Recommendations: (1) Selected helicopter units be provided with a Stoner 63 medium machinegun, if adopted, for use by the crew chief and gunner to replace or augment the M60C machineguns. (2) Allowance for these same helicopter units be established for an automatic carbine for use by the co-pilots, specifically the Stoner 63 carbine, if adopted by the Marine Corps.	Continued USMC evaluation of the Stoner 63 and 63A weapon systems.
463			To evaluate behavior of bullets in foliage.	Cornell Aero. Labs	Ballistic Behavior of Projectiles in Vegetation (Project FIBRE)	Jun 65	Foliage was set up in an instrumented tunnel, through which test weapons were fired. Deflection due to foliage was measured as a function of range. Only small deflections were observed with 5.56mm bullets. There was little difference between 5.56mm and 7.62mm ammunition.	
464	USAMC	28 Apr 64	To repeat the sound intensity phase of the military potential test of the AR18 rifle using more sensitive instrumentation.	DGPS	Military Potential Test of AR18 Rifle, Sound Intensity Phase	26 Mar 65 to 28 May 65	There was no significant difference in the peak blast over pressure and peak sound pressure of the AR18 and XM16E1 rifles. The difference in levels measured in the two tests can be attributed to the greater sensitivity of the instrumentation used in the later tests.	
465	USATECOM	30 Dec 64	To determine the suitability for U.S. Army use of the 5.56mm tactical ammunition packaging with the rifle, 5.56mm XM16E1.	USAIB	Service Test of Tactical Packaging for 5.56mm Ammunition	19 Apr 65 to 6 May 65	During those portions of testing which required test soldiers to crawl under simulated combat conditions, an overall 7.8% of the 5.56mm cartridges became disengaged from the clips. This was a deficiency. The test clip was not as suitable as the control clip (7.62mm). Recommendations: (1) A tactical packaging system for 5.56mm ammunition be modified to correct the deficiency and feasible shortcoming. (2) Three of the complete modified packaging systems be made available for confirmatory testing.	
466			To investigate the problems with the breakages of butt stocks and hand guards for the XM16E1 rifles and to discover any problem areas for the M16's issued to the 101st airborne division.	Colt's	Tactical Weapon Usage Evaluation	1 Jul 65	Investigation indicated relatively few stocks were cracked in jumps, and that some may have been cracks which were deliberately aggravated.	
467			The flash suppressor of a submachine gun had failed during cook-off tests at Aberdeen Proving Ground on 13 Jul 65. The circumstances were that 180 rounds, fired in 57 seconds produced a split on the outer wall of the suppressor assembly. Investigation of the problem was begun immediately at Colt's.	Colt's	Noise Suppressor of AR15 Submachinegun	16 Jul 65	Recommendations: (1) The original design of noise suppressor should not be used in any application which may raise the temperature of the outer wall to the red heat range (about 1100°F), which is reached in the firing of about 180-200 rounds at the maximum possible rate of fire. The strength is sufficient, however, for firing in which the temperature of the suppressor does not reach red heat. At least 100 rounds can safely be fired before cooling. (2) Improved design of the noise suppressor can safely withstand at least 200-300 rounds of firing at the maximum possible rate of fire, or firing indefinitely at a sustained rate of 30 rounds per minute. (3) The improved design should be used in lieu of the original design in all applications where the severity of these schedules may be approached.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
468			To determine the penetration of the XM144 flechette; the 5.56mm, M193 ball bullet; and the 7.62mm, M80 ball bullets into various target materials.	BRL	Ball Evaluation of the XM144 Flechette, the 5.56mm, M193 Ball Bullet and the 7.62mm, M80 Ball Bullet	Aug 65	The flechette and M80 ball bullet were competitive and both projectiles had a significantly greater capability than the M193 ball bullet.	
469			To evaluate the M193 and 68 grain Sierra and Federal bullet with respect to ballistic performance characteristics in an effort to improve the performance of the M16 rifle system.	Frankford Arsenal	Limited Evaluation of 68 Grain 5.56mm Bullets	15 Aug 65	The penetration and trajectory characteristics of the 68 grain 5.56mm Sierra projectile approached those of the 7.62mm M80 ball projectile. The 68 grain projectile represented a significant effectiveness increase over the standard 55 grain M193 projectile, especially at ranges beyond 300 meters.	
470	USAWECOM	15 Jun 65	To conduct a primer chemical analysis on one of the suspected lots to determine if the increase in fouling is due to unauthorized change in primers.	Frankford Arsenal	Excessive Fouling of 5.56mm Cartridge Ball, M193 Cartridge Lots	22 Sep 65	The ammunition sample was taken from cartridge lot WCC6051. The acceptance test report on this lot noted that the primer used was the WC 1160. Analysis of the primer composition showed that it corresponded to the WC292 primer mix. This indicated compliance with the chemical requirements of the 5.56mm primer drawing and tended to confirm that there had been no unauthorized change in primers.	
471	USAWECOM	7 Oct 65	To issue a safety confirmation of the bolt closure device for the XM16E1 rifle.	USAIB	Safety Confirmation of Bolt Closure Device for 5.56mm, XM16E1 Rifle	7 Oct 65	No unsafe conditions attributable to the bolt closure device were encountered in numerous tests involving the production model XM16E1. Thus, it was considered that the safety of subject device had been confirmed.	
472			To ascertain whether cost reduction might be achieved by use of less expensive surface treatments, and materials of lower cost or better machinability. Since the latter part of 1964, some tests had been conducted to determine the wear resistance of experimental surface treatments, and different materials in AR15 bolt carriers.	Colt's	Wear Resistance of Various Finishes Applied to AR15 Bolt Carriers	10 Nov 65	It was observed in all cases that the Parko Lubrite finish was worn from the guide ways for a distance of about one quarter inch at each end. The inference to be drawn from this observation was that the surface wear exceeded .0002 inches in these end regions, and between these regions it did not. The test weapons did not develop malfunctions which were ascribed to excessive wear of the interior or exterior surface of the carrier. Wear measurements were obtained based on firing 10,000 rounds in each of five experimental weapons.	Item 473.
473	USAWECOM	30 Nov 65	To provide life expectancy data on subject bolt carriers and to compare the Parko Lubrite and Electrolize finishes.	Springfield Armory	Bolt Carriers for 5.56mm Rifle M16 and XM16E1		Springfield Armory was of the opinion that bolt carriers made with an alternate steel, chrome plated on the inside and Parko Lubrited on the outside, would have the same round life as the original bolt carrier with an electrolize finish.	Subject bolt carriers were adopted.

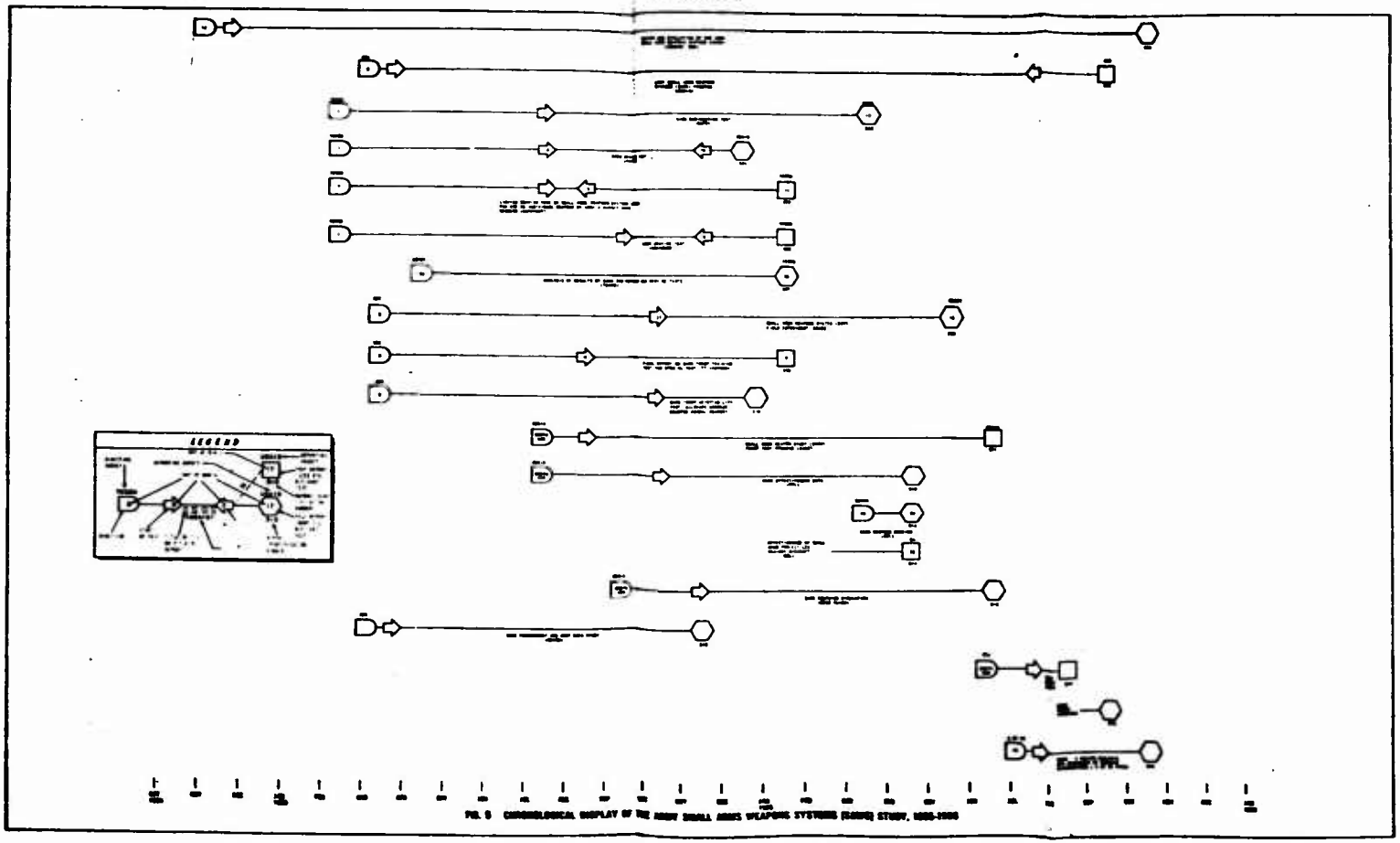


TABLE 2 - 22

CHRONOLOGICAL DISPLAY OF THE ARMY SMALL ARMS WEAPONS SYSTEMS (SAWS) STUDY, 1965-1966

NO.	TEST INITIATION: INITIATOR	TEST INITIATION: DATE	TEST INITIATION: PURPOSE	TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
501	CofSA	12 Nov 64	To conduct a comprehensive review and evaluation of the Army small arms weapon systems (SAWS), to include study of doctrinal employment and desired characteristics, test and evaluation of existing weapon systems and analytical evaluation of weapons under development or feasible within the time frame, 1965-80. The objective of this review is to develop the necessary analytical background upon which to base a program for replacement of existing stocks of small arms as the inventory drops below requirements, or replacement of the inventory with weapon families of demonstrated superiority over all other families, based upon cost effectiveness considerations.	ACSFOR USACDC	Review and Evaluation of the Army Small Arms Weapons Systems (SAWS)	Nov 64 to Oct 66	Results are contained in Item 502 through 517. Weapon systems considered were: (1) the standard 7.62 mm M14 rifle, M14E2 automatic rifle, and M60 machine gun; (2) the 5.56mm XM16E1 rifle and Colt automatic rifle and submachine gun; (3) the 5.56mm Stoner rifle, automatic rifle carbine, and fixed and light machine guns; (4) the 5.56mm Armalite AR15 and Harrington and Richardson modified G3 rifles; (5) the 7.62mm Soviet AK47 assault rifle and RPD machine gun; (6) the SPIW and universal machine gun flechette-firing systems; (7) the AVROC Gyrojet and Honeywell conceptual systems; and (8) optimum parametric design systems. Only the systems cited in (1) through (4) were tested by USATECOM. The Soviet weapons were considered only in the CDCEC field experimentation. Conceptual and parametric systems were evaluated only in the computer simulation.	ACSFOR prepared a plan for the required review and evaluation. The plan, contained in Chief of Staff Memorandum 64-555, subject: Army Small Arms Weapon Systems, was published on 17 Dec 64. USACDC was assigned major responsibility for conduct of the SAWS Study with the assistance of USAMC, USCONARC, and major overseas commands. USACDC's study directive to its major subordinate commands in Item 502.
502	USACDC	5 Mar 65	In addition to the purpose cited in Item 501 above, to develop the feasible alternative courses of action which can be pursued by the United States Army together with the implications of each course of action, and to recommend to the Chief of Staff the course of action which promises to accomplish best the Army mission.	USACDCIA	Army Small Arms Weapons System (SAWS) Program	Mar 65 to Jul 66	The detailed results are cited under Items 503 through 516. In Jul 66, the Infantry Agency submitted its report to USACDC with the recommendations: (1) Procure no additional rifles beyond those XM16E1's on order until the SPIW becomes available in 1970. (2) Initiate a program of selective modernization by procuring the SPIW, when available, only for infantry maneuver units. (3) Retain the M60 as the standard infantry machine gun until the universal machinegun (UMG) is developed in about 1972, and (4) Initiate and fund a vigorous research and development program for careless ammunition and new lethal mechanisms.	Review of USACDCIA recommendation by Headquarters, USACDC. (Item 517)
503	USATECOM	1 Feb 65	To determine the technical properties, performance, capabilities, and limitations of each of the candidate weapons and systems, in comparison with those of the 5.56mm and 7.62mm small arms weapons currently in Army use. To determine the degree to which the standard weapons fulfill user requirements, to provide [illegible] appropriate data for use in [illegible] studies to be [illegible] to provide, [illegible] for type [illegible] action.	[illegible]PS	SAWS Engineering Test	1 Jul 65 to 18 Mar 66	The bolt assist device, dust cover, and shielded configuration of the XM16E1 contributed significantly to weapon reliability. 5.56 weapon penetration and target [illegible] capabilities were significantly less at reasonable combat ranges than with 7.62mm weapons. [illegible] reliability was not attributed to basic design deficiencies. Test data indicated low level quality of test weapon samples. Product improvement of XM16E1 barrel was not justified. Firing at realistic combat ranges beyond 100m, the M14 system was deficient due to poor accuracy characteristics. Recommendations: (1) The M14 continue to be the standard infantry weapon and attention be given to improving 7.62mm ammunition quality. (2) The XM16E1 continue to be a standard weapon where lightweight is significant. (3) A comprehensive comparison type investigation of the XM16E1 be conducted to assess a broad level of performance. (4) The uncertainty concerning the suitability of WC 846 (ball) propellant for the XM16E1 system be resolved with an urgent and high priority accorded to the [illegible] testing.	Frankford Arsenal, at the request of the Project Manager based on reports from USATECOM and CDCEC, conducted a test of 5.56 mm cartridges loaded with ball and [illegible] propellants in Nov-Dec [illegible]. (Item [illegible]) USATECOM Analysis of engineering test results. (Item 507)

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
504	USATECOM	1 Feb 65	To measure weapon performance against user standards; to provide, through BRL, data resulting from tests for use in parametric design, operational effectiveness, and cost analysis studies to be conducted by USACDC; and to develop sufficiently comprehensive data as appropriate; to provide a basis for choice if type classification is desired.	USAIB	SAWS Service Test	6 Jul 65 to 15 Nov 65	Effectiveness comparison of test weapons included subtests for physical characteristics, training, rate of fire, sights, magazines, ammunition and packaging, defects, assault, mounts, record and transition firing, signature characteristics, pointed fire accuracy, portability and aerial delivery, accessories and training aids, maintenance, durability and reliability, versatility of weapon design, safety, human factors engineering and value analysis. There were no significant differences between the SAWS weapons except for reliability. The current standard weapons were the most reliable. Recommendation: No consideration be given to adoption of new weapon systems until a significant improvement over the standard 7.62mm system can be achieved.	USATECOM analysis of service test results (Item 507).
505	USATECOM	1 Feb 65	To determine the suitability of the candidate and comparison weapons for use by aircraft crew members as individual weapons.	USAAVNBD	Limited Service Test of Small Arms Weapons Systems for Use as Individual Weapons by Army Aircraft Crew Members	1 Jul 65 to 15 Aug 65	Recommendations: (1) None of the weapons be considered suitable as the individual air crew member's weapon. (2) The Colt GAR15 submachinegun be considered suitable for use as an additional weapon for air crew members. (3) A quick release device be installed in Army aircraft to retain shoulder weapons if they are to be transported as extra weapons.	USATECOM analysis of service test results (Item 507).
506	USATECOM	1 Feb 65	To determine the handling and transportability characteristics and suitability for use of individual weapons designed specifically for combat vehicle crew members.	USAARMBD	SAWS Service Test	1 Sep 65 to 15 Nov 65	Both the 5.56mm Stoner carbine and the Colt submachine gun were found to offer significant advantages over the standard caliber .45 M3A1 submachine gun. With respect to range, general utility, safety, and handling characteristics for use as an individual weapon for combat vehicle crew members. The Stoner carbine satisfied the test criteria, as did the Colt submachinegun except for excessive muzzle blast and flash. Recommendation: Adopt the Stoner carbine for combat vehicle crews if the Army adopts 5.56mm weapons for ground troops.	In 1967-68 the Colt submachinegun was being evaluated for adoption and was designated the XM177E1.
507	USAMC	28 Apr 65	To provide a detailed analysis in conjunction with BRL and HEL of the reports of the SAWS engineering and services tests conducted by D&PS and the Infantry, Aviation, and Armor Boards.	USATECOM	Analysis of Results of SAWS Engineering and Service Tests	28 Jan 66	Recommendations: (1) The XM16E1, the M14, and the M60 machinegun be considered the most suitable for Army use of any of the rifles and machine guns tested. (2) Current requirements for additional rifles and machineguns be met by procurement of the weapons above. (3) Development be continued to provide small arms weapons which will be significantly superior to those presently available and tested in this project. (4) In the event that a choice must be made between the XM16E1 and the M14 system, this choice be based upon user requirements and the relative weightings the user chooses to assign to the various performance characteristics reported on.	

O.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
08	USACDC	5 Mar 65	To determine the relative effectiveness of rifle and machinegun squads armed with 7.62mm (US and Soviet), Colt 5.56mm, and Stoner 5.56mm weapons. To develop quantitative effectiveness criterion by which rifle and machinegun squads armed with candidate weapon systems can be compared under tactical conditions. To provide hard data from which the combat effectiveness of small arms can be determined within the organizational and tactical context.	USACDCEC	SAWS Field Experimentation	22 Oct 65 to 10 May 66	Rifle squads armed with low muzzle impulse weapons were markedly superior in overall effectiveness to rifle squads armed with high muzzle impulse weapons. Rifle squads armed with Colt weapons were superior to those armed with Stoner weapons. Rifle squads equipped only with Colt automatic rifles appeared superior to all others evaluated in overall effectiveness. The AK47 was significantly more reliable than any U.S. 7.62mm or 5.56mm weapon. The standard 5.56mm ammunition was not satisfactory because of fouling characteristics, ball and tracer interior ballistics mis-match, and primer insensitivity. Either the 7.62mm or 5.56mm tracer rounds were considered satisfactory for adjusting fire during daylight hours. The 5.56mm Stoner machine gun was judged to have a high reliability potential.	Reported [illegible] ammunition problems were evaluated [illegible] Frankford Arsenal [illegible] 65 test directed by the Project Manager. (Item 607)
09	USACDC	5 Mar 65	To assist in the overall evaluation of the candidate weapon systems available in hardware form by conducting troop training. To compare characteristics of the candidate systems with respect to training of recruits, reliability, and durability. To gain insights into the development of new tactics and techniques required for adoption of a particular small arms weapon system.	Ft Jackson	SAWS Troop Training Test	16 Aug 65 to 8 Jan 66	The current 7.62mm weapons proved most durable and reliable as indicated by the number of stoppages, malfunctions, and amount of breakage. In the rifle category, the Stoner proved the most effective overall, at ranges from 250 to 550 meters based on percent of hits. The Stoner carbine attained a better overall percent of hits as compared to the M14 and Colt submachine gun.	Analysis of Troop Training Test. (Item 511)
10	USACDC	5 Mar 65	To develop implications of user acceptance of the candidate weapon systems available in hardware form, together with the impact each weapon system produces on training. To compare the performance of participating units armed with candidate weapon systems under a variety of tactical and quasi-tactical conditions in varying climate and terrain.	USCONARC USAKEUR USARPAC USARAL USARSO	SAWS Troop Acceptability Test	Oct 65 to Dec 65	Individual firing performance based on qualification scores did not establish any of the tested systems as clearly superior. The functional reliability of the 7.62mm and Colt families appeared superior to that of the Stoner system. The Colt weapons (XM16E1 and submachinegun) were significantly favored by participating troops. Based on limited testing, the tactical effectiveness of the 7.62mm M14, M14E2, and M60 weapons was increased by using duplex ammunition.	Analysis of Troop Acceptability Test. (Item 511)

NO	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
511	USACDCIA		To contribute to the SAWS Study program by comparing the candidate 7.62mm, Colt and Stoner weapon families with respect to training implications and tactical firing exercises. To provide quantitative information on man - weapon system performance, human factors, and training. To analyze the data generated in the SAWS Troop Training and Troop Acceptability Tests (Items 509 and 510).	CARO	SAWS Troop Test Program	Aug 65 to Jun 66	Within the record firing portion of the Troop Acceptability Test, the M14 generally ranked first; among automatic rifles, the Colt heavy barrel rifle ranked first, the 7.62mm M14E2 second, and the Stoner third in record firings; the Stoner machinegun ranked higher than the M60. In unit tactical exercises, no weapon family exhibited superior performance relative to the other two families. Within the Troop Training Test, the 5.56mm rifles generally ranked higher than the M14. Analysis of both tests ranked the weapons with respect to mechanical training and maintenance performance in the order: 7.62mm, Colt, and Stoner. Both instructor and firer opinions agreed on the superiority of the Colt and 7.62mm systems over the Stoner relative to execution of marksmanship fundamentals and firing procedures. The XM16E1 produced the highest performance with the least training. The M14 had the lowest performance both at the start and completion of the training phase. The majority of firers selected the XM16E1 as the weapon they would most like to carry if they went into combat.	
512	USACDCIA		To provide effectiveness data on candidate hardware and conceptual weapon systems for use in analytical comparisons and the SAWS computer simulation.	BRL	SAWS Effectiveness Data	Oct 65 to Apr 66	Data are presented for ranges from 100m to 1100m in 100m increments and for 1500m on striking velocity, probability of incapacitation given a hit for the 30-second defense and assault criteria, tactical delivery errors for day and night assault and defense engagements, tactical rate of fire, probability of incapacitation per trigger pull by target attitude (standing, prone, and foxhole), and the expected fraction of an 11-man squad incapacitated by a single trigger by target attitude.	SAWS Computer Simulation (Item 515).
513	USACDCIA	14 Mar 66	To rank candidate conceptual and parametric design weapons against standard hardware mechanisms on the basis of simplicity of design and construction.	BRL	SAWS Weapons Rankings	22 Apr 66	The rankings in decreasing order of simplicity were: 13mm Gyrojet, 20mm Gyrojet, AVROC 5-20, AVROC 8-30, Honeywell 40mm grenade launcher, XM16E1, Stoner rifle, 1.2 lb-sec impulse parametric design weapon, AVROC 25-40, AAI SPIW, M14, 2.6 lb-sec and 0.63 lb-sec impulse parametric design weapons, and the Springfield Armory SPIW.	This analysis formed a portion of the SAWS Effectiveness Data source document for the SAWS Study (Item 512).
514			To provide effectiveness data for various spin stabilized ball projectiles and fin stabilized flechettes against relatively low, slow flying aircraft.	BRL	Effectiveness of Small Arms Projectiles Against Aircraft	26 Apr 66	These data provide a basis for ranking the existing and parametric design weapons considered in the SAWS Study. The ranking in descending order were: M14; XM16E1; 52.5, 24.5, and 21.5 grain ball projectile parametric design; and the SPIW.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
515	USACDCIA		To determine how the various candidate small arms systems and their appropriate doctrine or tactics and techniques of employment compare when war gamed against the expected threat.	Booz-Allen Applied Research Inc.,	SAWS Computer Simulation	Nov 65 to Jun 66	The most significant finding was the operational effectiveness ranking of the candidate hardware, conceptual and parametric weapon mixes within various intensities of conflict, tactics, and over all situations considered. To achieve the final over all ranking, weapon mixes not differing in operational effectiveness were grouped; these groups were then ranked. The highest ranked group contained the 7.62mm M14, M14E2, and M60, with standard and duplex ammunition, and the SPIW with the universal machinegun as the automatic rifle and machinegun. The XM16E1 system with the 5.56mm Stoner and the 7.62mm M60 machineguns and the SPIW with 5.56mm and 7.62mm machineguns were in the second group of weapon mixes. Other systems were ranked in the third and fourth, and fifth groups.	
516	USACDC	Mar 65	To provide all pertinent logistical, cost, and procurement data on candidate small arms weapon systems. To define the Army position with respect to the small arms inventory and requirements.	USAWECOM	SAWS Procurement and Cost Data Study	Mar 65 to Nov 65	As good discrimination data between the cost and maintenance for small arms were not available, a meaningful comparison of systems could not be made. Costs were presented for each weapon and its ammunition at different levels of procurement based on acquisition, combat loss replacement, and peacetime maintenance costs.	
517	USACDC		To review, analyze, and comment on the SAWS Study as submitted by the USACDCIA.	USACDC	SAWS Study	Jul 66 to Aug 66	Hq, USACDC modified the recommendations of the USACDCIA SAWS Study (Item 515) as follows: (1) Rifle Procurement: Any requirement for an additional buy of rifles before 1970 should be satisfied by purchase of XM16E1's. (2) Adoption of SPIW: Final decision to adopt and field SPIW must be contingent upon results of further experiments and tests. (3) Automatic Weapons: The need for an automatic weapon in the squad is recognized. (4) General: While the 7.62mm systems do provide advantages over the 5.56mm systems against materiel targets, the intensity of conflict is not a sound basis for a clear choice between two weapons. An environmental distinction, giving due consideration to terrain, existing build-up areas, and estimated equipment resources of the enemy offers a better basis for choice. It was the USACDC position that the total SAWS Study does indicate that the 5.56mm rifle offers the most promise for improved capability for the money spent ... the concept of selective modernization, is an excellent idea whereby the Army takes deliberate advantage of progressive improvements in small arms.	Army Staff review of the SAWS Study.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
518			To provide the Army Staff review, analysis, and comment on the USACDC SAWS Study.	ACSFOR	SAWS Study	Sep 66	Recommendations: (1) Procure the XM16E1 to maintain the Army rifle stockage objectives until the SPIW becomes available. (2) Continue SPIW development as rapidly as possible. (3) Withhold approval of a program of selective small arms modernization pending further study. (4) Approve the SAWS Study recommendations except as altered by (1), (2), and (3) above.	OCofSA review of the SAWS Study. CofSA decisions on the SAWS Study.
519	OCofSA	26 Jul 66	To review and analyze the USACDC SAWS Study and the Army Staff analysis. To provide a statement of program alternatives.	OCofSA (FPAO)	SAWS: A Review, Analysis, and Statement of Program Alternatives	Jul 66 to Oct 66	The CofSA on 7 Nov 66 published his SAWS Study decisions: (1) The XM16E1 will be adopted as the standard Army rifle and will be reclassified as Standard A. The M14 and M14A1 will remain Standard A initially. (2) Pending the completion of the field experimentation, the XM148 will be issued as the companion grenade launcher for units armed with XM16E1. (3) The Colt submachinegun will be adopted in lieu of the XM16E1 where use of the XM16E1 is impractical as the individual weapon. (4) A companion automatic rifle will not be adopted. (5) The M60 will be retained until an improved machinegun is developed and adopted. Evaluation of the 5.56mm machinegun will continue. (6) The SPIW development cycle will be reoriented to the status of exploratory development and become a part of a broadened small arms research and development program. (7) The overall procurement objective is a single-family (rather than a multi-family) small arms weapon inventory based on the XM16E1 and Colt submachine gun and, for the present, the M60 machine gun. The first objective will be elimination of the caliber .30 family of infantry weapons. (8) Product improvement will be incorporated in the new production of XM16E1's 5.56mm ammunition, and the XM148. (9) The 7.62mm duplex ammunition will not be produced for other than development purposes. On 8 Mar 67 the CofSA provided guidance pertaining to future Army small arms weapon development, by stating the following objective: (1) Improvement in design and performance of the Army's current small arms system, within existing technology, to increase effectiveness. (2) Continuous investigation and development of new techniques, machines, procedures, and materials to provide a reduction in the unit cost of small arms ammunition and grenades. (3) Studies, field experimentations, tests, and evaluation to establish, validate, or develop small arms data, doctrine, or concepts which are required to improve effectiveness or utilization of current small arms systems and to provide a more valid basis for the development of new systems. (4) Research and development effort designed to identify new approaches or lethal mechanisms which could be more effective than conventional approaches in fulfilling the role of small arms systems.	Chief of Staff Memoranda 66-485, 7 Nov 66, subject: Army Small Arms Weapon Systems, and 67-96, 8 Mar 67, subject: Army Small Arms Program announced these decisions. Specific areas for M16 product improvement were analyzed by the Project Manager Rifle (Item 730-734).

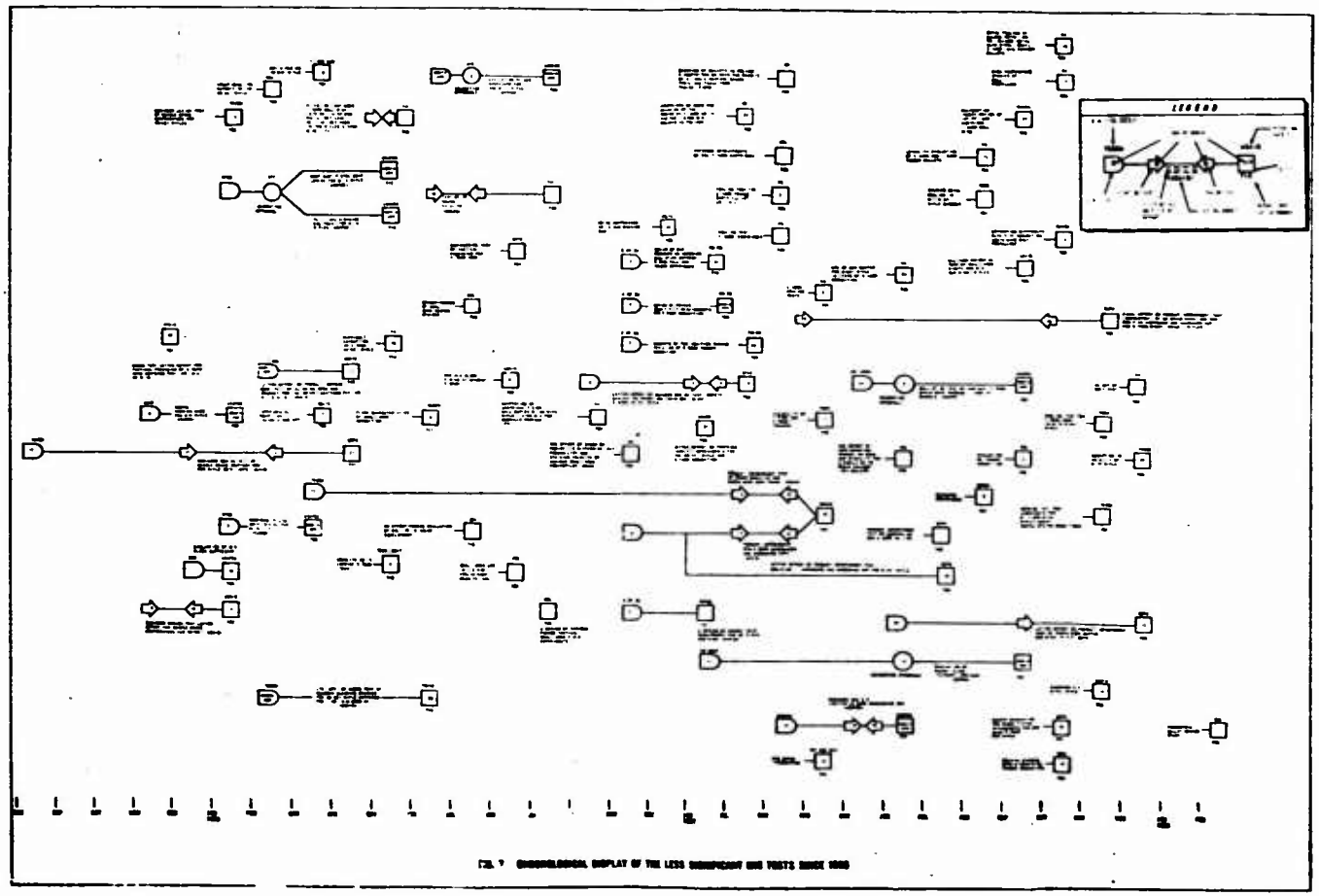


TABLE 2 - 23

CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT M16 TESTS SINCE 1966

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
601			To present and document an experiment to ascertain the magnitude of the effect on cyclic rate of the XM16E1 with a change from ammunition employing tubular grain (extruded) propellant to ammunition employing spherical grain (ball) propellant.	Colt's	Effect of Ammunition Variables on Acceptance Testing of XM16E1 Rifles	8 Nov 65	Fifty-two rifles, chosen at random, were tested. There was a significant change in typical cyclic rate performance of the rifles associated with a change in ammunition types, such as those represented by M193 ball Lots RA5060 (IMR 8136 propellant) and RA5135 (WC846 propellant). Weapons which readily met the cyclic rate requirement when using ammunition such as Lot RA5060 would frequently fail when using ammunition such as Lot RA5135.	Items 602 and 603.
602			To establish whether the port pressures of 5.56mm ammunition depend importantly on the position of the propellant in the cartridge case (and are thus likely to vary widely in different modes of fire), either with extruded propellant or with ball propellant.	Colt's	Effect of Ammunition Variables on Acceptance Testing of XM16E1 Rifles	11 Jan 66 to 17 Jan 66	Data showed no significant dependence of velocity or port pressure upon powder position with either of the ammunition lots tested. The observed dependence of ballistic levels on powder position in the cartridge case did not explain the typically higher cyclic rate of fire obtained with ball propellant ammunition.	Item 605.
603			To provide a simple means of determining when a rifle should be rebarreled; to test proposed design changes; to determine parts life of the current design and malfunction rate; and to test the M1 cleaning rod, and bore brush, 11010021.	Lackland AFB Springfield Armory	Barrel Erosion Study of Rifles, 5.56mm, M16, and XM16E1 - A Joint Army-Air Force Test	Jan 66	Erosion of the bore could be used reliably as one means of determining the need to rebarrel a rifle. The M11 cleaning rod and bore brush, 11010021, were not adequate. The bolt suffered the greatest breakage rate, followed by the extractor ejector and hammer springs; the action spring guide assembly; and the extractor. 82.5% of malfunctions were "failure to eject" and "bolt stop failed to function." Test magazines and the 30-round magazine functioned acceptably but suffered severe pitting after exposure to rain, and, therefore, were not acceptable. Bolt carrier GX5552 was not acceptable due to low service life. Hammer spring GX4976 provided no significant increase in life. Recommendations: (1) Barrel erosion gage C7799792 be adopted for use with the M16 and XM16E1. (2) Bolt, cleaning rod, and action spring guide assembly be redesigned.	
604	USWECOM	25 Nov 65	To determine the effect of propellant types on the functioning and reliability of 5.56mm XM16E1 rifles. This test was directed by the PM-RS in Nov 65 as a result of preliminary functioning and reliability problems reported in the SAWS evaluation.	Frankford Arsenal	Test of 5.56mm Ball Cartridge, M193, Lots RA5074 and WC6089	Feb 66	Lot WC6089 was found to give lower chamber pressure, higher port pressure, high cyclic rate, a greater malfunction rate, greater fouling, more velocity variation, and less bore erosion than Lot RA5074.	WC846 propellant eliminated from tracer ammunition in Nov 67, and used exclusively in ball ammunition after Jan 68.

	TEST INITIATION		TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE				
65			To evaluate the performance of an experimental buffer which Colt's had developed to reduce the excessively high cyclic rates which are encountered with some lots of ammunition employing ball WC846 propellant.	Colt's	Effect of Ammunition Variables on Acceptance Testing of M16 and XM16E1 Rifles	Mar 66	With ammunition Lots 5060 and 5163, and the present standard buffer, the limits of cyclic rate necessary to permit acceptance of a tolerable fraction of M16/XM16E1 rifles of the established and standardized design were lower limit, 650 rounds/minute; upper limits 950 rounds/minute. Recommendations: (1) Above limits could not be recommended on engineering grounds because upper limit was above rate at which functioning reliability and durability were generally impaired. (2) Assuming that ammunition such as Lots 5060 and 5163 must be accommodated and that Colt's improved buffer were used, the limits of cyclic rate recommended for adoption are: lower limit, 575 rounds/minute; upper limit, 850 rounds/minute. (3) With the present buffer, ammunition such as Lot 5163 cannot be accommodated without revision of the upper limit on permissible cyclic rate of fire and increase in allowable malfunction and parts breakage rates.	
66	USAWECOM		To supplement other tests on 5.56mm ball ammunition being carried out simultaneously, under Army auspices at Frankford Arsenal and at Aberdeen Proving Ground.	Colt's	Test of Experimental Propellants for 5.56mm M193 Ball Ammunition in M16 Rifles	Mar 66	Ammunition containing FXR208 propellant gave generally satisfactory performance in M16's with both standard and experimental buffer. With standard buffer, upper limit of 850 rounds/minute was sometimes exceeded. Ammunition containing IMR 11 propellant produced insufficient operating energy for reliable gun functioning. The sample containing WC846 propellant gave excessively high cyclic rates with standard buffer, but with experimental buffer cyclic rates were satisfactory.	Item 610.
67	USATECOM	15 Nov 65	To check the improved reliability of tracer ignition.	USAATC	Check Test of Cartridge, Tracer, 5.56mm, XM196 under Arctic Winter Conditions	12 Apr 66	The tracer cartridge was found suitable for use under all climatic extremes, including extreme cold. It would not be fully satisfactory until its position disclosing effects shortcoming was corrected. Recommendations: The cartridge be considered fully satisfactory for use by the Army under arctic winter conditions when the position disclosing effects shortcoming has been corrected.	
68	DAD, AFSC	Jan 66	To determine the acceptability of the new design action spring guide assembly for the M16 rifle.	Lackland AFB	New Design Action Spring Guide Assembly, M16 Rifle	1966	The newly designed action spring guide assembly was acceptable for Air Force use, and should reduce internal parts breakage considerably. Additional testing was needed by a service agency, combining newly designed action spring guid assemblies and shot peened bolts to establish new accuracy and parts breakage criteria. Recommendations: Air Force accept newly designed action spring guide assemblies to replace standard action spring guide assemblies.	New action spring guide (buffer) assembly introduced in Dec 66.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
609	USMC	7 Mar 66	To determine the suitability of Dri-Slide as a lubricant for infantry weapons.	USMC	Dri-Slide Lubricant	31 May 66	Dri-Slide was equal in performance in all critical areas to VV-L-800. Dri-Slide was significantly more effective than VV-L-800 in dry sand and in muddy water. Recommendations: (1) Dri-Slide be considered suitable for USMC use. (2) It be purchased and issued as soon as possible to Marine Corps units operating in sandy areas.	Army and Air Force Dri-Slide evaluation (Items 615 and 616). Item 620.
610	Frankford Arsenal	22 Oct 65	To ascertain the characteristics of two proposed alternate propellants (EX8208 and HPC11) in comparison with the standard ball (WC846) propellant.	D&PS	Engineer Design Test of Cartridge, 5.56mm, Ball, M193 (Evaluation of Improved and Alternate Propellants)	25 Jan 66 to 19 May 66	HPC11 propellant produced slightly less dense smoke for a given number of rounds fired than the other two types. Several stoppages were caused by the high cyclic rate of fire when using ammunition loaded with WC846 and EX8208 propellants. Internal fouling of the gas tubes of weapons using HPC11 propellant constricted the inside diameter to such an extent that malfunctions were caused by short recoil. Firing test data were summarized in tables including data on chamber and port pressure, velocity, action time, accuracy and dispersion, barrel erosion, propellant fouling, cyclic rate of fire, noise, smoke, and flash.	Item 612.
611			To evaluate four buffer types proposed by Colt's in comparison with the standard buffer.	Springfield Armory	Buffer for XM16E1 Rifle	6 Apr -- to 13 May 66	With WC846 propellant, the rifles functioned significantly better with the proposed buffers than with the standard. When IMR powder was used, all buffers functioned equally well. The test buffers with ball propellant did not function as well as the standard buffer with IMR.	Modified buffer introduced in Jan 66 production. Item 632.
612	Frankford Arsenal		To evaluate the test firings with two proposed alternate and the standard ball propellant.	Frankford Arsenal	Investigation of Alternate Propellants for Use in 5.56mm Ball and Tracer Ammunition	May 66 to Jan 66	The cartridge sample containing EX8208 propellant indicated this propellant was suitable for use in 5.56mm ball and tracer cartridges. It afforded a substantial advantage over the IMR(CR) 8136 propellant with respect to the velocity pressure relationship. The sample with HPC11 propellant met all specification criteria, but encountered an excessive number of malfunctions. HPC11 propellant could not be considered suitable for use. The WC846 propellant, although otherwise satisfactory, produced quantities of fouling in the bolt assembly area sufficient to affect weapon functioning unless the weapon was cleaned after at most 1,000 rounds.	Approval of IMR (CR) 8136 for loading in 5.56 mm cartridges withdrawn. EX 8208 (IMR 8208) propellant approved for loading. Approval of IMR 5475 for loading in 5.56 mm tracer withdrawn.

	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
3			To study the relationships among rim thickness, rim shears, and weapon cleanliness as they affect cartridge extraction. To determine the relative extractive effort in XM16E1 rifles of 5.56mm cartridges manufactured by three commercial producers. To determine whether cartridges tend to seize in chambers of XM16E1 rifles after environmental storage.	Frankford Arsenal	Difficult Extraction in XM16E1 Rifle	17 Jun 66	No rim deformation was observed. None of the tests revealed any shortcoming in the design of the M193 cartridge, and none gave insight into the cause of the reported difficulties in extraction or succeeded in duplicating the reported occurrences.	
4			To present the aerodynamic performance of a caliber .223 Remington bullet used in the M16 (AR15) Rifle.	BRL	Aerodynamic Properties of a Caliber .223 Remington Bullet Used in the M16 Rifle	Jun 66	The caliber .223 Remington bullet was gyroscopically unstable when fired at cold temperatures from a 1-in-14 inch twist barrel. No differences in the aerodynamic data were observed from rounds launched from the 1-in-12 and the 1:14 inch twist barrels. The results of climatic chamber tests at Eglin, Florida, indicated quite favorable agreement with the computed curves for the various test conditions using aerodynamic data.	Item 630.
5	USAMC	20 Jan 66	To determine whether properties and uses of Dri-Slide as described and claimed by Dri-Slide, Inc., are valid and whether Dri-Slide is inferior, superior, or equal to the authorized lubricants.	USAWECOM	Evaluation of Dri-Slide as a lubricant for Small Arms Weapons	Aug 66	Not all the claims for Dri-Slide as printed in their literature were correct. In particular, information on flash point, percent composition, drying, and penetrating capability were inaccurate. Dri-Slide was equal to VV-L-800 in load carrying capacity and friction, equal in firing of weapons during normal and dusty conditions, inferior in wear and corrosion protection, and superior in sandy environment.	Item 624.
16	USAWECOM	11 May 66	To test the lubricating qualities of Dri-Slide Lubricant as compared to Oil, General Purpose, Special.	Lackland AFB	Evaluation of Dri-Slide Lubricant	1966	No malfunctions were attributed to the use of either type of test lubricant. When equal amounts of each of the test lubricants were applied to bolt assemblies in accordance with the technical manual no significant differences in carbonization, weapon operation, or weapon cleaning were discernible. Dri-Slide was easier to apply correctly when compared to oil. Recommendations: (1) Air Force substitute Dri-Slide lubricant for general purpose oil. (2) Change the technical manual instructions on the amount of lubricant required for the bolt, bolt carrier, and gas tube from 3 drops to 1 drop.	
17	USAF	30 Jan 67	To test six M16 chrome plated chamber barrels for suitability for reduction of rusting problems, and for adverse functioning effects.	Lackland AFB	Test of M16 Rifle Barrels with Chrome Plated Chambers	4 Apr 67	The chrome plated chamber M16 barrel as then designed was acceptable for Air Force use. The new type chrome chamber barrel was measurably more suitable than standard M16 barrels under atmospheric conditions of extremely high humidity. Recommendations: Air Force consider substituting new chrome chamber barrels in M16 weapons.	Chrome-plated barrels introduced into production in [illegible] 67.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
618			To determine whether or not IMR 8208M and WC846 propellants produce different cyclic rates in new production weapons.	Colt's	Cyclic Rate Evaluation of IMR and Ball Propellants	16 May 67	A definite difference in cyclic rates between the two propellants was noted. There were no malfunctions.	
619	USATECOM	24 Oct 66	To determine the suitability of the test lubricants for U.S. Army use when applied to small arms weapons under arctic winter and spring "break up" conditions.	USAATC	Engineer Design Test of Preservative Lubricants, MIL-L-14107 (LAW), MIL-L-46000A (USA), MIL-L-46010A (Solid Film Lubricant), Experimental Lubricant A and Experimental Lubricant B for Small Arms Weapons under Arctic Winter and Spring "Break up" Conditions	13 Nov 66 to 25 May 67	Experimental lubricants A and B were best suited for U.S. Army use on small arms weapons under Arctic winter and spring "break up" conditions. Recommendations: (1) Experimental lubricants A and B be returned to the Arctic Test Center for an integrated engineering and service test under arctic winter and spring "break up" conditions. (2) Lubricant MIL-L-46010A (Solid Film lubricant be considered unsuitable for U.S. Army use on small arms weapons under both arctic winter and spring "break up" conditions.	Item 744.
620			To evaluate test lubricants by supplementing the laboratory data acquired by Rock Island Arsenal early in 1966 and to investigate weapon reliability with the test lubricants under "real life" conditions. To establish a clear basis for decisions as to whether or not a lubricant of the Dri-Slide type offers sufficient merit to justify the development of a military specification.	DWPS Rock Island Arsenal	Military Potential Test of Weapon Lubricants	Feb 67 to Jun 67	Recommendations: (1) MIL-L-46000A lubricant replace [illegible] MIL-G-46003 as a compliment for use with the M16A1 at temperatures above 32°F. (2) Troop units operating in temperatures above 32°F be advised that liberal lubrication of the M16A1 is not detrimental to weapon functioning during actual firing operations. (3) Testing be conducted at temperatures below 32°F with MIL-L-46000A to determine the suitability of this lubricant for use with the M16A1 at low temperatures. (4) The technical manual for the M16A1 be changed to reflect the necessity for cleaning the inside of the bolt carrier, firing pin, and the firing-pin well in performing after-firing maintenance. (5) Instructions be provided to the field that ammunition be maintained in as clean a condition as possible and that it should not be lubricated.	Evaluation with tracer ammunition (Item 624).
621	M111 AFB	26 Jan 67	To test the suitability of caliber .223 cartridges loaded with IMR 8208M and WC846 propellants for Air Force use.	Lackland AFB	Test IMR 8208M and WC846 Powder in M193 5.56mm cartridges.	1967	Both test lots (from Lake City) with WC846 and IMR 8202M propellants were superior to the WC846 propellant in control lot PA 5257. Average extreme group spread for WC846 was .35 inches smaller than for IMR 8208M and .72 smaller than for PA 5257. Recommendations: WC846 propellant be adopted for Air Force use.	
622	USAMC	Dec 64	To record results of erosion tests on 5.56mm rifle barrels fabricated from AISI/SAE 4150 and chromium-molybdenum-vanadium steels with and without chromium plated bores.	Springfield Armory	Erosion Test on 5.56mm Rifle Barrels Small Arms Weapon Systems Study (ASWS)	30 Jun 67	All barrels of both steels, chromium-molybdenum-vanadium (Cr-Mo-V) and AISI/SAE 4150 resulphurized, with chromium plated bores successfully withstood firing test. Barrels made from (Cr-Mo-V) steel with unplated bores were rejected. Recommendations: (1) Barrels made from 4150 resulphurized steel be chromium plated to a thickness of .0005 to .0015 inches. (2) Bore tests be made to determine rejection point of the plated barrels so that differences between the plated 4150 and the plated Cr-Mo-V barrels can be determined.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	Test DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
623	USAMUCOM	Dec 66	To identify the cause of excessive fouling accumulation of the bolt group of the M16A1 and M16 rifles.	Frankford Arsenal	Fouling Test Investigation of 5.56mm Ammunition and Weapon Systems	Jul 67	No noticeable difference in fouling build-up was observed on the bolt or bolt carrier with the various lots of ammunition. Fouling on the shoulder of the barrel and metal fouling in the bore were heavier with WC846 propellant than with IMR 4198. Metal fouling in bore was light to nil with IMR 4198 propellant. Recommendations: Engineering tests should continue using LSA lubricant and other lubricants to investigate the possibility of minimizing the fouling residue.	Initiation in Feb 68 of a fouling test for all lots of 5.56 mm ammunition
624	USATECOM	5 Jun 67	To provide information supplementary to the military potential test of weapon lubricants. To evaluate the compatibility of MIL-L-46000A lubricant with the M16A1 rifle while firing tracer ammunition. To investigate effect on rifle function of storing the rifle in a hot, humid environment with salt-water-dipped round of ammunition in chamber.	D&PS	Military Potential Test of Lubricant for XM16A1 Rifles--Using Tracer Ammunition	Jun 67 to Jul 67	Functioning performance of M16A1 rifles lubricated with MIL-L-46000A and firing all tracer ammunition was satisfactory. Extended firing of all-tracer ammunition with the M16A1 severely degraded its accuracy. The M16A1 stored with a salt-water dipped round in the chamber for over two days was apt to fail to extract the fired case of the chambered round. Recommendations: (1) MIL-L-46000A be considered suitable as a replacement for the standard VV-L-800 lubricant when firing either tracer or ball ammunition from the M16A1 rifle at temperatures above 32°F. (2) Extensive firing of all-tracer ammunition with the M16A1 not be recommended unless the metal fouling problem is resolved. (3) Cause of metal fouling when firing all-tracer ammunition be investigated.	MIL-L-46000A adopted as the standard lubricant for the M16A1.
625	USMC	29 May 67	To determine suitability of lubricant MIL-L-46000A as a lubricant for small arms and compare it with Dri-Slide and lubricant VV-L-800. Test followed USATECOM report stating that MIL-L-46000A is more effective than Dri-Slide in all respects.	USMC	Automatic Weapons Lubricant MIL-L-46000A	1967	Dri-Slide was significantly more effective as a lubricant in dry sandy conditions than the other lubricants. MIL-L-46000A was significantly more effective on M14 rifles and M60 machineguns in muddy water. Dri-Slide and MIL-L-46000A were equally effective on M16 or M16A1 rifles in muddy water. Recommendations: (1) MIL-L-46000A be authorized as a general purpose lubricant for all small arms. (2) Dri-Slide be used as a supplemental lubricant in dry sandy areas. (3) PL Special, VV-L-800 be discontinued as a general purpose small arms lubricant.	
626	USATECOM	21 Oct 66	To determine the overall comparability of the disposable and standard magazines. Only technical aspects are evaluated; the cost factor is not considered.	D&PS	Engineer Design Test of Magazine, 20-round, Disposable for M16A1 (XM16E1) Rifle	22 Mar 67 to 24 Aug 67	Over-all evaluation of the magazine, submitted by US Army Limited War Laboratory (LWL) indicated that it was equal to or better than the other test magazines. Recommendations: (1) The LWL magazine be considered for limited production procurement if one of the disposable test magazines is selected to meet the ENSURE requirements. (2) Further design modification would be required to alleviate certain problem areas.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	AT DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
627			To evaluate excessive yaw and ballistics dispersion of tracer ammunition loaded with ball propellant in the submachine gun.	USAMUCOM	Firing of Ball Propellant M196 Cartridges in XM177E2 Submachine gun	10 Oct 67	Failure to trace and excessive yaw dispersion were noted when firing one lot of M196 tracer ammunition during product improvement tests of subject weapon. Further testing is directed.	Item 624.
628	USAMUCOM		To determine bullet break-up and tracer ignition characteristics of IMR and ball loaded tracer cartridges, stored and fired at high temperatures.	Frankford Arsenal	High Temperature Test of 5.56mm Tracer Ammunition	29 Nov 67	Test data indicated 26 to 84 percent of the tracer projectiles fired with WC846 ball propellant at 155°F broke up in flight. In firings at 95°F, 1 to 14 percent of the WC846 propellant fired projectiles broke up. With IMR 8091 propellant, only 2 percent of the tracer projectiles broke up at 155°F and 1 percent at 95°F. Recommendation: Discontinue loading of WC846 ball propellant in 5.56mm tracer cartridges.	Use of WC846 propellant discontinued for 5.56mm tracer ammunition in Nov 67.
629	DA	Oct 67	To present reliability data on M16A1 rifle as collected in the Infantry Rifle Unit Study (IRUS) experiment whose main purpose was to help determine doctrine of employment and organization of US Army small infantry units during 1967-1975.	USACDCEC	Reliability of the M16A1 Rifle During Phase I of IRUS 70-75 Field Experimentation	6 Mar 67 to 22 Jul 67	In the field experimentation trials at Fort Ord, employing 120 M16A1's and firing nearly 500,000 rounds, the malfunction rate per 1,000 rounds was 1.17. The most prevalent malfunctions were double feed, failure to extract, failure to feed, and failure to fire.	
630	CS/SA	16 May 67	To develop hit probability and incapacitation probability per trigger pull for the M16A1 rifle with the two barrel twist rates under consideration as a function of range, temperature, aiming error, and casualty criteria.	BRL	Effectiveness Comparison of 1-in-12 and 1-in-14 Barrel Twist Rates for M16A1 Rifle	Dec 67	Aspects of performance such as round-to-round dispersion, exterior ballistic flight characteristics and wound ballistic assessment were based on test firing data. The two twist rates had nearly equivalent P_{HK} values and the 1-in-12 twist yielded equivalent, nearly equivalent, or significantly higher P_K values for all ranges, temperature and aiming errors as compared to the 1-in-14 twist.	
631	USATECOM	31 Oct 67	To determine the relative performance levels of chrome plated and nonplated chambers when subjected to selected adverse conditions and extended firings under temperatures of 60 + 10°F.	D&PS	Initial Production Test of Chrome Plated Chambers for M16A1 Rifles	20 Dec 67	Chrome plated chambers were superior to non plated chambers in avoiding failures to extract under dust and saltwater environments. With regard to other types of malfunctions, performance with and without chrome plating was comparable. Recommendation: Chrome plating of M16A1 rifle chambers be considered for adoption.	Chrome plated chambers had been introduced into production in Sep 67.
632	USATECOM	26 Jun 67	To confirm that the redesigned buffer would be suitable for field issue and compatible with four basic types of ammunition.	D&PS	Product Improvement Test of Redesigned Buffer for M16A1 Rifle	7 Sep 67 to 15 Jan 68	The redesigned buffer has reduced significantly incidence of failures to fire at expense of increasing incidence of failures to feed. The M16A1 with the redesigned buffer showed improved overall reliability with ball projectiles and ball propellant loaded cartridges. Recommendation: The redesigned buffer be considered an acceptable replacement for the original design for use with ball ammunition loaded with ball propellant and tracer ammunition loaded with IMR propellant pending determination of a suitable ball and tracer mix.	The redesigned buffer had been introduced into production in Dec 66. The buffer retrofit program in USA was to have been completed in Oct 67.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
33	DEPSECDEF		To determine the operational reliability (malfunction rate) of three different types of rifles: the M16 with modified buffer, M16 with modified buffer and chrome chambers, and the M14.	WSEG USMC	M16 Rifle Operational Reliability Test	10 Jan 68 to 24 Jan 68	The operational reliability of the M16A1 with ball propellant approached, but was less than, that of the M14. The number of malfunctions per 1,000 rounds fired were: M16A1 (ball propellants), 1.95; M16A1 (IMR propellant), 4.81; M14, 1.40. The chrome chambered M16A1's required less cleaning. All rifles tested were more prone to malfunction when firing in the automatic, rather than the semi-automatic mode. 36-40 percent of M16A1 malfunctions occurred during the first two rounds of the magazine, independent of whether the magazine had originally been loaded with 18 or 20 rounds. The effect of environmental exposure and the "wear in" of the weapon were most marked in the M16A1's firing IMR propellant.	Army and DDR&E assigned data analysis responsibility.

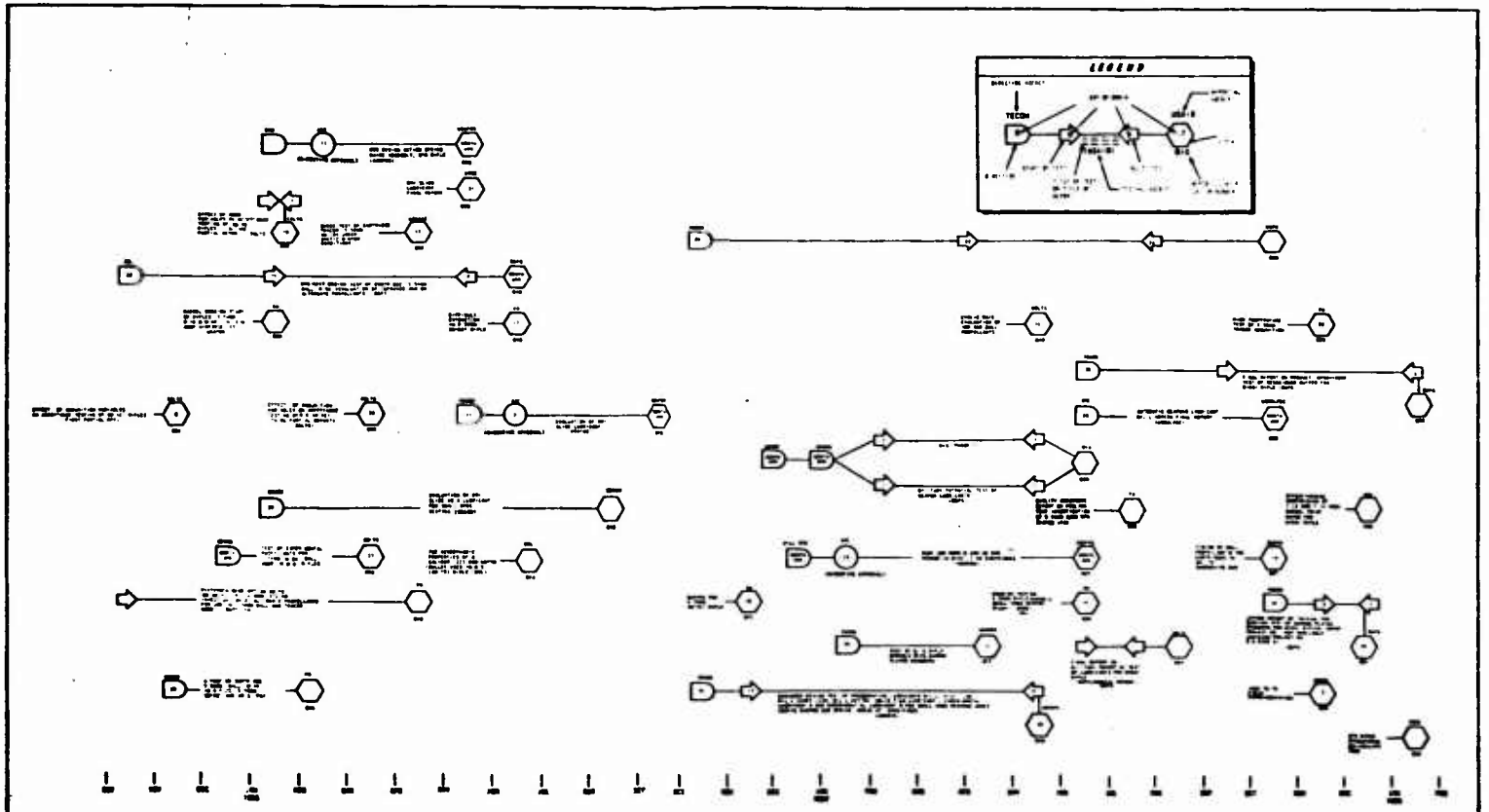


FIG. 6 CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT HNO TESTS SINCE 1980

TABLE 2 - 24

CHRONOLOGICAL DISPLAY OF THE LESS SIGNIFICANT M16 TESTS SINCE 1966

No.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
701			To test a redesigned ammunition clip for 5.56mm ammunition.	USAIB	Tactical Packaging for 5.56mm Ammunition	27 Oct 65 to 17 Nov 65	Only 6 of 1,680 cartridges disengaged from test clips during a crawling exercise. Tactical packaging system was acceptable. Recommendations: (1) Expeditious approval of the packaging system for type classification. (2) Priority production of the system for issue to troops.	Item 721.
702			Forwards analysis of USAIB report (Item 705).	USATECOM	Engineer Design Test of Muzzle Brake Compensators for XM16E1 Rifles	26 Jan 66	Tests conducted were physical characteristics, quick fire, portability, transportability, aerial delivery, position disclosing effects, durability, maintenance, and bayonets. Neither of the muzzle brake designs provided a significant effectiveness increase.	Item 711.
703	USAF	4 Nov 65	To determine the suitability of barrel erosion gage part number 7799792 (b) for Air Force acceptance.	Lackland AFB	Barrel Erosion Gage for M16 Rifle		The gage was not as easy to use as the M14 or carbine gages. The gage only designated two specific areas; combat reject and training reject. Recommendations: (1) In its present configuration, the gage is not acceptable for Air Force use. (2) A calibrated barrel erosion gage should be developed for making bore erosion readings.	
704	USAF	2 Dec 65	To compare a new type flash suppressor for the M16 against the present production version.	Lackland AFB	Evaluation of M16 Flash Suppressor	10 Jan 66	New suppressor launched a grenade farther. There is no difference in sound intensity or ground blast effect, and a very minute difference in extreme spread. The new suppressor was superior for flash suppression and in the brush. Recommendations: (1) Further tests to determine torque installation effects, if fouling can be removed by normal cleaning, and whether deterioration of accuracy or function results from fouling. (2) New suppressor was superior and should be adopted.	
705	USAVECOM		To determine the effectiveness of three muzzle brake compensators (MBC) for the XM16E1.	USAIB	Engineer Design Test of Muzzle Brake Compensators for XM16E1 Rifle	5 Nov 65 to 10 Dec 65	Three new designs were tested. None of the designs provided a significant increase in XM16E1 effectiveness. Recommendation: No further consideration be given to the development of compensators tested in this project.	Item 702.
706			To determine and evaluate troop reaction to subject rifles.	PM-RS	Troop Reaction Reports on XM16E1 Rifle	17 Feb 66	Report presents a final analysis of Field Commanders Reports on the XM16E1 from 1 Nov 64 through 31 Oct 65. The XM16E1 was favorably received by units and had been proven in combat and training. Complaints would continue to arise as a result of individual objections to specific items. Recommendations: (1) Correct known problems. (2) Draft type classification of the XM16E1 as Standard A for Army use is being submitted to USAMC Headquarters.	M16A1 type classified a Standard A on 23 Feb 67

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
707			To report on M16 reliability problems and other deficiencies experienced by combat personnel in Vietnam.	173d Abn Brigade	Deficiencies in M16 Rifle	10 Mar 66	Deficiencies reported were failure to extract, due to dirty and pitted chambers caused in part by the absence of any issued chamber cleaning brush, faulty ammunition, and worn or weak extractor and extractor spring; firing pin retaining pin breakage; front handguards chipped or broken; failure to feed from a full magazine; extensive corrosion of interior of bolt carrier key; flash suppressor tendency to snag on brush; and corrosion of the lower receiver extension.	Chrome chamber introduced in Sept 67.
708	USAWECOM		To determine the cyclic rate and velocity with two test propellants. To supplement tests conducted by Frankford Arsenal and Development and Proof Services.	Colt's	Experimental Propellants EX8208-4 and HPC 11	23 Mar 66	Ten new M16's from current production with standard and experimental buffers were used. The test sample containing EX8208 propellant gave generally satisfactory performance, with both the standard and experimental buffers. The upper cyclic rate limit of 850 rds/min was occasionally exceeded with the standard buffer. The test sample containing HPC 11 propellant gave evidence of insufficient operating energy for reliable weapon functioning. The control sample containing WC846 propellant gave excessively high cyclic rates with the standard buffer and satisfactory rates with the experimental buffer.	Item 610.
709	USAF	31 Jan 66	To determine suitability of Neoprene Pistol Grip Caps for USAF acceptance.	Lackland AFB	Neoprene Pistol Grip Covers for M16 Rifles		Caps functioned well under all operating conditions. Recommendation: The test items be accepted by the Air Force.	
710	USATECOM		To determine and compare the relative suitability of test cleaning and control cleaning items.	USAIB	Product Improvement Test of Cleaning Rods and Brushes For XM16E1 Rifle	Apr 66	Cleaning rods: M11E2 more suitable than M11 & M11E1; M11E2 not as suitable as M14. Cleaning brush: M11E/M11E2 more suitable than M11; M11E1/M11E2 not as suitable as M14. Chamber brush: M11E2 not as suitable as M14. Recommendations: (1) The M11E2 cleaning rod and M11E1/M11E2 cleaning brush be considered suitable for Army use with the XM16E1. (2) Upon correction of deficiency (durability), the M11E2 chamber brush be considered suitable for Army use.	Chamber brush issue begun in May 66.
711	USATECOM	17 Aug 65	To evaluate muzzle brake compensators for use on the XM16E1.	DARCOM USAIB	Engineer Design Test of Muzzle Brake Compensators for Rifle, XM16	26 Dec 65 to 24 Feb 66	Two muzzle brake compensators (HBC) were tested, one from Springfield Armory (SA) and one from the Human Engineering Laboratories (HEL). The HEL model was more effective with respect to muzzle climb and sound. The SA model was superior in the flash test, and the two models were equal in the smoke test. The HEL model was a pound heavier and could not be used to launch grenades.	
712	Eglin AFB	31 Jan 66	To determine the suitability of Snap-shut pistol grip covers for USAF acceptance.	Lackland AFB	Snap-Shut Pistol Grip Covers for the M16 Rifle		Regardless of tension, the cover was easily opened; failed to form a weather tight seal; and jarred open during fire. Recommendation: Not recommended for USAF acceptance.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT RE
	INITIATOR	DATE	PURPOSE					
713	Eglin AFB	31 Jan 66	To determine the suitability of pull-thru cleaning equipment for USAF acceptance.	Lackland AFB	Pull-Thru Cleaning Equipment for M16 Rifles		Cable dragging on muzzle would cause serious wear. It could not be used to clean an obstructed bore, or to remove a failure to extract. An excessive amount of time was required to perform cleaning. Recommendation: Not recommended for USAF acceptance.	
714	USAMUCOM	1 Apr 66	To simulate an extreme climatic and usage condition which could be expected to affect adversely cartridge case extraction.	Frankford Arsenal	Difficult Extraction in 5.56mm XM16E1 Rifle		No indications of failures to extract, bent or sheared rims were observed.	
715			To submit the weapon to comparative user handling and firing tests.	United Kingdom	Colt Armalite AR15 5.56mm Carbine (submachine gun)	May 66	A bayonet or grenade launcher could not be mounted. The night firing capability was ineffective. Automatic fire should be reserved for very short range. The lethality of bullet was suspect under all conditions. The weapon was insufficiently robust to withstand rough usage. Recommendations: (1) Comprehensive lethality trials should be conducted. (2) The AR15 rifle could be replaced by the Colt AR15 submachine gun subject to confirmation of the continuing need for a bayonet, the grenade launching capability and consideration of the overall findings.	
716			To investigate reports of failures of the XM16E1 to extract expended cases.	Frankford Arsenal	Test of Cartridge, 5.56mm Ball, M193, Lots RA5074, RA5089, RA5147, WCC6000, and WCC6089 in Two Rifles, XM16E1	19 Apr 66 to 2 May 66	The conditions of this test were not sufficiently severe or of sufficient duration to cause failures to extract. Recommendation: Samples of the rifle and cartridge which gave failure to extract in the field be sent to Frankford Arsenal for examination.	
717	USAMUCOM	3 Jun 66	To evaluate the actual flash produced by small arms and also the many subjective variables associated with the position of the observer and the conditions of the observation.	Frankford Arsenal	Flash Characteristics of Small Arms Ammunition		A comparative test of the M14, M16 and AK47 with respect to muzzle flash characteristics was ordered. (Results not available.)	
718	USATECOM		To determine whether the deficiency of the chamber cleaning brush, drawing no. 8432358, for the XM16E1 has been corrected.	USAIB	Check Test of Chamber Cleaning Brushes for XM16E1	28 Jan 66	The deficiency of the brush had been corrected. Recommendation: The bethanized brush and the stainless steel brush be considered suitable for U.S. Army use with the XM16E1, with the stainless steel brush considered more suitable.	
719			To compare the caliber .30/.16 system effectiveness, in terms of hit and incapacitation capabilities with that of the M14, XM16E1, and SPIW.	BRL	Effectiveness Evaluation of Caliber .30/.16 Salvo Squeezebore	Jul 66	Performance test data with respect to barrel erosion, projectile malformation, velocity, and projectile dispersion indicated that the proposed squeezebore system was unacceptable. Hit and incapacitation capability per trigger pull was significantly less for the squeezebore system than for competing weapon systems.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
720			To obtain the quantitative data relative to performance of weapons as a function of impulse, weight, configuration, and range. To summarize the large scope of work on measures of effectiveness encompassed by the SAWS Study.	BRL	Effectiveness of Small Arms Weapon Systems	Jul 66	A day defense experiment in which impulse and weight were systematically varied was conducted. The results of this experiment and of a pilot experiment which immediately preceded it in order to determine appropriate test conditions were summarized in this report. Also presented were BRL's responses, based on the subject experiments, relative to certain Essential Elements of Analysis of the SAWS Study.	
721	USATECOM	30 Dec 64	To determine the suitability of the 5.56mm tactical ammunition packaging for Army use with the XM16E1.	DuPS	Engineering Test of Tactical Packaging for 5.56mm Ammunition	Aug 66	The tactical packaging tested gave adequate protection to the clipped ammunition when subjected to the environmental conditions used in this test.	Tactical packaging adopted.
722			To evaluate the proposed blank firing attachment for semiautomatic firing, effective muzzle blast, flash, and rifle condition upon completion of firing.	USAIS	Enfield Blank Firing Attachment, 5.56mm	8 Aug 66	(Results not available.)	
723			To evaluate small arms use in Vietnam.	HFL	Small Arms Use in Vietnam: Preliminary Results	Aug 66	A questionnaire was developed to find out how small arms are used in Vietnam. This report gives preliminary results from a sample of 121 combat troops.	
724	USAF		To test newly designed hand guards for the M16 rifle to determine suitability for Air Force use.	Lackland AFB	Evaluation of New Hand Guard for the M16	Nov 66	Heat dissipating qualities needed improvement. Old and new hand guards were not interchangeable. Recommendation: The newly designed hand guards, in their present form, are unacceptable for Air Force adoption.	
725				Colt's	Test of 30-Round Magazine	16 Jun 66 to 5 Jul 66	Approximately 400 rounds were fired from each of 44 magazines. Malfunctions were attributed directly to 31 of the magazines. Three types of malfunctions occurred: failure of bolt to lock to the rear after last round, failure to feed (semi-automatic), and failure to feed (automatic). It was felt that many of the problems would be eliminated if the standard 20-round magazine type follower and method of connecting the follower would be utilized.	
726	BRL		To determine what definitive guidance could be provided by past pseudo-tactical experience.	BRL	Review of Various Pseudo-Tactical Small Arms Field Experiments	Sep 66	The study presented a review of various small arms field experiments to determine what aspects of weapons systems performance had not been adequately defined, even though these performance characteristics are necessary for a precise evaluation of existing and proposed weapons.	

TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS-RECOMMENDATIONS	SUBSEQUENT ACTI
INITIATOR	DATE	PURPOSE					
7		To generate effectiveness data on the 7.62mm duplex M198A cartridge which are then compared to that of the M14 using M80 and the M16M using M193M ammunition.	Frankford Arsenal	Adaption of Cartridge, 7.62mm Ball, Duplex, M198 with Rifle 7.62mm, M14 for Guerrilla Warfare	Oct 66	Semiautomatic effectiveness for M14/M198A was ? to M16M but less than M14/M80; two round burst fire effectiveness of M14/M198A was about 5% > M14/M80. The effectiveness of M14M/M198A was about 10% < M16M. Recommendations: (1) Assumptions about aiming error, ballistic dispersion and weapon climb should be confirmed. (2) Obtain test data to check the theoretical results on lethality and effectiveness of the adapted M14 rifle and cartridge. (3) Immediate consideration should be given to employing the 7.62mm M14A with 7.62mm M198A ammunition for guerrilla and counter-guerrilla warfare.	
28		To present the results of the brush test conducted as part of the SPIW evaluation.	USAMC	Effect of Brush on Projectile Dispersion, Hit Probability and Striking Velocity of Small Arms Projectiles	1 Apr 64 to 7 Aug 64 (BRL report date is Nov 66)	Hit probability for the 7.62mm M80 ball, 5.56mm M193 ball and the XM144 SPIW flechette cartridges was significantly reduced. The M193 yielded about 20 to 30% lower hit probability than the M80. The flechette yielded 30 to 55% lower hit probability than the M80. Differences in striking and exit velocity from the brush between the M80 and M193 were small with some advantage to the M80. Percentage loss of striking velocity was essentially equal for all projectiles.	
29		To determine if the noise suppressor affects accuracy.	Colt's	Noise Suppressor - AR15 Submachine Gun	14 Jul 65 to 15 Jul 65	Six suppressors were modified by enlarging the core hole by 11%. Accuracy with the modified suppressors was equal to accuracy without the suppressor. There was no change in noise level between standard and modified suppressors. The modified suppressor temperature was considerably lower. Recommendation: The present design noise-flash suppressor should be modified by increasing the core hole diameter from .250" to .281".	
30	CofSA	16 Dec 66		PM-RS	Proposed Product Improvements for the XM16E1 Rifle and 5.56mm Ammunition	31 Jan 67	A report was made of the status and future plans with respect to a new buffer design and propellant to be used for the XM16E1 rifle.	
31	CofSA	7 Nov 66	To obtain USAMC comment on optimum barrel rifling for the XM16E1, using the 5.56mm 55-grain bullet, to maximize lethality and effectiveness with a view to adopting the 1-turn-in-14 inches twist rate for the XM16E1 in the new production.	PM-RS	Review of Barrel Twist Requirements for AR15, M16, and XM16E1 Rifles	31 Jan 67	The history of the twist in the AR15 (12" per turn vs 14" per turn) since 1962, related to different echelons of the military services, as well as Colt's and Remington, was presented. Recommendation: Barrels having a twist rate of 12" per turn be continued in production and use.	Item 630.

	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
32	CofSA	7 Nov 66	To obtain USAMC comment on the mismatch between ball cartridges (loaded with ball powder) and tracer cartridges (loaded with an extruded powder) with respect to effect on weapon cyclic rate and reliable weapon functioning in the XM16E1.	PM-RS	Review of Differences in Interior Ballistics Between 5.56mm Ball and Tracer Cartridges	31 Jan 67	The exterior ballistic (trajectory) matching, throughout the range of tracer burning, is somewhat better for 5.56mm ammunition than for either 7.62mm or caliber .30 ammunition. The superior trajectory matching characteristics of 5.56mm ball and tracer ammunition have been achieved with less interior ballistic "mismatch" than appears in either 7.62mm or caliber .30 ammunition. Recommendation: No change in the present designs of 5.56mm ball and tracer cartridges be made with the object of reducing interior ballistic "mismatch".	
33	CofSA	7 Nov 66	To obtain USAMC comment on misfires due to possible incorrect primer sensitivity adopted at the time of the original military specification.	PM-RS	Review of Primer Sensitivity Requirements for 5.56mm Ammunition		The 5.56mm primer sensitivity limits were recommended only after the most careful and deliberate consideration of all of the many technical factors, and were approved at the highest levels of all four Services. These primer sensitivity limits continue to be the most efficient available for compatibility between 5.56mm ammunition and the XM16E1. Changes in these limits are not considered advisable or warranted on the basis of available information.	
34	CofSA	7 Nov 66	To obtain USAMC comment on the effect on barrel fouling and accuracy of the 5.56mm tracer element's being manufactured to ignite in the barrel.	PM-RS	Comments on the Ignition Characteristics of 5.56mm Tracer Ammunition	23 Feb 67	The pyrotechnic element in tracer bullets of all calibers is ignited in the barrel of the weapon. The dispersion of tracer bullets in all calibers is typically greater than that of the related ball bullets, due to construction features and the in-flight burning of the pyrotechnic composition. Available data indicated that the difference between 5.56mm ball and tracer was not greater than the corresponding difference in other calibers. There was some general evidence that continuous firing of tracer cartridges only, without periodic cleaning, will aggravate barrel fouling problems.	
35			To compare the bullets of the AR15 and the United Kingdom's Self-Loading Rifle (SLR) with respect to deflection by foliage, break up of rounds, and residual energy after penetrating foliage.	United Kingdom	Comparison Between the Behavior of the Remington 5.56mm AR15 and the 7.62-mm SLR Bullets in Foliage	22 Feb 67	The 5.56mm bullet was only slightly more subject to foliage deflection than the 7.62mm bullet, nor did it show any greater tendency to break up. The residual energy in both bullets after penetrating foliage was similar. The AR15 was considerably better than the SLR for target grouping.	
36			To determine the conditions under which the blank cartridge, fired without the blank firing attachment, may be hazardous to users.	[illegible]	Engineer Design Test (Safety Evaluation Phase) for Cartridge, Blank 5.56mm for [illegible] Rifle	11 Jan 64 to 24 Jan 64	Recommendations: The 5.56mm blank cartridge be considered safe for troop use subject to the limitations: no exposure to expelled particles within a defined cone area unless personnel are located at least 20 ft. from muzzle; reliance should not be placed on clothing for protection within 20 ft. from muzzle; and be sure that no foreign matter such as mud or sand is allowed in the bore prior to firing a blank cartridge.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
737			To compare the experimental projects on behavior of bullets on foliage.	United Kingdom	Behavior of Bullets in Foliage; A Comparison Between the Results of a Jungle Warfare School Trail and Those From Project FIBRE	Mar 67	The projects tackled the problem in different classical ways so that it was of unusual interest to compare them. Results were compatible. Although neither experiment actually measured it, the degradation of lethality caused by foliage was reported similar for the two calibers. Very little difference between the two calibers in terms of foliage deflection.	
738	Frankford Arsenal		To determine the level of peak chamber pressure in weapons firing a 5.56mm point-fire cartridge signed by Frankford Arsenal.	BRL	Pressure Measurements: Caliber 5.56mm Cartridge	Mar 67	Chamber pressure measurements taken by three different gages were presented. The correlation of data, such as discussed, should provide more realistic guidelines for determining the accuracy of a particular gage-recording system.	
739				Frankford Arsenal	Fouling Tests for 5.56mm Tracer Cartridge	2 Mar 67	The first round of series 700, 800, and 900 failed to chamber normally. Manual closing of bolt was required. The weapon functioned normally for balance of each series except for the last series; failure to fire on round 975. Failure to function caused by light primer strike was attributed to fouling of firing pin.	Item 623.
740			To conduct fouling tests on cartridges representing all producers of the 5.56mm cartridge.	Frankford Arsenal	Fouling Tests - 5.56mm Cartridges	1 Mar 67	Test required that 1000 rounds be fired without stoppage due to fouling. Results: Olin Mathieson - Ball, M193, no stoppages; Tracer, M196, weapon stopped on 801st round; Remington - Ball, M193, stoppage due to misfire on 921st round; Tracer, M196, stoppage due to misfire on 903rd round; Federal Cartridge Corp. - Ball, M193, no stoppages due to fouling; Lake City Army Ammunition Plant - Tracer, M196, no stoppage due to fouling.	Item 623.
741			To check production lots of ammunition for fouling characteristics.	Frankford Arsenal	5.56mm Fouling Tests	6 Apr 67	To date 14 lots have been fired on fouling tests; ten lots passed and four failed. Three of the failing lots were M196 tracer cartridges. The number of rounds fired prior to failure were: 800, 822, 921, and 902. Rifles used for these tests were not equipped with the new buffer.	Item 623.
742	CofSA	7 Nov 66	To investigate and comment on the problem of tracer visibility.	HEL	Visibility of 7.62mm and 5.56mm Tracers	17 Apr 67	The problem of tracer visibility had not previously been completely investigated. Data to explain inability of firer to see traces visible to observers on the flanks is not available. A research program was proposed.	
743	USATECOM	8 Nov 66	To conduct a product improvement test of the 30-round magazine, redesigned handguards, and redesigned ammunition pouch.	USAIB	Product Improvement Test of 30-Round Magazine and Redesigned Handguard for M16 and XM16E1 Rifle and Colt Submachine Gun	6 Feb 67 to 10 Mar 67	Recommendations: (1) 30-round test magazine and pouch replace the standard 20-round magazine and ammunition pouch. (2) Redesigned handguards and caps be incorporated into the design of the M16 and XM16E1 and CAR 15 submachine gun. (3) Redesigned handguard for XM148 Grenade Launcher be modified to afford greater protection for the firer and the barrel.	Item 765.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS/RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
744	USARV		To forward reports of copper fouling and corrosive deposits associated with the use of 5.56mm ammunition in Vietnam.		M16 Rifle Information	12 Apr 67	Cited excessive coppering of the barrel, especially when firing large quantities of M196 tracer cartridge. Requested technical evaluation.	Item 751
745			To check average cyclic rates of ammunition with different buffers.	Frankford Arsenal	Use of New Buffer for M16A1 Rifle in Tests of 5.56mm Ammunition	28 Jun 67	Results: Average cyclic rate 5 lots ball cartridges with M946 old buffer, 919, new buffer, 864 - 1 lot ball (IHA8208) old buffer, 823; 3 lots new buffer, 806 - 2 lots tracer (M196) old buffer, 839; new buffer, 825 - 5 lots tracer (IHA8208) new buffer, 773 - 1 lot tracer (CRA136) new buffer, 667. No problem had been encountered with regard to stoppage or parts breakage attributable to the buffer, since introduction of new buffer for M16 rifles used for ammunition testing.	
746	USAMC		To design a projectile such that its gyroscopic stability, when fired from a 1-in-12 inch twist, would be the same as that of the M193 from a 1-in-14 inch twist.	BRL	Effect of Configuration Changes on Drag and Stability for a Family of 55 Grain Caliber .223 Bullets	Jul 67	Estimates of the static aerodynamic characteristics and gyroscopic stability factors were tabulated. Some additional problems with the low stability design were discussed. Several intermediate designs were recommended for fabrication and free-flight range firings.	Item 770.
747	Eglin AFB	14 Mar 67	To determine the suitability of the Colt submachine gun, 5.56mm for Air Force use.	Lackland AFB	Evaluate XM177, 5.56mm Submachine Gun	1967	Recommendations: (1) The XM177 5.56mm submachine gun is not recommended for AF use in its present configuration. (2) Redesigned flash and sound suppressor on the 11 1/2" barrel requires additional study. (3) Standardize the new style handguard slipring for use with the M16.	
748	USATECOM		To evaluate weapon performance when using extruded grain and ball propellant cartridges with ball and tracer projectiles.	D&PS	Product Improvement Test of Submachine Gun, 5.56mm XM177E2	Jul 67 to Feb 68	(Report not available.)	Tracer ammunition deficiencies examined (Item 627)
749	USATECOM		To establish the actual handguard comparability, relative to thermal conductivity and heat dissipation.	D&PS	Product Improvement Test of Modified Handguard and Handguard Cap for M16A1 Rifle	28 Aug 67	Performance of the test handguard and handguard cap was satisfactory, and comparable to the standard item. Recommendations: Modified handguard and handguard cap is considered for adoption as substitutes for the items presently used on the M16A1.	
750	USAMUCOM		To determine if the 5.56mm tracer bullet is essentially as lethal as the 5.56mm ball bullet for all rifle ranges to 600 meters.	PEL	Lethality Evaluation of 5.56mm and 7.62mm Tracer Bullets	25 Aug 67	The tracer projectiles were less lethal, and significantly so after tracer burn out (which is beyond 600 meters).	Item 755.
751	PEL-RS	17 Aug 67	To report [illegible] on the accumulation of gilding metal fouling following [illegible] straight [illegible] conditions.		Gilding [illegible] Fouling in M14 and M16 Rifle Barrels	14 Sep 67	Preliminary tests of sample ball and tracer ammo failed to indicate any significant effects of gilding metal clad steel jacket material on erosion or metal fouling. In view of contrary results reported in other firings, further study is indicated.	Items 627 and 628.

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
752			To evaluate ruptured cartridge case problems possibly resulting from water trapped in the barrel.		Ruptured Cartridges	8 Aug 67	Field units reported instances of cartridge case ruptures under conditions indicating possible water in the M16 barrels. USAIS was advised to emphasize proper drainage techniques in training.	
753	USAMUCOM		To investigate causes of malfunctions reported at Fort Ord with subject lot.	Frankford Arsenal	Malfunction Investigation of Lot FC 1830, Cartridge, 5.56mm Ball, M193	22 Sep 67	Frankford Arsenal had released lot FC 1830 containing ball propellant after its suspension because of reported high temperature instability problems.	
754	USATECOM	22 Aug 67	To evaluate combat effectiveness of the luminous iron and optical type candidate sights in comparison with standard iron sights on the M14 and M16A1 rifles under day and low light level conditions, when the target is visible to the unaided eye.	USAIB	Military Potential Test of Small Arms Sights for M14 and M16A1 Rifles		(Test data not available.)	
755	USAF	31 May 67	To compare accuracy, trajectory, velocity, and yaw characteristics, jacket stripping tendency and penetration of pine boards and steel helmets of various barrels and cartridges which were submitted by AFATL with the standard service ball, 5.56mm cartridge.	Lackland AFB	Ballistics Test of Various 5.56mm Cartridges Through 1 Turn in 7" Barrels	1967	Accuracy at 100 yards: Both service ball and 68 grain bullet loads were marginal. At longer ranges, accuracy became increasingly more satisfactory. Trajectory: The 68 grain bullet performance was very close to the 7.62mm NATO Ball M80 cartridge to 600 yards and only 38" lower at 1000 yards. The 55 grain service ball was close to the same to 600 yards and about 73" lower at 1000 yards.	
756	USARV	5 Jul 67	Tests requested as result of battlefield experiences in Vietnam which cast doubts on efficacy of 5.56mm M196 tracer ammunition.	Edgewood Arsenal	Evaluation of Tracer Ammunition	21 Sep 67	Animal tests showed that the 5.56mm tracer ammunition was as lethal as the ball ammunition when an area having a high potential for lethality is struck. The average wound cavity volumes, on the other hand, showed that the tracer bullets might not tumble as readily as the M193 ball bullets.	Follow-up [illegible] studies to examine tumbling (Item 762).
757	USAF	11 Jan 67	To test the cleaning and lubricating qualities of Essentialube as compared to standard issue solvents and lubricants.	Lackland AFB	Evaluation of Essentialube (Cleaner and Lubricant)	1967	Essentialube removed carbon slightly faster than issue solvents. Essentialube and oil, general purpose, were comparable as lubricants after cleaning, but Essentialube has the advantage of being a one-step cleaner and lubricant operation. Recommendation: Essentialube is recommended for Air Force adoption, except in cleaning operations which incorporate an ultrasonic cleaner.	
758			To study and evaluate metal fouling in M16A1 rifles. Obtain [illegible] rifles are subjected to firing cartridges with [illegible] and with cartridges [illegible] under Smith [illegible]	Frankford Arsenal	Metal Fouling of Gilded Metal (GM) vs Gilded Metal Clad Steel (GCMS) 5.56mm M196 Tracer Bullets	Oct 67	(Test data not available.)	

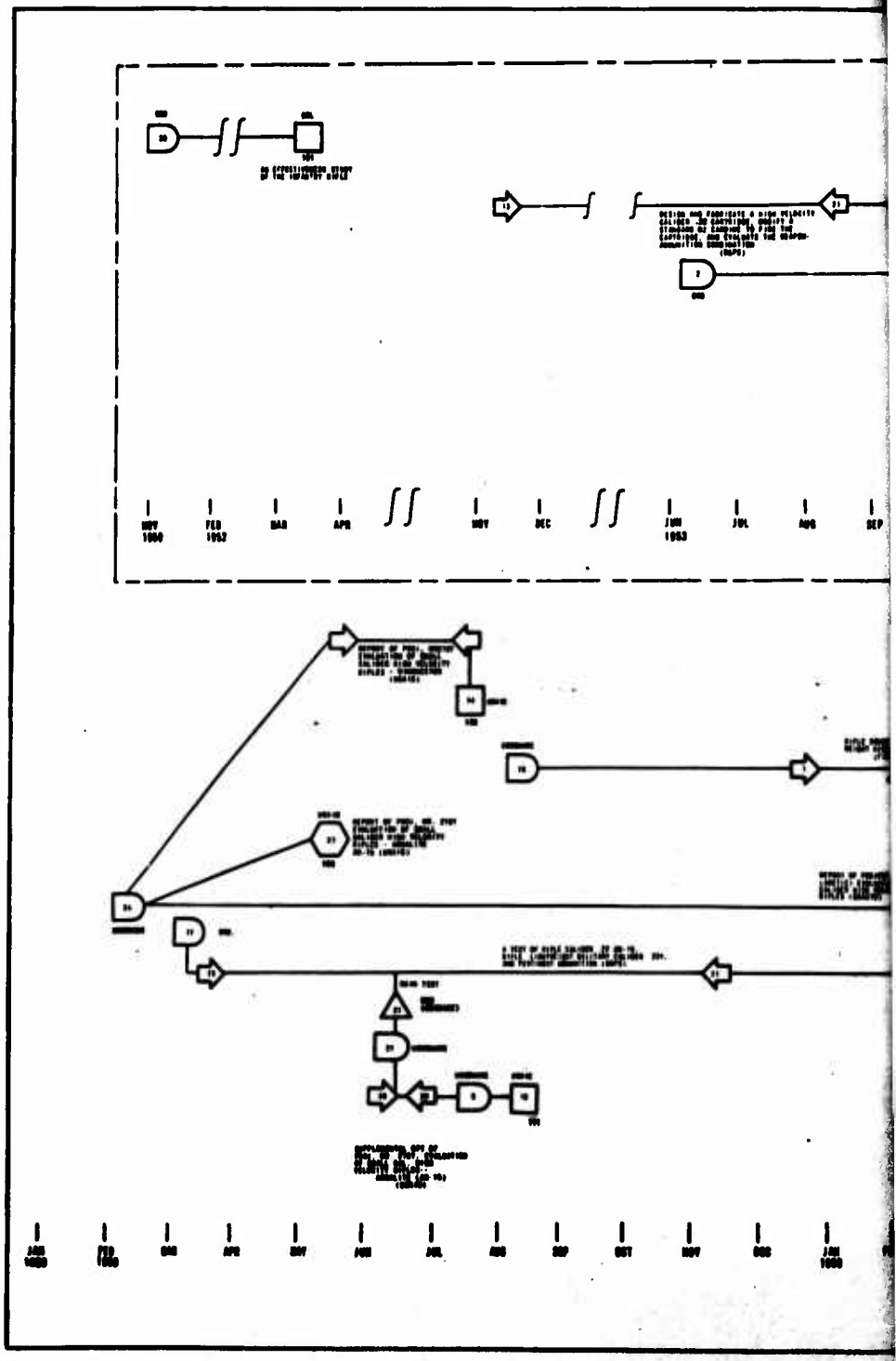
O.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS: RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
759	Under Secretary of the Army	25 Aug 67	To evaluate the effect of high temperature storage conditions upon the ballistic and chemical properties of small arms propellants using analytical rather than experimental methods to estimate storage stability in 5.56mm ammunition from data previously available on storage of 7.62mm ammunition.	Frankford Arsenal	High Temperature Studies of Ball Propellant	4 Oct 67	Both IMR and ball propellant cartridges cooked-off at approximately 300°F. Accelerated stability testing of ball propellant to evaluate storage conditions should be approached with caution, since ballistic performance changes of ammunition, assembled with ball propellant are accelerated to a greater degree in going from approximately 120°F to 150°F than is the case with other propellants.	
760	USAWECOM	25 Sep 67	To investigate the reported extraction difficulty phenomenum using M16A1 rifles with both chromed and unchromed chambers.		United Kingdom Report of Extraction Difficulty with 5.56mm Ammunition Containing Ball Propellant	Oct 67	(Results not available.)	
761	USATECOM	9 Oct 67	To evaluate test blank firing attachments with respect to safety hazards.	USAIB	Safety Evaluation for Blank Firing Attachments for Use with the 5.56mm M16 Rifle	26 Oct 67	No hazards were found in the tests. Recommend that the blank firing attachment be considered safe for use with the M16A1 rifle.	
762	USAMUCOM	15 Aug 67	To evaluate M196 tracer bullets for stability in soft targets and wound cavities.	CRDL	Gelatin Studies with 5.56mm M196 Tracer Ammunition	10 Oct 67	M196 and M193 rounds were fired into gelatin blocks at 100 meters range. The M196 tracer did not tumble as much and penetrated soft targets better, but expended less energy and produced smaller wound cavities than the M193 ball rounds.	
763	USAWECOM	15 Nov 67	To report on the development of quantitative criteria for the degree of fouling deposited in the gas tube of the M16 and M16A1 rifles.	Frankford Arsenal	Fouling Test for 5.56mm Ammunition in M16 and M16A1 Rifle	15 Nov 67	Project Manager-Rifles letter cites proposed method to determine the quantity of fouling in the M16A1 gas tube. The operation was of interest because of reports of ball propellant fouling. (Further details as to test results not available.)	
764	USATECOM	26 Sep 67	To evaluate lubricants when applied to weapons operated under arctic conditions and to evaluate the performance of unlubricated weapons and minimal maintenance under arctic winter conditions.	USAATC	Service Test for Lubricants for M14 and M16A1 Rifles Under Arctic Winter Conditions	2 Nov 67 to - - - -	(Results not available. Test completion target date was March 1968.)	
765	USATECOM	8 Nov 66	To determine the reliability and performance of subject test items.	DPS	Product Improvement Test (Concurrent) of 30-Round Magazines and Handguard and Handguard Cap for 5.56mm M16A1 (M16E1) Rifle	11 Apr 67 to 16 Oct 67	DPS noted original conclusions and recommendations to reflect the following: 30 round magazine has potential for satisfactory performance with M16A1 and XM177E1; increase in fire with 30 round magazine; redesigned handguards and handguard caps are as durable as the standard items. Recommendations: (1) 30 Round magazine and redesigned ammunition pouch be fabricated and subjected to production test prior to release for field use. (2) Subject 30 round magazine to engineering and service tests with XM177E1. (3) Redesigned handguard and handguard cap be considered suitable for adoption.	

NO.	TEST INITIATION			TESTING AGENCY	TEST TITLE	TEST DATES	TEST RESULTS RECOMMENDATIONS	SUBSEQUENT ACTION
	INITIATOR	DATE	PURPOSE					
766			To state the Infantry Agency's position on the selection and production of M16A1 cleaning kits.		Cleaning Kit, M16A1 Rifle	17 Nov 67	Recommendations: (1) Pouch-type, one compartment nylon carrier as desired. (2) Carrier should accommodate four sections of cleaning rods. (3) Carrier should be attachable to soldier's equipment.	
767	USAMC		To compare fouling residue resulting from the use of WC 846 and IMR 4475 propellants.	Frankford Arsenal	Weight of Bolt Test	1 Dec 67	The weight increase of the bolt and bolt carrier after firing 200 rounds with WC846 propellant and 100 rounds with IMR4475 was determined to be 2.49 grains using WC846, and .34 grains using IMR4475.	
768			To evaluate the practicability of demonstrating the effectiveness impact of a muzzle velocity reduction by a firing program.	USATECOM	Reduction in Velocity of M16 Rifle	22 Dec 67	BRL had estimated that a 50fps muzzle velocity would provide equivalent terminal effects at a 13m decrease in range. Because of variabilities between rounds, lots, and weapons, USATECOM reported they could not provide a significant evaluation of such a small effectiveness change.	
769			To compare cyclic rates using the old and new buffers and bolt rebound using the old and new buffers.	D&PS	Product Improvement Test of Redesigned Buffer for M16A1 Rifle	12 Dec 67	The redesigned buffer improved overall reliability of XM16A1 except in extreme cold environment. The redesigned buffer effectively reduced rate of fire regardless of test condition, ammunition lot or individual weapon; no absolute functional relationship existed between high rates of fire and high malfunction rate. The redesigned buffer provided a higher number of feeding-type malfunctions.	
770			To develop performance data such as round-to-round dispersion, exterior ballistic flight characteristics (striking velocity and yaw, stability factor, etc.) and wound ballistic assessment based on analysis of design parameters for 5.56mm bullets.	BRL	Parametric Bullet Design Study	Feb 68	The BRL computing laboratory developed a computer model for predicting the distribution of pressures on the projectile in flight. These pressure forces were integrated to express projectile drag and stability as a function of projectile characteristics. Data were examined for 55,65, and 75 grain 5.56mm projectiles. Good data correlation was obtained with experimental firings on an aerodynamic range for some rounds, but less good for others. The theory assumed axial-symmetric, non-deforming projectiles.	Continued evaluation of parametric designs by live firing of prototype projectiles.

F. Bibliography

An Annotated Bibliography of M16A1 Rifle System Tests, prepared in the Office of the Director of Weapon Systems Analysis, Office of the Chief of Staff, U.S. Army, April 1968. (This bibliography includes tests of the M16A1 rifle and ammunition system, both formal and informal. Entries are arranged chronologically by sponsoring test agency, with annotations citing the test purpose and abstract.)

Chief of Staff Memorandum 66-485, 7 November 1966, Army Small Army Weapon System.



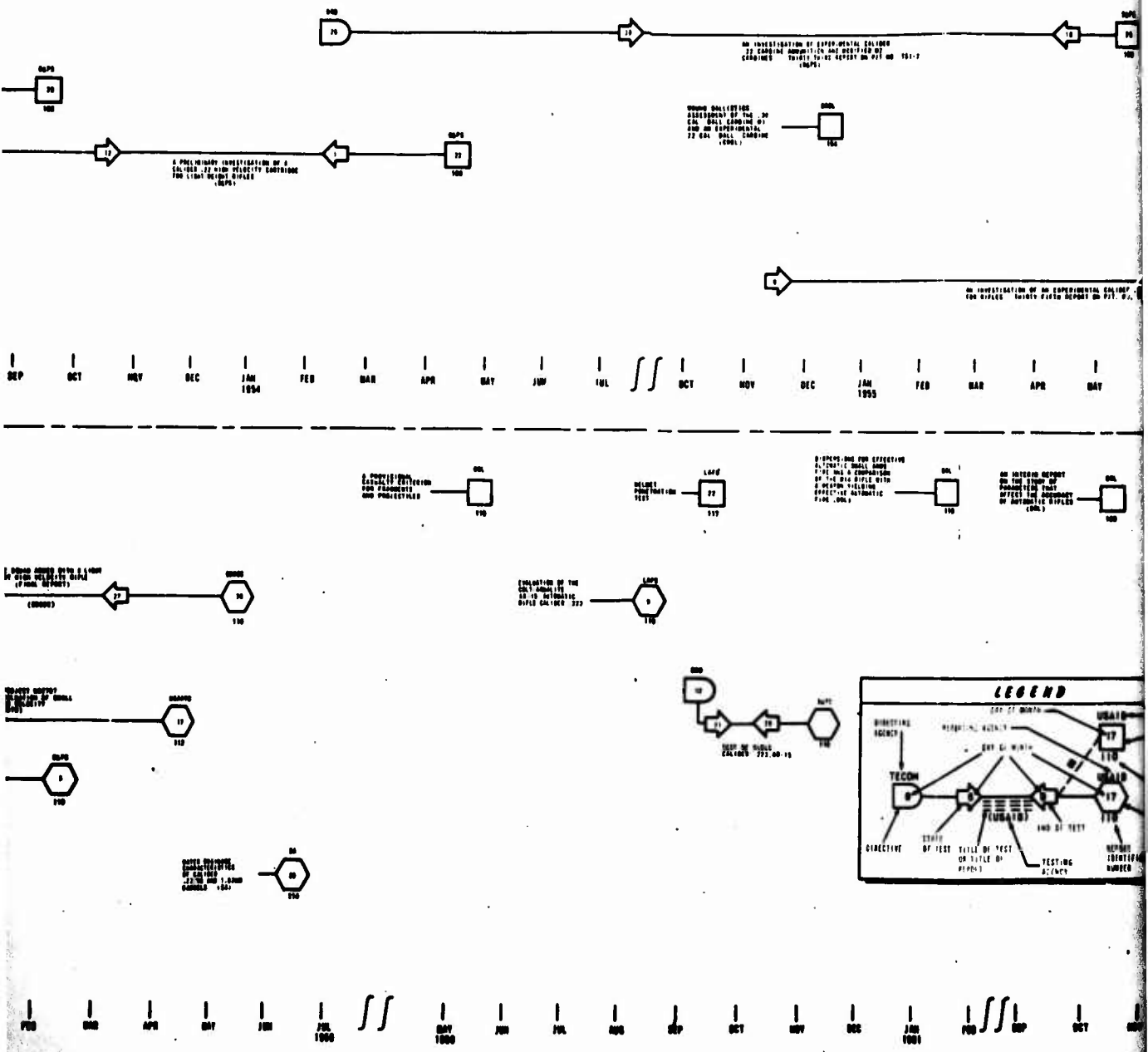
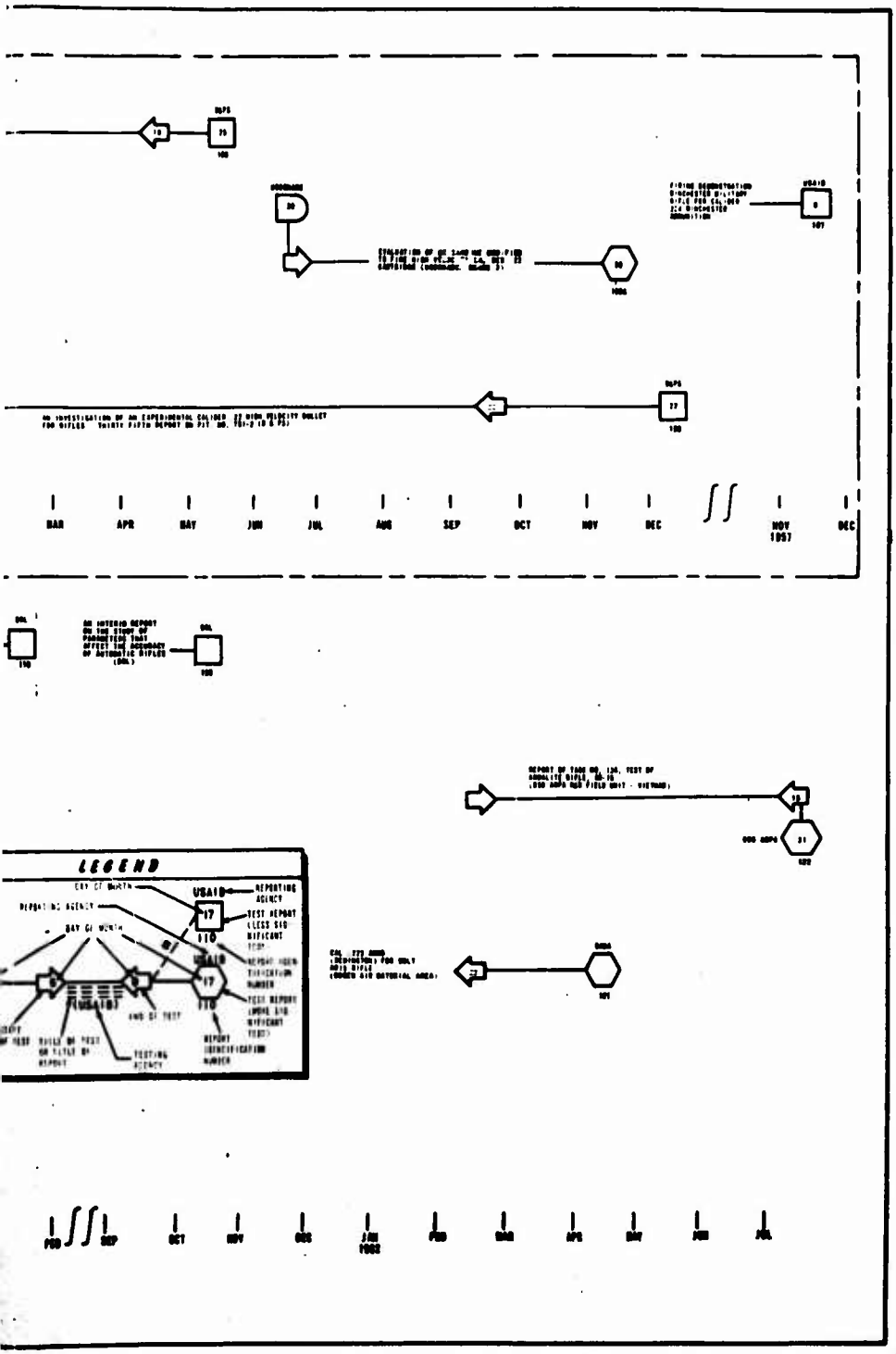


FIG. 1 CHRONOLOGICAL DISPLAY OF M16 TESTS IN THE EARLY DEVELOPMENTAL PERIOD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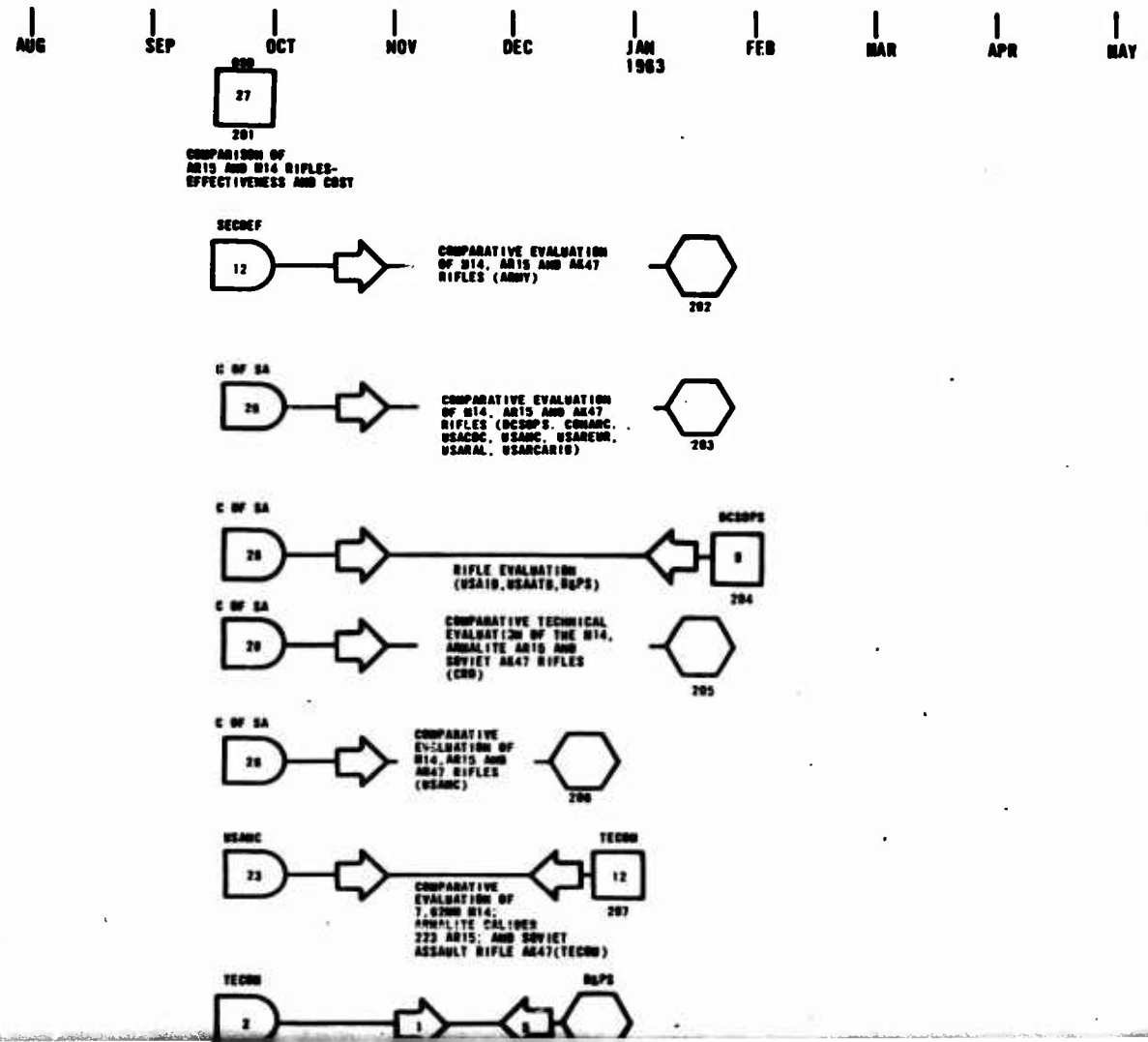
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COMPARATIVE EVALUATION
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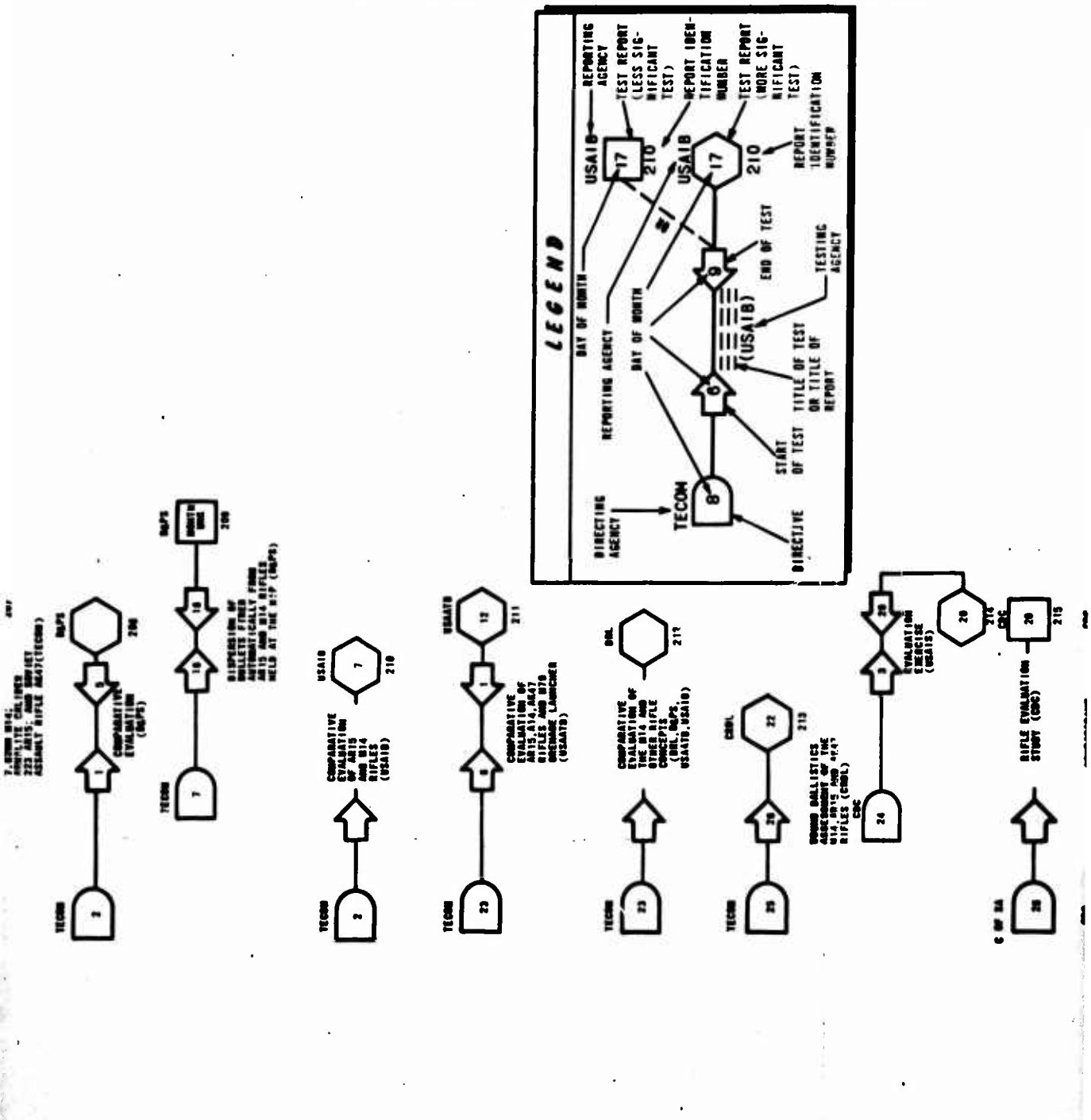
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COMPARATIVE EVALUATION OF AR15,A14,AK47 RIFLES AND M79 GRENADE LAUNCHER (USAATB)
COMPARATIVE EVALUATION OF THE M14 AND OTHER RIFLE CONCEPTS (DRL,DLPS, USAATB,USAIB)
SOUND BALLISTICS ASSESSMENT OF THE M14,AR15 AND AK47 RIFLES (CRDL)
EVALUATION EXERCISE (USAIS)
RIFLE EVALUATION STUDY (CDC)

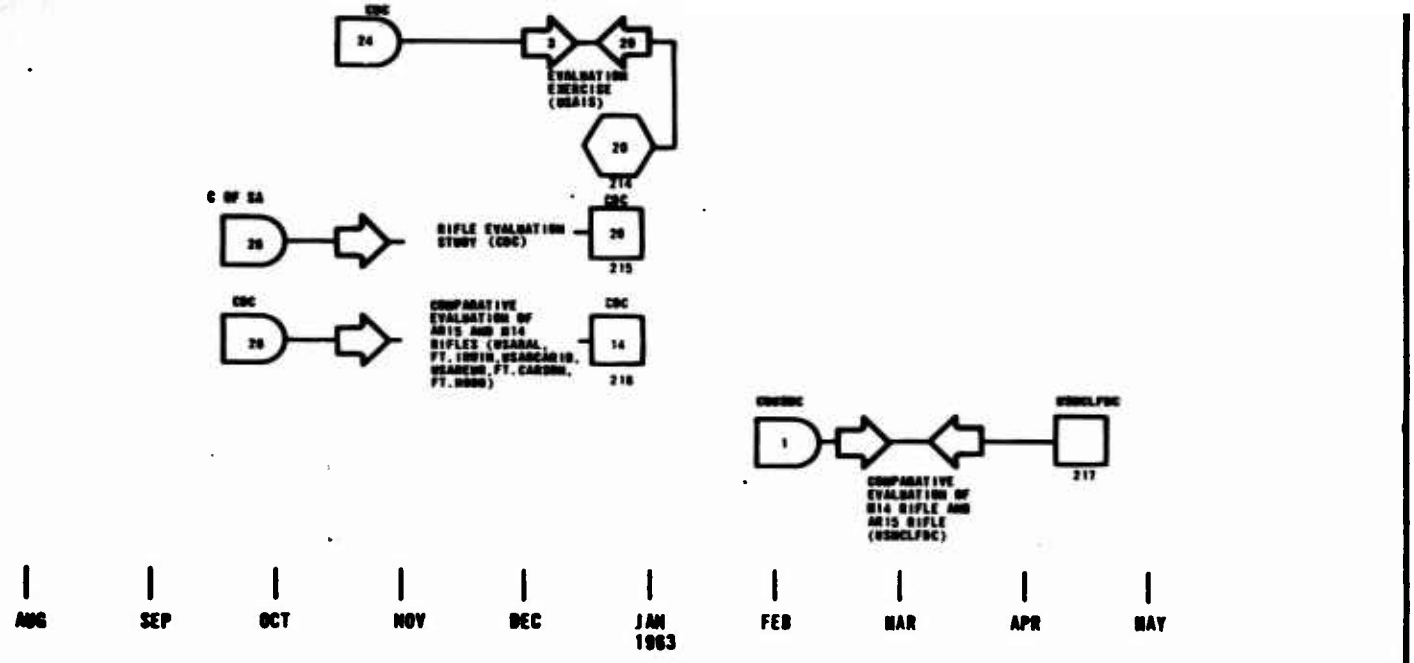
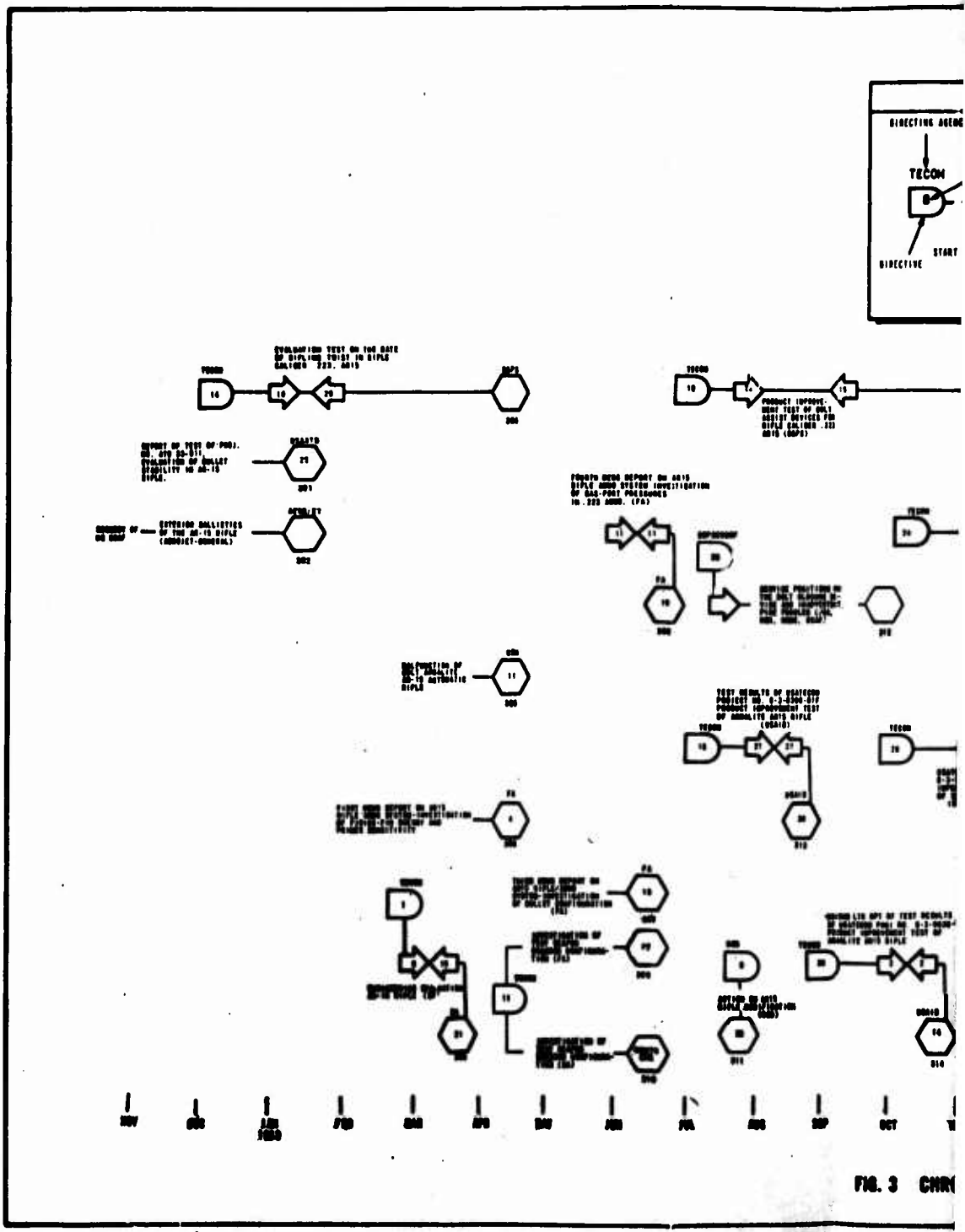


FIG. 2 CHRONOLOGICAL DISPLAY OF M16 TESTS DURING THE 1962-1963 COMPARATIVE EVALUATION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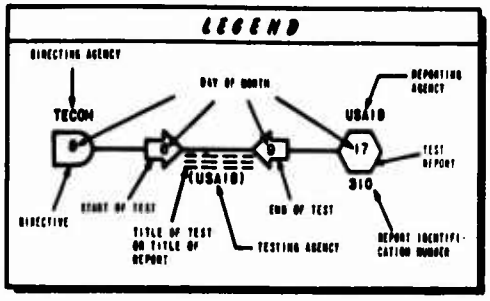


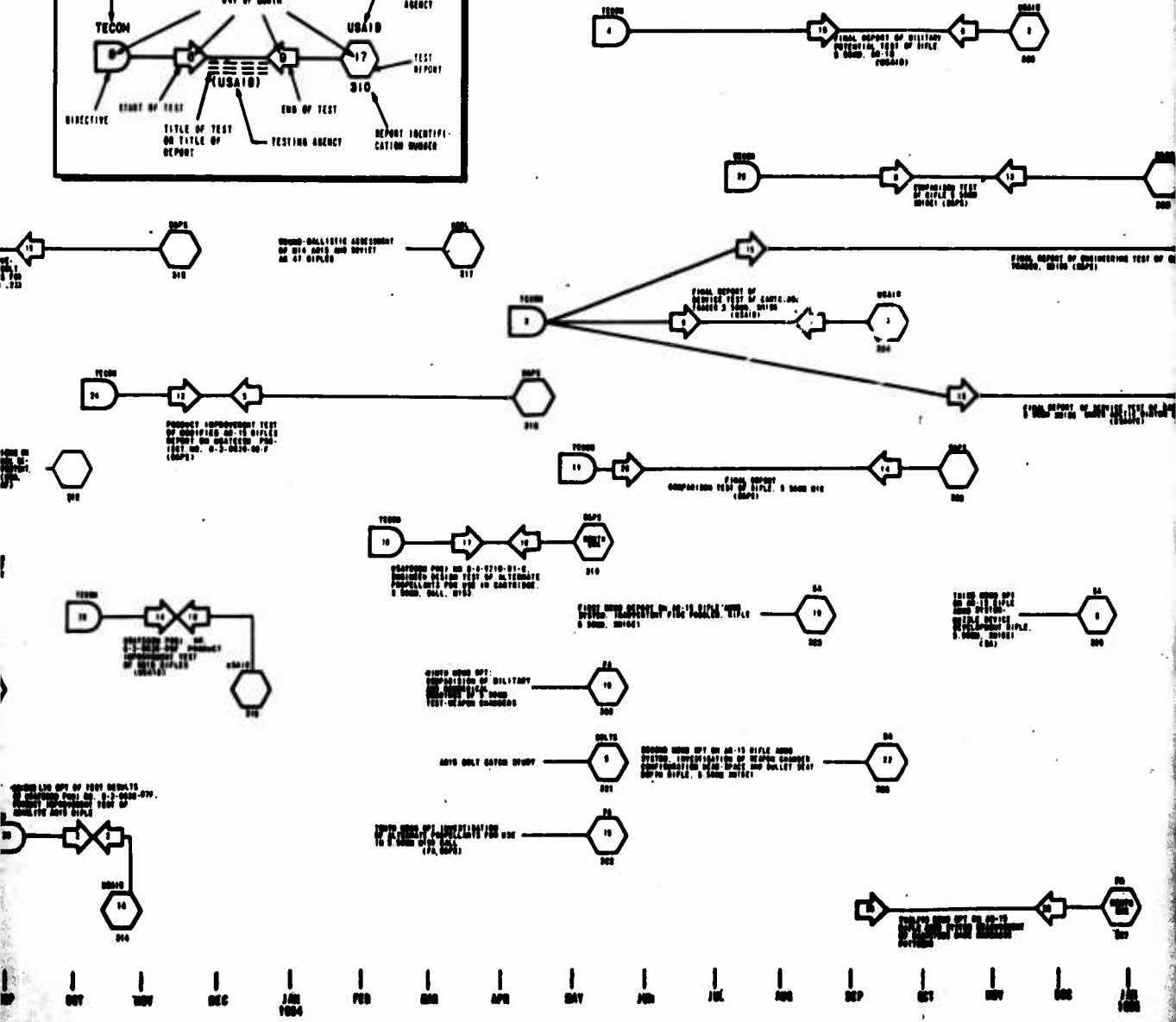
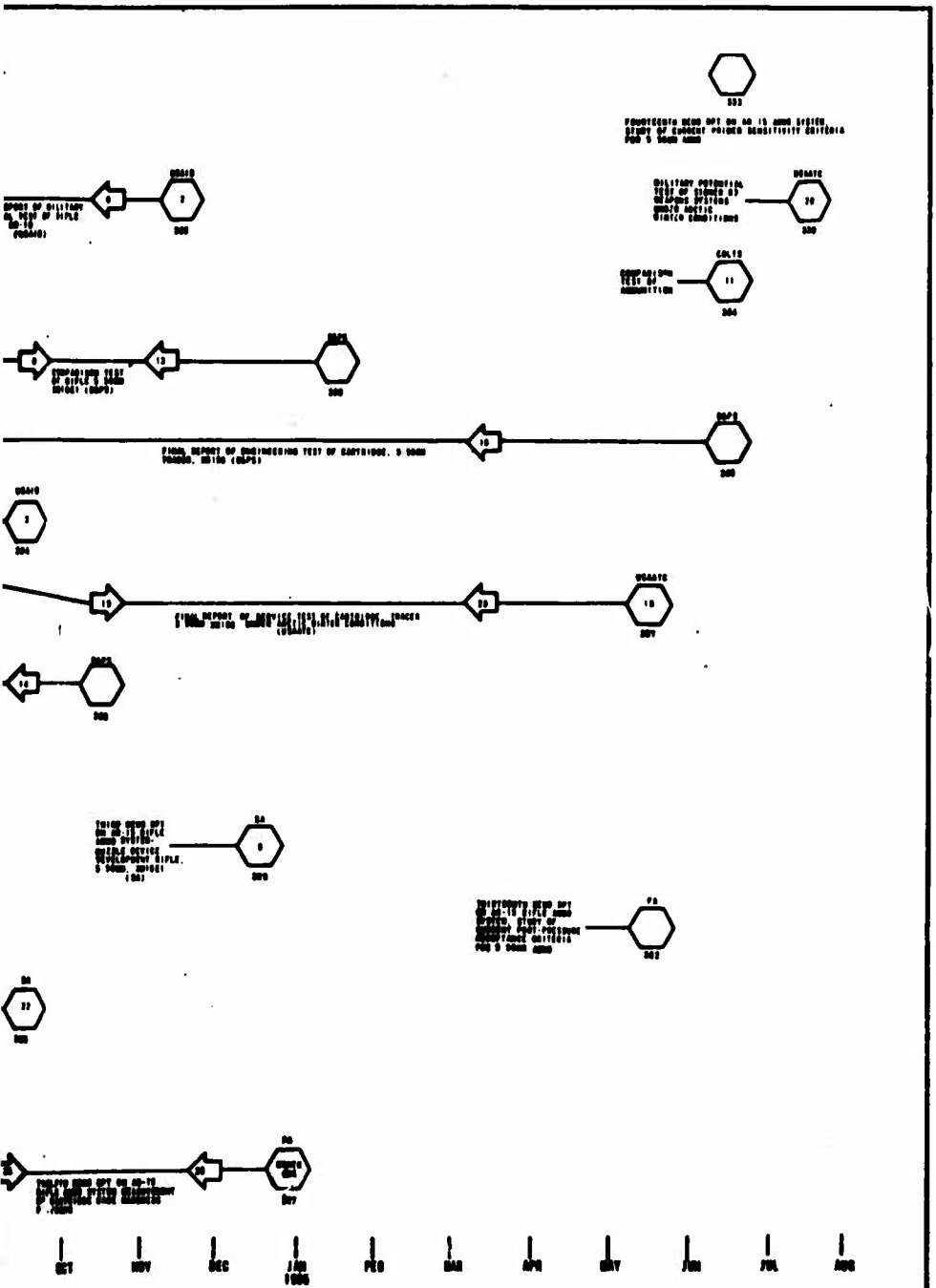


FIG. 3 CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT M16 TESTS IN THE 1963-1965 TIME PERIOD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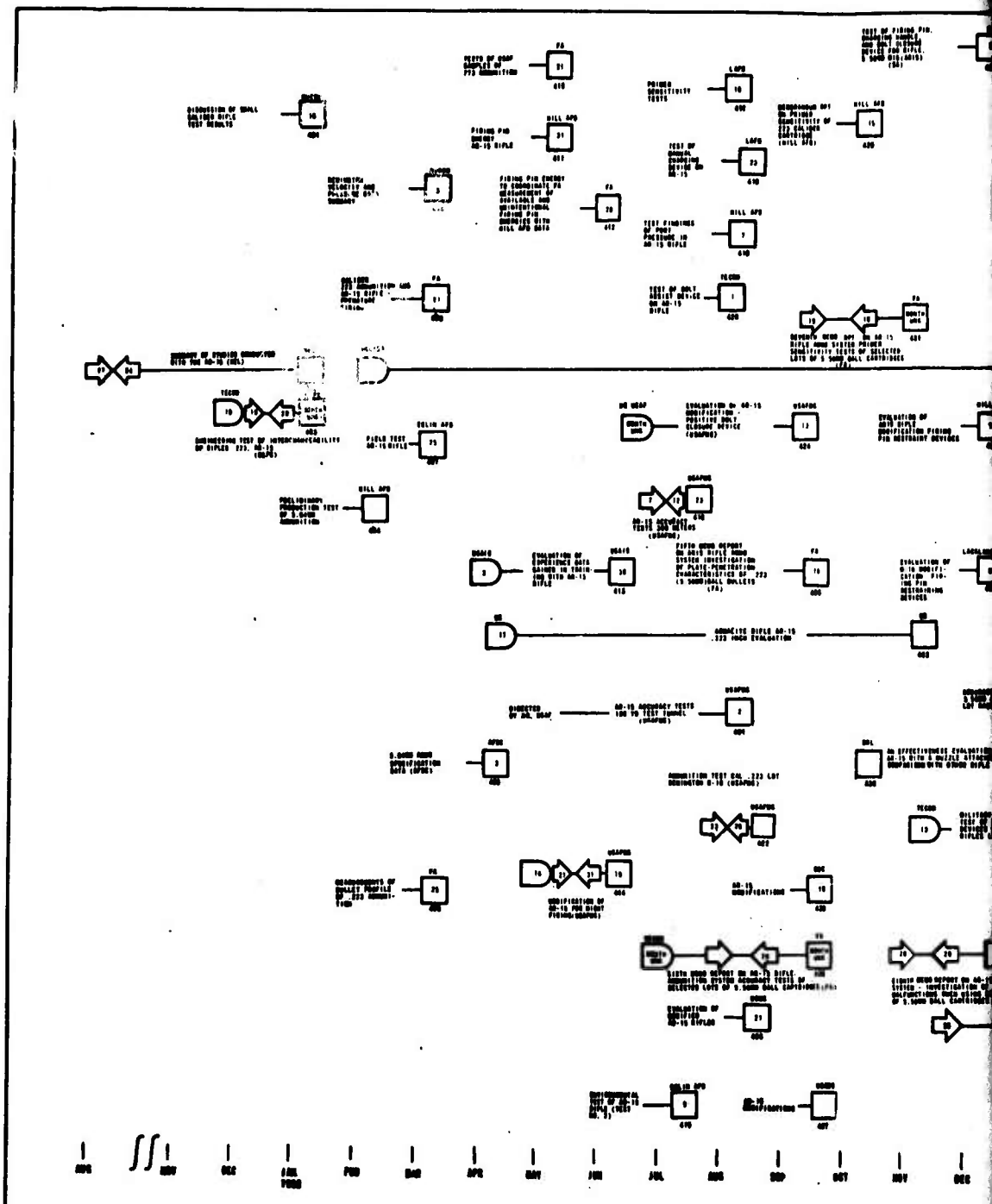


FIG. 4 CHRO

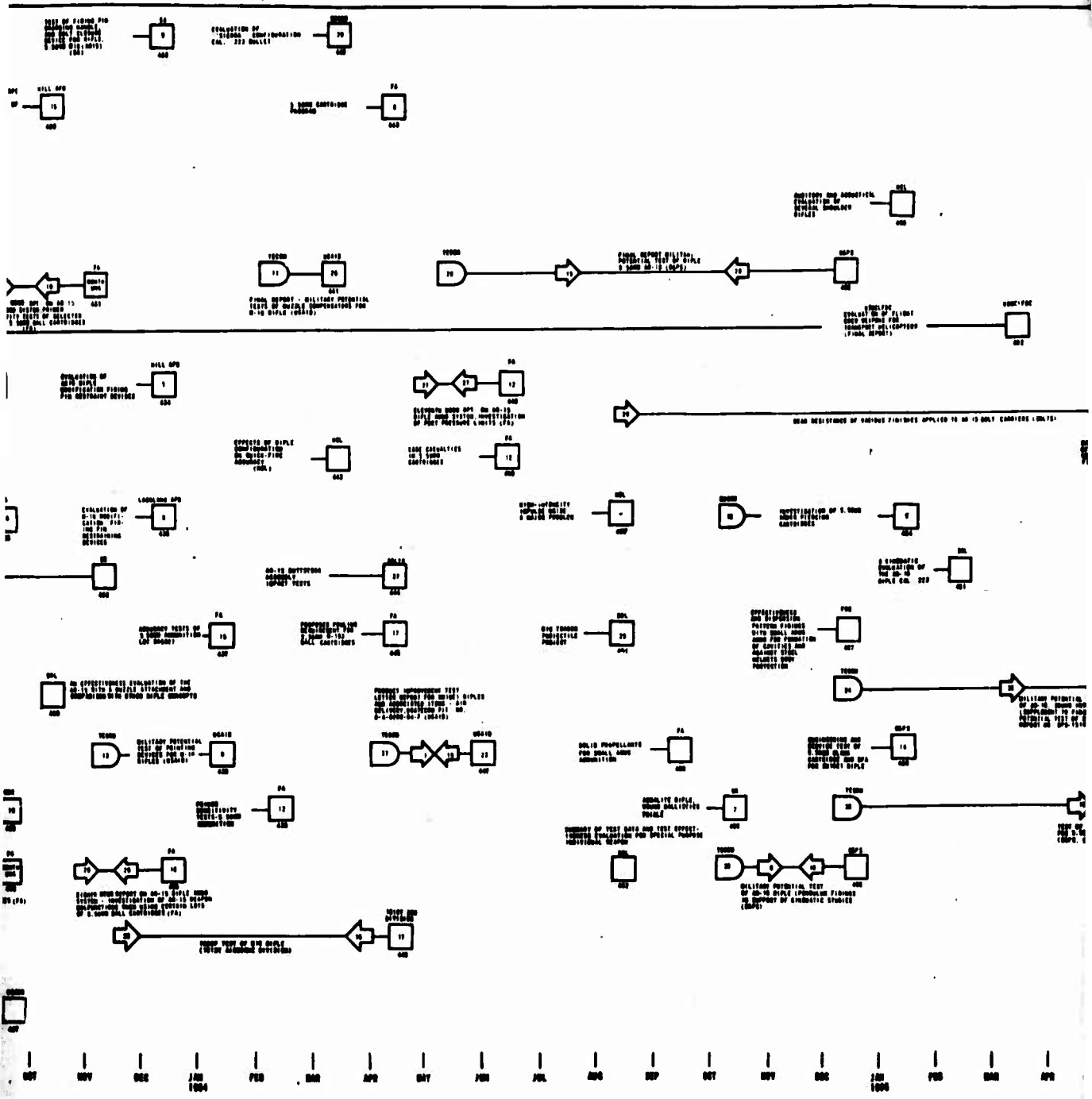
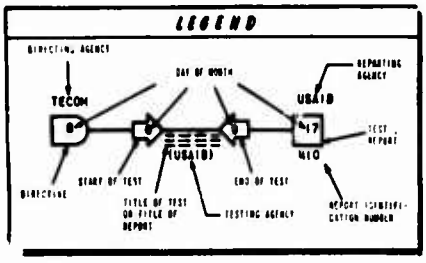
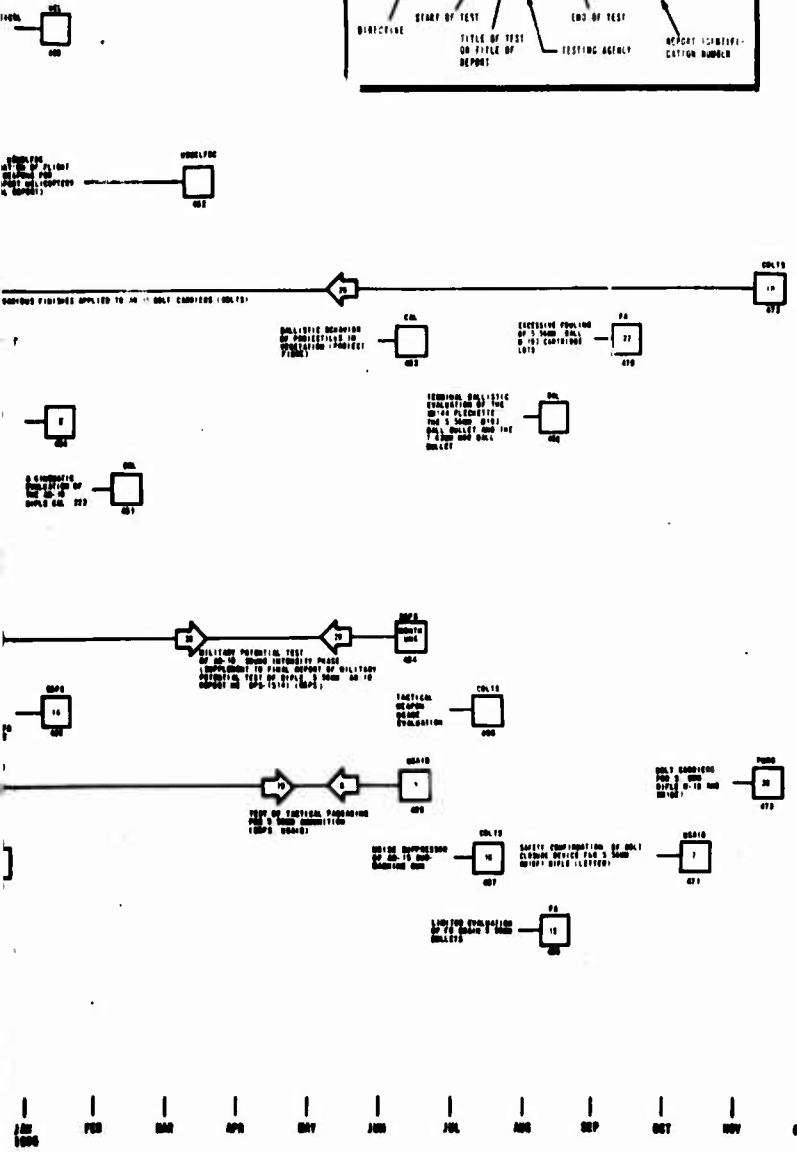
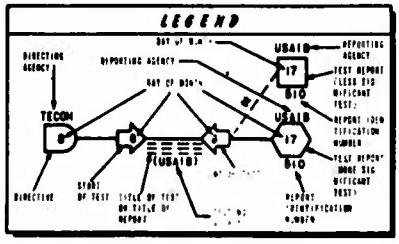


FIG. 4 CHRONOLOGICAL DISPLAY OF THE LESS SIGNIFICANT M16 TESTS IN THE 1963-1965 TIME PERIOD

2

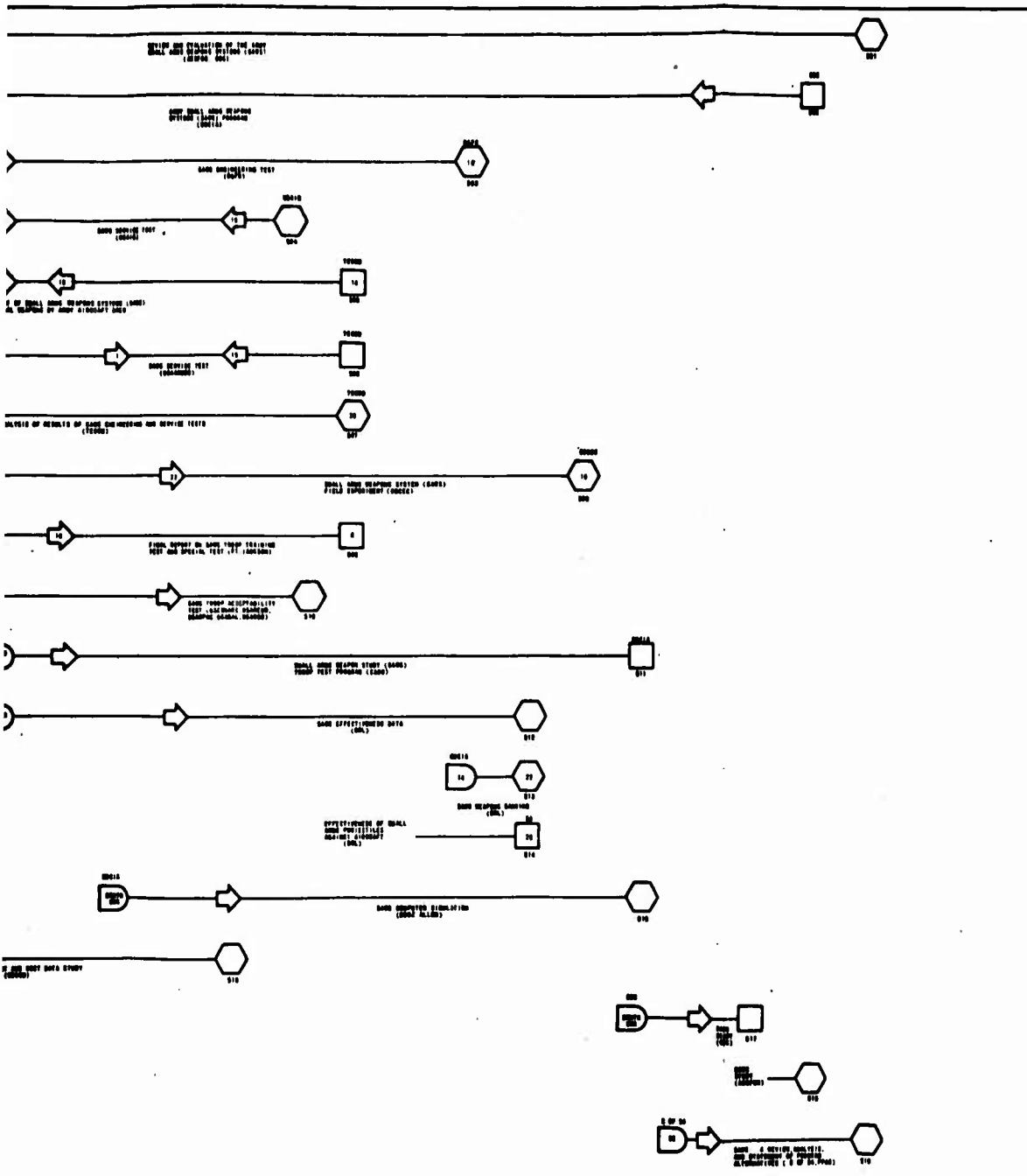

LEGEND
DIRECTING AGENCY
DAY OF MONTH
REPORTING AGENCY
TECOM
USAID
TEST REPORT
(USAID)
M10
START OF TEST
END OF TEST
DIRECTIVE
TITLE OF TEST OR TITLE OF REPORT
TESTING AGENCY
REPORT IDENTIFICATION NUMBER


JAN 1986
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC



OCT 1984 | NOV | DEC | JAN 1985 | FEB | MAR | APR | MAY | JUN | JUL | AUG

FIG. 5 CHRONOLOGICAL DISPL



AUG SEP OCT NOV DEC JAN 1966 FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN 1967

OGICAL DISPLAY OF THE ARMY SMALL ARMS WEAPONS SYSTEMS (SAWS) STUDY, 1965-1966

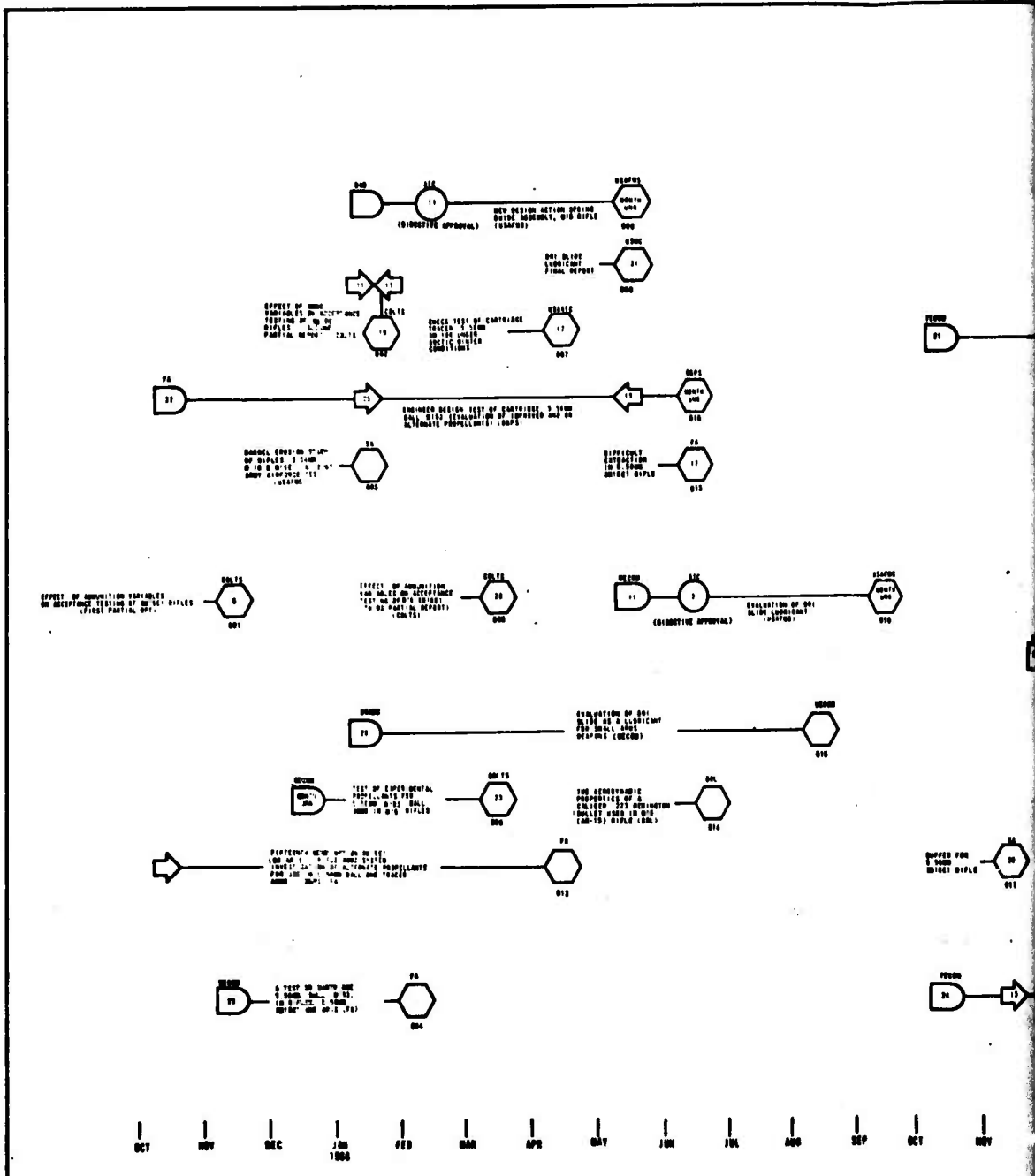
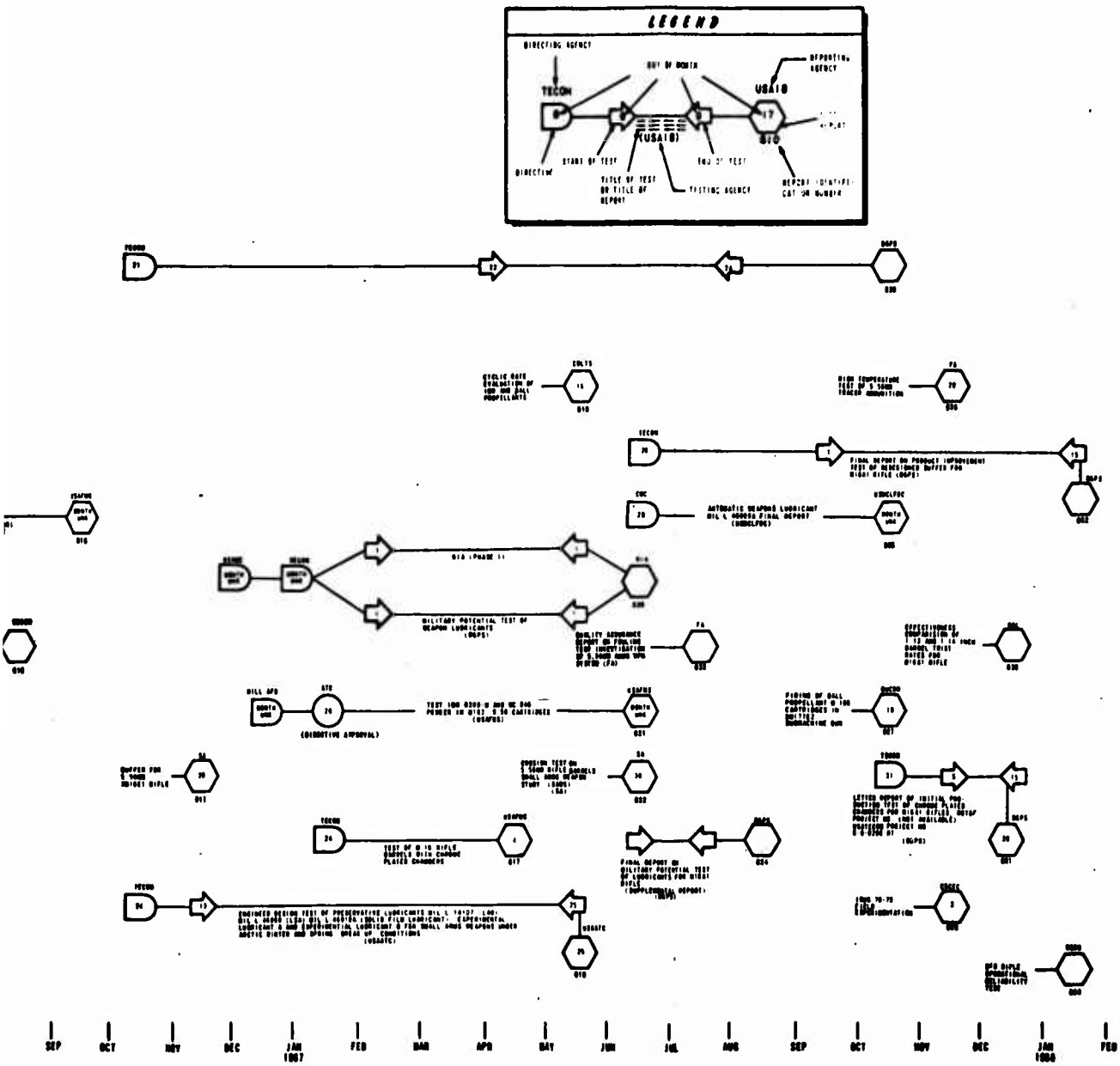


FIG. 8 CHRONOLOGICAL DISPLAY OF THE



CHRONOLOGICAL DISPLAY OF THE MORE SIGNIFICANT M16 TESTS SINCE 1966

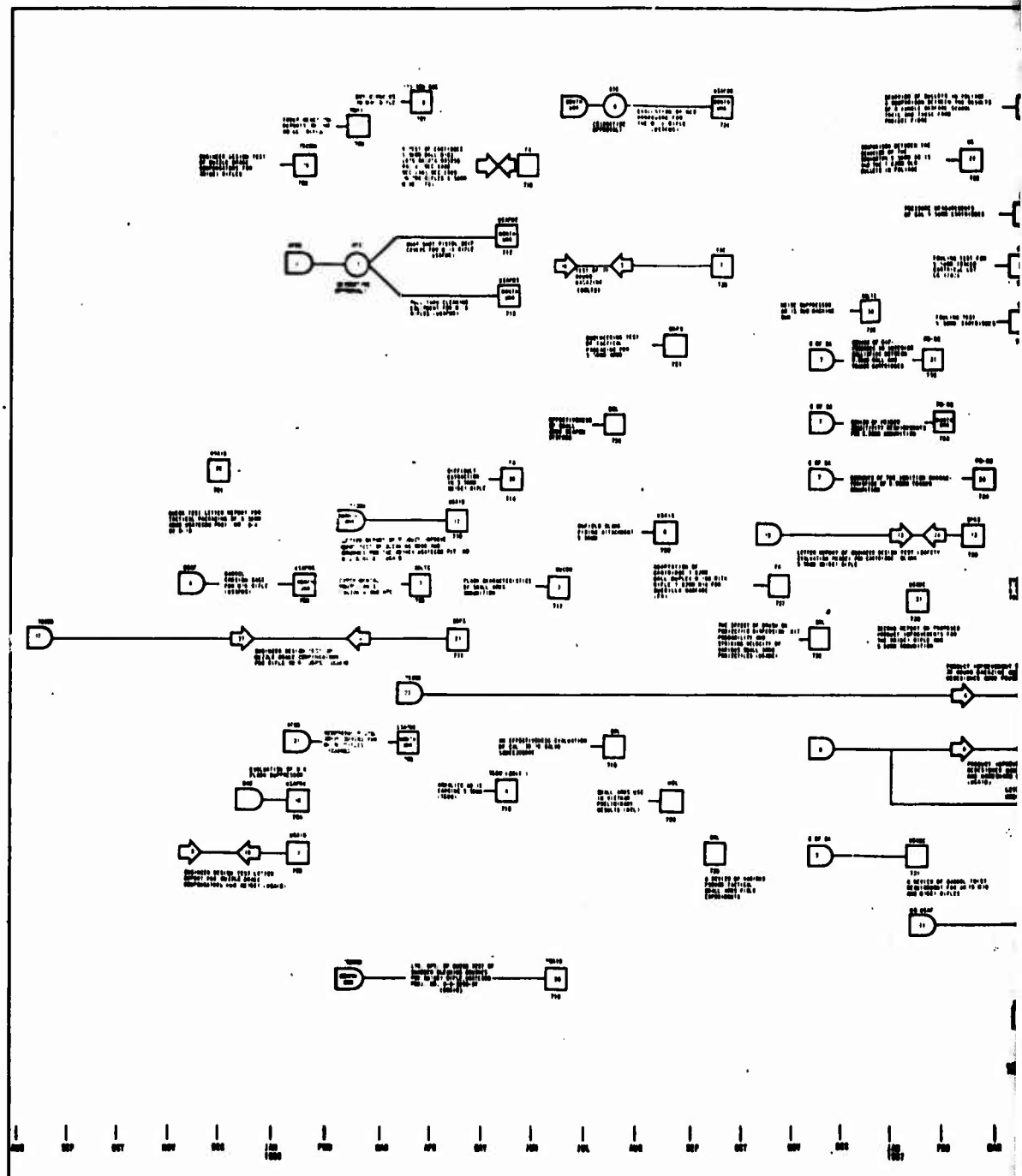
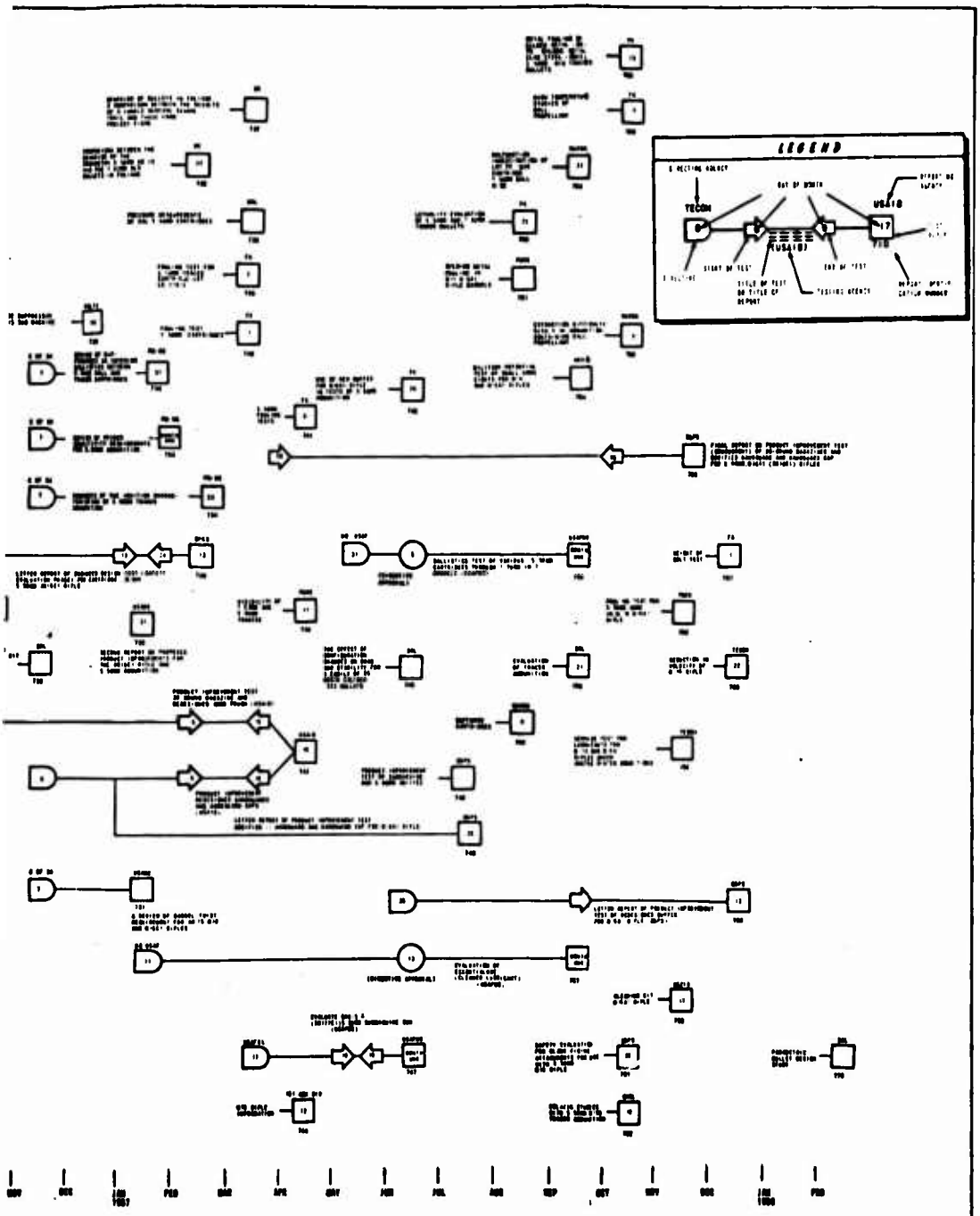


FIG. 7 CHRONOLOGICAL DISPLAY OF THE LESS SIGNIFICANT M16 TE



ISPLAY OF THE LESS SIGNIFICANT M16 TESTS SINCE 1966