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M16A1 RIFLE ACCURACY PARAMETERS

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

An accuracy test program was conducted to determine which factors if any limit the accuracy of the M16A1 Rifle, those factors being; looseness of the weapon's components, lubrication, corrosion, mixing of different types of ammunition, and types of rests used.

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M16A1 RIFLE ACCURACY PARAMETERS

DECEMBER 1973

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ABSTRACT

This test program was conducted at Rock Island Arsenal by the Weapons Test Division from 20 March to 11 April 1972. The purpose of the program was to determine the effect of each of the following parameters on accuracy of the M16A1 Rifle:

1. Loose sights
2. Looseness between upper and lower receivers
3. Loose handguards
4. Lubricant, corrosion, and heat in the bore
5. Mixing of ball and tracer rounds
6. Type of rest

SECTION 1: SUMMARY

1.1 BACKGROUND

In September 1970, USAWECOM sent LTC Eugene West and Mr. Lawrence Moore to Viet Nam to assess the accuracy and physical condition of M16A1 Rifles being used in Southeast Asia. Upon their return, they reported several conditions which might be deleterious to accuracy. Their observations guided the direction and depth of this study.

1.2 TEST OBJECTIVES

The objective of this test program was to define which, if any, of several factors that might limit the M16A1's accuracy potential, actually do significantly affect accuracy. More specifically, the following six parameters were evaluated to determine their effects on M16A1 Rifle accuracy:

A. Loose sights

B. Looseness between upper and lower receivers

C. Loose handguards

D. Lubricant, corrosion, and heat in the bore

E. Mixing of ball and tracer rounds

F. Type of rest

1.3 DESCRIPTION OF MATERIEL

Ninety-nine used M16A1 Rifles were obtained from Viet Nam. Of these, ten were picked which best exemplified looseness in the handguards, receiver, and/or sights. These ten were inspected to quantitatively determine the looseness present. Nine of the ten were then used in the test; three were used for an analytical determination of the effect of loose sights while the other six were rebarreled and fired in the studies of loose handguards and looseness between upper and lower receivers.

In addition, seven new M16A1's and two M16A1's which had previously been fired in 6,000 round contractor endurance tests were fired during the test.

1.4 SCOPE

After the preliminary work described in Section 1.3, testing was conducted by the Weapons Test Division during the period from 20 March to 11 April 1972. In the main, testing followed the test plan, "M16A1 Rifle Accuracy Test Program", found in the Appendix. Deviations from that plan will be noted in Section 2 of this Note.

1.5 CONCLUSIONS

The following five factors were shown to have a significant effect on accuracy:

A. Looseness of sights can affect horizontal center of impact by as much as six minutes of angle. This may cause a similar increase in extreme spread.

B. Lubrication of the bore can affect the point of impact of the first one or two rounds fired after lubrication.

C. Heat can have an effect, usually deleterious, on both extreme spread and center of impact.

D. Firing tracer ammunition, or a mixture of tracer and ball can degrade accuracy when compared to the accuracy obtained when firing solely ball ammunition.

E. Firing from unsupported hand or from the bipod can cause changes in vertical center of impact compared to the center of impact when firing from a sandbagged rest.

The following four factors were not found to have a significant effect on accuracy:

F. Looseness between upper and lower receivers does not appear to have an effect on accuracy.

G. Loose handguards do not appear to have an effect on accuracy.

H. Firing limited quantities of tracer ammunition does not affect the accuracy of subsequently-fired ball ammunition.

I. Type of rest does not have a significant effect on extreme spread or horizontal center of impact.

SECTION 2: DETAILS OF TEST

2.1 EFFECT OF LOOSE SIGHTS ON ACCURACY

2.1.1 Objective

The objective was to determine the effect of loose sights on accuracy of the M16A1 Rifle.

2.1.2 Criteria

Looseness in the sights should be considered to have a significant effect on accuracy if such looseness could cause a change in extreme spread of more than 2.2 inches at 100 yards. The 2.2 inches criteria was chosen because new rifle acceptance criteria is 4.8 inches extreme spread at 100 yards and the user rejection criteria is 7.0 inches extreme spread at 100 yards. It is felt that any single parameter which could degrade the weapon from new-weapon-status to unfit-for-use is significant.

2.1.3 Method

From ninety-nine M16A1 Rifles out of Viet Nam, ten were chosen for a quantitative check of the vertical and horizontal looseness in the front and rear sights. A mathematical analysis was then accomplished to determine the effect of this looseness on accuracy.

2.1.4 Results

The looseness found in the sights of the ten weapons is recorded in Table 2.1-1.

Maximum experimental net movement between opposite equilibrium positions was .011 for both front and rear sight lateral movements. Calculations show that these movements in combination could lead to a horizontal sight misalignment of four minutes of angle or about four inches at 100 yards.

A dimensional analysis of the drawings revealed a maximum theoretical lateral rear sight movement of .022. Assuming that the maximum experimental and theoretical front sight movements are approximately equal, the maximum theoretical horizontal sight misalignment would be about six minutes of angle or six inches at 100 yards.

TABLE 2.1-1

M16A1 RIFLE SIGHT LOOSENESS

WEAPON S/N LOOSENESS	136773	150255	176734	516993	523741	832924	882510	922985	925102	925335
FRONT SIGHT VERTICAL	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
[1]FRONT SIGHT LATERAL	.000	.007	.008	.007	.004	.011	.006	.010	.003	.000
REAR SIGHT VERTICAL	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
[1]REAR SIGHT LATERAL	.011	.004	.000	.000	.007	.000	.000	.000	.000	.000
[2]REAR SIGHT LATERAL	.011	.004	.017	.020	.007	.005	.015	.000	.000	.006

[1]Net movement between equilibrium positions when sight is forced to opposite extreme positions and then released.

[2]Total movement when sight is forced to opposite extreme positions.

2.1.5 Analysis

Both the theoretical and the experimental horizontal sight looseness were significant when judged by the criteria of 2.1.2, but the vertical looseness was not.

2.2 EFFECT OF LOOSENESS BETWEEN UPPER AND LOWER RECEIVERS ON ACCURACY

2.2.1 Objective

The objective was to determine the effect of looseness between upper and lower receivers on the accuracy of M16A1 Rifles.

2.2.2 Criteria

Looseness between the upper and lower receivers should be considered to have a significant effect on accuracy if such looseness causes a change in extreme spread of more than 2.2 inches at 100 yards. The reasoning applied in Section 2.1.2 was also applied here.

2.2.3 Method

Ten M16A1 Rifles returned from combat in Viet Nam were measured for looseness between the upper and lower receivers. The three weapons exhibiting the most looseness were rebarreled and fired in this subtest.

First, each of the three test rifles was fired two ten-shot targets by each of two shooters under each of the following conditions:

CONDITION	DESCRIPTION
A	The original looseness was left in the handguards and between the receivers. Firing was done from a benchrest. The handguards and upper receiver were rotated to opposite extreme positions for alternate shots.
B	Same as "A" except that the handguards and upper receiver were allowed to seek their own positions.
C	Same as "A" except that firing was done from the prone position.
D	Same as "A" except that the handguards and upper receiver were allowed to seek their own positions, and firing was done from the prone position.
E	The original looseness was left in the handguards. The looseness was removed from the receivers by inserting shims between them. Firing was done from a benchrest. The handguards were allowed to seek their own positions.
F	Same as "E" except that firing was done from the prone position.

Then, each of the three test weapons fired was fired two ten-shot targets by one shooter under each of the following conditions:

CONDITION	DESCRIPTION
G	All looseness was removed from both the handguards and the upper receiver. Firing was done from a benchrest.
H	All looseness was removed from the handguards. The original looseness was left between the upper and lower receivers. The upper receiver was rotated to opposite extreme positions for alternate shots. Firing was done from a benchrest.

2.2.4 Results

The average extreme spread for all weapons and shooters is recorded by condition in Table 2.2-1. In addition, Table 2.2-1 also notes the difference in extreme spread between condition "A" and each of the other conditions. Since condition "A" exhibits maximum looseness and succeeding conditions have less looseness, any trend toward increased accuracy as the looseness is removed, should be reflected in consistently negative numbers in the ΔES column.

Only one condition differed significantly in extreme spread from condition "A". Condition "H" averaged 2.5 inches larger than condition "A". No cause for this unexpected increase in extreme spread could be found during the test. However, it was noted that the increase was due almost entirely to vertical stringing of the shots. It is hypothesized that perhaps the manner in which the handguards were epoxied to the barrel nuts was responsible.

2.2.5 Analysis

No detrimental effects on accuracy due to loose upper receivers and/or loose handguards were discernible in this test.

TABLE 2.2-1

EFFECT OF LOOSE HANDGUARDS & LOOSENESS BETWEEN UPPER & LOWER RECEIVERS ON ACCURACY

AVERAGE FOR ALL WEAPONS AND SHOOTERS	CONDITION							
	A	B	C	D	E	F	G	H
EXTREME SPREAD[1]	4.5	3.9	4.7	4.5	3.7	3.9	5.8	7.0
CHANGE IN EXTREME SPREAD	0	-0.6	+0.2	0	-0.8	-0.6	+1.3	+2.5

[1]All extreme spreads are for ten-shot targets fired at a range of 300 yards.

2.3 EFFECT OF LOOSE HANDGUARDS ON ACCURACY

2.3.1 Objective

The objective was to determine the effect of loose handguards on the accuracy of M16A1 Rifles. This subtest is essentially an extension of the previous subtest.

2.3.2 Criteria

Looseness in the handguards should be considered to have a significant effect on accuracy if such looseness causes a change in extreme spread of more than 2.2 inches at 100 yards. The reasoning applied in Section 2.1.2 was also applied here.

2.3.3 Method

Ten M16A1 Rifles, returned from combat in Viet Nam, were measured for handguard looseness. The three weapons exhibiting the most looseness were rebarreled and fired in this subtest.

Each of the three test rifles was fired two ten-shot targets by each of two shooters under each of the following conditions:

CONDITION	DESCRIPTION
J	The original looseness was left in the handguards. All looseness between the upper and lower receivers was removed by the insertion of shims. Firing was done from a benchrest. The handguards were rotated to opposite extreme positions for alternate shots.
K	Same as "J" except that the handguards were allowed to seek their own positions.
L	Same as "J" except that firing was done from the prone position.
M	Same as "K" except that firing was done from the prone position.
N	All looseness was removed from the handguards by a generous application of epoxy. No looseness was allowed between upper and lower receivers. Firing was done from a benchrest.
O	Same as "N" except that firing was done from the prone position.

2.3.4 Results

The average extreme spread for all weapons and shooters is recorded by condition in Table 2.3-1. That same table also shows the change in extreme spread due to removing looseness from handguards.

Any significant increase in dispersion due to looseness in the handguards should be reflected as positive numbers greater than 2.2 in the "Change In Extreme Spread" row of Table 2.3-1.

2.3.5 Analysis

No detrimental effects on accuracy due to loose handguards were discernible in this test.

TABLE 2.3-1

EFFECT OF LOOSE HANDGUARDS ON ACCURACY

AVERAGE FOR THREE WEAPONS & TWO SHOOTERS	CONDITION					
	J	K	L	M	N	O
EXTREME SPREAD[1]	5.2	4.5	4.4	4.3	4.1	4.5
	J-N	K-N	L-O	M-O	---	---
CHANGE IN EXTREME SPREAD	+1.1	+0.4	-0.1	-0.4	---	---

[1]All extreme spreads are for ten-shot targets fired at a range of 100 yards.

2.4 EFFECT OF LSA IN THE BORE ON ACCURACY

2.4.1 Objective

The objective was to determine the effect of lubricant in the bore on point of impact.

2.4.2 Criteria

Lubricant in the bore should not be considered to have a significant effect on the accuracy of M193 ball unless all of the following criteria are met for the average of all targets fired with M193 ball:

A. An increase in lubricant (condition O deposits more lubricant than condition P) must cause a corresponding increase in the distance from the first shot to the center of impact of the group.

B. Condition O must consistently cause the first round to be furthest from the group's center of impact.

Exactly the same criteria were applied for M196 tracer.

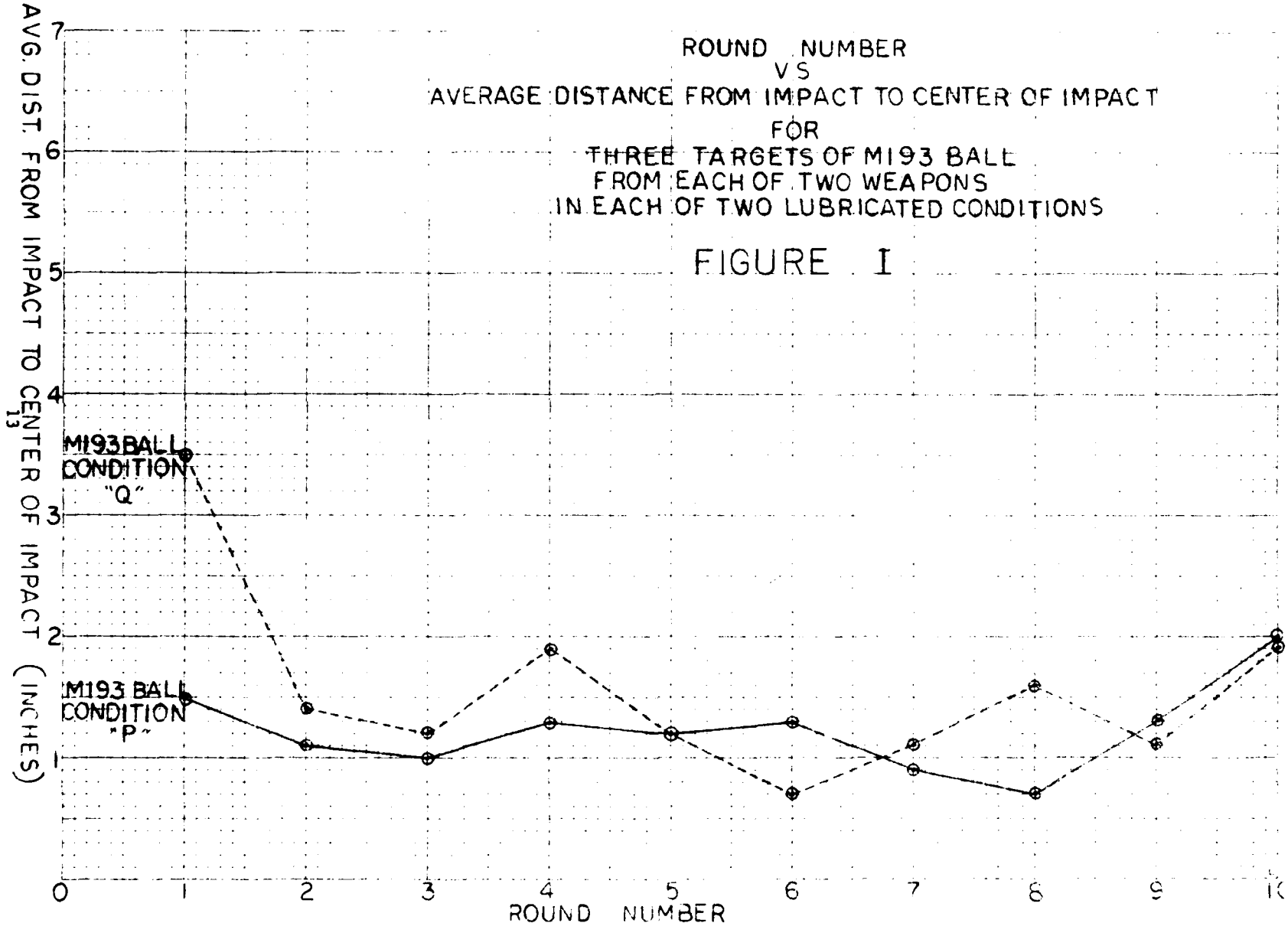
2.4.3 Method

Two M16A1 Rifles, one new and one 6,000 round endurance test rifle, were each fired three ten-shot targets of M193 ball and three ten-shot targets of M196 tracer under each of the following conditions:

CONDITION	DESCRIPTION
P	The weapon was cleaned and lubricated normally. A patch was dipped in LSA, squeezed dry, and passed one round trip through the bore. The chamber was dried with a clean patch and one ten-shot target was fired.
O	Same as "P" except that patch was not squeezed dry.

2.4.4 Results

Figures 1, 2, and 3 plot round number versus the average distance of that round's point of impact from the center of impact of the group. (Round number refers to the order of firing of the rounds of a ten shot target; 1 is the first round fired, 2 the second, etc.).


ROUND NUMBER
VS
AVERAGE DISTANCE FROM IMPACT TO CENTER OF IMPACT
FOR
THREE TARGETS OF M193 BALL
FROM EACH OF TWO WEAPONS
IN EACH OF TWO LUBRICATED CONDITIONS
FIGURE I
AVG. DIST. FROM IMPACT TO CENTER OF IMPACT (INCHES)
M193 BALL CONDITION "Q"
M193 BALL CONDITION "P"
0
1
2
3
4
5
6
7
8
9
10
ROUND NUMBER

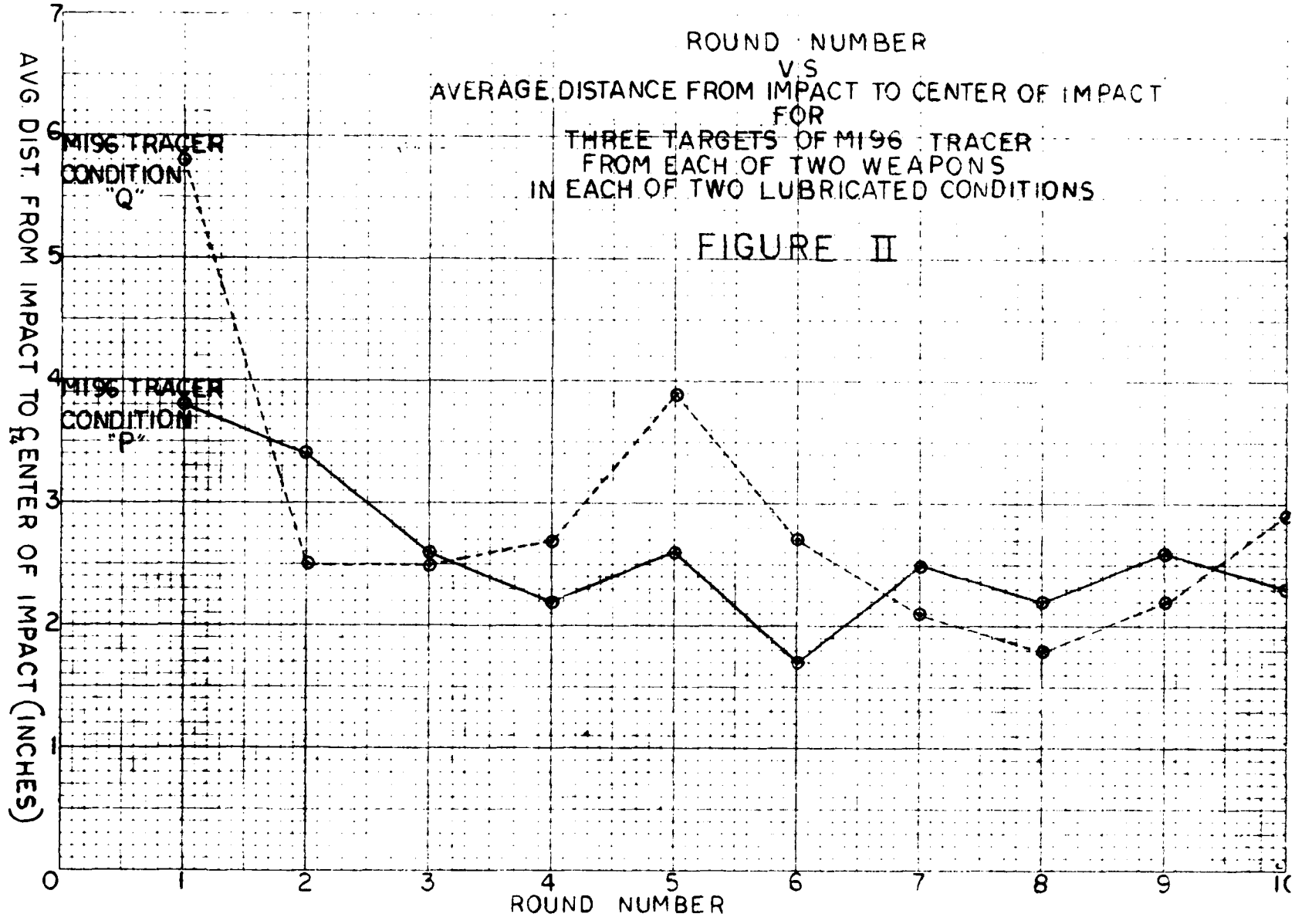
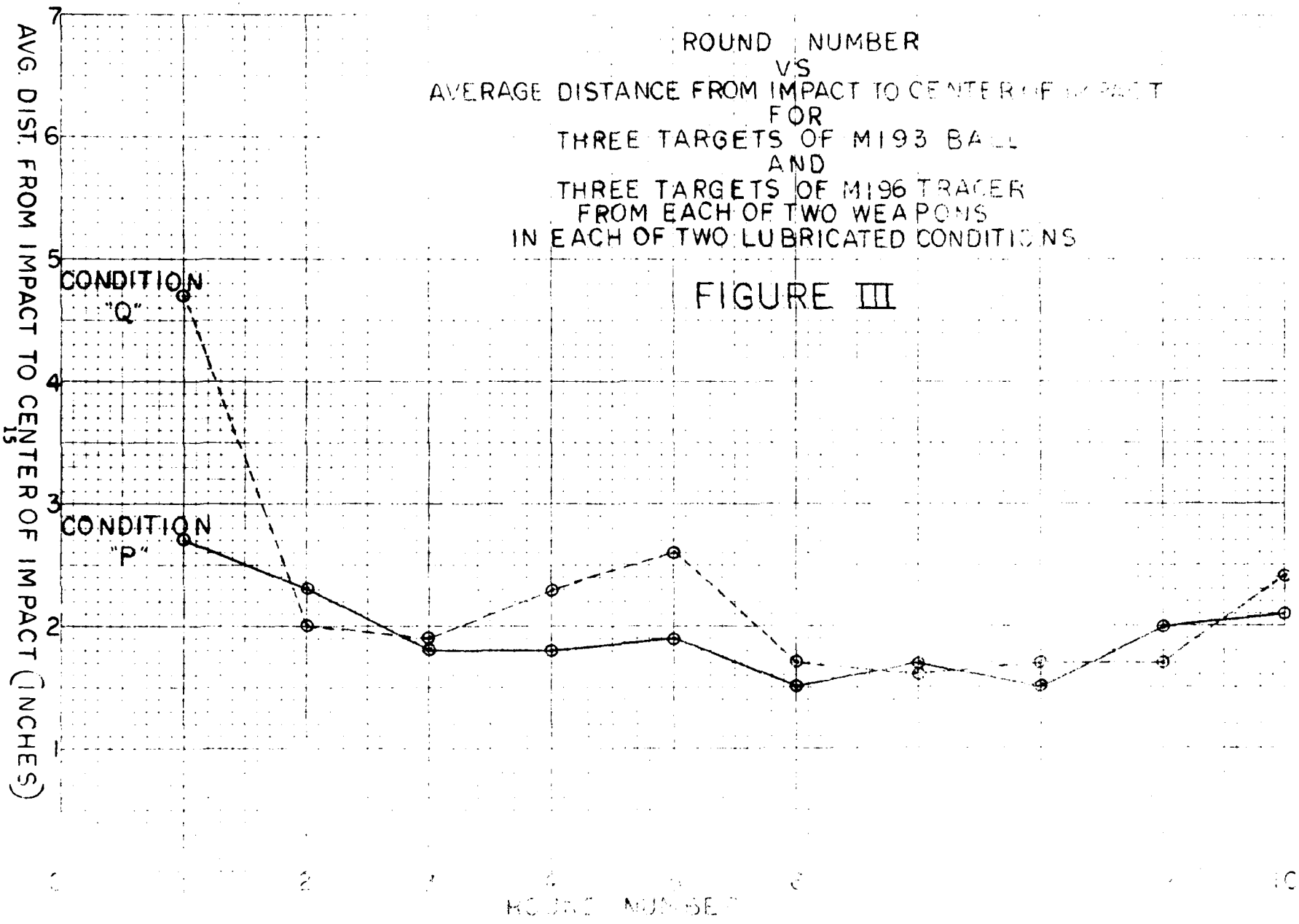

ROUND NUMBER
VS
AVERAGE DISTANCE FROM IMPACT TO CENTER OF IMPACT
FOR
THREE TARGETS OF M196 TRACER
FROM EACH OF TWO WEAPONS
IN EACH OF TWO LUBRICATED CONDITIONS
M196 TRACER
CONDITION
"Q"
M196 TRACER
CONDITION
"P"
AVG. DIST. FROM IMPACT TO CENTER OF IMPACT (INCHES)
ROUND NUMBER
0
1
2
3
4
5
6
7
8
9
10

FIGURE II

ROUND NUMBER
VS
AVERAGE DISTANCE FROM IMPACT TO CENTER OF IMPACT
FOR
THREE TARGETS OF M193 BALL
AND
THREE TARGETS OF M196 TRACER
FROM EACH OF TWO WEAPONS
IN EACH OF TWO LUBRICATED CONDITIONS

FIGURE III



Regardless of the ammunition type used, the round furthest from the center of impact of the group was the first round fired in condition Q.

When M196 tracer was fired the round second furthest from the center of impact was the first round fired in condition P.

2.4.5 Analysis

Tables 2.4-1 and 2.4-2 record the test results which were evaluated against the criteria of 2.4.2.

Table 2.4-1 shows that for ball and for tracer ammunition the first round of each target is further from the center of impact of the group when the bore is more heavily lubricated (condition Q) than when the bore is less heavily lubricated (condition P). Table 2.4-2 reveals that under the more heavily lubricated test condition (condition Q), the first round of a target is, on the average, furthest from the center of impact regardless of the type of ammunition used.

Therefore, the criteria of Section 2.4.2 have been met; lubrication appears to have a significant effect on the distance from first round impact to group center.

TABLE 2.4-1

AMMUNITION	DISTANCE FROM FIRST ROUND TO CENTER OF IMPACT	
	CONDITION P	CONDITION Q
M193	1.5	3.5
M196	3.0	5.8
BOTH	2.2	4.7

TABLE 2.4-2

AMMUNITION	DISTANCE TO CENTER OF IMPACT (CONDITION Q)	
	FIRST ROUND	FURTHEST OF OTHER 9 RDS
M193	3.5	1.9
M196	5.8	3.9
BOTH	4.7	2.6

2.5 EFFECT OF CORROSION/EROSION ON ACCURACY

The effects of corrosion and erosion in the bore were analyzed in Technical Note No. SWERR-S-5-72, titled "Corrosion/Erosion Analysis of M16A1 Rifle Bores Exposed to Field Conditions", dtd April 1972. The conclusions of that technical note are quoted below, followed by pertinent comments on them.

2.5.1 Conclusions

"The following conclusions were deduced from the analysis:

a. The high incidence of bore enlargement at the muzzle end was concluded to be caused by corrosive rather than erosive attack, and as such, probably reflects inadequate care and/or maintenance of the rifles in the field. Thus, we can conclude that field care and/or maintenance of M16/M16A1 Rifles should be improved.

b. Our previous testing has demonstrated that chrome plated rifle bores greatly reduce the necessity for maintenance in the field by reducing the susceptability of the bore to corrosive attack. Therefore, chrome plating of the bore should be introduced for field use as soon as possible to minimize that portion of the problem which might be due to inadequate maintenance.

c. Standard bore erosion gage penetration greater than 1/4 inch into the muzzle end of the barrel should be cause for rejection*.

d. A separate gage for use in detection of muzzle erosion should be designed and developed * since rework of the present gage would be impractical because of financial and logistical considerations. In addition, the required modification marks could create confusion.

e. The current cleaning rod design should be reviewed to determine if sharp or abrasive edges on the sections would cause the oversize bore condition.

* The rejection criterion of erosion gage penetration into the muzzle, as determined by this technical note, may not necessarily be applicable to the chrome plated bore. As the chrome bore is introduced, the depth of the penetration should be re-evaluated to determine both qualitatively and quantitatively the rejection criterion."

2.5.2 Comments

Recent work makes several comments on these conclusions pertinent.

A. This Arsenal, having assured that adequately designed cleaning equipment is supplied, with clear instructions for its use, has no other means of improving field maintenance.

B. Chrome plated bores are now being produced on all major item and repair part contracts.

C. Barrel rejection at 1/4 inch gage penetration into the muzzle still appears valid for unchromed bores, but probably is not correct for chrome bores.

D. A muzzle erosion gage has been designed and fielded.

E. Further testing has not revealed any indication of cleaning-rod-induced bore damage.

2.6 EFFECT OF HEAT ON ACCURACY

2.6.1 Objective

The objective of this test was to determine the effects of barrel heat on accuracy of the M16A1 Rifle.

2.6.2 Criteria

Heat should be considered to have a significant effect on group size if the heat causes a change of more than 2.2 inches extreme spread from the group size obtained with the cool barrel.

Heat should be considered to have a significant effect on point of impact if the center of impact is changed more than two inches vertically or horizontally from the center of impact of rounds fired from the cool barrel.

2.6.3 Method

Two M16A1 Rifles, one new and one 6,000 round endurance test rifle, were each tested as follows: The weapon was cleaned and lubricated normally. One ten-shot target was fired. Then 100 rounds were continuously fired through the weapon in the full automatic mode. Before the weapon could cool, a second target was fired. Finally, after the weapon had cooled, a third target was fired. This sequence of firings was accomplished twice with M193 ball and twice with M196 tracer from each weapon.

Analysis of data from the above testing was inconclusive. Thus, in order to obtain a larger data base, additional testing was undertaken as follows: Both weapons were cleaned and lubricated normally. Each was then fired one target semiautomatically. Immediately after 100 rounds of full automatic firing, a second target was fired. The weapon was allowed to cool, and a third target was fired. Another 100 rounds of full automatic fire were followed immediately by a fourth target. Finally, after the weapon had cooled, a fifth target was fired. This sequence of firings was accomplished once with M193 ball and once with M196 tracer. For informational purposes, this firing schedule was also accomplished once with experimental steel-jacketed tracer ammunition except that an additional sequence of 100 rounds full automatic, one target hot, and one target cold was added.

2.6.4 Results

Table 2.6-1 shows the fraction of targets fired from hot guns which varied significantly in extreme spread and/or center of impact from the following target fired from the same weapon after it had cooled. 5/8 of the targets fired with M193 ball, 5/8 of the targets fired with M196 tracer, and 6/6 of the targets fired with steel jacketed tracer demonstrated significant changes in extreme spread and/or center of impact.

2.6.5 Analysis

Heat has a significant, usually deleterious, effect on both center of impact and extreme spread.

TABLE 2.6-1

NUMBER OF TARGETS FROM HOT WEAPONS WHICH DEMONSTRATE SIGNIFICANT CHANGE IN PARAMETER COMPARED TO THE NEXT TARGET FIRED FROM THE SAME WEAPON / NUMBER OF TARGETS FIRED FROM HOT WEAPONS

AMMO	WEAPON(S)	EXTREME SPREAD INCREASE	EXTREME SPREAD DECREASE	EXTREME SPREAD CHANGE	HORIZONTAL C OF I CHANGE	VERTICAL C OF I CHANGE	C OF I CHANGE	C OF I AND/OR ES CHANGE
M193 BALL	2068834	0/4	0/4	0/4	0/4	1/4	1/4	1/4
	4402653	4/4	0/4	4/4	2/4	1/4	3/4	4/4
	BOTH	4/8	0/8	4/8	2/8	2/8	4/8	5/8
M196 TRACER	2068834	2/4	0/4	2/4	2/4	1/4	2/4	3/4
	4402653	1/4	1/4	2/4	1/4	0/4	1/4	2/4
	BOTH	3/8	1/8	4/8	3/8	1/8	3/8	5/8
STEEL-JACKET TRACER	2068834	1/3	1/3	2/3	1/3	0/3	1/3	3/3
	4402653	3/3	0/3	3/3	0/3	1/3	1/3	3/3
	BOTH	4/6	1/6	5/6	1/6	1/6	2/6	6/6
ALL	BOTH	11/22	2/22	13/22	6/22	4/22	9/22	16/22

2.7 ACCURACY OF M193 BALL, TRACER, AND THEIR MIX

2.7.1 Objective

The objectives of this portion of the test were to determine the relative accuracy of ball, tracer, and their mix, as well as to determine the effect of firing tracer ammunition on the accuracy of subsequently fired ball ammunition.

2.7.2 Criteria

Firing tracer or a mixture of tracer and ball ammunition should be considered to have a significant effect on group size if the extreme spread of the tracer, mixed ammunition, or subsequently fired ball ammunition, varies more than 2.2 inches extreme spread from the extreme spread of ball ammunition initially fired from the same weapon.

Firing tracer or a mixture of tracer and ball ammunition should be considered to have a significant effect on point of impact if the center of impact of the tracer, mixed ammunition, or subsequently fired ball ammunition varies more than two inches vertically or horizontally from the center of impact of ball ammunition initially fired from the same weapon.

2.7.3 Method

Two M16A1 Rifles, one new and one 6,000 round endurance test rifle, were each tested as follows: The weapon was cleaned and lubricated normally. Three targets were fired with M193 ball, three targets with M196 tracer, then two targets firing one M196 then one round M193 alternately, and finally two targets of M193 ball. The weapon was cleaned and lubricated normally. Three targets of M193 ball were fired. Then 100 rounds of M196 tracer were fired automatically. This was immediately followed by three more targets of M193 ball.

2.7.4 Results

Tables 2.7-1, 2.7-2, and 2.7-3 detail the results of this firing.

Table 2.7-1 demonstrates the relative accuracy of M193 ball, M196 tracer, and their mix. No significant differences in extreme spread or center of impact were noted for the first rifle regardless of whether M193, M196, or a mixture of the two was fired. However, it should be noted that all extreme spreads for this weapon were relatively large compared to the acceptance criteria of 4.8 inches extreme spread.

The second weapon, which demonstrated good accuracy with M193 ball, showed significant increases in extreme spread when M196 or a mixture of M193 and M196 was fired.

TABLE 2.7-1

RELATIVE ACCURACY OF M193 BALL, M196 TRACER, & THEIR MIX

WEAPON	PARAMETER	M193* BALL	M196* TRACER	CHANGE	** ALTERNATE	CHANGE	M193** BALL	CHANGE
2076798	EXTREME SPREAD	5.4	7.2	NONE	6.2	NONE	4.5	NONE
	HORIZONTAL C OF I	-1.7	-1.8	NONE	-1.4	NONE	-1.4	NONE
	VERTICAL C OF I	+4.2	+4.2	NONE	+5.5	NONE	+5.1	NONE
3300176	EXTREME SPREAD	3.3	8.1	INCREASE	6.6	INCREASE	2.9	NONE
	HORIZONTAL C OF I	-1.3	-3.5	DOWN	-2.5	NONE	-1.8	NONE
	VERTICAL C OF I	+2.7	+1.3	NONE	+2.0	NONE	+4.0	NONE

* Average of three ten-shot targets

**Average of two ten-shot targets

TABLE 2.7-2

RELATIVE ACCURACY OF M193 BALL, STEEL JACKET TRACER, & THEIR MIX

WEAPON	PARAMETER	M193* BALL	STEEL* JACKET TRACER	CHANGE	** ALTERNATE	CHANGE	M193** BALL	CHANGE
2076798	EXTREME SPREAD	6.4	9.0	INCREASE	13.5	INCREASE	3.7	DECREASE
	HORIZONTAL C OF I	-0.3	+1.7	RIGHT	+2.7	RIGHT	-1.8	NONE
	VERTICAL C OF I	+1.3	+1.1	NONE	+2.3	NONE	+3.5	UP
300176	EXTREME SPREAD	3.2	12.9	INCREASE	14.5	INCREASE	2.9	NONE
	HORIZONTAL C OF I	-2.1	+7.1	RIGHT	+2.9	RIGHT	-1.7	NONE
	VERTICAL C OF I	+5.4	+3.7	NONE	+4.5	NONE	+4.8	NONE

* Average of three ten-shot targets

**Average of two ten-shot targets

TABLE 2.7-3

EFFECT ON ACCURACY OF M193 BALL DUE TO PREVIOUS FIRING OF TRACER

WEAPON	PARAMETER *	M193 BALL	100 RDS TRACER	M193 BALL	SIGNIFICANT CHANGE
2076798	EXTREME SPREAD	4.4	M196	6.1	NONE
	HORIZONTAL C OF I	-0.8		+0.4	NONE
	VERTICAL C OF I	+4.1		+1.0	DOWN
3300176	EXTREME SPREAD	3.3	M196	3.8	NONE
	HORIZONTAL C OF I	-0.8		-2.4	NONE
	VERTICAL C OF I	+4.2		+4.2	NONE
2076798	EXTREME SPREAD	7.4	STEEL JACKET	6.4	NONE
	HORIZONTAL C OF I	-1.3		-0.7	NONE
	VERTICAL C OF I	+1.8		+1.4	NONE
3300176	EXTREME SPREAD	3.8	STEEL JACKET	3.6	NONE
	HORIZONTAL C OF I	-1.9		-2.7	NONE
	VERTICAL C OF I	+5.6		+5.6	NONE

* Average of three ten-shot targets

Firing steel jacketed tracer or a mixture of M193 and S-J tracer resulted in significant increases in extreme spread and changes in horizontal center of impact for both weapons.

As can be seen in all three tables, prior firing of M196 or steel jacketed tracer had little, if any, effect on the accuracy of subsequently fired M193 ball.

2.7.5 Analysis

Firing tracer ammunition, either M196 or steel jacketed, may cause significant increases in group size and changes in center of impact when compared to M193 ball. However, firing tracer ammunition, at least in limited quantities, does not appear to have a significant effect on either extreme spread or center of impact of subsequently fired M193 ball.

2.8 EFFECT ON ACCURACY OF TYPE OF REST

2.8.1 Objective

The objective was to determine the effect of type of rest on group size and point of impact of the M16A1 Rifle.

2.8.2 Criteria

Type of rest should be considered to have a significant effect on group size if the rest causes a change of more than 2.2 inches extreme spread from the group size obtained from the sandbagged benchrest position. The reasoning applied in Section 2.1.2 was also applied here.

Type of rest should also be considered to have a significant effect on point of impact if the center of impact is changed more than two inches vertically or horizontally from the center of impact of the sandbagged benchrest firing.

2.8.3 Method

Three new M16A1 Rifles were each fired one ten-shot target by each of two shooters under each of the following conditions:

CONDITION	DESCRIPTION
AA	A sandbag was used as the rest for firing from a benchrest.
BB	The supported hand was used as the rest for firing from the benchrest.
CC	The unsupported hand was used as the rest for firing from the benchrest.
DD	A concrete block was used as the rest for firing from the benchrest.
EE	A bipod was used as the rest for firing from the benchrest.
FF	A log was used as the rest for firing from the benchrest.
GG	A sandbag was used as the rest for firing from the prone position.
HH	The supported hand was used as the rest for firing from the prone position.

CONDITION	DESCRIPTION
II	The unsupported hand was used as the rest for firing from the prone position.
JJ	A concrete block was used as the rest for firing from the prone position.
KK	A bipod was used as the rest for firing from the prone position.
LL	A log was used as the rest for firing from the prone position.

2.8.4 Results

Table 2.8-1 is a compilation of the results of this test's firing. The "ES" line shows the average extreme spread by condition. Using the "AA" condition as a standard, the ΔES row shows the change in average extreme spread of each of the other conditions. When the ΔES numbers are compared with the 2.2 inch extreme spread criteria defined in Section 2.8.2, no extreme spreads differ significantly from the extreme spread of condition "AA".

The ΔCI rows of Table 2.8-1 demonstrate the change in center of impact of each of the conditions relative to condition "AA". A comparison of these numbers with the two inch criteria outlined in Section 2.8.2 reveals no significant horizontal changes. However, vertically, conditions "CC", "EE", and "II" differ significantly from "AA".

2.8.5 Analysis

No significant changes in extreme spread due to type of rest were observed.

No significant horizontal changes in point of impact due to type of rest were observed.

From the benchrest, the unsupported hand shot approximately three inches lower than the sandbag rest while the bipod shot an average of two inches higher than the sandbag. From the prone, the unsupported hand repeated its benchrest performance, while the bipod shot only 1.4 inches high.

TABLE 2.8-1

EFFECT OF TYPE OF REST ON ACCURACY

PARAMETER*	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL
ES	3.5	3.2	4.1	3.5	4.3	3.6	3.4	3.4	4.7	3.5	3.8	3.6
Δ ES	0	-0.3	+0.6	0	+0.8	+0.1	-0.1	-0.1	+1.2	0	+0.3	+0.1
HORIZONTAL Δ C OF I	0	+0.1	-0.2	-0.5	-0.1	+0.1	-0.2	-0.1	-0.3	-0.4	-1.4	0
VERTICAL Δ C OF I	0	-0.6	-2.9	-0.7	+2.0	-0.5	+0.3	-0.8	-2.9	-0.8	+1.8	+1.2

* Average of three weapons and two shooters (six targets)

APPENDIX

M16A1 RIFLE ACCURACY TEST PROGRAM

22 November 1971
SWERR-S-P
Ronald E. Elbe

M16A1 RIFLE ACCURACY TEST PROGRAM

1. Material For Test:

   1.1 7 new M16A1 rifles.

   1.2 2,520 rounds of M193 5.56MM Ball Ammunition.

   1.3 740 rounds of M196 5.56MM Tracer Ammunition.

   1.4 140 rounds of steel jacket tracer.

   1.5 30 used M16A1 rifles from RVN which exemplify the problem areas to be studied.

   1.6 Two 6,000 round endurance M16A1 rifles.

2. Project Authority:

3. Test Program Request Number: SAL-71-P-004.

4. Test Installation: AMSWE-REE.

5. Purpose: The purpose of this test program is to evaluate potential problem areas including those reported by Larry Moore, AMSWE-REE, after his recent trip to RVN. Mr. Moore reported the following six potential problem areas which will be explored in this test:

   (a) Effect on accuracy of loose sights.

   (b) Effect on accuracy of loose upper receiver.

   (c) Effect on accuracy of loose handguards.

   (d) Effect on accuracy of LSA, corrosion, and heat in the bore.

   (e) Effect on accuracy and point of impact of M193 Ball due to having previously fired tracer.

   (f) Effect on accuracy of type of rest.

6. Test Program:

6.1 Test preparation and maintenance.

6.1.1 All weapons shall be cleaned and lubricated per SAPD-253F before the initiation of each test and at all other points indicated in the test plan.

6.1.2 Necessary maintenance shall be performed by the testing agency in accordance with applicable TMs and instructions stated herein.

6.1.3 The testing agency is authorized to use standard instrumentation or other suitable means to define test conditions and results, analyze shortcomings, deficiencies, breakages. malfunctions, and other unusual conditions.

6.1.4 All hardware, including that which is damaged, broken, or rendered unserviceable during testing shall be returned to this office at the conclusion of testing.

6.1.5 The use of photography by the testing agency is encouraged to define test conditions and results, breakages, malfunctions, and other unusual occurrences.

6.1.6 All test equipment shall be initially inspected by the testing agency to determine its completeness and suitability for the test.

6.2 Data to be Recorded:

6.2.1 Time (date and hour).

6.2.2 Test Title.

6.2.3 Identification of weapons and problem areas being tested.

6.2.4 Identification of gunner(s) and all other participants.

6.2.5 All stoppages, malfunctions, or other irregularities in the test schedule regardless of their cause(s).

6.2.6 Cause(s) of each stoppage, malfunction or other irregularity.

6.2.7 Accuracy data to be recorded are: mean radius, mean vertical dispersion, mean horizontal dispersion, extreme vertical dispersion, extreme horizontal dispersion, extreme spread, horizontal distance from aiming point to center of group, and vertical distance from aiming point to center of group.

6.2.8 The data listed above shall be included in the final test report, but shall not in any way exclude items and data normally provided in the test agency's report.

6.3 Miscellaneous Requirements:

6.3.1 All firing shall be conducted at a minimum range of 100 yards.

6.3.2 No deviation from the test procedure will be allowed without the official concurrence of SWERR-S-P.

6.3.3 Unless otherwise specified, the test weapon shall be allowed to cool after every target throughout the testing of problem areas 5.(d), 5.(e) and 5.(f). Forced air may be applied to the weapon's exterior surface, but not to the bore, in order to facilitate cooling.

7. Problem Area (a): Effect On Accuracy of Loose Sights.

7.1 A minimum of ten (10) M16A1 Rifles exemplifing loose sight problems will be obtained from RVN.

7.2 The RVN weapons will then be sent to SWERI-QAI for a quantitative analysis of the problem.

7.3 Based on input from SWERI-QAI, this office will mathematically determine the approximate magnitude of the problem.

8. Problem Area (b): Effect on Accuracy of Loose Upper Receivers.

8.1 A minimum of ten (10) M16A1 Rifles exemplifying typical loose upper receiver problems shall be requisitioned from RVN.

8.2 The RVN weapons shall be sent to SWERI-QAI for a quantitative analysis of the problem.

8.3 Three of the RVN weapons shall be rebuilt to eliminate or minimize all potential accuracy problems except loose upper receiver problems.

8.4 Each of the three rifles shall be fired two ten-shot targets from the benchrest by each of two Master Riflemen. During this firing, the riflemen shall hold the upper receivers in opposite extreme positions for alternate shots.

8.5 Section 8.4 shall be repeated except that the upper receivers shall be allowed to seek their own positions during the firing.

8.6 Sections 8.4 and 8.5 shall be repeated except that firing shall be done from the prone position.

8.7 The test weapons shall then be modified to remove all play between the upper and lower receivers.

8.8 Each rifle shall then be fired two ten-shot targets by each of two Master Riflemen from a benchrest.

8.9 Section 8.8 shall be repeated from the prone position.

9. Problem Area (c): Effect on Accuracy of Loose Handguards.

9.1 A minimum of ten (10) M16A1 Rifles exemplifying typical loose handguard problems will be requisitioned from RVN.

9.2 The RVN weapons shall be sent to SWERI-QAI for a quantitative analysis of the problem.

9.3 Three of the RVN weapons shall be rebuilt to eliminate or minimize all potential accuracy problems except loose handguard problems.

9.4 Each of the three rifles shall be fired two ten-shot targets from the benchrest by each of two Master Riflemen. During this firing, the riflemen shall hold the handguards in opposite extreme positions for alternate shots.

9.5 Section 9.4 shall be repeated except that the handguards shall be allowed to seek their own positions during the firing.

9.6 Sections 9.4 and 9.5 shall be repeated except that firing shall be done from the prone position.

9.7 The test weapons shall then be modified to remove all looseness in the handguard area.

9.8 Each rifle shall then be fired two ten-shot targets by each of two Master Riflemen from a benchrest.

9.9 Section 9.8 shall be repeated from the prone position.

10. Problem Area (d): Effect On Accuracy of LSA, Corrosion, and Heat In the Bore.

10.1 Effect of LSA:

10.1.1 Two M16A1 Rifles with acceptable accuracy, one new and one 6,000 round endurance gun, will be used as test weapons.

10.1.2 Each weapon shall be tested as follows: The weapon shall be cleaned and lubricated normally. A patch shall be dipped in lubricant and squeezed dry. This patch shall be passed one round trip through the bore. The chamber shall then be dried with a clean patch. A ten-shot target of M193 Ball Ammunition shall be fired. Each shot shall be consecutively numbered on the target so that the order of firing may be ascertained.

10.1.3 Section 10.1.2 shall be repeated twice more.

10.1.4 Section 10.1.2 shall be repeated three times except that the patch, having been dipped in the LSA, shall not be squeezed dry, but rather shall be immediately passed through the bore.

10.1.5 Section 10.1.2, 10.1.3 and 10.1.4 shall be repeated using M196 Tracer Ammunition only.

10.1.6 Approximately 120 rounds of M193 Ball and 120 rounds of M196 Tracer Ammunition will be required for this test.

10.2 Effect of Corrosion:

10.2.1 Testing in this area is already underway at SWERR-S-P. Results of subject test, "Effect Of Bore Damage Due To Induced Corrosive Pitting," will be included in this report when they become available.

10.3 Effect Of Heat:

10.3.1 Two M16A1 Rifles, one new and one 6,000 round endurance gun, will be used as test weapons.

10.3.2 Each weapon shall be tested as follows: The weapon shall be cleaned and lubricated normally. 100 rounds shall be continuously fired through the weapon in the full automatic mode (Target data need not be taken for the above 100 rounds). Before the weapon can cool, a ten-shot target shall be fired semi-automatically. The weapon shall then be allowed to cool and then a ten-shot target shall be fired, letting the weapon cool between shots. Each shot shall be consecutively numbered on the target so that the order of firing may be ascertained. All ammunition fired in this section shall be M193 Ball.

10.3.3 Section 10.3.2 shall be accomplished a total of two times with M193 Ball Ammunition.

10.3.4 Section 10.3.3 shall be repeated two times except that M196 Tracer Ammunition shall be used exclusively.

10.3.5 Approximately 480 rounds of M193 Ball and 480 rounds of M196 Tracer Ammunition will be required for this test.

11. Problem Area (e): Effect On Accuracy Of M193 Ball Due To Having Previously Fired Tracer.

11.1 Two M16A1 Rifles with acceptable accuracy will be used as test weapons.

11.2 The first weapon shall be tested as follows: The weapon shall be cleaned and lubricated normally, making certain that no fouling, gilding metal, lubricant, or other contaminant which could affect accuracy remains in the bore. Then, the following test schedule shall be fired:

(a) Three 10-shot targets - M193 Ball.

(b) Three 10-shot targets - M196 Tracer.

(c) Two 10-shot targets - one round M196 Tracer then one M193 Ball alternately.

(d) Two 10-shot targets - M193 Ball.

The weapon shall not be cleaned or lubricated during this firing. All shots on each target shall be consecutively numbered.

11.3 The second weapon shall be tested as follows: The weapon shall be cleaned and lubricated normally, making certain that no fouling, gilding metal, lubricant, or other contaminant which could affect accuracy remains in the bore. Then, the following test schedule shall be fired:

(a) Three 10-shot targets - M193 Ball.

(b) 100 rounds of M196 Tracer as rapidly as possible in the full automatic mode. (Note: No accuracy data should be recorded for this 100 rounds).

(c) Immediately after (b), fire three 10-shot targets - M193 Ball. Do not cool the weapon between targets while firing (c).

11.4 Sections 11.2 and 11.3 shall be repeated except that gilding metal clad steel tracer shall be used instead of M196 Tracer.

11.5 Approximately 240 rounds of M193 Ball, 140 rounds of M196 Tracer, and 140 rounds of steel jacketed tracer will be required.

12. Problem Area (f): Effect On Accuracy Of Type Of Rest.

12.1 Three M16A1 Rifles of proven accuracy shall be used as test weapons.

12.2 The types of rest to be shot from are log, cement block, sandbag, supported hand, unsupported hand and bipod.

12.3 Each of two Master Riflemen shall fire one ten-shot target from each type of rest with each rifle from the prone position.

12.4 Section 12.3 shall be repeated except that the firing shall be done from a benchrest.

12.5 M193 Ball Ammunition shall be used for all testing.

12.6 Approximately 720 rounds of M193 Ball Ammunition shall be used for this test.