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REPORT R-1894

INVESTIGATION OF U. K. EXTRACTION DIFFICULTIES  
WITH 5.56 mm AMMUNITION

by

ARTHUR J. MAGAR

July 1968

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ARTHUR J. MAGAR

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Ammunition Development & Engineering Laboratories  
FRANKFORD ARSENAL  
Philadelphia, Pa. 19137

July 1968

## ABSTRACT

The tests evaluated in this report represent one phase of a series of special M16A1 tests conducted at Frankford Arsenal, requested by U.S. Army Munitions Command. The purpose was to investigate a particular type of extraction difficulty using 5.56 mm ammunition reported by the British Defence Command. The theory was that small particles of unburnt propellant became entrapped between the cartridge case and the chamber wall during weapon function and, subsequently, became ignited by successive firings, causing extraction difficulties.

Three firing programs were developed in attempts to resolve this problem. The first series consisted of sustained firings which incorporated the same methods and procedures followed by the British in their tests. No extraction difficulties were observed.

The second series consisted of firings with propellant-coated cartridges in the semiautomatic and full automatic modes, in attempts to induce extraction difficulties similar to those described by the British. Again, no extraction difficulties were observed.

The third series consisted of cook-off firings with propellant-coated and uncoated cartridges, to check weapon function under severe firing conditions. No extraction difficulties were observed.

Conclusions were that U.S. -made M16A1 weapons (with either plated or unplated barrels) tested under this program were not susceptible to the type of extraction difficulties described by the British Defence Command in their report.

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## FOREWORD

The author wishes to acknowledge his appreciation of the assistance given by Jacob Repholz and Raymond Steele, of the Ammunition Development & Engineering Laboratories, during these tests.

## INTRODUCTION

In a letter dated 18 September 1967, Lt. Col. L. W. Thorne of the R & D Staff, United Kingdom (U. K.) Defence Staff, British Embassy, Washington, D. C., reported to the Project Manager for Rifles, U. S. Army Weapons Command, that while testing their 5.56 mm weapons, U. K. personnel came across "stiff" bullet extractions. The cause for this was new to them, and it was necessary to use a ramrod to remove the fired cases from the chamber. These stiff bullet extractions occurred during sustained firing tests with various lots of ball propellant ammunition from their supplies. The tests were conducted to check the effects of firings in the 5.56 mm automatic light machine gun.

A follow-up letter from Lt. Col. J. V. Dier, dated 28 November 1967, gave further details on the tests during which the extraction difficulties were observed. In their tests, British-made weapons were used and Belgian-manufactured ammunition was fired. A direct quotation from this letter reads:

"Attempts were made to fire 1000 rounds in ten automatic bursts at the following rates of fire: 30 rpm (10 rounds auto, each 20 sec); 40 rpm (10 rounds auto, each 15 sec); 50 rpm (10 rounds auto, each 12 sec); 60 rpm (10 rounds auto, each 10 sec). All failures to complete the tests were due to hard extraction stoppages after approximately 500° C (930° F)."

In communications from Mr. W. C. Davis, Jr., Chief of the Technical Management Division, Rock Island Arsenal, and in discussions with the Congressional Investigation Group in charge of 5.56 mm tests at Frankford Arsenal, it was pointed out that unrelated damage would happen to the M16A1 weapon if the sustained firings were conducted on a continuous basis in a manner similar to those conducted by the British. Firing the weapons under these circumstances could cause temperatures of the barrels to exceed 1000° F, endangering the normal function of the weapon. Hence, it was decided that sustained firings conducted at Frankford Arsenal for these tests would be limited to 500 rounds or less before cooling in order to prevent barrel temperatures from exceeding the 1000° F temperature limitations.

## OBJECTIVES

The objectives of this investigation follow.

1. Simulating U. K. sustained firing tests, determine whether, during weapon function, small elements of propellant grain are deposited between the cartridge case and the chamber wall of M16A1 weapons (having chrome-plated and unplated barrels), using U. S. - made ammunition loaded with ball and IMR propellant. Determine, also, if these grains are ignited when the temperature of the barrel reaches approximately 1000° F, causing extraction difficulties.
2. Attempt to duplicate extraction difficulties similar to those described by British personnel in their tests by conducting firings with both types of 5.56 mm ammunition (M193 ball cartridge and M196 tracer cartridge) precoated with small particles of propellant grain drawn from the same lots and fired in temperature-conditioned M16A1 weapons with chrome-plated and unplated barrels.
3. Determine if unburnt propellant particles between the cartridge case and the chamber wall could cause extraction difficulties during cartridge cook-off firings and, also, if weapon function is seriously impaired due to cartridge cook-off when firing propellant-coated and uncoated cartridges.

## DISCUSSION

Sustained firings (with a limitation of 500 rounds or less before cooling) were planned for the tests simulating those conducted by the British. In the Frankford Arsenal tests, U. S. -made M16A1 weapons were to be fired, using cartridges loaded with Western ball and IMR propellants. The same rates of fire as those listed by the British were to be used. Weapons with chrome-plated and unplated barrels were selected, and both types of cartridge (M193 and M196) were to be fired. The test plan is presented in Appendix A. Ammunition, weapons, and equipment used in all the tests are detailed in Appendix B.

A second series of firings was arranged, using cartridges drawn from the lots tested above but precoated with small particles of ball and IMR propellant grains. These cartridges were scheduled for firing in weapons temperature-conditioned by sustained rapid firing. This was an attempt to induce the phenomenon described by the British.

In the last phase of these tests, firings were scheduled to determine if unburnt propellant particles between the cartridge case and the chamber wall could seriously hamper normal weapon function during cartridge cook-off firings. Coated and uncoated cartridges would be fired in weapons temperature-conditioned by sustained rapid firings. Initial firing temperatures would be approximately 980° F. The initial cartridge would then be chambered by remote control from a loaded magazine and permitted to remain chambered until a cook-off resulted. Successive firings from the same magazine would then be permitted to occur by cook-off until the firings ceased automatically due to the loss in barrel temperature by cooling through a time lapse between each successive cook-off firing.

The rounds selected for the cook-off tests included two propellant-coated cartridges drawn from each lot fired in the previous series of tests and a full magazine (20 rounds) of uncoated cartridges drawn from the same lots. A total of seven lots were tested. When the last cook-off firing was accomplished for each lot, a waiting period of ten minutes was allowed before the remaining rounds were fired for weapon function.

### Sustained Firing Tests

The tests planned were designed to accomplish the aims listed under OBJECTIVES of this report. The first series of ten tests was designed to simulate the U. K. tests by conducting sustained firings, in groups of 500 or less, at rates of fire of 30, 40, 50, and 60 rpm. Four M193 cartridge lots loaded with ball propellant and four weapons with unplated barrels were selected for the initial four tests (tests 1, 2, 3, and 4, Appendix C) in this series.

The firing schedule for these tests consisted of four magazines, 20 rounds each, fired in the specified semiautomatic mode, followed immediately by one magazine of 20 rounds fired in the full automatic mode. This arrangement of firings was repeated continuously until the desired weapon temperature (between 900° and 1000° F) was reached or 500 rounds had been fired, whichever happened first. Immediately after the desired temperature was reached, a full magazine of 20 rounds was fired in each weapon to see if any extraction difficulties would occur.

In the group of firings at 30 rpm, a weapon temperature of 900° F was reached at the completion of the 500th round; in the remaining tests of this group, the limiting temperature was reached before 500 rounds were fired.

Additional tests in this series included firings conducted in two weapons with chrome-plated barrels, using two M193 cartridge lots loaded with ball propellant, selected from the four lots used above (tests 5 and 6, Appendix C). Rates of fire were 40 and 60 rpm.

Other tests included two cartridge lots (one M193 and M196) loaded with IMR propellant and fired in unplated weapons (tests 7 and 10, Appendix C). The rate of fire for these IMR lots was 60 rpm.

The final set in this series consisted of M196 cartridges loaded with ball propellant, fired first in a weapon with an unplated barrel and then in a weapon with a chrome-plated barrel (tests 8 and 9, Appendix C). Rates of fire for these M196 cartridges were 40 and 60 rpm.

Tables and graphs showing the number of rounds fired vs temperature rise in the weapon for each of the ten tests in this series are presented in Appendices C and D, respectively. No extraction difficulties were observed in these tests. Findings observed in the sustained firing tests are covered under ANALYSIS OF TEST RESULTS.

## Tests with Propellant-coated Cartridges

Since no extraction difficulties occurred in the sustained firing tests, it was decided to fire a series of tests with cartridges coated on the outside with small particles of propellant drawn from the lots tested. Firings were scheduled to be conducted in weapons temperature-conditioned by sustained rapid firings. These tests were divided into two groups. In one group, two propellant-coated cartridges from each lot were fired in the semiautomatic mode. Each round was carefully hand-loaded into the heated weapon so that the particles of propellant would not become dislodged by the process of automatic loading. Observation of the fired cartridge cases (Appendix E) showed that several small particles of propellant were lodged between the cartridge case and the chamber wall during weapon function.

In the second group of firings with the propellant-coated cartridges, four sets of four rounds each were fired in the full automatic mode. These latter rounds were magazine-loaded in a special sequence of four live rounds and one dummy round, for a total of 16 rounds fired from each lot. This skip-fire test was conducted to increase the chances of observing any extraction difficulties that might occur.

## Cook-off Tests

Cook-off tests were designed to determine if extraction difficulties might occur with propellant-coated and uncoated cartridges prior to cartridge cook-off, in temperature-conditioned weapons and, also, if cartridge cook-off firings would impair the normal function of the weapon.

Two rounds from each lot were coated with small particles of propellant, chambered by remote control, and permitted to cook-off in temperature-conditioned weapons. The weapons were then immediately brought back to a temperature of approximately 980° F by rapid firings, whereupon a full magazine of uncoated cartridges was loaded into each weapon and as many as possible allowed to cook-off while the temperature receded below the cook-off level. When the last cook-off firing occurred and a ten-minute waiting

period had elapsed, the remaining rounds were fired by remote control to check for weapon function.

## ANALYSIS OF TEST RESULTS

### Sustained Firing Data

Test results for the simulated U. K. sustained firings of 500 rounds or less are summarized in Table I. Complete data are presented in Appendix C. The highest temperature observed in these firings was 990° F, and this was obtained after firing 160 rounds at 60 rpm and one 20-round burst full automatic in a weapon with a chrome-plated barrel, using M196 type cartridges loaded with ball propellant, lot LC 12115.

Table I. Results of Tests Simulating U. K. Sustained Firings

| Cartridge |            | Propellant<br>Type    | Weapon<br>Number     | RPM | No. of<br>Rounds | Highest Temp.<br>(°F) |
|-----------|------------|-----------------------|----------------------|-----|------------------|-----------------------|
| Type      | Lot Number |                       |                      |     |                  |                       |
| M193      | WC 6157    | Ball                  | 816986               | 30  | 500              | 910                   |
| M193      | LC 12296   | Ball                  | 822855               | 40  | 240              | 950                   |
| M193      | RA 5316    | Ball                  | 823422               | 50  | 200              | 920                   |
| M193      | FCC 1888   | Ball                  | 825187               | 60  | 200              | 910                   |
| M193      | WCC 6157   | Ball                  | 916986C <sup>a</sup> | 40  | 240              | 940                   |
| M193      | RA 5316    | Ball                  | 823422C              | 60  | 200              | 925                   |
| M193      | LC 12236   | IMR                   | 825187               | 60  | 220              | 925                   |
| M196      | LC 12115   | Ball (T) <sup>b</sup> | 822885               | 40  | 220              | 950                   |
| M196      | LC 12115   | Ball (T)              | 823422C              | 60  | 180              | 990                   |
| M196      | TW 18037   | IMR (T)               | 816986               | 60  | 200              | 900                   |

<sup>a</sup>C = weapon with chrome-plated barrel.

<sup>b</sup>T = cartridge with tracer mix.

No extraction difficulties such as described by the British were observed, nor was there any record of propellant entrapment between the cartridge case and the chamber wall. Several weapon stoppages from other causes were observed during these tests. They included charge handle and bolt breakages, failures of magazines to feed properly, bolt overrides, as well as buffer and buffer-spring damage.

### Propellant-coated Cartridge Firing Data

The results of the tests with propellant-coated cartridges (other than cook-offs) are presented in Table II. These firings were conducted in weapons temperature-conditioned between 900° and 1050° F through series of sustained rapid firings. The highest initial temperature observed in these firings was 1050° F in a weapon with a chrome-plated barrel using M193 type cartridge loaded with ball propellant, lot RA 5316.

No extraction difficulties were observed, but evidence of burnt propellant was found on the outside of some cartridge cases in the form of propellant residue, and indents were observed on the body of the cases and near the neck. A chemical laboratory analysis (Appendix F) of the residue on the spent cartridge cases drawn from these tests verifies these findings.

### Cook-off Firing Data

Table III presents a summary of the results of the cook-off firings.

No extraction difficulties were observed, but several indents on the spent cartridge cases showed traces of propellant residue. Weapon function was not impaired by cartridge cook-off firings since, in every case but one, the remaining rounds were fired successfully. Due to a bolt override situation, one weapon ruptured in the process of the final cook-off firing. This occurred with an M196 type cartridge loaded with IMR propellant, lot TW 18037, fired in a weapon with an unplated barrel at 730° F. Complete

Table II. Results of Firings with Propellant-coated Cartridges

| Cartridge Lot No. | Propellant Type | Rifle Number | Mode of Firing | No. of Rounds | Highest Temp. (°F) | Cyclic Rate (rpm) |
|-------------------|-----------------|--------------|----------------|---------------|--------------------|-------------------|
| WCC 6157          | Ball            | 816986       | Full Auto      | 16            | 910                | 761               |
| WCC 6157          | Ball            | 816986C      | Full Auto      | 16            | 950                | 799               |
| WCC 6157          | Ball            | 816986       | Semi Auto      | 2             | 940                | -                 |
| WCC 6157          | Ball            | 816986C      | Semi Auto      | 2             | 950                | -                 |
| LC 12296          | Ball            | 822885       | Full Auto      | 16            | 980                | 912               |
| LC 12296          | Ball            | 822885       | Semi Auto      | 2             | 950                | -                 |
| RA 5316           | Ball            | 823422       | Full Auto      | 16            | 950                | 799               |
| RA 5316           | Ball            | 823422C      | Full Auto      | 16            | 950                | 859               |
| RA 5316           | Ball            | 823422       | Semi Auto      | 2             | 950                | -                 |
| RA 5316           | Ball            | 823422C      | Semi Auto      | 2             | 1050               | -                 |
| FCC 1888          | Ball            | 825187       | Full Auto      | 16            | 980                | 773               |
| FCC 1888          | Ball            | 825187       | Semi Auto      | 2             | 960                | -                 |
| LC 12236          | IMR             | 825187       | Full Auto      | 16            | 925                | 701               |
| LC 12236          | IMR             | 825187       | Semi Auto      | 2             | 970                | -                 |
| LC 12115          | Ball (T)        | 822885       | Full Auto      | 16            | 980                | 950               |
| LC 12115          | Ball (T)        | 822885       | Semi Auto      | 2             | 950                | -                 |
| LC 12115          | Ball (T)        | 823422C      | Full Auto      | 16            | 970                | 840               |
| LC 12115          | Ball (T)        | 823422C      | Semi Auto      | 2             | 980                | -                 |
| TW 18037          | IMR (T)         | 816986       | Full Auto      | 16            | 990                | 773               |
| TW 18037          | IMR (T)         | 816986       | Semi Auto      | 2             | 930                | -                 |

Table III. Results of Cook-off Firings

| Cartridge<br>Lot No.         | Propellant<br>Type | No. of<br>Rounds | Total Time<br>for Cook-off | Temperature (°F) |       |
|------------------------------|--------------------|------------------|----------------------------|------------------|-------|
|                              |                    |                  |                            | Initial          | Final |
| Propellant-coated Cartridges |                    |                  |                            |                  |       |
| WCC 6157                     | Ball               | 2                | 49 sec                     | 950              | 880   |
| FCC 1888                     | Ball               | 2                | 33 sec                     | 950              | 880   |
| RA 5316                      | Ball               | 2                | 40 sec                     | 980              | 920   |
| LC 12236                     | IMR                | 2                | 25 sec                     | 940              | 900   |
| LC 12115                     | Ball (T)           | 2                | 20 sec                     | 950              | 920   |
| LC 12296                     | Ball               | 2                | 33 sec                     | 975              | 880   |
| TW 18037                     | IMR (T)            | 2                | 26 sec                     | 940              | 890   |
| Uncoated Cartridges          |                    |                  |                            |                  |       |
| WCC 6157                     | Ball               | 5                | 2 min, 49 sec              | 940              | 780   |
| FCC 1888                     | Ball               | 8                | 5 min, 6 sec               | 930              | 620   |
| RA 5316                      | Ball               | 4                | 2 min, 4 sec               | 940              | 820   |
| LC 12236                     | IMR                | 8                | 2 min, 54 sec              | 900              | 740   |
| LC 12115                     | Ball (T)           | 10               | 3 min, 27 sec              | 940              | 710   |
| LC 12296                     | Ball               | 9                | 4 min, 48 sec              | 930              | 720   |
| TW 18037                     | IMR (T)            | 6                | 4 min, 51 sec              | 900              | 730   |

data on the cook-off firings are furnished in Appendix G. Significant data obtained from the cook-off firings follow.

1. The greatest number of rounds to cook-off in these tests occurred while using M196 type cartridge loaded with ball propellant, lot LC 12115, fired in a weapon with an unplated barrel, at an initial temperature of 940° F. Ten rounds cooked-off in succession within a time lapse of 3 minutes and 27 seconds, the final cook-off firing occurring at 710° F.

2. The least number of rounds to cook-off in these tests occurred while using M193 type cartridge loaded with ball propellant, lot RC 5316, fired in a weapon with an unplated barrel, at an initial temperature of 940° F. Four rounds cooked-off in succession within a time lapse of 2 minutes and 4 seconds, with the final cook-off firing occurring at 820° F.

3. The minimum number of rounds required to heat a weapon to approximately the cook-off temperature level was obtained with an uncoated M196 cartridge loaded with ball propellant, lot FCC 1888, fired in a weapon with an unplated barrel. It required a total of 120 rounds of sustained firings (100 at 60 rpm and 20 in a full automatic burst) to raise the temperature of the weapon slightly above 660° F, whereas, on another occasion the final cook-off firing occurred at 620° F in a temperature-conditioned weapon after a lapse of 5 minutes and 6 seconds from the time the initial cook-off was recorded.

\* Based temp of barrel in vicinity still higher than recorded on outside. 620° F was probably peak temp reached, and probably represented equal surface point between inside and outside of barrel.

#### CONCLUSIONS

1. Simulation of the U. K. sustained firing tests, using M16A1 rifles and U. S. -made M193 and M196 cartridges loaded with ball and IMR propellant, did not produce any evidence of propellant ignition or deposit between the cartridge cases and the chamber wall, extraction difficulties, or adverse chamber conditions.

2. Particles of propellant grains deliberately inserted between the cartridge case and the chamber wall in rifles temperature-

conditioned to approximately 900° to 1000° F produced indents on the cartridge cases covered with traces of propellant residue, but did not result in extraction difficulties.

3. Chemical laboratory findings verify the fact that elements of propellant residue were deposited on the wall and neck of the cartridge cases during weapon function when the propellant-coated cartridges were fired, but this condition did not cause extraction difficulties similar to those observed in the U. K. tests.

4. No extraction difficulties were observed during the cartridge cook-off firings with propellant-coated and uncoated cartridges in M16A1 rifles when fired either in the semiautomatic or full automatic mode. In addition, weapon function was not seriously impaired by cartridge cook-off firings with ball or IMR propellant lots that were tested under this program.

5. Cook-off firing of a chambered cartridge can occur in the M16A1 weapon after at least 120 rounds of sustained firings (100 at 60 rpm and 20 rounds full automatic) wherein the barrel temperature can reach 660° F. This temperature is 40 degrees higher than the lowest temperature observed in the sustained firing tests (620° F), which was recorded when an M196 type cartridge loaded with ball propellant, lot FCC 1888, was fired in a non-temperature-conditioned weapon with an unplated barrel.

## APPENDIX A

### TEST PLAN FOR SIMULATING U. K. SUSTAINED FIRING TESTS

Subject: U. K. Extraction Difficulty with 5.56 mm Ammunition  
Containing Western Ball Propellant, Lot WC 846.

#### 1. Reference:

- a. Ltr, 18 Sep 67, from Lt. Col. L. W. Thorne, Munitions/ Artillery, Defence Research and Development Staff, British Defence Staff, British Embassy, Washington, D. C., to U.S. Army Weapons Command, Attn: AMCPM-RS; subj: "5.56 mm Weapon - Stiff Extraction."
- b. 1st Ind, 25 Sep 67, to ltr above, from Hq, U.S. Army Munitions Command, AMSMU-RE-M, to CG, U.S. Army Weapons Command, Attn: W. C. Davis, Jr., Chief, Technical Management Div.; subj: "Extraction Difficulty with 5.56 mm Ammunition Containing Ball Propellant."
- c. Ltr, 25 Sep 67, from W. D. Davis, Jr., Ch, Technical Management Div, U.S. Army Weapons Command, to CG, U.S. Army Munitions Command, Attn: AMSMU-RE-M; subj: "Extraction Difficulties with 5.56 mm Ammunition Containing Ball Propellant."
- d. Ltr, 9 Oct 67, from CG, U.S. Army Munitions Command, AMSMU-RE-M, to CO, Frankford Arsenal, Attn: SMUFA J1000; subj: "Extraction Difficulty with 5.56 mm Ammunition Containing Ball Propellant."

#### 2. Discussion:

a. U. K. Report (reference letter 1a above) states that they... "have recently come across stiff extraction from a cause which was new to us. The stoppage was serious and the fired case could only be removed from the chamber by use of a ramrod from the nozzle. This occurred when we were testing various 5.56 mm weapons for their ability to give a measure of sustained fire in

the L. M. G. automatic rifle role. Examination of the fired cases showed that small elements of ball propellant had ignited between the case and the chamber wall, apparently resulting in several small localized areas where the case was darkened and pitted, with some indication of fusion with the chamber wall. Our limited firings indicate that this is associated with the coincident use of ball propellant and A. R. 15 type of gas system, where gas pressure within the weapon body can apparently cause propellant residues to be deposited in the chamber. Under similar firing and heating conditions, it did not occur with: conventional gas track and ball ammunition, or A. R. 15 gas track and tubular propellant. "

b. Reference b (1st Ind to a, from AMSMU-RE-M) decided that investigations would be conducted within limits imposed by safety considerations.

c. References c (letter from U.S. Army Weapons Command) and d (letter from U.S. Army Munitions Command, AMSMU-RE-M) directed the Commanding Officer of Frankford Arsenal to prepare a draft test plan to investigate the reported (U. K. ) phenomenon, using M16A1 rifles with unplated and plated barrels, and to submit test plan to them prior to initiating tests for their concurrence.

### 3. Purpose:

a. To duplicate tests conducted by the U. K. , but using our M16A1 weapon with plated and unplated barrels, firing at least six cartridge lots loaded with ball propellant.

b. To verify or nullify the U. K. theory by conducting tests with M16A1 weapons with plated and unplated barrels, using the same type of 5.56 mm cartridges described in 3a above, but first having the cartridge case exterior walls thinly dusted with small particles of ball and IMR tubular propellant, this test to be conducted only if the tests in 3a are not successful in inducing the U. K. phenomenon.

c. To conduct tests with several M196 cartridge lots loaded with ball propellant in M16A1 weapons with unplated barrels in the same manner as described in 3 a and b above.

d. To verify that the U. K. phenomenon does not occur with cartridges loaded with IMR (tubular) propellant in M16A1 weapons

with unplated barrels with at least two M193 cartridge lots and one M196 cartridge lot loaded with IMR propellant, as described in 3a above.

4. Material for Tests:

9000 M193 cartridges loaded with ball propellant - 9 different lots, 1000 each.

3000 M193 cartridges loaded with IMR propellant - 3 different lots, 1000 each.

4000 M196 cartridges - 2000 loaded with ball propellant and 2000 loaded with IMR propellant.

5. Test Equipment:

a. Standard test equipment prescribed in conducting official Engineering Tests for sustained rapid firings.

b. Six new M16A1 weapons with unplated barrels and two additional M16A1 weapons with chrome-plated barrels.

6. Test Procedure:

a. Tests are to be conducted in group 3a above in the following manner. Firings will be conducted as rapidly as possible, both semiautomatically (SA) and full-automatically (FA) in cycles of 80 rounds SA and 20 rounds FA; a second 80 rounds SA and 20 rounds FA; then cool. Then, continue on into the next cycle. The aim in each case is to complete a total of 1000 rounds with each lot at 30 rpm SA for the first two cycles of this group and 60 rpm SA for the last portion of the 1000 rounds other than the ten 20-round groups at Frankford Arsenal. \* Rates of fire are to be 30, 40, 50, and 60 rpm until 1000° F is reached. This firing procedure will continue throughout up to 1000 rounds or until a "difficult extraction" occurs, whichever happens first.

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\*If stoppage takes place at any time during these tests due to occurrence of the U. K. phenomenon, this lot will be withdrawn from the test schedule, the barrel temperature and cyclic rate recorded, and the spent cartridge case and complete weapon thoroughly analyzed by the Chemical Section to determine the nature of residues and abrasions.

b. The test as outlined above will be repeated with at least two of the lots used above, using M16A1 weapons with chrome-plated barrels and completely replaced bolt assemblies and gas tubes. If these parts are not available, use of new weapons is recommended.

c. For tests outlined in 3b, the following schedule is recommended. Six magazines are to be loaded, one each lot, in series of 4 propellant-coated cartridges loaded with ball propellant and one dummy cartridge, fired at Frankford Arsenal after the barrels have been brought up to heated temperature level from firing at least 200 rounds (30 SA, 20 FA, 80 SA, 20 FA) in group 3a above.

d. Two lots of M196 cartridges loaded with ball propellant and one lot loaded with IMR propellant (1000 each lot) shall be included in this group. The schedule in 6a will be followed.

7. Recording of Data:

a. Tests will be conducted at 70° F and barrel temperature measurements will be taken at a point 8 inches from the breech face.

b. All malfunctions with weapon and/or ammunition will be checked by inspection group.

c. Total number of successful firings with each type of barrel and each type of cartridge will be recorded by Proof Testing Laboratory.

d. Highest cyclic rate obtained with each test and barrel temperature (°F) obtained during tests or at rate when observed stoppage occurs will be recorded.

8. Funding Authority:

E.D.S.P. (5.56 mm Program)

9. X.O. Charge No.:

83916-41

10. Recommendations for these Tests:

a. After each test is completed, a chemical analysis will be conducted by the Chemistry Section to determine the nature of the coatings accumulated on the surface of the spent cartridge cases.

b. Lubricant MIL-L-46,000 will be used on all weapons in these tests. (Laboratory is currently using Lubricant Oil, General Purpose, V8000.)

c. Conduct pre-firing inspection of all weapons used in these tests.

d. Newest type of Parkerized bolt and buffer assembly will be used for these tests.

## APPENDIX B

### AMMUNITION AND EQUIPMENT USED IN THESE TESTS

The propellant-coated 5.56 mm cartridges used in these tests were drawn from aggregate samples of cartridges taken from each lot tested. In the case of ball propellant, the grains were sifted and the finer grains collected. The gunner caused the grains to adhere to the cartridge wall by rolling the cartridges in the palm of his hands. He had previously dampened his hand with a few drops of lubricant oil and wiped them with a dry cloth. In each case, at least a dozen or more grains were made to adhere to the outside of the cartridge case. (See Figure B1.) With the IMR (tubular) propellant, crushed particles were sifted, then collected and applied in the same manner as the ball propellant.

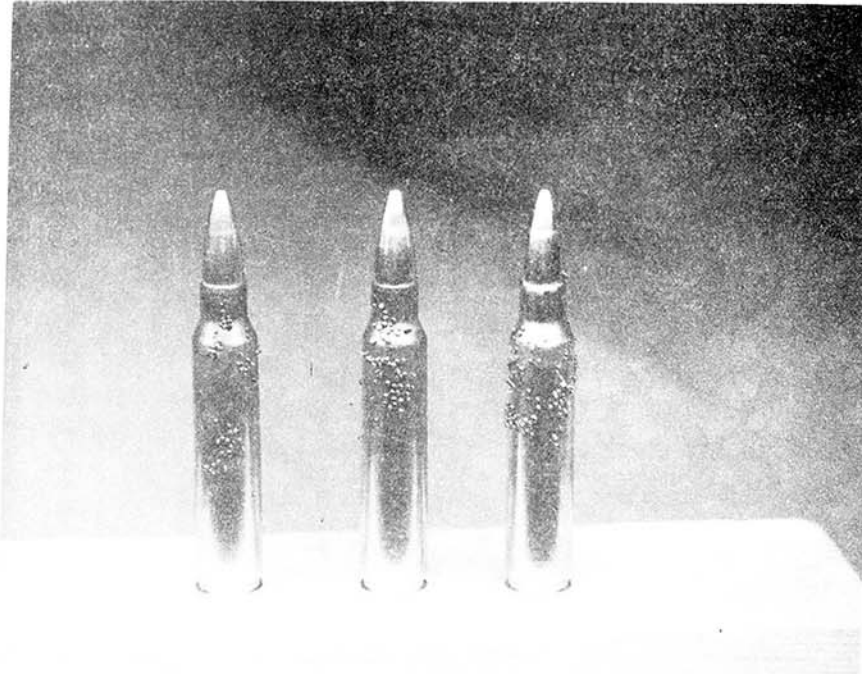


Figure B1. Propellant-coated cartridges

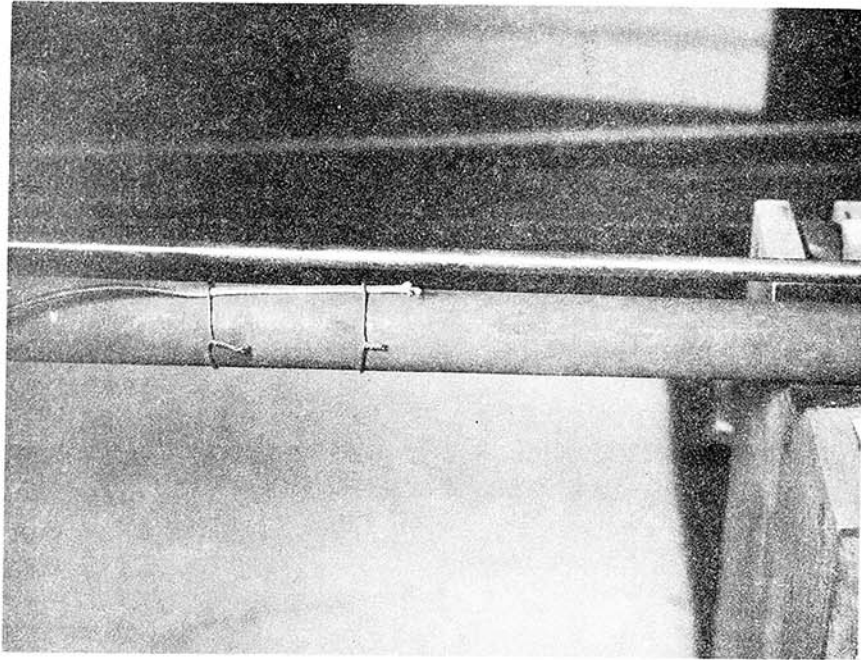
For obtaining barrel temperature data, a thermal recording machine was employed which instantaneously charted the fluctuating temperatures. Thermocoupling leads from this recorder were spot-welded to the outer surface of the gun barrel at a distance of 8 inches from the breech face on an angle of 180° F above the trigger mechanism of the weapon. (Location views of the leads are shown in Figure B2.) This machine was also equipped with a recording potentiometer, calculated to show readings from 0.25° to a maximum of 1250° F. An attached pyrometric instrument was employed to give direct readings in °F.

To obtain the specific semiautomatic rates of fire used in these tests, a universal timer (Figure B3) was used so that precise timing of the firing for each round could be executed in each series. A cyclic rate timing instrument was also used to record the cyclic rate of the full automatic bursts. Impulses from a miniature microphone located adjacent to the muzzle of the weapon were transmitted and recorded on a tape.

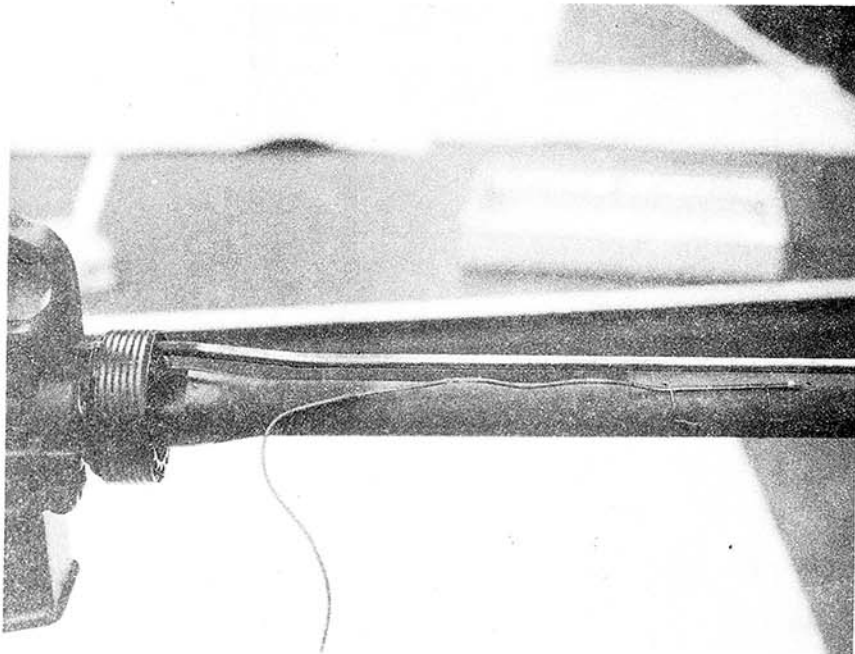
The M16A1 weapons used in these tests were assembled to a slide on a gun mount and fired in a machine rest position. (See Figure B4.) The muzzle was secured, by clamping, between the flash suppressor and the front sight, and the buttstock of the weapon was similarly secured by clamping. Recoil springs were employed on the slide to allow the weapon to recoil and return. All firings were accomplished by remote control, with the gun room padlocked during firings.

The following is a list of cartridge lots.

| <u>Cartridge Lot</u> | <u>Cartridge Type</u> | <u>Propellant Type</u> | <u>Number of Rounds</u> |
|----------------------|-----------------------|------------------------|-------------------------|
| WCC 6157             | M193                  | Ball                   | 2000                    |
| LC 12296             | M193                  | Ball                   | 1000                    |
| RA 5316              | M193                  | Ball                   | 2000                    |
| FCC 1888             | M193                  | Ball                   | 1000                    |
| LC 12236             | M193                  | IMR                    | 1000                    |
| LC 12115             | M196                  | Ball                   | 2000                    |
| TW 18037             | M196                  | IMR                    | 1000                    |



A



B

Figure B2. A. Location of Thermocoupling Lead Wires at a Point on the Barrel 8 inches from the Face of the Breech  
B. Close-up of Thermocoupling Lead Wires at Point of Attachment to the Exterior

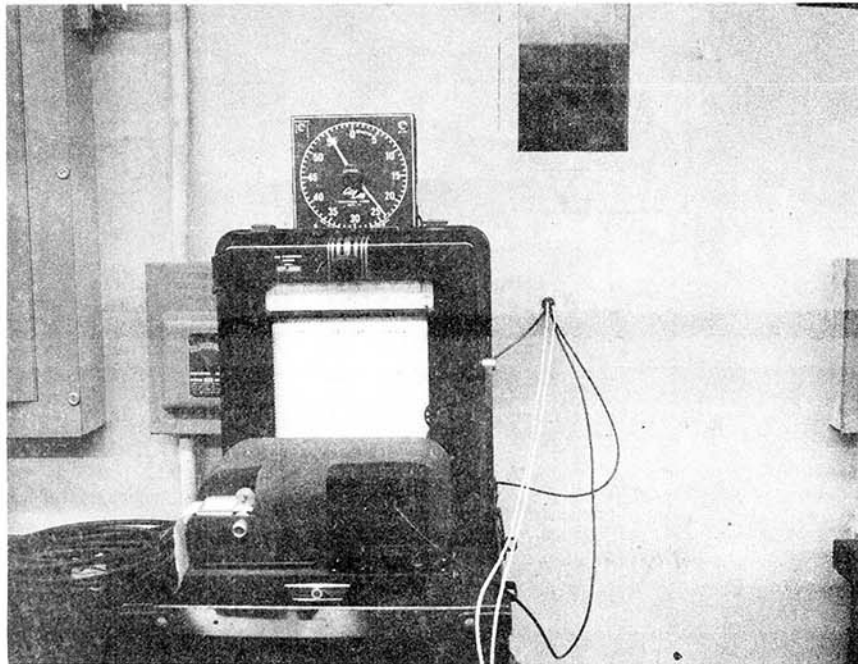


Figure B3. Universal Timer

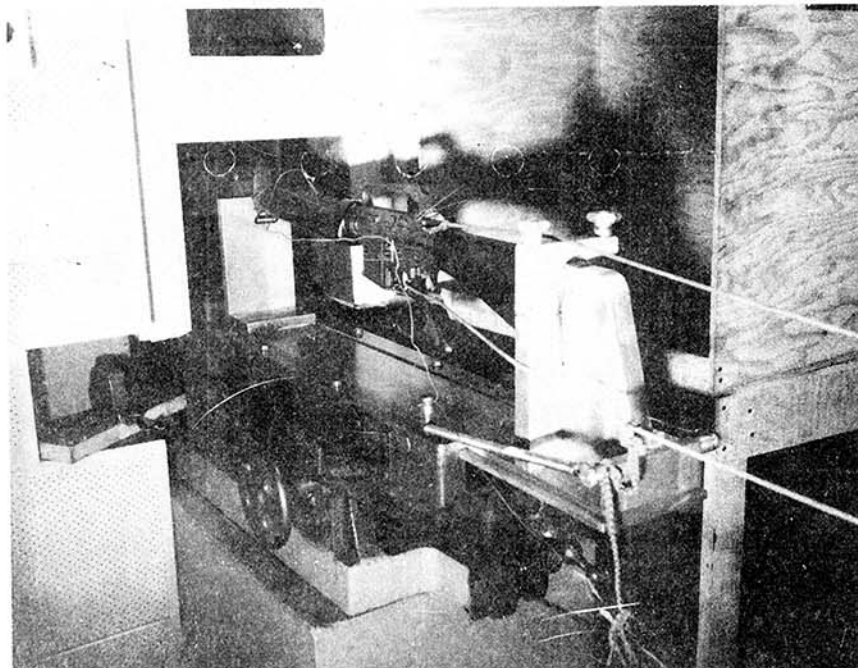


Figure B4. Weapon and mount set-up in gun room with rifle pointing down range.

Following is the sequence of weapons with ammunition, as used in these tests. The first ten weapons were used in the simulated U. K. sustained firing tests; rifle #825187 (fired with the last seven cartridge lots listed) was also used in the cook-off tests. The letter C after the rifle serial number indicates a chrome-plated barrel was used.

| <u>Weapon Serial No.</u> | <u>Cartridge Lot Used</u> |
|--------------------------|---------------------------|
| 816986                   | WCC 6157                  |
| 822885                   | LC 12296                  |
| 823422                   | RA 5316                   |
| 825187                   | FCC 1888                  |
| 816986C                  | WCC 6157                  |
| 822885C                  | RA 5316                   |
| 825187                   | LC 12236                  |
| 822885                   | LC 12115                  |
| 823422                   | LC 12115                  |
| 816986                   | TW 18037                  |
| 825187                   | WCC 6157                  |
| 825187                   | LC 12296                  |
| 825187                   | RA 5316                   |
| 825187                   | FCC 1888                  |
| 825187                   | LC 12115                  |
| 825187                   | TW 18037                  |
| 825187                   | LC 12236                  |

APPENDIX C

TABULATION OF DATA  
 SIMULATED U.K. SUSTAINED FIRING TEST  
 (Number of Rounds Fired vs Temperature Rise in Weapon)

Note - The letter C after the rifle number indicates chrome-plated barrel

| <u>Round Nos</u>   | <u>Firing Mode (Automatic)</u> | <u>Rate of Fire (rpm)</u> | <u>Temperature (°F)</u> |              |
|--|--------------------------------|---------------------------|-------------------------|--------------|
|  |                                |                           | <u>Initial</u>          | <u>Final</u> |
| Test #1 - Rifle #816986; M193 Ball Propellant, Lot WCC 6157. |                                |                           |                         |              |
| 1-20   | Semi                           | 30                        | 70                      | 200          |
| 21-40  | Semi                           | 30                        | 200                     | 310          |
| 41-60  | Semi                           | 30                        | 310                     | 400          |
| 61-80  | Semi                           | 30                        | 400                     | 480          |
| 81-100   | Full                           | 761                       | 480                     | 580          |
| 101-120  | Semi                           | 30                        | 580                     | 625          |
| 121-140  | Semi                           | 30                        | 625                     | 665          |
| 141-160  | Semi                           | 30                        | 665                     | 700          |
| 161-180  | Semi                           | 30                        | 700                     | 715          |
| 181-200  | Full                           | 761                       | 715                     | 770          |
| 201-220  | Semi                           | 30                        | 800                     | 820          |
| 221-240  | Semi                           | 30                        | 820                     | 830          |
| 241-260  | Semi                           | 30                        | 830                     | 840          |
| 261-280  | Semi                           | 30                        | 840                     | 850          |
| 281-300  | Full                           | 787                       | 800                     | 820          |
| 301-320  | Semi                           | 30                        | 820                     | 850          |
| 321-340  | Semi                           | 30                        | 820                     | 850          |
| 341-360  | Semi                           | 30                        | 850                     | 860          |
| 361-380  | Semi                           | 30                        | 860                     | 875          |
| 381-400  | Full                           | 797                       | 865                     | 875          |
| 401-420  | Semi                           | 30                        | 870                     | 880          |
| 421-440  | Semi                           | 30                        | 875                     | 880          |
| 441-460  | Semi                           | 30                        | 880                     | 890          |
| 461-480  | Semi                           | 30                        | 885                     | 900          |
| 481-500  | Full                           | 761                       | 900                     | 910          |

| <u>Round<br/>Nos</u> | <u>Firing Mode<br/>(Automatic)</u> | <u>Rate of Fire<br/>(rpm)</u> | <u>Temperature (°F)</u> |              |
|----------------------|------------------------------------|-------------------------------|-------------------------|--------------|
|                      |                                    |                               | <u>Initial</u>          | <u>Final</u> |

Test #2, Rifle #822885, M193 Ball Propellant, Lot LC 12296

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 40  | 70  | 220 |
| 21-40   | Semi | 40  | 220 | 340 |
| 41-60   | Semi | 40  | 340 | 440 |
| 61-80   | Semi | 40  | 440 | 540 |
| 81-100  | Full | 787 | 540 | 630 |
| 101-120 | Semi | 40  | 630 | 700 |
| 121-140 | Semi | 40  | 700 | 740 |
| 141-160 | Semi | 40  | 740 | 790 |
| 161-180 | Semi | 40  | 790 | 830 |
| 181-200 | Full | 931 | 830 | 850 |
| 201-220 | Semi | 40  | 850 | 890 |
| 221-240 | Semi | 40  | 890 | 900 |
| 241-260 | Full | 912 | 900 | 950 |

Test #3, Rifle #823422, M193 Ball Propellant, Lot RA 5316

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 50  | 70  | 240 |
| 21-40   | Semi | 50  | 240 | 330 |
| 41-60   | Semi | 50  | 330 | 440 |
| 61-80   | Semi | 50  | 440 | 530 |
| 81-100  | Full | 845 | 530 | 620 |
| 101-120 | Semi | 50  | 620 | 680 |
| 121-140 | Semi | 50  | 680 | 740 |
| 141-160 | Semi | 50  | 740 | 800 |
| 161-180 | Semi | 50  | 800 | 850 |
| 181-200 | Full | 799 | 850 | 920 |
| 201-220 | Full | 799 | 920 | 950 |

| <u>Round</u><br><u>Nos</u> | <u>Firing Mode</u><br><u>(automatic)</u> | <u>Rate of Fire</u><br><u>(rpm)</u> | <u>Temperature (°F)</u> |              |
|----------------------------|--|-------------------------------------|-------------------------|--------------|
|                            |  |                                     | <u>Initial</u>          | <u>Final</u> |

Test #4, Rifle #825187, M193 Ball Propellant, Lot FCC 1888

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 60  | 70  | 200 |
| 21-40   | Semi | 60  | 200 | 310 |
| 41-60   | Semi | 60  | 310 | 420 |
| 61-80   | Semi | 60  | 420 | 520 |
| 81-100  | Full | 814 | 520 | 600 |
| 101-120 | Semi | 60  | 600 | 660 |
| 121-140 | Semi | 60  | 660 | 730 |
| 141-160 | Semi | 60  | 730 | 780 |
| 161-180 | Semi | 60  | 780 | 840 |
| 181-200 | Full | 773 | 840 | 880 |
| 201-220 | Semi | 60  | 880 | 910 |
| 221-240 | Full | 733 | 910 | 960 |

Test #5, Rifle #816986C, M193, Ball Propellant, Lot WCC 6157

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 40  | 70  | 210 |
| 21-40   | Semi | 40  | 210 | 340 |
| 41-60   | Semi | 40  | 340 | 440 |
| 61-80   | Semi | 40  | 440 | 520 |
| 81-100  | Full | 773 | 520 | 590 |
| 101-120 | Semi | 40  | 590 | 660 |
| 121-140 | Semi | 40  | 660 | 710 |
| 141-160 | Semi | 40  | 710 | 760 |
| 161-180 | Semi | 40  | 760 | 800 |
| 181-200 | Full | 773 | 800 | 850 |
| 201-220 | Semi | 40  | 850 | 870 |
| 221-240 | Semi | 40  | 870 | 900 |
| 241-260 | Full | 799 | 900 | 940 |

| <u>Round<br/>Nos</u> | <u>Firing Mode<br/>(automatic)</u> | <u>Rate of Fire<br/>(rpm)</u> | <u>Temperature (°F)</u> |              |
|----------------------|------------------------------------|-------------------------------|-------------------------|--------------|
|                      |                                    |                               | <u>Initial</u>          | <u>Final</u> |

Test #6, Rifle #823422C, M193 Ball Propellant, Lot RA 5316

|         |      |     |     |      |
|---------|------|-----|-----|------|
| 1-20    | Semi | 60  | 70  | 220  |
| 21-40   | Semi | 60  | 220 | 350  |
| 41-60   | Semi | 60  | 350 | 460  |
| 61-80   | Semi | 60  | 460 | 530  |
| 81-100  | Full | 845 | 530 | 640  |
| 101-120 | Semi | 60  | 640 | 720  |
| 121-140 | Semi | 60  | 720 | 790  |
| 141-160 | Semi | 60  | 790 | 840  |
| 161-180 | Semi | 60  | 840 | 940  |
| 181-200 | Full | 859 | 940 | 990  |
| 201-220 | Full | 859 | 990 | 1050 |

Test #7, Rifle #825187, M193 IMR Propellant, Lot LC 12236

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 60  | 70  | 220 |
| 21-40   | Semi | 60  | 220 | 345 |
| 41-60   | Semi | 60  | 345 | 460 |
| 61-80   | Semi | 60  | 460 | 540 |
| 81-100  | Full | 660 | 540 | 620 |
| 101-120 | Semi | 60  | 620 | 690 |
| 121-140 | Semi | 60  | 690 | 740 |
| 141-160 | Semi | 60  | 740 | 800 |
| 161-180 | Semi | 60  | 800 | 840 |
| 181-200 | Full | 650 | 840 | 865 |
| 201-220 | Semi | 60  | 865 | 900 |
| 221-240 | Full | 690 | 900 | 925 |

| <u>Round<br/>Nos</u> | <u>Firing Mode<br/>(automatic)</u> | <u>Rate of Fire<br/>(rpm)</u> | <u>Temperature (°F)</u> |              |
|----------------------|------------------------------------|-------------------------------|-------------------------|--------------|
|                      |                                    |                               | <u>Initial</u>          | <u>Final</u> |

Test #8, Rifle #822885, M196 Ball Propellant, Lot LC 12115

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 40  | 70  | 220 |
| 21-40   | Semi | 40  | 220 | 360 |
| 41-60   | Semi | 40  | 360 | 470 |
| 61-80   | Semi | 40  | 470 | 550 |
| 81-100  | Full | 895 | 550 | 610 |
| 101-120 | Semi | 40  | 610 | 700 |
| 121-140 | Semi | 40  | 700 | 750 |
| 141-160 | Semi | 40  | 750 | 795 |
| 161-180 | Semi | 40  | 795 | 830 |
| 181-200 | Full | 931 | 830 | 880 |
| 201-220 | Semi | 40  | 880 | 910 |
| 221-240 | Full | 950 | 910 | 950 |

Test #9, Rifle #823422C, M196 Ball Propellant, Lot LC 12115

|         |      |     |     |     |
|---------|------|-----|-----|-----|
| 1-20    | Semi | 60  | 70  | 230 |
| 21-40   | Semi | 60  | 230 | 360 |
| 41-60   | Semi | 60  | 360 | 460 |
| 61-80   | Semi | 60  | 460 | 560 |
| 81-100  | Full | 820 | 560 | 640 |
| 101-120 | Semi | 60  | 640 | 720 |
| 121-140 | Semi | 60  | 720 | 780 |
| 141-160 | Semi | 60  | 780 | 830 |
| 161-180 | Semi | 60  | 830 | 875 |
| 181-200 | Full | 895 | 875 | 910 |
| 201-220 | Full | 840 | 910 | 970 |

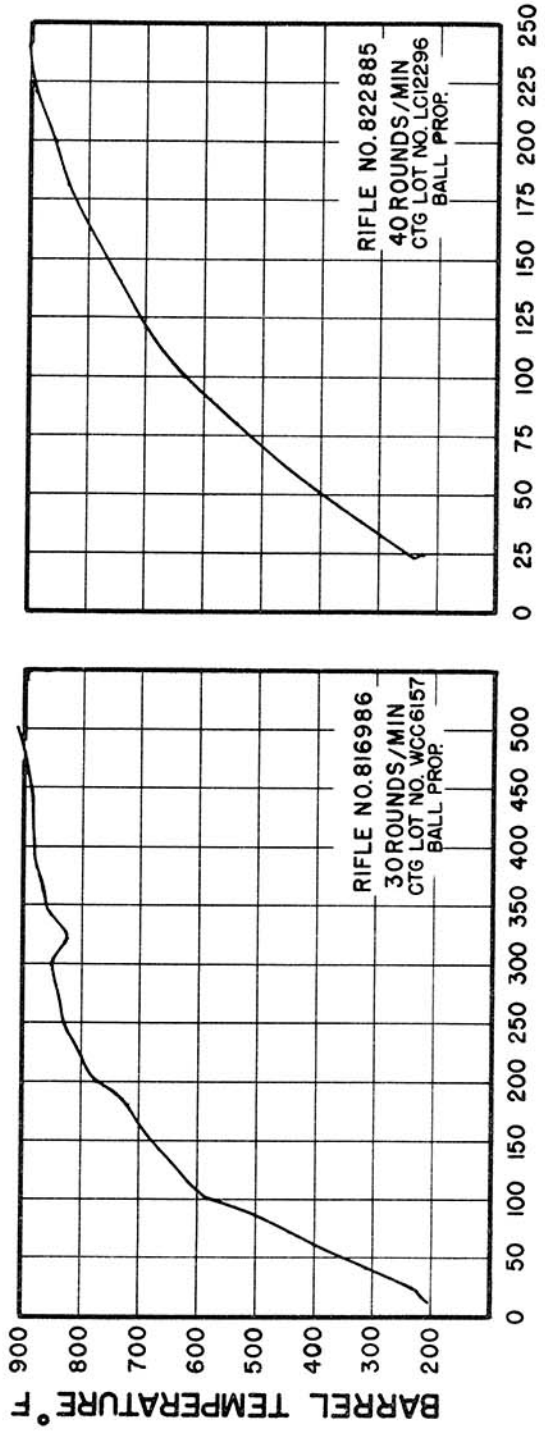
Test #10, Rifle #816986, M196 IMR Propellant, Lot TW 18037

|        |      |     |     |     |
|--------|------|-----|-----|-----|
| 1-20   | Semi | 60  | 70  | 200 |
| 21-40  | Semi | 60  | 200 | 320 |
| 41-60  | Semi | 60  | 320 | 420 |
| 61-80  | Semi | 60  | 420 | 510 |
| 81-100 | Full | 820 | 510 | 600 |

| <u>Round<br/>Nos</u> | <u>Firing Mode<br/>(automatic)</u> | <u>Rate of Fire<br/>(rpm)</u> | <u>Temperature (°F)</u> |              |
|----------------------|------------------------------------|-------------------------------|-------------------------|--------------|
|                      |                                    |                               | <u>Initial</u>          | <u>Final</u> |
| Test #10, cont'd.    |                                    |                               |                         |              |
| 101-120              | Semi                               | 60                            | 600                     | 690          |
| 121-140              | Semi                               | 60                            | 690                     | 760          |
| 141-160              | Semi                               | 60                            | 760                     | 800          |
| 161-180              | Semi                               | 60                            | 800                     | 850          |
| 181-200              | Full                               | 761                           | 850                     | 870          |
| 201-220              | Semi                               | 60                            | 870                     | 900          |
| 221-240              | Full                               | 773                           | 900                     | 940          |

APPENDIX D  
GRAPHS OF DATA FROM SIMULATED U. K. SUSTAINED FIRING TEST  
(Number of Rounds Fired vs Temperature Rise in Weapon)

Graphs are presented showing number of rounds fired vs temperature rise in the various weapons, with chrome-plated and unplated barrels and using various lots of ball and tracer ammunition. Weapon temperatures were taken at a point 8.5 inches from the breech face of the M16A1 rifle. Firing schedule consisted of 80 rounds semiautomatic and 20 rounds full automatic, repeated until the temperature rose to approximately 900° F. Rifle, rate of fire, and cartridge type and lot used are indicated on each graph.

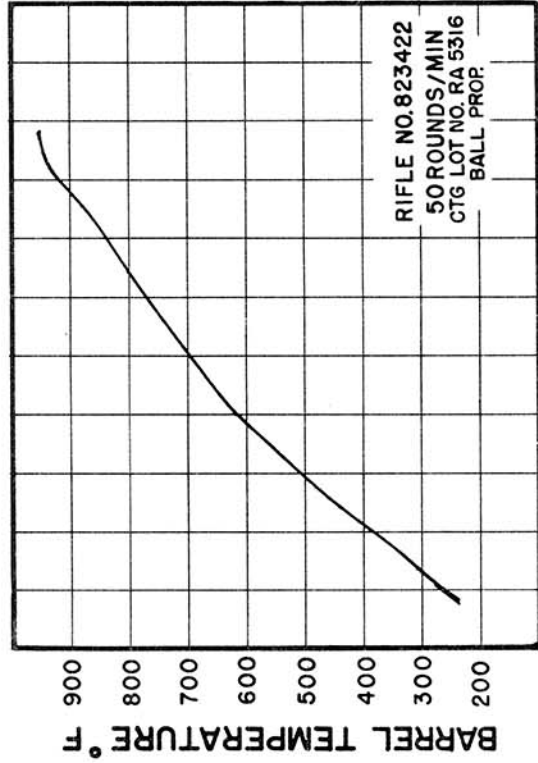


UNPLATED BARREL

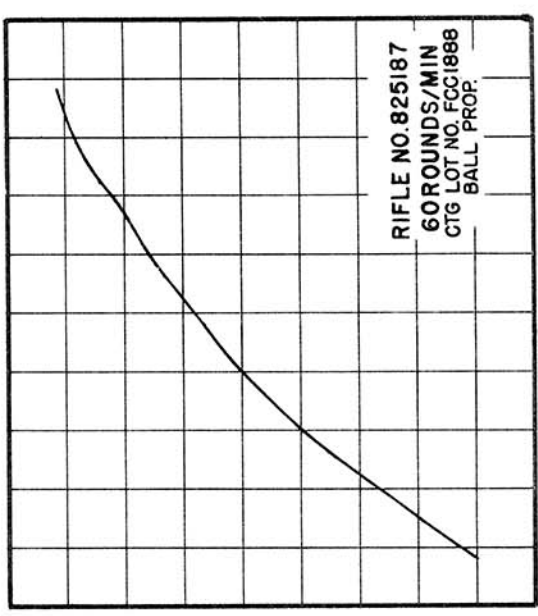
Test #1

ROUNDS FIRED

Test #2



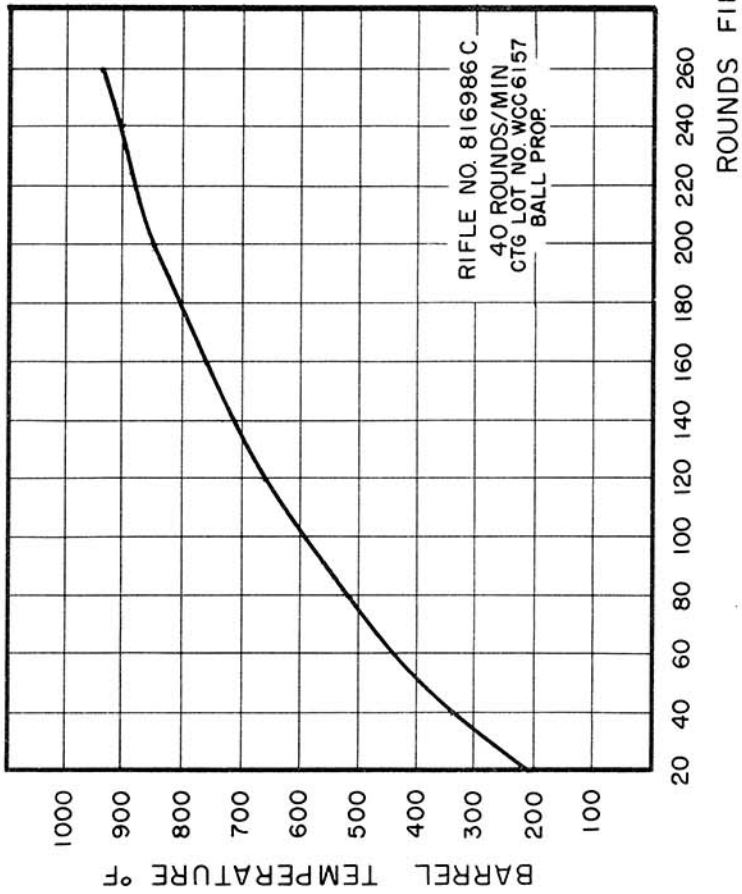
Test #3



Test #4

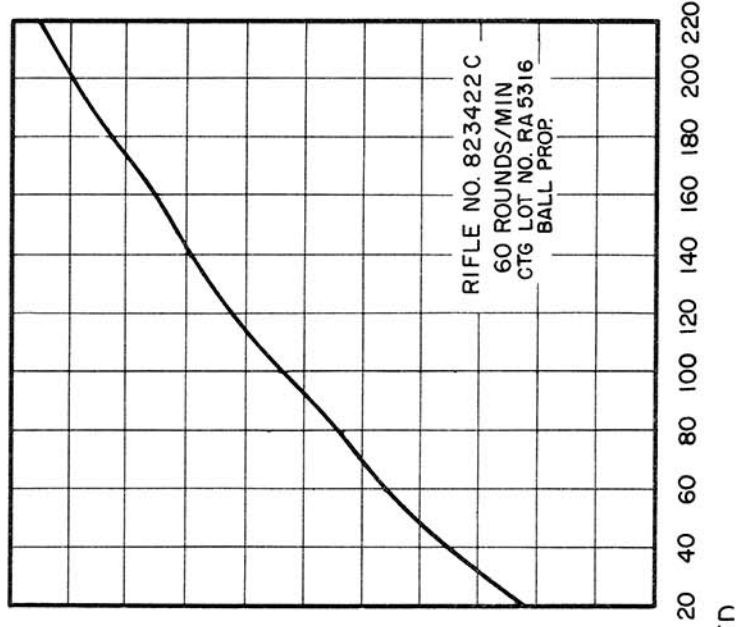
ROUNDS FIRED  
BARRELS UNPLATED WC PROPELLANT

UNPLATED BARREL      ROUNDS FIRED      UNPLATED BARREL



CHROME-PLATED BARREL

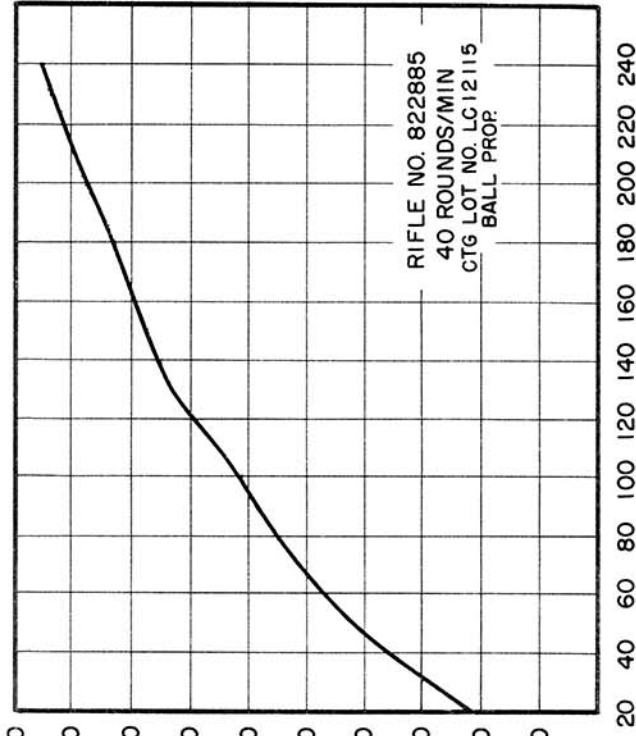
Test #5



CHROME-PLATED BARREL

Test #6

BARREL TEMPERATURE °F

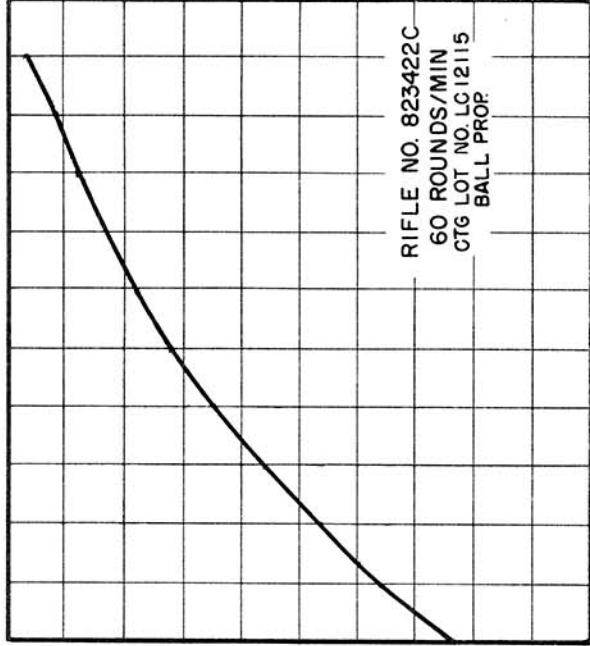


RIFLE NO. 822885  
40 ROUNDS/MIN  
CTG LOT NO. LC12115  
BALL PROP.

ROUNDS FIRED

UNPLATED BARREL

Test #8

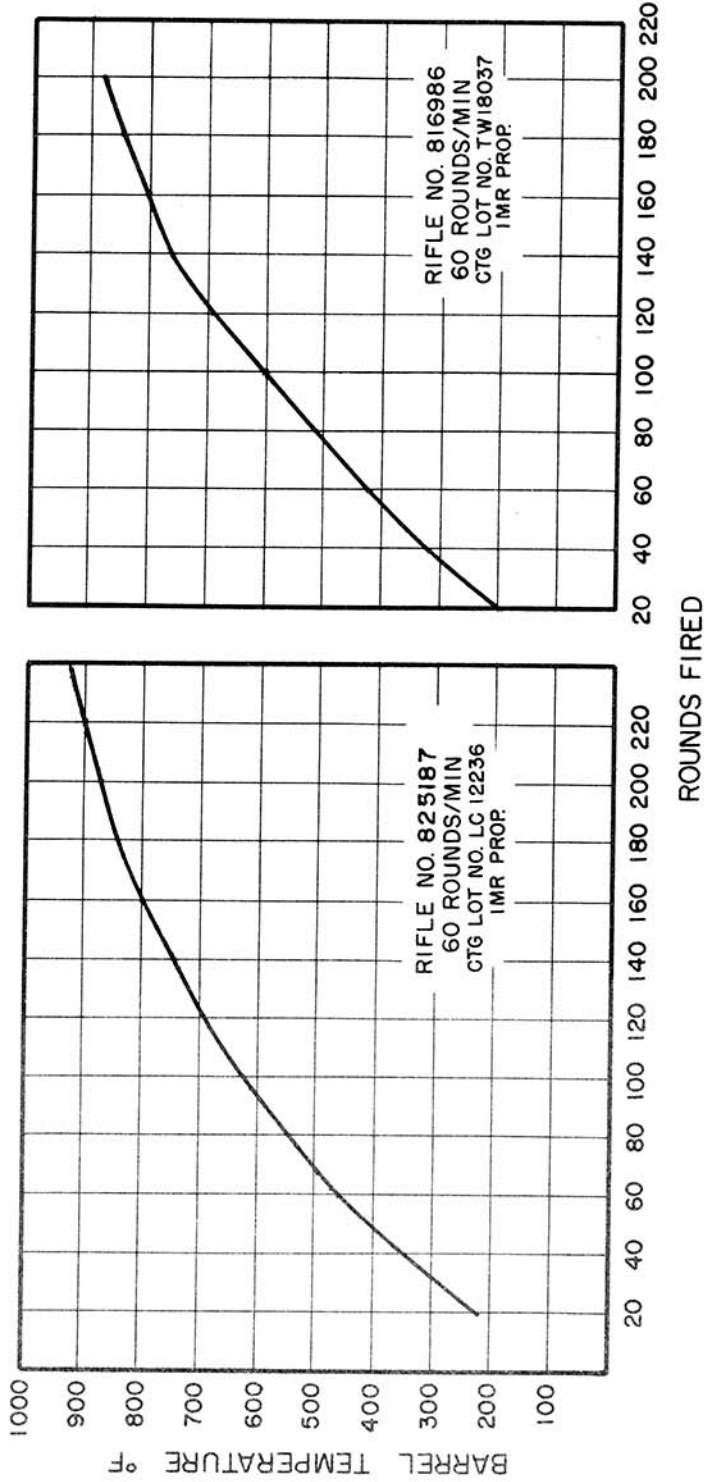


RIFLE NO. 823422C  
60 ROUNDS/MIN  
CTG LOT NO. LC12115  
BALL PROP.

ROUNDS FIRED

PLATED BARREL

Test #9



UNPLATED BARREL

Test #7

UNPLATED BARREL

Test #10

APPENDIX E

DATA AND PHOTOGRAPHS, DAMAGED CARTRIDGE CASES

M193 cartridges loaded with ball propellant, lot LC 12296 (cases coated with propellant before firing), fired in rifle #822885:

2 cases - residue on shoulder.

Chemical Analysis: Traces of sodium and calcium, indicating propellant residue.

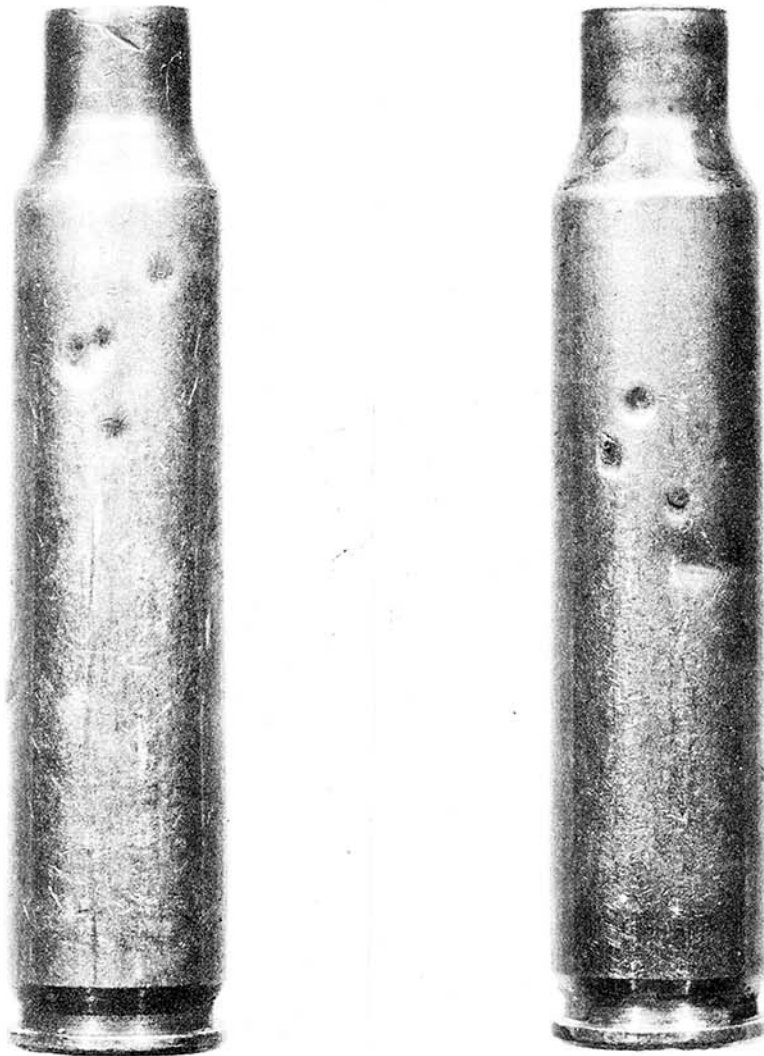


NOTE: Oblong indent in cartridge on left was caused by magazine autofeeding.

M193 cartridges loaded with ball propellant, lot FC 1888 (cases coated with propellant before firing), fired in rifle #825187:

2 cases - indent on fired cases.

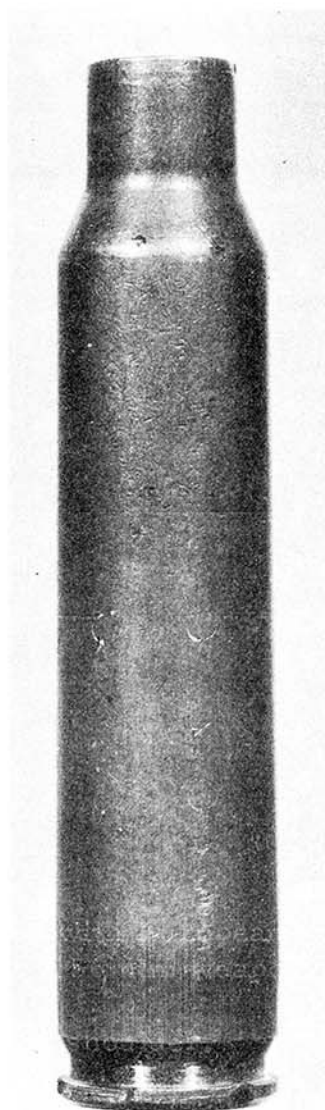
Chemical Analysis: Traces of sodium and calcium, indicating propellant residue.



U. K. cartridge loaded with European-manufactured ammunition,  
fired in a heavy-duty 5.56 mm weapon.

1 case - 2 spots at shoulder.

Chemical Analysis: Traces of potassium, sodium, and calcium,  
indicating propellant residue.



APPENDIX F  
 U S ARMY FRANKFORD ARSENAL  
 BASIC MATERIALS EVALUATION LABORATORY (Q6100)  
 QUALITY ASSURANCE DIRECTORATE  
**LABORATORY REPORT**

NO. 155118 DATE 22 January 1968  
 MATERIAL Cartridge Cases - Indents and Residues  
 REPRESENTING Western Propellant LOT NO. \_\_\_\_\_ P. O. \_\_\_\_\_  
 FROM \_\_\_\_\_ TO J. Repholtz, J9200/521-B Foreman Ldr  
A. Magar, J7300/521-1, Project Engineer  
 SPECIFICATION & DATE \_\_\_\_\_ x.o. 86206-92 SEA

IDENTIFICATION

| <u>Envelope</u> | <u>Lot No.</u> | <u>Remarks</u>               |
|-----------------|----------------|------------------------------|
| #1 - 1          | LC 12296       | Smudge at shoulder and base. |
| #1 - 2          | LC 12296       | Smudge at shoulder and base. |
| #3              | RA 5316        | 1 case - indent - propellant |
| #6              | U.K            | 2 spots at shoulder          |
| #8              | LC 12236       | coated at neck               |
| #9              | 8-FC1888       | coated at mouth              |

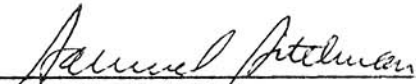
Spectrographic analysis of the areas of the cartridge cases submitted indicated the presence of potassium, sodium, and calcium in each sample from envelope 1-1, 3, 6, 8, and 9.

Sample 1-2 indicated the presence of sodium and calcium.

For Information Only:

GEORGE NORWITZ  
 Chemist

Report Approved:

  
 \_\_\_\_\_  
 SAMUEL STELMAN  
 Chief, Basic Materials Evaluation Laboratory

## APPENDIX G

### COOK-OFF FIRING TEST DATA

Cook-off firing tests were conducted with various lots of both M193 and M196 cartridges. In each test, two rounds of the cartridge lot were coated with small particles of propellant and permitted to cook-off in a temperature-conditioned weapon. The weapon was then immediately brought back to a temperature between 900° and 1000° F by rapid firings, and then a full magazine of 20 rounds of uncoated cartridges of the same lot was inserted. The initial round of the full magazine was chambered by remote control, and as many rounds as possible were permitted to cook-off in the slowly cooling weapon. When the last cook-off occurred and a ten-minute waiting period had elapsed, the remaining rounds in the magazine were fired to check for weapon function. Rifle #825187 was used in all these tests. Test data and graphs of temperature vs cook-off time for each test follow.

5.56 mm M193 Cartridge Loaded with Ball Type Propellant, Lot WCC 6157

| Rd. No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|---------|------------------|-----------------------|-------------------------------------|
|---------|------------------|-----------------------|-------------------------------------|

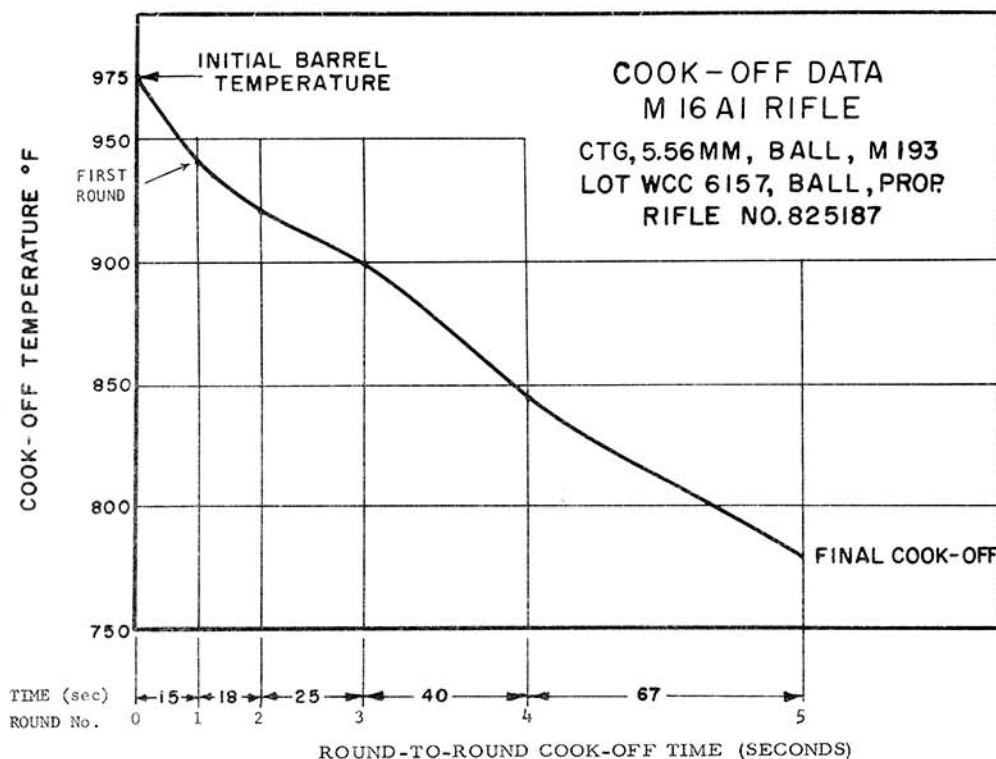
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 950° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 950 | 16 | 16 |
| 2 | 880 | 17 | 33 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 975° F

|   |     |    |        |
|---|-----|----|--------|
| 1 | 940 | 15 | 15     |
| 2 | 920 | 18 | 33     |
| 3 | 900 | 25 | 58     |
| 4 | 845 | 40 | 1 + 38 |
| 5 | 780 | 67 | 2 + 45 |

Ten minutes after the fifth cook-off occurred with this lot, the weapon temperature receded to 400° F. Assured that no further rounds would cook-off at this temperature, the remaining 15 rounds in the magazine were fired by remote control for weapon function. Inspection of the head space and chamber components of the weapon showed no damage.



5.56 mm M193 Cartridge Loaded with Ball Type Propellant, Lot LC 12296

| Rd. No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|---------|------------------|-----------------------|-------------------------------------|
|---------|------------------|-----------------------|-------------------------------------|

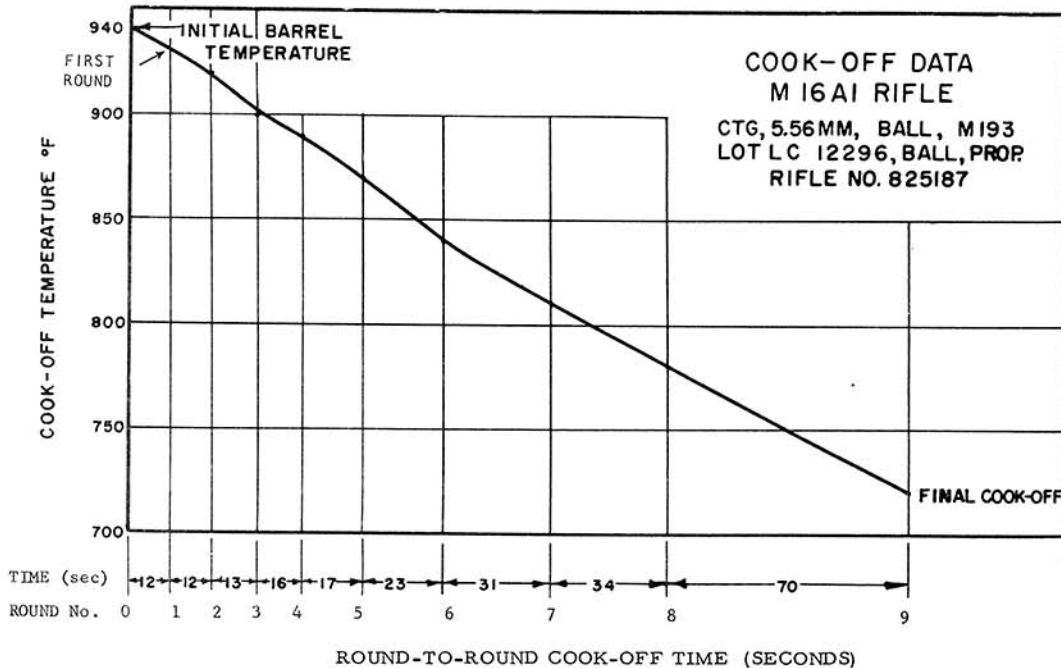
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 975° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 950 | 16 | 16 |
| 2 | 880 | 17 | 33 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 950° F

|   |     |    |        |
|---|-----|----|--------|
| 1 | 930 | 12 | 12     |
| 2 | 920 | 12 | 24     |
| 3 | 900 | 13 | 37     |
| 4 | 890 | 16 | 53     |
| 5 | 870 | 17 | 1 + 10 |
| 6 | 840 | 23 | 1 + 33 |
| 7 | 810 | 31 | 2 + 4  |
| 8 | 780 | 34 | 2 + 38 |
| 9 | 720 | 70 | 4 + 48 |

After a 10-minute waiting period elapsed, the remaining 11 rounds were fired by remote control for weapon function.



5.56 mm M193 Cartridge Loaded with Ball Type Propellant, Lot RA 5316

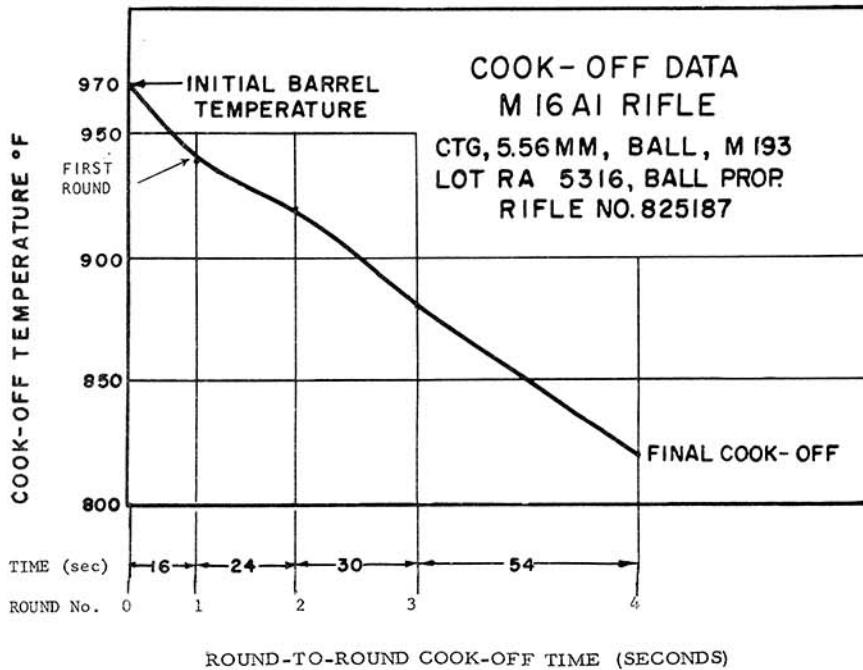
| Rd No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|--------|------------------|-----------------------|-------------------------------------|
|--------|------------------|-----------------------|-------------------------------------|

Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 980° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 980 | 10 | 10 |
| 2 | 940 | 30 | 40 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 970° F

|   |     |    |        |
|---|-----|----|--------|
| 1 | 940 | 16 | 16     |
| 2 | 920 | 24 | 40     |
| 3 | 880 | 30 | 1 + 10 |
| 4 | 820 | 54 | 2 + 4  |



5.56 mm M193 Cartridge Loaded with Ball Type Propellant, Lot FCC 1888

| Rd No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|--------|------------------|-----------------------|-------------------------------------|
|--------|------------------|-----------------------|-------------------------------------|

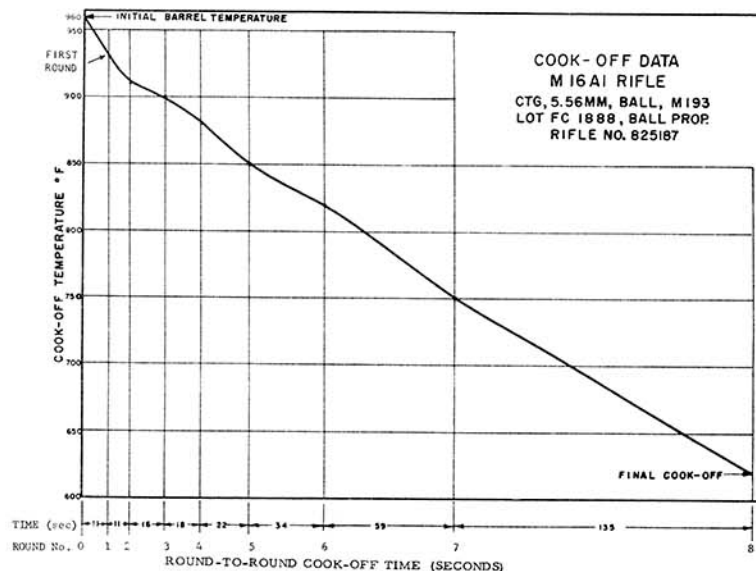
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 980° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 950 | 16 | 16 |
| 2 | 930 | 17 | 33 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 960° F

|   |     |     |        |
|---|-----|-----|--------|
| 1 | 930 | 11  | 11     |
| 2 | 910 | 11  | 22     |
| 3 | 900 | 16  | 38     |
| 4 | 880 | 18  | 56     |
| 5 | 850 | 22  | 1 + 18 |
| 6 | 820 | 34  | 1 + 52 |
| 7 | 750 | 59  | 2 + 51 |
| 8 | 620 | 135 | 5 + 6  |

After a 10-minute waiting period, and the temperature of the weapon had receded to approximately 400° F, the remaining 12 rounds were fired for weapon function. This procedure was followed after each set of cook-off firings with regular 5.56 mm ammunition in these tests.



5.56 mm M196 Tracer Cartridge Loaded with Ball Type Propellant,  
Lot LC 12115

| Rd No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|--------|------------------|-----------------------|-------------------------------------|
|--------|------------------|-----------------------|-------------------------------------|

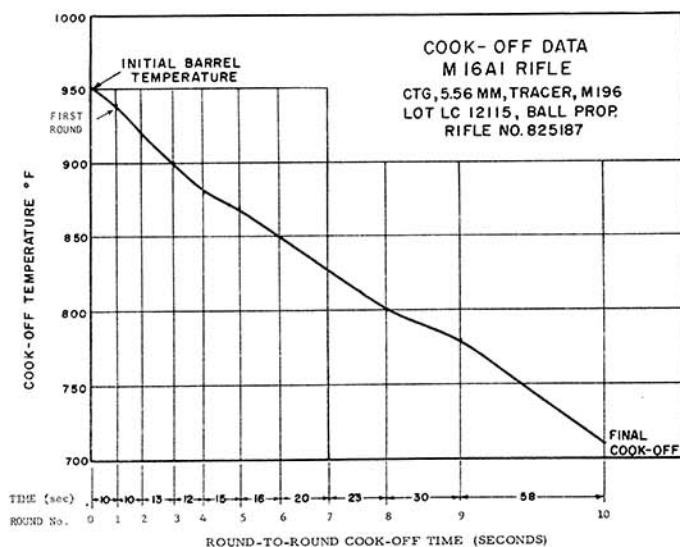
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 980° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 960 | 10 | 10 |
| 2 | 920 | 10 | 20 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 960° F

|    |     |    |        |
|----|-----|----|--------|
| 1  | 940 | 10 | 10     |
| 2  | 920 | 10 | 20     |
| 3  | 900 | 13 | 33     |
| 4  | 880 | 12 | 45     |
| 5  | 870 | 15 | 60     |
| 6  | 850 | 16 | 1 + 16 |
| 7  | 830 | 20 | 1 + 36 |
| 8  | 800 | 23 | 1 + 59 |
| 9  | 780 | 30 | 2 + 29 |
| 10 | 710 | 58 | 3 + 27 |

After a 10-minute waiting period and the weapon temperature receded to approximately 400° F, the remaining 10 rounds were fired for weapon function.



5.56 mm M196 Tracer Cartridge Loaded with IMR Propellant,  
Lot TW 18037

| Rd No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|--------|------------------|-----------------------|-------------------------------------|
|--------|------------------|-----------------------|-------------------------------------|

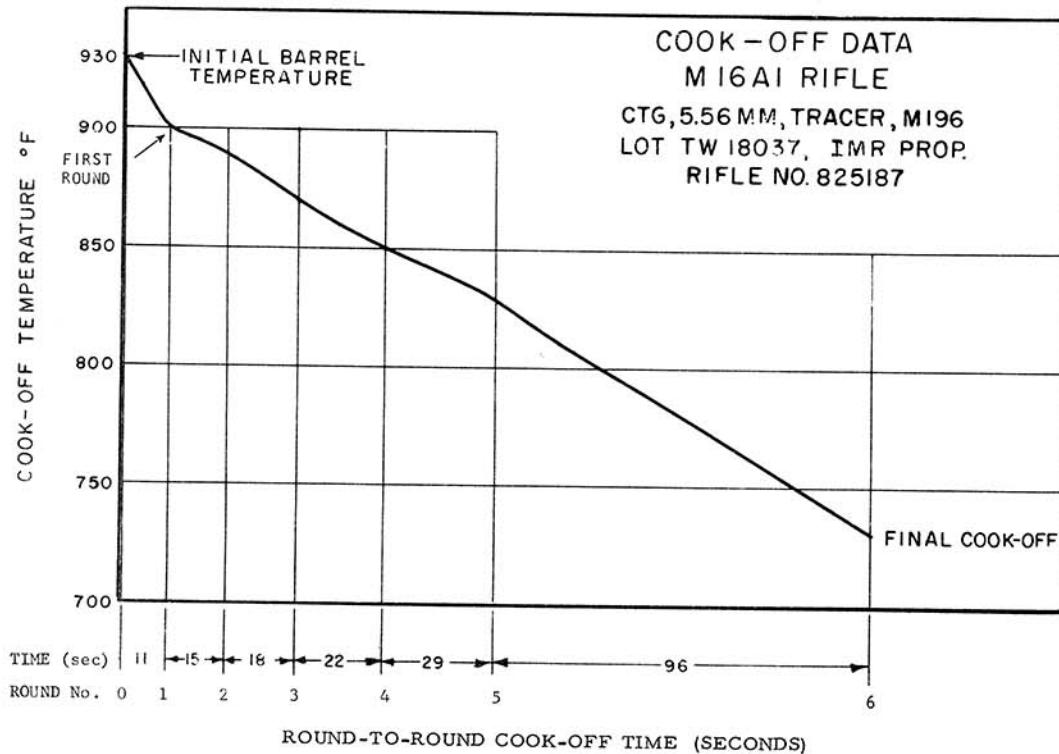
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 980° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 940 | 12 | 12 |
| 2 | 890 | 14 | 26 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 940° F

|   |     |    |        |
|---|-----|----|--------|
| 1 | 900 | 11 | 11     |
| 2 | 890 | 15 | 26     |
| 3 | 870 | 18 | 44     |
| 4 | 850 | 22 | 1 + 6  |
| 5 | 830 | 29 | 1 + 35 |
| 6 | 730 | 96 | 3 + 11 |

After a 10-minute waiting period and the weapon temperature receded to approximately 400° F, the remaining 14 rounds were fired for weapon function.



5.56 mm M196 Tracer Cartridge Loaded with IMR Propellant,  
Lot LC 12236

| Rd No. | Temperature (°F) | Time in Chamber (sec) | Total Time for Cook-off (min + sec) |
|--------|------------------|-----------------------|-------------------------------------|
|--------|------------------|-----------------------|-------------------------------------|

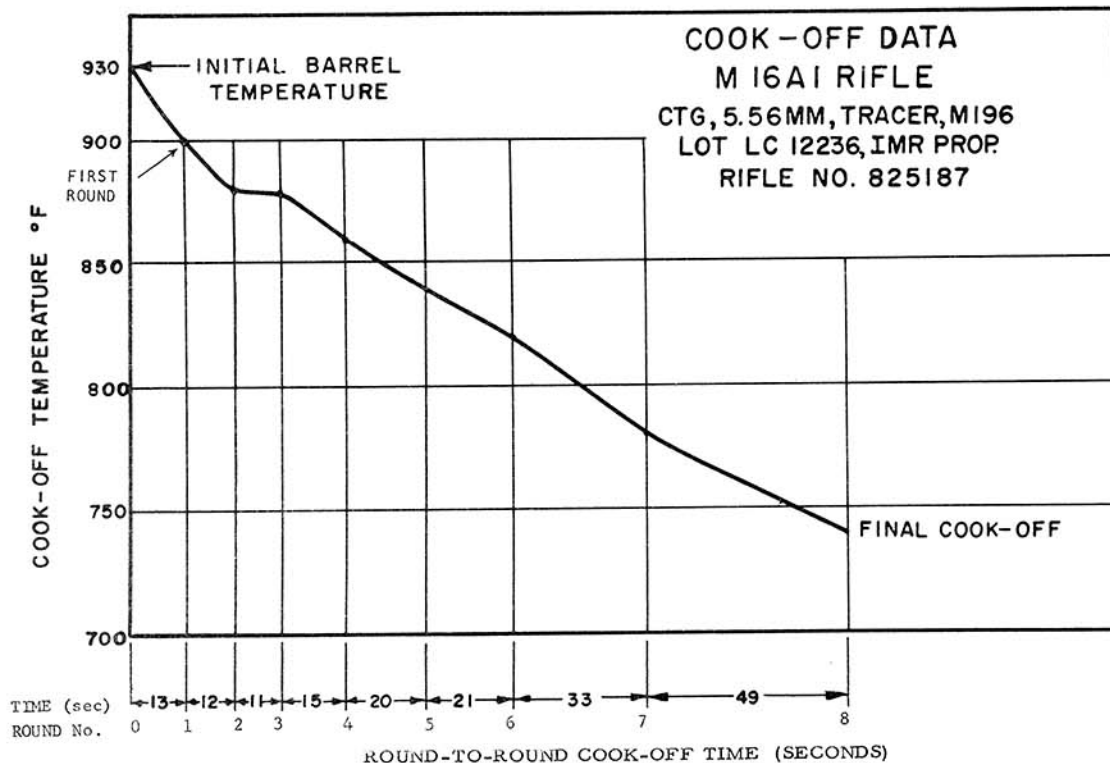
Propellant-coated Cartridges Fired by Cook-off  
in Weapon Heated to 980° F

|   |     |    |    |
|---|-----|----|----|
| 1 | 960 | 12 | 12 |
| 2 | 920 | 13 | 25 |

Uncoated Cartridges Fired by Cook-off  
in Weapon Reheated to 940° F

|   |     |    |        |
|---|-----|----|--------|
| 1 | 900 | 13 | 13     |
| 2 | 880 | 12 | 25     |
| 3 | 880 | 11 | 36     |
| 4 | 860 | 15 | 51     |
| 5 | 840 | 20 | 1 + 11 |
| 6 | 820 | 21 | 1 + 32 |
| 7 | 780 | 33 | 2 + 5  |
| 8 | 740 | 49 | 2 + 54 |

After the eighth cook-off, the weapon ruptured, due to bolt override of the ninth round to be chambered automatically in this test.



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| <p>The tests evaluated in this report represent one phase of a series of special M16A1 tests conducted at Frankford Arsenal, requested by U.S. Army Munitions Command. The purpose was to investigate a particular type of extraction difficulty using 5.56 mm ammunition reported by the British Defence Command. The theory was that small particles of unburnt propellant became entrapped between the cartridge case and the chamber wall during weapon function and, subsequently, became ignited by successive firings, causing extraction difficulties.</p> <p>Three firing programs were developed in attempts to resolve this problem. The first series consisted of sustained firings which incorporated the same methods and procedures followed by the British in their tests. No extraction difficulties were observed.</p> <p>The second series consisted of firings with propellant-coated cartridges in the semiautomatic and full automatic modes, in attempts to induce extraction difficulties similar to those described by the British. Again, no extraction difficulties were observed.</p> <p>The third series consisted of cook-off firings with propellant-coated and uncoated cartridges, to check weapon function under severe firing conditions. No extraction difficulties were observed.</p> <p>Conclusions were that U.S.-made M16A1 weapons (with either plated or unplated barrels) tested under this program were not susceptible to the type of extraction difficulties described by the British Defence Command in their report.</p> |  |  |                 |

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