DEPARTMENT OF THE ARMY
UNITED STATES ARMY MATERIEL COMMAND
PROJECT MANAGER – RIFLES
ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61201

JM
25-4

IN REPLY REFER TO:
AMCPM-RS

27 APR 1966

SUBJECT: Minutes of M16/XM16E1 Rifle Technical Coordinating Committee Meeting of 13 April 1966.

TO: SEE DISTRIBUTION

1. Attached hereto for your retention and necessary action are the minutes of the 13 April 1966 meeting of the M16/XM16E1 Rifle Technical Coordinating Committee.

2. The action agencies designated after each paragraph are requested to take aggressive follow-up action to complete assigned tasks. Any delay in completion of the assigned tasks should be reported telephonically to the Project Manager, Rifles.

3. Sufficient copies have been included for each addressee for distribution to personnel listed in inclosure 1 (of the minutes), as well as other interested agencies.

1 Incl
as

HAROLD W. YOUNT
Colonel, GS
Project Manager, Rifles

AMCPM-RS

SUBJECT: Minutes of M16/XM16E1 Rifle Technical Coordinating Committee Meeting of 13 April 1966

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27 APR 1966

MINUTES
M16/XM16E1 RIFLE TECHNICAL COORDINATING COMMITTEE MEETING
FRANKFORD ARSENAL, PHILADELPHIA, PENNSYLVANIA
13 APRIL 1966

1. A meeting of the Technical Coordinating Committee for the M16/XM16E1 Weapon System was held at Frankford Arsenal on 13 April 1966. The primary purpose of the meeting was to discuss the results of Springfield Armory's testing of new rifle buffers and TECOM's testing of two new propellants. A list of attendees is attached as inclosure 1.

2. Buffer Test Results - Previous testing of buffers includes a complete test of the first prototype which performed satisfactorily under all conditions; however, the internal buna discs failed as a result of the -65°F test. The buna discs in this prototype were then changed to withstand lower temperatures and again tested with the same results. The present test is of four new configurations designed to standup satisfactorily at -65°F. The four types differ only in the design of the rear bumpers (large or small polyurethane bumpers) and in the composition of the plastic discs inside (buna or polyurethane discs). Springfield Armory has partially completed the -65°F test on all four types. So far all types are performing satisfactorily and have not shown any failure of components. It was decided that Springfield Armory would complete the -65°F test of all four types and then make the test results available to Mr. Davis of Colt's Inc. Mr. Davis will then decide on two of the buffers to be continued in test. Following Mr. Davis' decision, Springfield will continue testing with the two types selected. The first test following the decision will be the +125°F test. Other tests will then be run in the order desired by Springfield Armory. It was emphasized that all testing, discussion of test results, and notification of interested parties in the event of trouble during testing, was to be expedited so that the best buffer could be determined at the earliest possible date.

ACTION: SA, Colt's

3. Propellant Test Results - Attached as inclosure 2 is a detailed summary of ballistic results of propellant testing. The results indicate that the Dupont 8208-4 propellant performs satisfactorily and very closely resembles the performance of the WC846 (ball) propellant now in use. In addition, the results show that Hercules HPC-11 propellant is unsatisfactory due to a high chamber pressure (48,300 psi) which does not allow a sufficient safety factor before maximum chamber pressure (50,000 psi) is exceeded and due to a low cyclic rate (653 rpm's) which created excessive malfunctions. The committee decided that Dupont 8208-4 would be qualified and that the qualification for CR 8136 should be withdrawn. In addition, Mr. Conlin of Frankford was asked to take immediate action to procure 8208-4 and use it in cartridge production as soon as possible in quantities which would provide experience sufficient to determine that 8208-4 can be satisfactorily produced.

ACTION: FA

4. The committee discussed the interrelationship between the buffer design, the new propellant, and the blank and blank firing attachment. It was agreed that by qualifying the new propellant (8208-4), price competition should result. Also the two propellants (WC 846 and 8208-4) cause the rifle to perform in much the same manner and when the new buffer is incorporated the cyclic rate should be reduced to a more acceptable level (definitely within the range of 650-850 rpm's). Lastly the blank and blank firing attachment will probably work satisfactorily with the new buffer, but this must be verified prior to continuing with the blank and blank firing attachment program. Springfield will check this performance immediately after it has been determined which of the buffers is to be put into use. ACTION: SA

5. The committee then discussed fouling of the rifle. During the discussion, it was pointed out that present methods of determining fouling are subjective and, therefore, very inconclusive. It was resolved that Frankford Arsenal would investigate fouling and recommend necessary changes to specifications to adequately test and control fouling in the acceptance of ammunition. Meanwhile, if Colt's, during their rifle reliability testing, is required to use cartridges loaded with WC846 propellant, they may request a waiver on the restriction of only cleaning the rifle every 1,000 rounds if the results are unsatisfactory due to fouling. ACTION: FA

6. Before adjournment the committee was provided the minutes of a meeting held at Frankford on 29 March 1966 (inclosure 3), in which cyclic rate of the M16/XM16E1 Rifle was discussed. These minutes indicate that any reduction in cyclic rate is desirable from an automatic accuracy and ammunition expenditure point of view as long as reliable functioning of the rifle is retained.

H P Underwood

H. P. UNDERWOOD
Major, GS
Recorder

3 Incls
as

ATTENDEES

NAME	ORGN	OFC SYMBOL	ADDRESS	TELE
Maj H. P. Underwood	USAWECOM	AMCPM-RS	RIA, RI, Ill.	6843
C. L. Crider	USATECOM	AMSTE-BC	APG, Md.	3608
A. E. Whitner	Wpns Prod Eng Cen	WEP	USNAD Crane, Ind.	325
F. E. Sturtevant	Colt's Inc	N/A	Hartford, Conn.	527-4101
W. C. Davis	Colt's Inc	N/A	Hartford, Conn.	527-4101
Col H. W. Yount	USAWECOM	AMCPM-RS	RIA, RI, Ill.	5546 ✓
C. E. Freeman	USAWECOM	AMCPM-RS	RIA, RI, Ill.	6636 ✓
W. S. Aumen, Jr.	AFATL	ATWG	Eglin AFB, Fla.	882/2488 ✓
Maj M. S. Edmunds	USMC	CSY	Wash, D. C.	41341
C. E. Shindler	FA	U4300	Phila, Pa.	6112
S. W. Spaulding	USAMUCOM	AMSMU-RE-M	Dover, N. J.	2269 ✓

Incl #1

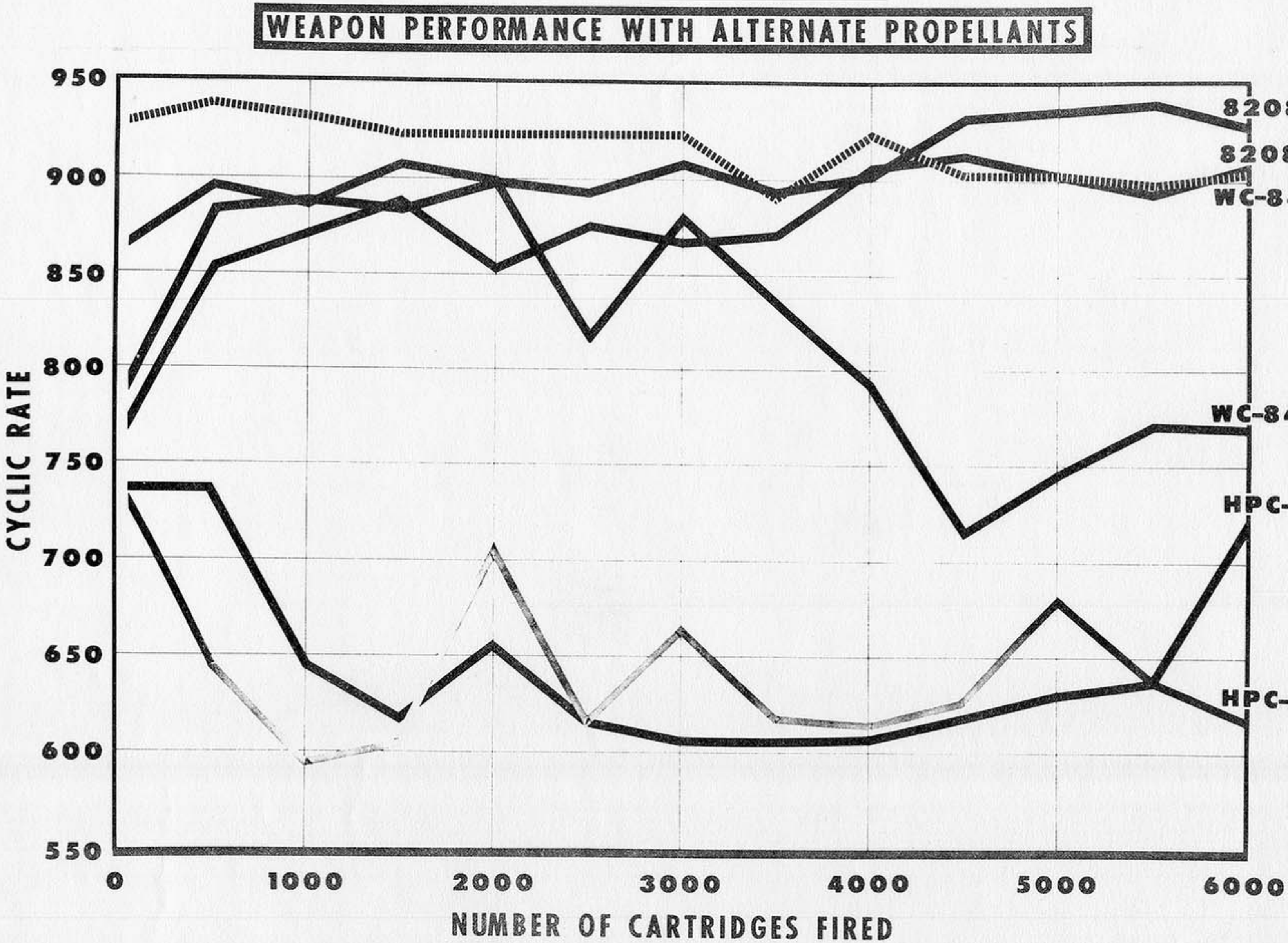
INVESTIGATION OF ALTERNATE PROPELLANTS
FOR USE IN 5.56MM BALL M193 AMMUNITION

BALLISTIC SUMMARY OF RESULTS

Incl 2

	8208-4 (25.3)	HPC-11 (22.6)	WC 846 (28.3)	Propellant Spec MIL-P-3984	Ctg Spec MIL-C-9963
Velocity @70°, fps (F.A.)	3235	3227	3230	3250 + 20	3250 + 40
Standard Deviation (F.A.)	22	20	31	26	40
Velocity Change (125° vs. 70°F), fps	+73	+65	+3	+ no limit -250	+ no limit -250
Velocity Change (-65° vs. 70°F), fps	-121	-85	-114	+ no limit -250	+ no limit -250
Velocity Change @+160° conditioning, fps	+127	+91	+17	+ no limit -250	+ no limit -250
Velocity Change @-80° conditioning, fps	+6	+13	+7	+ no limit -250	+ no limit -250
Chamber Pressure @70°, psi (F.A.)	44,000	47,200	43,300	50,000 max	52,000 max
Chamber Pressure @ 70°, psi (F.A.) corrected to 3250 fps	44,700	48,300	44,100	50,000 max	52,000 max
Chamber Pressure Change (125° vs. 70°F), psi	+1700	+2000	-1150	+5000 -no limit	+5000 - no limit
Chamber Pressure Change (-65° vs. 70°F), psi	-400	+600	+50	+5000 - no limit	+5000 - no limit
Chamber Pressure Change @+160° conditioning	+1650	+2300	+3500	+5000 - no limit	+5000 - no limit
Chamber Pressure Change @ 80° conditioning	-1200	-200	-1800	+5000 - no limit	5000 - no limit
Chamber Pressure, Max Individual @Extreme temperature	54,300	54,600	59,300	62,000	-

	8208-4	BPC-11	WC 846	Propellant Spec MIL-P-3984	Ctg Spec MIL-C-9963
Port Pressure @70, psi (P.A.)	15,700	14,300	15,500	15,000 ± 2,000	15,000 ± 2,000
Port Pressure Change (125° vs. 70°F), psi	-100	-200	+50	±2,000	±2,000
Port Pressure Change (-65° vs. 70°F), psi	-150	+150	-100	±2,000	±2,000
Port Pressure Change @ +160° conditioning, psi	-100	-400	-300	±2,000	±2,000
Port Pressure Change @ -80° conditioning, psi	+100	-0-	-50	±2,000	±2,000
Smoke	Approximately same	Slightly less	Control	Not more than control	-
Flash	Slightly less	Slightly less	Control	Not more than control	-
Fouling	Better	Better	Control	Test requirement 1500 rds.	1000 rds.
Noise Level	148.2 DB	148.2 DB	149.3 DB	-	-
Sound Pressure	0.07 psi	0.07 psi	0.08 psi	-	-
Action Time, MS	1.37	1.50	1.27	2.5	4.0
Barrel Erosion, Velocity Drop	+6	-40	-2	-	-
Accuracy, A_o, MR @100 yds. (XM16E1)	1.0"	1.2"	1.3"	-	-
Accuracy, A6000, MR @100 yds (XM16E1)	1.1"	1.3"	1.4"	-	-
Velocity, V_o, fps (XM16E1)	3120	3067	3151	-	-
Velocity, V6000, fps (XM16E1)	3126	3027	3149	-	-
Cyclic Rate Average (12,000 rds in 2XM16E1's)	887	653	893	-	-
Cyclic Rate, Individual Low	727	571	700	-	-
Cyclic Rate, Individual High	967	863	997	-	-



WEAPON PERFORMANCE WITH ALTERNATE PROPELLANTS
CYCLIC RATE
950
900
850
800
750
700
650
600
550
0
1000
2000
3000
4000
5000
6000
NUMBER OF CARTRIDGES FIRED
8208-4
8208-4
WC-846
WC-846
HPC-11
HPC-11

MEETING AT FRANKFORD ARSENAL

29 MARCH 1966

SUBJECT: CYCLIC RATE OF FIRE
M16/XM16E1 RIFLE

Incl 3

MEETING RATE OF FIRE XM16E1 RIFLE

29 MARCH 1966

AGENDA

Introduction - Major H. P. Underwood
Frankford Arsenal Presentation - Dr. W. J. Kroeger
Ballistic Research Laboratories Presentation - Mr. S. Lentz
Colt's Inc Presentation - Mr. W. C. Davis Jr.
Discussion

29 March 1966

INTRODUCTION

As you have observed from our teletype, our discussion today will center around the subject of "Rate of Fire of the XM16E1 Rifle".

To give you some background: not by APG!

In November of 1965 it was reported to us from Aberdeen Proving Ground that they were experiencing an exceptionally high number of malfunctions of all types during the testing of the XM16E1 Rifle in the SAWS Program. These malfunctions and some parts breakage were attributed to the higher cyclic rates which were encountered when cartridges using Olin Propellant WC 846 were fired in the weapons. In addition to the foregoing excessive fouling of weapons when using cartridges loaded with Ball Propellant was reported by Ft. Ord, California.

In order to determine whether or not these statements were well founded and if these reported conditions represented a present or potential field problem the Project Manager for Rifles on 25 November 1965 requested Frankford Arsenal to conduct a test program which consisted of the following:

Two 5.56mm, Ball, M193, Ammunition Lots, WCC 6089 (Olin Manufacture) and RA 5074 (Remington Manufacture) were fired in four XM16E1 and two AR15 rifles. Physical, chemical, metallurgical and ballistic tests were performed to determine ammunition characteristics. Each rifle was fired for accuracy and velocity initially and after each 3,000 rounds of firings in a 12,000 round test. The rifles were inspected after each 1,000 rounds and malfunctions, stoppages and cyclic rates were recorded. Frankford Arsenal concluded in their final report dated February 1966 that Cartridge Lot WCC 6089 gave a lower chamber pressure, a higher port pressure, a higher cyclic rate, a greater malfunction rate, greater fouling, more variations in handling, and less bore erosion than did Lot RA 5074. We have copies available for your use at this meeting; if you wish to obtain one on a permanent basis, please contact USAWECOM (Office for Rifles, Mr. Pilcharsky).

YOUNT

During the M16E1/XM16E1 Rifle Technical Coordinating Committee Meeting held at Frankford Arsenal on 12 & 13 Jan 1966 an interim report was made on the results of the tests. The committee agreed that the malfunction rate was not serious enough to interfere with combat operations in the field, but enough to warrant corrective action. Corrective actions recommended and approved by the committee were as follows:

a. Colt's Inc to design a new buffer to reduce cyclic rate of weapon.

b. Frankford Arsenal to continue to investigate the problems caused by Ball Propellant and determine what changes to the ammunition purchase description could be made to define acceptable performance with Ball as well as IMR Propellant.

INTRODUCTION (Cont'd) 29 March 1966

Since it is the feeling of the Project Manager, Col Yount, that solutions to the problems involved are dependent on systems analysis supported by sound engineering computation and test data he agreed to sponsor a conference of this type as proposed by Frankford Arsenal. It is our hope that at the conclusion of today's meeting we will have gained a better knowledge of the dynamics of the subject weapon, and a more complete definition of ammunition interface problems, and through proper application be able at a subsequent meeting possibly on 12 April determine the most appropriate solutions to these problems.

SUMMARY OF FRANKFORD ARSENAL PRESENTATION 29 MARCH 1966

Frankford reported progress on its "theoretical model" for simulation of the 5.56mm XM16E1 rifle system. The model predicts a characteristic curve of rate-of-fire of the rifle versus the bolt- bolt-carrier velocity, V_o, impacted by the ammunition.

Here V_o is the common velocity achieved by bolt and bolt-carrier as a result of all forces traceable to the cartridge (viz., gas flow to the bolt-carrier, forces to extract case, etc.). It is the predominant "ammunition input" to the system.

The corresponding rate-of-fire R is then the dynamic response of the rifle as determined by its mechanical parameters. This response, with and without buffer compression, has been calculated for a range of V_o. (The system "model" is still idealized," since friction and other energy dissipative effects such as ammunition feed have not yet been included; these will be included in future steps.)

The rate-of-fire curve of this simple "model" has a minimum R_{min} which is a characteristic of each rifle, and is independent of the ammunition; i.e., each rifle has a $(V_o)^*$ corresponding to its R_{min}, or the V_o^* found for any rifle will not necessarily produce R_{min} in another rifle. Ammunition impulses V_o, less than the value V_o^* required to produce R_{min}, fall in the "short recoil" or non-rebounding" region. Ammunition impulses which exceed V_o^* for R_{min} fall in the "rebound region" (i.e., represent rebound of the carrier after buffer compression).

Potential causes of weapon or cartridge malfunction, such as insufficient carrier displacement to extract or to feed; magnitudes of kinetic energy just prior to rearward buffer impact or just before forward bolt impact; time-phase relations of weapon-cartridge kinematics; are being surveyed to trace and identify the criteria governing the specific malfunctions observed in recent test firings. While the study is yet incomplete, we are proceeding with the hypothesis that many, if not all criteria for specific malfunctions will correspond with specific regions of the R versus V_o curve. (Case "stiction" and specific dimensional malfunction have been so identified).

If malfunction criteria can be thus mapped into "zones" on the R versus V_o diagram, it may be possible to discern corresponding "zones" of optimum performance for the ammunition-rifle. We believe this "zone" of optimum performance will lie in the rebound region and will have its left edge near the minimum (R_{min}).

Frankford presented a tentative scheme for acceptance of ammunition lots in the event measures are needed to insure their rate-of-fire performance. A group of selected calibrated XM16E1 rifles would be chosen. A set of calibration lots would be supplied, giving a range of impulses V_o. By firing these in the test rifle, it could then be calibrated in terms of rate-of-fire, including a point at R_{min}. By firing the lot sample, its rate-of-fire R_{lot} would be measured. The ratio $n_{lot} = \frac{R_{lot}}{R_{min}}$ must pass the acceptance criteria established,

$$N_{min} \leqq N_{lot} \leqq N_{max}$$

MALFUNCTION CRITERIA

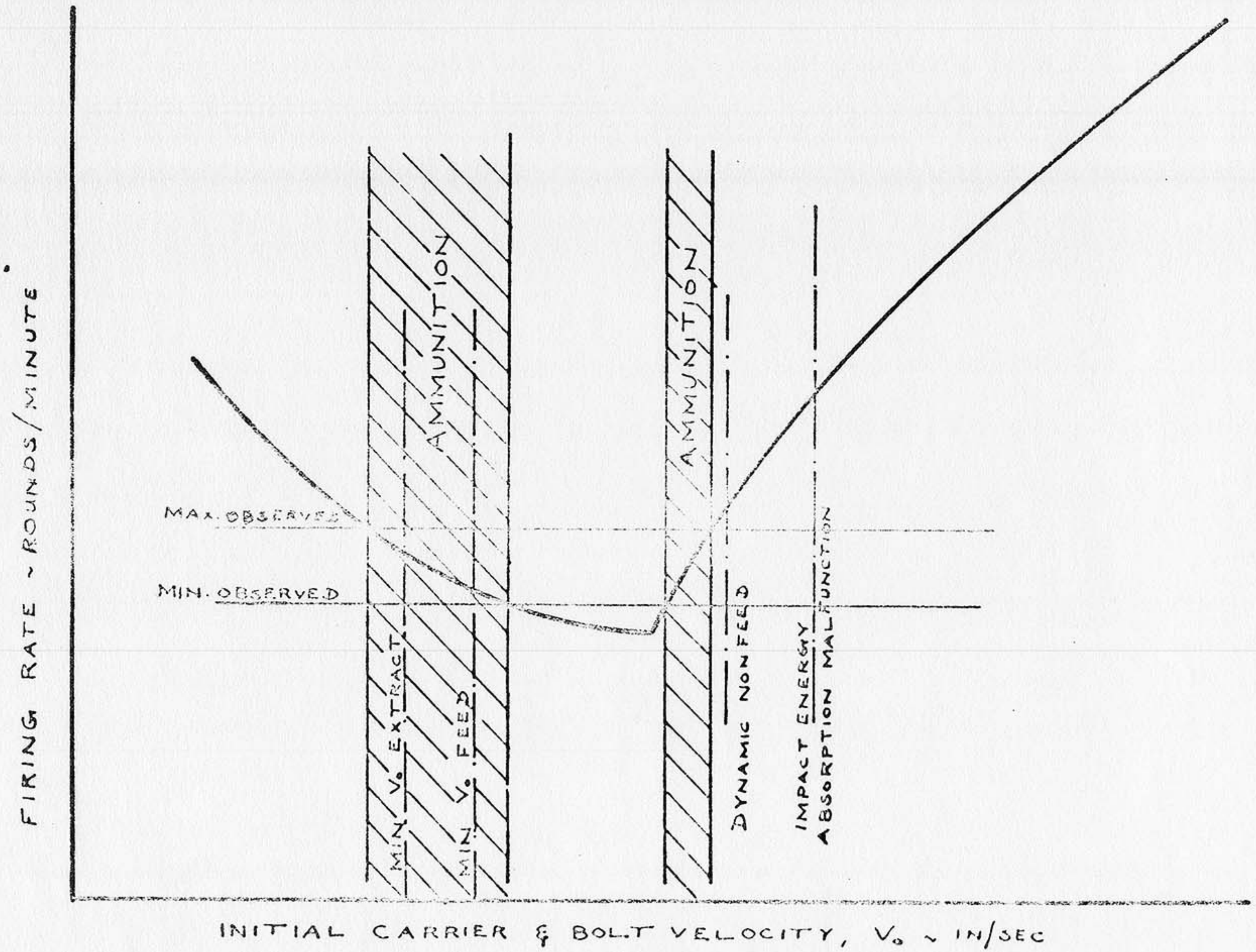


FIG 8

22

FIRING RATE

(BUFFER EFFECT INCLUDED)

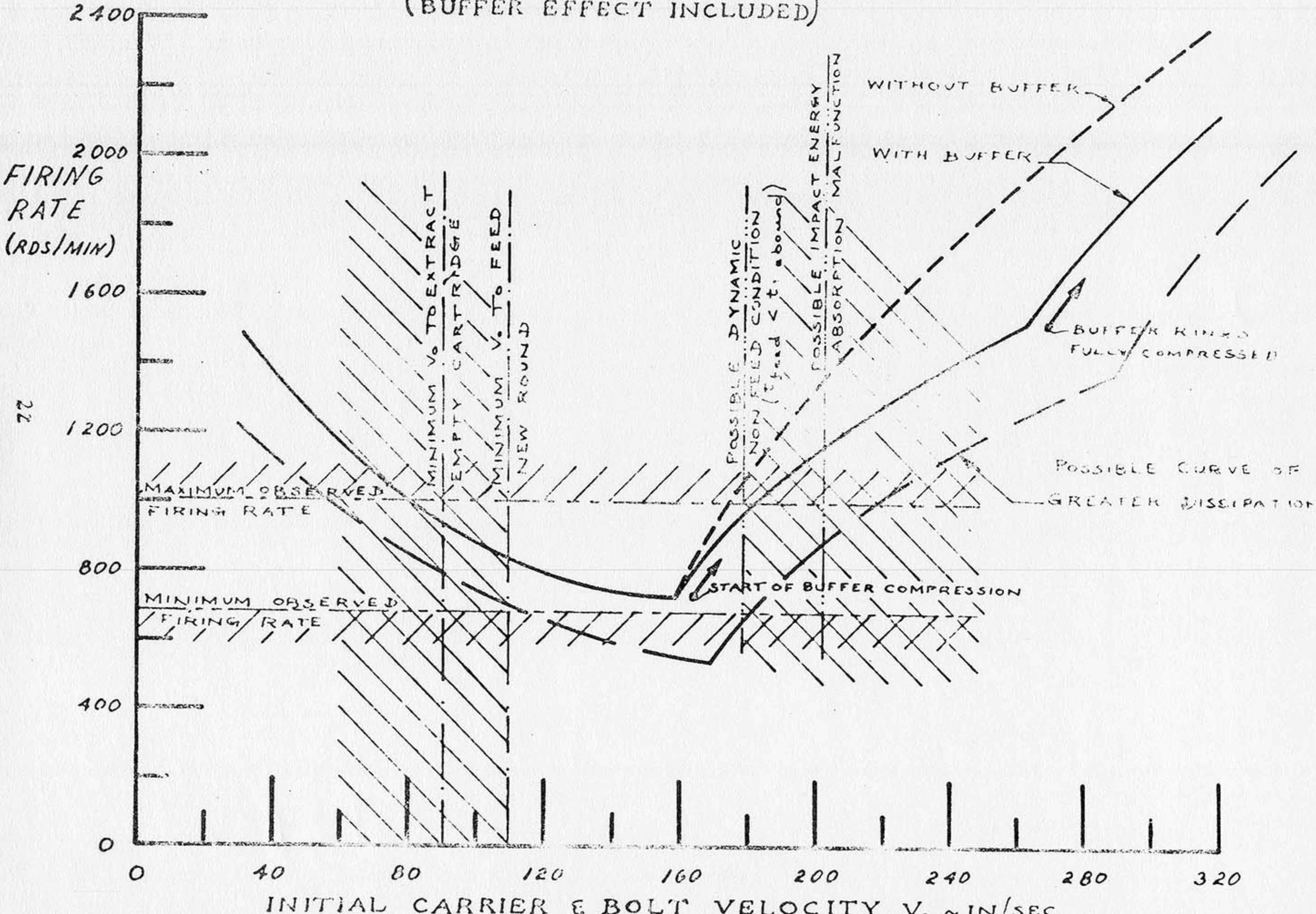
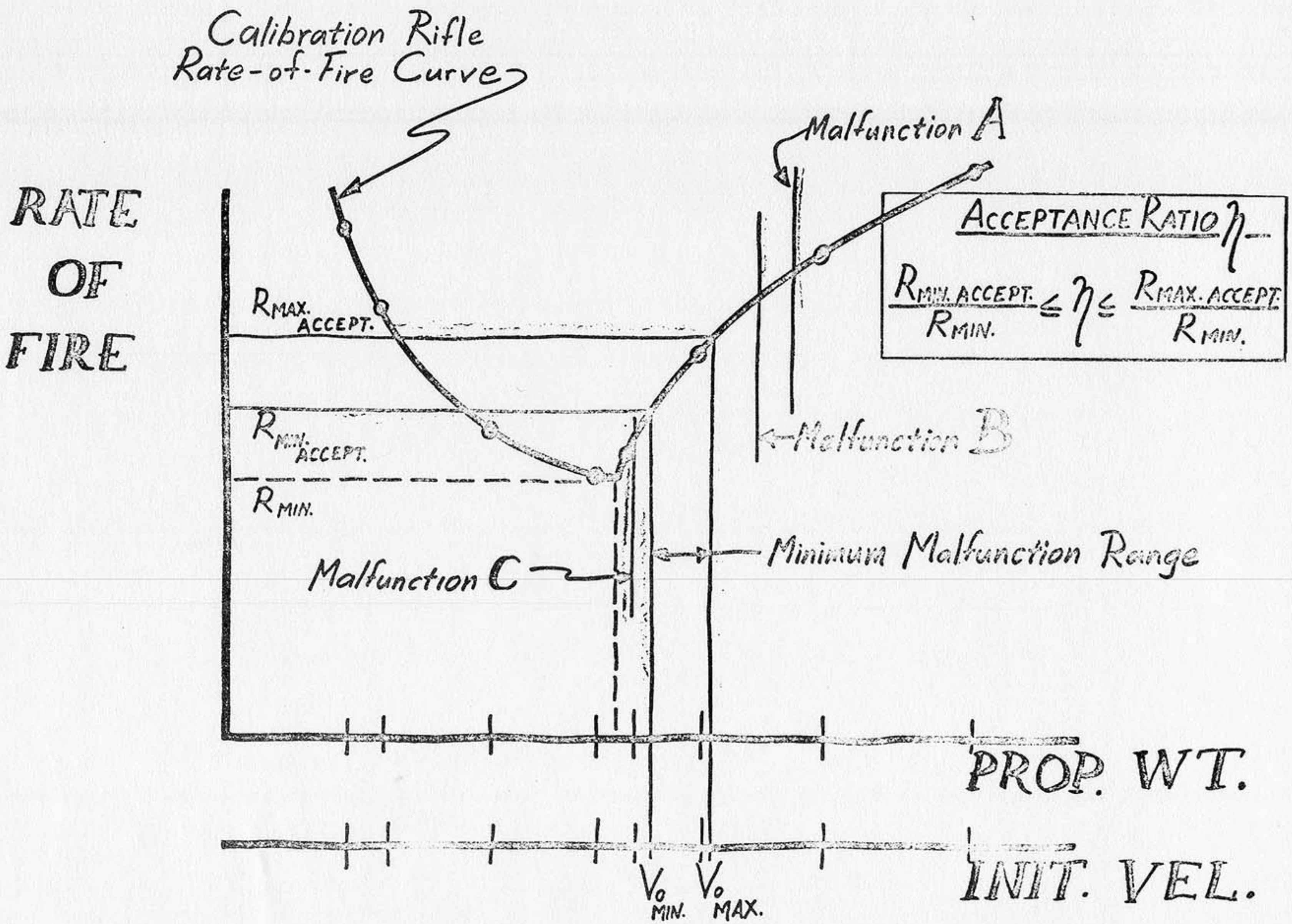


FIG 9



Calibration Rifle Rate-of-Fire Curve
Malfunction A
RATE OF FIRE
ACCEPTANCE RATIO η -
$\frac{R_{MIN.ACCEPT.}}{R_{MIN.}} \leq \eta \leq \frac{R_{MAX.ACCEPT.}}{R_{MIN.}}$
$R_{MAX.ACCEPT.}$
$R_{MIN.ACCEPT.}$
$R_{MIN.}$
Malfunction B
Minimum Malfunction Range
Malfunction C
PROP. WT.
INIT. VEL.
$V_{o\ MIN.}$
$V_{o\ MAX.}$

Frankford also reported on its studies of the impulse V_o imparted to the XM16E1 by specific ammunition lots. This has been done by three methods:

(a) theoretical calculations of gas inputs to the bolt-carrier based on the port pressure-time data of the ammunition lots in question;

(b) very recently performed pressure-time measurements made near the outlet of the gas-tube; and

(c) through integration of accelerometer-time, velocity measurements of the bolt. (Both (b) and (c) were carried out in automatic fire (20 rounds)).

The integrated impulses predicted by all three methods are reasonably self-consistent and so far have ranked the ammunition lots in the correct sequence to explain observed rates-of-fire. More of the experimental measurements need to be made, however before all questions about absolute magnitude and time characteristics can be resolved.

SUMMARY OF COLT'S INC PRESENTATION ON 29 MARCH 1966

The following is extracted from Colt's Inc. report entitled, "Test of Experimental Propellants for 5.56MM M193 Ball Ammunition in M16 Rifles". Date of report 23 March 1966. These items are particularly pertinent to the subject meeting.

At the request of the M16/XM16E1 Rifle Technical Coordinating Committee, Colt's Firearms Division carried out some tests on 5.56mm ball ammunition containing samples of two experimental propellants. The samples available were small, and the tests were not exhaustive, or intended to be definitive by themselves. They were intended instead to supplement other tests being carried out simultaneously, under Army auspices, at Frankford Arsenal and at Aberdeen Proving Ground.

The test material consisted of two samples, of 2000 rounds each, containing respectively a Dupont propellant designated EX8208-4 (from packaging labels) and Hercules HPC-11. Propellant EX8208-4 is an extruded tublar-grain type, reported to be of single-base composition. Propellant HPC-11 is an extruded tubular-grain type, reported to be of double-base composition. The ammunition containing EX8208-4 employed cartridge cases of Federal manufacture. The average charge weight in five rounds containing EX8208-4 was 25.3 grains, and the corresponding figure for the sample containing HPC-11 was 22.8 grains.

There was furnished also a 2000-round sample for control purposes, containing Olin WC 846 spherical-grain propellant. This sample employed Remington cases, and the cartons bore the identification number 223-163. The average charge weight, determined from a sample of five rounds, was 28.2 grains.

Ten M16 rifles were employed for cyclic-rate tests, using a Watchmaster cyclic timer. One 20-round burst was fired with each rifle, with each of the test samples and with the control sample of ammunition. This schedule was fired first using the standard action-spring guide assembly (buffer), corresponding to Colt's Drawing 62119. Each rifle had installed its original and different specimen of the standard buffer. From each of the rifles in turn, the standard buffer was removed, and replaced by one (the same) specimen of Colt's experimental buffer assembly (Drawing 62339), and the cyclic-rate test was repeated. A summary of these results follows:

CYCLIC RATE, RDS/MIN

	Standard Buffer			Experimental Buffer		
	WC846	EX8208	HPC-11	WC846	EX8208	HPC-11
Trial 1	912*	803	681	789	726	645
Trial 2	934	857	743	797	752	687
Trial 3	891	773	663	773	708	647
Trial 4	867	740	638	773	697	600
Trial 5	938**	838	740	800	757	673
Trial 6	950*	905	786	823	765	689
Trial 7	905	800	689	745	728	608
Trial 8	851	738	642	731	651	575
Trial 9	942	823	697	797	750	665
Trial 10	905	784	717	786	738	681
Average Rate	910	806	700	781	727	647
Highest Rate	950	905	786	823	765	689
Lowest Rate	851	738	638	731	651	575

REMARKS: *Bolt failed to remain rearward after last round was fired.
**One failure to eject occurred.

The foregoing table permits the following further comparisons of differences, in respect to average cyclic rates, obtained with the three respective ammunition samples, and with the two designs of buffer:

	EX8208	HPC-11
Average difference of test sample from control sample (WC846):		
With standard buffer:	-104 rds/min	-210 rds/min
With experimental buffer:	-54 rds/min	-134 rds/min

Average difference of experimental buffer from standard buffer:	
With control sample (WC846):	-129 rds/min
With EX8208 sample:	-79 rds/min
With HPC-11 sample:	-53 rds/min

FOULING TEST:

Only one M16 rifle was used for this test, because the ammunition samples were not large enough to obtain meaningful results on a larger number of weapons. This weapon was thoroughly cleaned before firing each type of ammunition. Each ammunition sample was fired in turn. With each sample, 1000 rounds were fired. The schedule of firing was 80 rounds semiautomatic and 20 rounds automatic, with cooling after each 100 rounds, which is the schedule prescribed for standard endurance testing of M16/XM16E1 rifles.

With the control sample, containing WC846 propellant, there were no malfunctions during the 1000-round schedule. Upon completion of firing, there was evidence of bore fouling in the region from the front-sight position to the muzzle. The amount of fouling visible in the vicinity of the bolt, barrel-extension, and upper receiver was noted for later comparison.

With the test sample containing HPC-11 propellant, the weapon functioned normally and without stoppages for 700 rounds. Upon commencement of the eighth 100-round cycle, the first eight rounds failed to give full recoil of the bolt. The weapon thus required manual charging 8 times. The weapon then resumed normal functioning. After cooling, upon commencement of the ninth cycle, the weapon behaved in the same way, and ten kounds were charged manually before normal functioning was resumed. Performance was exactly similar at beginning of the tenth cycle ten rounds being manually charged before normal functioning resumed. Upon completion of the 1000-round schedule, the visible accumulation of fouling in both bore and mechanism was remarkably small, being much less than that observed after the firing of the control sample.

With the test sample of EX8208-4 propellant, there were no malfunctions during the 1000-round schedule. The visible accumulation of fouling was less than that of the control sample, but more than that of the sample containing HPC-11 propellant.

OBSERVATIONS:

CYCLIC RATE:

The cyclic rate of fire, using the standard buffer assembly, and the control sample of ammunition, was much too high. None of the ten rifles met the criteria of 650-850 rds/min, based on a single trial, with this combination of buffer and ammunition sample. Three malfunctions occurred which might reasonably be ascribed to high cyclic rate of fire.

Using the test sample containing EX8208 propellant, and the standard buffer assembly, two of the ten rifles exceeded the upper limit of 850 rds/min in cyclic rate of fire. The mean cyclic rate with the group of ten rifles was 56 rds/min above the nominal design rate of 750 rds/min for the M16.

Using HPC-11 propellant, the cyclic rate was much lower than with the other samples. With the standard buffer assembly, two of the ten rifles failed to meet the lower limit of 650 rds/min, and the mean of the group was 50 rds/min below the design rate of 750 rds/min. Rates of fire below 650 rds/min, especially with the standard weight of recoiling parts (buffer), is indicative of marginal operating energy, and indicates risk of short-recoil malfunctions under adverse conditions. However, no such malfunctions occurred in this limited firing, with clean well lubricated weapons.

Using the experimental buffer assembly, all of the rifles met the cyclic-rate criteria of 650-850 rds/min, with both the control sample of ammunition (WC846) and the test sample containing EX8208. However, with this buffer assembly and HPC-11 propellant, five of the ten rifles failed to meet the lower limit of 650 rds/min. No malfunctions occurred in this limited firing, however, with any of the ammunition samples.

FOULING AND FUNCTIONING:

In the 1000-round fouling test, the control sample (WC846) gave the greatest amount of visible accumulation of residue, and the test sample containing EX8208 gave the next greatest visible accumulation. However, no malfunction occurred during the firing of these two samples.

The sample containing HPC-11 gave the least amount of visible fouling during the 1000-round test, but short-recoil malfunctions occurred after 700 rounds, and persisted thereafter whenever the rifle was allowed to cool before resumption of firing. It therefore appears that the relatively low operating energy which the HPC-11 provides for the M16 gas system (as was apparent from the low cyclic rates) as insufficient to overcome even the resistance of the small accumulation of fouling which results from use of this propellant.

CONCLUSIONS:

It must be emphasized that the following conclusions are limited to the extent that the respective samples of ammunition furnished are representative of the propellant types employed. They are limited also to the characteristics which could be investigated with the rather small samples available, and do not take account of such characteristics as chamber pressure, port pressure, environmental conditions, etc., which are being investigated separately in the more comprehensive programs of government testing agencies.

In these tests, the test sample containing EX8208 propellant gave generally satifactory performance in M16 rifles, both with the present standard buffer and with the experimental buffer now being evaluated for use in the M16/XM16E1. With the standard buffer, however, the upper limit of 850 rds/min is occasionally exceeded.

In these tests, the test sample containing HPC-11 propellant gave evidence of producing insufficient operating energy for reliable gun functioning. In all other respects, its performance was very satisfactory.

In these tests, the control sample containing WC846 gave excessively high cyclic rates of fire, when the standard buffer was used. With the experimental buffer assembly, the cyclic rates of fire were satisfactory. The accuracy of the control sample was also unsatisfactory for testing of rifles, but the uncertain influence of important uncontrolled variables (especially the quality of bullets employed in this sample) prevents making any meaningful comparison among the propellant types in respect to their respective effects on accuracy.

Mr. Lentz discussed BRL studies as background to our Rate of Fire considerations.

1. Prediction Formulas:

In considering the dispersion of the normal 3 shot target pattern in automatic fire, if the total time involved is less than man's reaction time (0.14 to 0.20 seconds), the contribution of the first shot to the target dispersion for the second shot, θ_2, can be computed from the prediction formula (for the standing mode of fire):

$$\theta_2 = A_2 \frac{\left[L_x (h + a + \Delta h + \delta h) - L_d (1)\right]}{I \cdot R} \qquad \text{- - - - (1)}$$

θ_2 = angle between first and second shot.

L_x = impulse of rifle (without brake or compensator).

L_d = counter impulse due to compensator, etc.

h = lever arm (℄ of bore to ℄ of butt).

a = effective lever arm (℄ to butt to c.g. of "man-weapon".

l = lever arm for counter impulse.

Δh = variation in butt-plate shoulder positions for individual.

δh = " " " " " among individuals.

I = movement of inertia of rifle.

R = cyclic rate of rifle.

When counter impulses (muzzle brake, compensator) are available, it may be possible that

$$L_x (h + a) - L_d \cdot 1 = 0 \qquad \text{- - - - (2)}$$

Then the prediction formula becomes

$$\theta_2 = A_2 \left[L_x \frac{(\Delta h + \delta h)}{I.R}\right] \qquad \text{- - - - (3)}$$

It is again emphasized that this relation holds only if the time represented in going from first to second round is less than the reaction time of the individual.

2. Typical Values

From many tests, subject to a computer-smoothing program, the value of $A_2 \cong 3100$.

$L_x \cong$ 1.18 to 1.30 lb. secs. (without brake)

= approximately 2/3 of this with brake.

$\Delta h = \pm 0.3''$, $Sh = \pm 1.2''$

For a three round burst from the M16 Rifle, the total spread from the first shot may be as much as 100 - 120 m̸, or about 30-40 m̸ between the first and second shot.

This is to be compared with the value of the aiming error, which is about 3.4 m̸, and the normal "weaving" error, which is about 5 m̸.

In general, for the quick fix situation, where a short burst is desired, it appears desirable to keep R up. This is typical of the assault situation. On the other hand, usually at longer ranges, where time is not critical and where a very long burst of searching fire is desired, we may want to lower R. Here the individual will have time to gain control of the weapon and redirect and compensate its aim.

The situation becomes much more complex, when man's reactions have time to assert control over the weapon pattern. These may be voluntary or involuntary; for example, in the standing position, the left arm becomes a "spring".

3. Rate of Fire Experiments.

The BRL has been exploring the extreme spread obtained in one to three round bursts, which are delivered in times less than man's reaction time, over ranges of fire from single shot and semi-automatic to about 600 rpm, and from 1100 rpm to about 2800 rpm. In the low rate of fire regime, the extreme spread approaches asymptotically to the value of the "weaving" dispersion at zero rate of fire. The dispersion then rises with rate of fire.

On the other hand, in the higher regime (from 1100 to 2800 rpm), extreme spread decreases with rate of fire. In the central regime (600 to 1100 rpm) not yet covered by experiment, it may have a maximum.

4. Control Pattern

Considerations have also been given to achieving a control pattern for coping with certain field situations such as "human wave tactics". Here the idea is to sweep the weapon across a broad linear distribution of targets with initial values of horizontal and vertical velocity. The values of R and choices of initial velocity which will then lead to a controllable and effective shot-pattern are being studied.

5. In the subsequent discussions, it appeared that the BRL experience indicated that the present M16 rate of fire could be lowered from the 900 rpm level to some lower value, probably with significantly beneficial effects on the extreme spread of shot pattern in both the short burst situation, and in the long burst search situation.

Major Pfanzelter (USACDC) offered the following:

The user will accept the lowest rate of fire that will function the weapon properly in automatic fire. Lower rate will permit the soldier to get back on target and not waste ammunition.

In general all attendees agreed that a lower cyclic rate of fire in the XM16E1 rifle would be desirable and beneficial. The optimum rate, considering all factors discussed, appears to be between 575 and 850 rpm.

MEETING 29 MARCH 1966

ATTENDEES

NAME	ORGANIZATION	ADDRESS	PHONE
V. W. Walters	Frankford Arsenal	U1000	X4142
C. M. Dickey	Frankford Arsenal	U2100	X5121
Dr. Mel Zaid	Technik Inc	50 Jericho Tpk Jericho, N.Y.	516-ED-3-3750
Lt C. P. Armstrong	Frankford Arsenal	A1000	X24240
C. F. Packard	Springfield Armory	SWESP-RED	(413) RE9-6911 X3157
Stanley S. Lentz	Ballistics Res Lab	AMXBR-ID	X4771
William J. Kroeger	Frankford Arsenal	SMUFA-H1000	X4100
Maj M. R. Pfanzelter	Hq USACDC	Ft. Belvoir, Va.	43337
Foster E. Sturtevant	Colt Inc	Hartford, Conn	527-4101
William C. Davis Jr.	Colt Inc	Hartford, Conn	527-4101
C. E. Freeman	U.S. Army Weapons Cmd	Rock Island, Ill	X6636
Capt W. T. Barrett	U.S. Army Weapons Cmd	Rock Island, Ill	X6818
Scott W. Spaulding	U.S. Army Munitions Cmd	Dover, New Jersey	3232, 2269
Maj H. P. Underwood	Project Manager, Rifles	Rock Island, Ill	794-6843
A. P. Batezell	Frankford Arsenal	B1000	X7289
F. J. Shinaly	Frankford Arsenal	U3000	X4200
E. R. Barrett	Springfield Armory	SWESP-PMM	X4128
S. Kucsan	Frankford Arsenal	U2100	X7179
W. A. Dittrich	Frankford Arsenal	U3100	X23247
F. A. Malinoski	Frankford Arsenal	U2100	X5122
H. Jaslow	Technik Inc	50 Jericho Tpk Jericho, N.Y.	516-ED-3-7520
A. Hirsch	Frankford Arsenal	U4300	X21130
L. F. Moore	Frankford Arsenal	U4200	X24148