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RDT&E PROJECT NO 1C024401A10701

USATECOM PROJECT NO 8-8-0060-03

SERVICE TEST OF LUBRICANTS FOR M14 AND M16A1 RIFLES UNDER ARCTIC WINTER CONDITIONS

FINAL REPORT

BY

LT JACK C. COOK, JR.

8 April 1968

U. S. ARMY ARCTIC TEST CENTER

APO SEATTLE 98733

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APPROVED:

GEORGE A. NABORS
Colonel, Armor
Commanding

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ABSTRACT

An arctic service test of lubricant MIL-L-46000A (LSA) and experimental lubricant "A" was conducted by the U. S. Army Arctic Test Center, Fort Greely, Alaska from 29 January to 6 April 1968. The purpose of the test was to evaluate the lubricants when applied to weapons that were operated and maintained under arctic winter field conditions and to evaluate the performance of weapons operated without lubrication and with minimum maintenance under arctic winter conditions. After approval of the plan of test, another objective was added to the test by USATECOM, this being to compare the performance of the M16A1 rifle when using extruded grain (IMR) powder and ball powder ammunition under arctic winter conditions.

Testing was conducted in ambient temperatures of 35°F to -58°F using soldiers representative of those who would normally use the lubricants.

Due to the late arrival of ball powder ammunition for the M16A1 rifle, testing was not initiated until 29 January 1968. Two 1,000-round sequences were fired in ambient temperatures of -46°F to -58°F. One 1,000-round sequence was fired in an ambient temperature range of -25°F to -45°F. All other sequences were fired in temperatures which ranged from 35°F to -7°F.

It was concluded that LSA was a better lubricant in temperatures of -28°F to -58°F. In temperatures of 35°F to -58°F both "LSA" and "A" lubricants were highly comparable; however, these results are not conclusive due to the wide variation in temperatures at which the different ammunitions were fired.

It was further concluded that ball powder ammunition was superior to IMR powder ammunition in M16A1 rifles.

It was recommended that: (1) The test lubricants be returned for further testing under arctic winter conditions; (2) All test and support items be sent to the U. S. Army Arctic Test Center prior to 15 October 1968 to insure completion of testing during the FY 69 test season; (3) Only ball powder ammunition be used in the M16A1 rifle.

FOREWORD

The U. S. Army Arctic Test Center was responsible for preparing the test plan, test execution and preparing the test report.

Testing was authorized by letter, AMSTE-BC, USATECOM, 26 September 1967, subject: Test Directive for Service Test of Lubricants for M14 and M16A1 Rifles Under Arctic Winter Conditions, RDT&E Project No. 1C024401A10701, USATECOM Project No. 8-8-0060-03; and USATECOM Message 10233 from AMSTE-BC, for STEAC-IN, 8 December 1967, subject: Change I to Test Directive, Service Test of Lubricants for M14 and M16A1 Rifles, Under Arctic Winter Conditions, RDT&E Project No. 1C024401A10701, USATECOM Project No. 8-8-0060-03.

Tests were conducted at the U. S. Army Arctic Test Center from 29 January to 6 April 1968 by members of the Infantry, Airborne, and Individual Equipment Division, USAATC.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY ARCTIC TEST CENTER
APO SEATTLE 98733

FINAL REPORT
OF
SERVICE TEST OF LUBRICANTS FOR M14 AND M16A1 RIFLES UNDER ARCTIC WINTER CONDITIONS

RDT&E PROJECT NO. 1C024401A10701 USATECOM PROJECT NO. 8-8-0060-03

SECTION 1. INTRODUCTION

1.1 BACKGROUND

In April 1965, USATECOM recommended that an arctic winter test be conducted using current U. S. Army standard lubricants and other developmental lubricants as available. This recommendation was prompted by reported weapon failures attributed to lubricants. This test was conducted under controlled test conditions and reported in reference d, appendix III. At the conclusion of the referenced test, the Rock Island Arsenal requested a further evaluation of lubricants under arctic winter conditions using authorized procedures contained in the applicable field manuals.

On 27 October 1967, test lubricants were received at USAATC for the arctic service test conducted during the FY 68 test season.

1.2 DESCRIPTION OF MATERIEL

1.2.1 Lubricant MIL-L-46000A (LSA)

This is a semifluid, synthetic base, preservative lubricating oil which is inhibited to provide resistance to corrosion and oxidation. It has a viscosity of 11.0 centistokes at 100°F and a viscosity of 12,000 centistokes at -65°F. It is an authorized lubricant for automatic weapons within a temperature range of -65°F to 260°F.

1.2.2 Experimental Lubricant A

This is an experimental, synthetic, fluid lubricating oil for small arms weapons. It is similar to MIL-L-46000A (LSA) except that the thickener has been omitted.

1.3 TEST OBJECTIVES

To evaluate lubricants when applied to weapons that are operated and maintained under arctic winter field conditions.

To evaluate the performance of weapons operated without lubrication and with minimum maintenance under arctic winter conditions.

To compare the performance of M16A1 rifles when using extruded grain (IMR) powder and ball powder ammunition under arctic winter conditions.

1.4 SUMMARY OF RESULTS

Based on the 3,000 rounds fired in temperatures of -28°F to -58°F, "LSA" lubricated weapons malfunctioned fewer times than "A" lubricated weapons. Considering all 6,000 rounds fired from each weapon in all temperatures both "LSA" and "A" lubricants were highly comparable.

Dry weapons functioned better in colder temperatures (-28°F to -58°F) than in temperatures above -10°F. However, lubricated weapons outperformed dry weapons in all temperatures.

There were fewer malfunctions of M16A1 rifles firing ball powder ammunition than those firing IMR powder ammunition.

No deficiencies or shortcomings were recorded during this test.

1.5 CONCLUSIONS

It was concluded that:

a. "LSA" was the best overall lubricant when used in temperatures of -28°F to -58°F.

b. Ball powder ammunition is superior to IMR powder ammunition for the M16A1 rifle.

c. In all temperatures (35°F to -58°F) "LSA" and "A" were highly comparable.

1.6 RECOMMENDATIONS

It is recommended that:

a. The test lubricants be returned for further testing under arctic winter conditions.

b. All test and support items be sent to USAATC prior to 15 October 1968 to insure completion of testing during the FY 69 test season.

c. Only ball powder ammunition be used in M16A1 rifles.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

2.1.1 General Test Conditions

Test plan was approved 2 November 1967 and testing started 11 November 1967. Testing was suspended on 8 December 1967 as a result of USATECOM Message No. 10233 AMSTE-BC, which changed test directive. Revised plan of test was approved 16 January 1968 and testing was resumed on 29 January 1968 when the ball powder ammunition for the M16A1 rifles arrived. Two 1,000-round sequences were then fired in ambient temperatures of -46°F to -58°F.

On 2 February 1968, USATECOM Message No. 0959, AMSTE-BC changed the method for firing the next 2,000 rounds.

The third 1,000-round sequence was fired on 3 February 1968 in ambient air temperatures of -28°F to -46°F. After this sequence was fired cold weather was not available for testing as originally planned (i.e., the test plan required that two 1,000-round sequences next be fired at ambient temperature range of -25°F to -45°F. This temperature range did not recur during the FY 68 season).

On 21 February 1968, Mr. Goodwin Morrow, USATECOM, by FONECON with LTC Williams, Chief, Infantry Division, instructed this Center to fire in temperatures of -10°F to -25°F. (NOTE: This temperature range was not available in 12-hour blocks of time for the remainder of the FY 68 test season.)

On 18 March 1968, Mr. Morrow, USATECOM, again called LTC Williams and instructed him to resume testing regardless of the temperature. On 18 March 1968 the fourth 1,000-round sequence was fired. On 20 March 1968, when preparing to fire the fifth 1,000-round sequence the rate-of-fire recorders became inoperable and testing was haulted.

On 25 March 1968, a new rate-of-fire recorder was received from USATECOM. Testing was reinitiated on 25 March and was completed on 5 April 1968.

Soldiers participating in this test were instructed as to the objectives of the test and the methods to be used in applying the lubricant to the weapons. They were instructed on the operation and maintenance of the weapons that were employed in the test.

The arctic winter uniform (appendix II) and individual equipment was carried or worn as appropriate.

Photographs for identification and to supplement test data were taken.

Throughout the conduct of the test the test lubricant, ammunitions and weapons were stored outdoors in an unsheltered area and exposed to the prevailing weather conditions except when required for repair, maintenance "D" and testing.

The test lubricants were evaluated using a set of 10 new weapons consisting of five M14's and five M16A1's for each lubricant. A duplicate set of 10 weapons were tested without lubricant. A total of 30 new weapons (three sets) were used.

2.1.2 Cyclic Rate Determination

The cyclic rate of fire for each weapon was determined at the start and end of each 1,000-round group. The cyclic rate of fire for each weapon was determined by firing 40 rounds, automatic, in two continuous 20-round bursts. A rate-of-fire recorder was used to determine the rate of fire.

2.1.3 Test Environment

Prior to the conduct of test all weapons were inspected for damage. Following this inspection, a set of weapons (five weapons of each type) were color-coded for each of the two test lubricants. An identical set of weapons without lubricants was also color-coded. The lubricant containers for each weapon were similarly color-coded to insure that the same type lubricants were applied to the same set of weapons throughout the conduct of test.

2.1.4 Maintenance "D"

Maintenance "D" was performed on all weapons after they had been color-coded.

The M14 rifles were disassembled in accordance with paragraphs 49, 58, 63 and 68a through h, reference e, appendix III. The M16A1 rifles were disassembled as shown in figure 8-1 (steps 1, 2, 3 and 4), figure 8-2 (steps 1 through 17), and figure 8-3 (steps 10, 11 and 17 through 24), reference f, appendix III.

The weapons were inspected and placed individually in a cleaning vat containing dry cleaning solvent Type 2, FSN 6850-285-8011. The parts were thoroughly cleaned of all grease and lubricants and then air-dried using compressed air. The test lubricants were applied lightly to each applicable set of weapons in accordance with paragraph 115a, TM-9-207, dated September 1959. The test lubricants were applied using the plastic lubricant dispenser.

2.1.5 Maintenance "A"

The following procedures were performed by the operator on each weapon after each 1,000 rounds.

The M14 rifles were cleaned in accordance with paragraph 36, reference e, appendix III. The M16A1 rifles were cleaned in accordance with paragraph 3-25, reference f, appendix III.

Two sets of weapons were then inspected and lubricated with the applicable test lubricants. One set of weapons was not lubricated.

2.2 PREOPERATIONAL INSPECTION

2.2.1 Objective

Determine if the required amount of test lubricants were on hand and if the weapons were in the proper condition for testing under arctic winter conditions.

2.2.2 Method

The maintenance package for the weapons was inventoried and inspected. Maintenance "D" was performed on the weapons. Each weapon was lubricated and color-coded for the applicable test lubricant. The quantity and type of container for each test lubricant was recorded. Identification photographs were taken of each test lubricant container. Photographs were taken of each type of weapon disassembled to describe Maintenance "A" and "D" (figures 2, 3, 4, and 5, appendix I).

2.2.3 Results

Fifteen M14 and 15 M16A1 rifles were received along with maintenance packages.

The following quantities of lubricants were on hand for the test:

	Plastic Bottles	Spray Cans
Type "A"	14 ea	15 ea
LSA	6 ea	16 ea

The following quantities of ammunition were on hand for this test:

a. Lot No. FC 1805, 7.62mm M59 Ball: 100,000 rounds.

b. Lot No. TW 18206, 5.56mm M193 Ball: 50,000 rounds (IMR powder).

c. Lot No. LC 12304, 5.56mm M193 Ball: 50,000 rounds (Ball powder) which arrived at the U. S. Army Arctic Test Center on 29 January 1968.

Photographs of test items and weapons are in appendix I.

2.2.4 Analysis

The required amount of lubricants and ammunition were on hand and the weapons were in proper condition for testing.

2.3 FIRING TESTS

2.3.1 Objectives

Determine the suitability of the test lubricants when applied to weapons being fired, semiautomatic and automatic, under arctic winter conditions.

Evaluate the performance of weapons operated, with and without lubrication and with minimum maintenance under arctic winter conditions.

Compare the performance of the M16A1 rifles when using extruded grain (IMR) powder and ball powder ammunition under arctic winter conditions.

2.3.2 Method

Each weapon fired 40 rounds at the start and 40 rounds at the completion of each 1,000-round sequence to determine its cyclic rate of fire (paragraph 2.1.2).

This sub-test consisted of six 1,000-round sequences fired as follows (table 2, appendix I):

a. Two 1,000-round firing sequences conducted in ambient temperatures of -46°F to -58°F.

b. One 1,000-round firing sequence conducted in ambient temperatures of -28°F to -46°F.

c. One 1,000-round firing sequence conducted in ambient temperatures of 13°F to -7°F.

d. One 1,000-round firing sequence conducted in ambient temperatures of 12°F to 6°F.

e. One 1,000-round firing sequence conducted in ambient temperatures of 35°F to 3°F.

Weapons were fired at zero elevation for all exercises except for two 1,000-round sequences which were fired with M16A1 rifles at 45° elevation above the horizontal.

During each 1,000-round sequence, each weapon was (in sequence):

a. Fired 40 rounds to determine rate of fire (two 20-round continuous bursts).

b. Fired 40 rounds automatic (two 20-round continuous bursts).

c. Fired 80 rounds automatic in three to five round bursts in 2 minutes.

d. Fired 90 rounds semiautomatic in 5 minutes.

e. Stored for 3 hours in open storage.

f. Fired 80 rounds automatic in three to five round bursts in 2 minutes.

g. Fired 90 rounds semiautomatic in 5 minutes.

h. Fired 80 rounds automatic (four 20-round continuous bursts).

i. Stored for 3 hours in open storage.

j. Fired 90 rounds semiautomatic in 5 minutes.

k. Fired 80 rounds automatic (four 20-round continuous bursts).

l. Fired 80 rounds automatic in three to five round bursts in 2 minutes.

m. Stored for 3 hours in open storage.

n. Fired 80 rounds automatic in three to five round bursts in 2 minutes.

o. Fired 90 rounds semiautomatic in 5 minutes.

p. Fired 40 rounds automatic (two 20-round continuous bursts).

q. Fired 40 rounds to determine rate of fire (two 20-round continuous bursts).

Upon completion of this sequence each weapon was given Maintenance "A" and lubricated with the applicable lubricant using the plastic dispensers. After Maintenance "A", the weapons were stored outdoors in open storage until required for testing.

2.3.3 Results

Detailed results can be found in tables 1 through 18, appendix I.

Based on the first 3,000 rounds fired through each weapon in temperatures of -28°F to -58°F, the following results were recorded:

a. M16A1 rifles, without lubrication, firing 2,000 rounds of ball powder ammunition and 1,000 rounds IMR powder ammunition, malfunctioned 14 times; weapons lubricated with "LSA" malfunctioned 18 times; weapons lubricated with type "A" malfunctioned 33 times. Malfunctions for each type ammunition powder can be found in tables 3 through 5, appendix I.

b. M14 rifles, without lubircation, firing all ball powder ammunition, malfunctioned 44 times; weapons lubricated with type "A" malfunctioned 5 times; weapons lubricated with "LSA" malfunctioned 7 times.

Based on the total 6,000 rounds fired through each weapon in temperatures of 35°F to -58°F, the following results were recorded:

a. M16A1 rifles, without lubrication, firing 3,000 rounds of ball and 3,000 rounds of IMR powder ammunition, malfunctioned 91 times; weapons lubricated with "LSA" malfunctioned 60 times; weapons lubricated with type "A" malfunctioned 76 times.

b. Of the total malfunctions for M16A1 rifles after firing 6,000 rounds, 161 of the 227 malfunctions occurred with IMR powder ammunition (tables 3 through 8).

Data concerning M16A1 malfunctions with weapons at 45° angle can be found in tables 5 and 6, appendix I.

c. M14 rifles, without lubrication, firing 6,000 rounds of ball ammunition malfunctioned 137 times; weapons lubricated with type "A" malfunctioned 10 times; weapons lubricated with "LSA", malfunctioned 23 times.

2.3.4 Analysis

It appears that "LSA" is the best lubricant in temperatures of -28°F to -58°F for both the M14 and M16A1 rifles based on a malfunction rate of .28 malfunctions per 1,000 rounds.

"LSA" and "A" are highly comparable in temperatures of 35°F to -58°F with overall malfunction rates of .46 malfunctions per 1,000 rounds and .47 malfunctions per 1,000 rounds respectively.

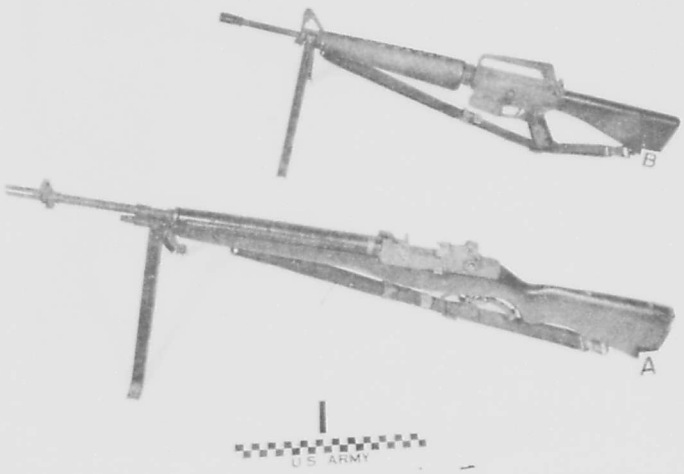
Weapons operated without lubricants functioned better in ambient temperatures of -28°F to -58°F; however, when the total test is considered, lubricated weapons outperformed dry weapons.

Performance of the M16A1 rifle was adversely affected when firing IMR powder ammunition under arctic winter conditions. Ball powder ammunition was superior to IMR powder ammunition (table 15, appendix I).

Due to the extreme temperature differences during level and elevated firings, no conclusive analysis can be made of the effects on M16A1 rifle firings at elevated positions.

SECTION 3. APPENDICES

APPENDIX I TEST DATA



3 APRIL 1968 USAATC NEGATIVE NO. 400 4-4

FIGURE 1

WEAPONS USED IN TEST.
A - M14 RIFLE W/ARCTIC TRIGGER
B - M16A1 RIFLE

3 APRIL 1968 USAATC NEGATIVE NO. 400 1-4

FIGURE 2

M16A1 RIFLE DISASSEMBLED FOR MAINTENANCE "A" WITH CLEANING EQUIPMENT USED BY TEST PERSONNEL TO PERFORM THIS MAINTENANCE.

3 APRIL 1968 USAATC NEGATIVE NO. 400 3-4

FIGURE 3

M16A1 RIFLE ASSEMBLED AND DISASSEMBLED
FOR MAINTENANCE "D".

3 APRIL 1968 USAATC NEGATIVE NO. 400 2-4

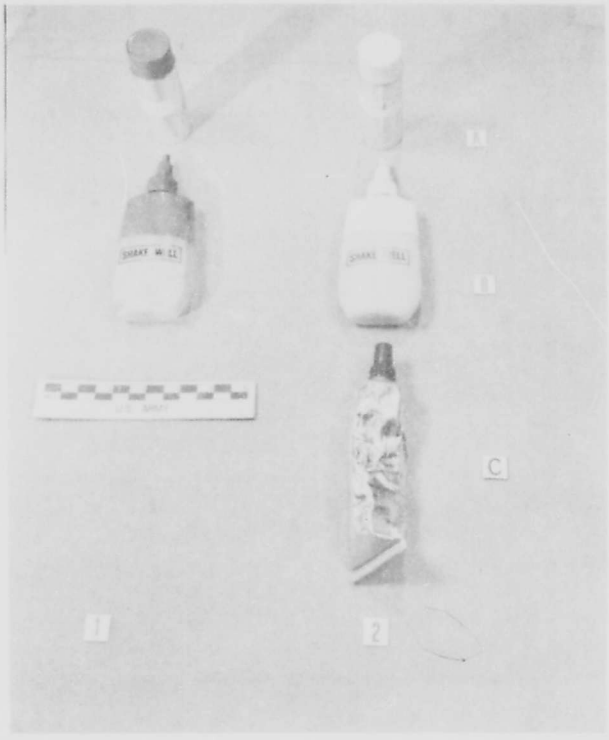
FIGURE 4

M14 RIFLE DISASSEMBLED FOR MAINTENANCE "A" WITH CLEANING EQUIPMENT USED BY TEST PERSONNEL TO PERFORM THIS MAINTENANCE.

27 OCTOBER 1967 USAATC NEGATIVE NO. 78 5-5

FIGURE 5

M14 RIFLE ASSEMBLED AND DISASSEMBLED
FOR MAINTENANCE "D".



15 JANUARY 1968 USAATC NEGATIVE NO. CS-45, 1-1

FIGURE 6

TEST LUBRICANTS FOR M14 AND M16A1 RIFLES:

ROW A - SPRAY CANS
ROW B - PLASTIC CONTAINERS
ROW C - STANDARD CONTAINER

COLUMN 1 - LUBE "A"
COLUMN 2 - LUBE "LSA"

TABLE 1.--Method of Firing Each 1,000-Round Group

Round Number	Type of Firing
1 - 40	Rate of fire (two 20-round continuous bursts).
41 - 80	Automatic (two 20-round continuous bursts).
81 - 160	Automatic in 3- to 5-round bursts in 2 minutes.
161 - 250	Semiautomatic in 5 minutes.
251 - 330	Automatic in 3- to 5-round bursts in 2 minutes.
331 - 420	Semiautomatic in 5 minutes.
421 - 500	Automatic (four 20-round continuous bursts).
501 - 590	Semiautomatic in 5 minutes.
591 - 670	Automatic (four 20-round continuous bursts).
671 - 750	Automatic in 3- to 5-round bursts in 2 minutes.
751 - 830	Automatic in 3- to 5-round bursts in 2 minutes.
831 - 920	Semiautomatic in 5 minutes.
921 - 960	Automatic (two 20-round continuous bursts).
961 - 1000	Rate of fire (two 20-round continuous bursts).

TABLE 2.--Temperatures During Firings

1,000-Round Group	Maximum Temperature (°F)	Minimum Temperature (°F)
1 - 1,000	-46	-58
1,001 - 2 000	-46	-58
2,001 - 3,000	-28	-46
3,001 - 4,000	13	-7
4,001 - 5,000	12	6
5,001 - 6,000	35	3

TABLE 3.--M16A1 Malfunctions of First 1,000 Rounds
Utilizing Ammunition Loaded With IMR Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FBR	FJ	BOB	Total Malfunctions	Remarks
866691	Dry	1,000					0	
860077	Dry	1,000					0	
864508	Dry	1,000					0	
864206	Dry	1,000		1			1	FBR-220
855743	Dry	1,000					0	Trigger pin became loose-190
863298	A	1,000			1		1	FJ-583
862999	A	1,000	1		1	1	3	FBL-25 FJ-695 BOB-697
864353	A	1,000					0	
855194	A	1,000	1				1	FBL-273
859386	A	1,000	1		1		2	FBL-506 FJ-653
808612	LSA	1,000				2	2	BOB-90-508
861465	LSA	1,000			2		2	FJ-208-250
869526	LSA	1,000					0	
859623	LSA	1,000					0	
856182	LSA	1,000					0	

The ambient air temperatures during this sequence ranged from -46°F to -58°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
BOB - Bolt overrides the base of the round
FBR - Failure of the bolt to remain to the rear after the last round is fired
FJ - Failure to eject

TABLE. 4.--M16A1 Malfunctions of Second 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	BOB	FFR	Total Malfunctions	Remarks
866691	Dry	2,000		1	1		2	FJ-1185 BOB-1845
860077	Dry	2,000				1	1	FFR-1817
864508	Dry	2,000					0	
864206	Dry	2,000					0	
855743	Dry	2,000					0	Trigger pin became loose-1730-1890
863208	A	2,000					0	
862999	A	2,000					0	
864353	A	2,000		2			2	FJ-1029-1030
855194	A	2,000	1				1	FBL-1775
859386	A	2,000					0	
808612	LSA	2,000					0	
861465	LSA	2,000					0	
869526	LSA	2,000					0	
859623	LSA	2,000			1		1	BOB-1971
856182	LSA	2,000					0	

The ambient air temperatures during this sequence ranged from -46°F to -58°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
FJ - Failure to eject
BOB - Bolt overrides the base of the round
FFR - Failure to fire

TABLE 5.--M16A1 Malfunctions of Third 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBR	BOB	COEC	FFS	FFR	FFA	Total Malfunctions	Remarks
866691	Dry	3,000					4		4	FFR-2036-2037-2039-2040
860077	Dry	3,000			2				2	COEC-2272-2280 Frozen selector-2251
864508	Dry	3,000							0	
864206	Dry	3,000	4						4	FBR-2040-2770-2790-2810
855743	Dry	3,000							0	
863298	A	3,000				3			3	FFS-2008-2010-2012
862999	A	3,000				3			3	FFS-2501-2503-2505
864353	A	3,000		3				3	6	BOB&FFA-2041-2042-2123
855194	A	3,000		1		4		1	6	BOB-2560 FFA-2560 FFS-2008-2010-2012-2520
859386	A	3,000		1		3		1	5	BOB-2304 FFA-2304 FFS-2004-2006-2008
808612	LSA	3,000							0	
861465	LSA	3,000							0	
869526	LSA	3,000							0	
859623	LSA	3,000							0	
856182	LSA	3,000	13						13	FBR-2020-2040-2060-2080- 2100-2120-2140-2160-2178- 2196-2214-2232-2250

The ambient air temperatures during this sequence ranged from -28°F to -46°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBR - Failure of the bolt to remain to the rear after the last round is fired
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber
FFS - Failure to fire semiautomatically
FFR - Failure to fire
FFA - Failure of forward assist assembly to lock the bolt

TABLE 6.--M16A1 Malfunctions of Fourth 1,000 Rounds
Utilizing Ammunition Loaded With IMR Powder

Gun Number	Type Lube	Cumulative Rounds Fired	BOB	COEC	FFS	Total Malfunctions	Remarks
866691	Dry	4,000	6			6	BOB-3004-3041-3022-3924-3926-3928
860077	Dry	4,000				0	
864508	Dry	4,000		2		2	COEC-3673-3675
864206	Dry	4,000				0	
855743	Dry	4,000				0	
863298	A	4,000				0	
862999	A	4,000	9			9	BOB-3332-3334-3336-3338-3752-3754-3756-3812-3814
864353	A	4,000	1	6		7	BOB-3320 COEC-3292-3293-3294-3295-3312-3313
855194	A	4,000				0	
859386	A	4,000				0	
808612	LSA	4,000				0	
861465	LSA	4,000				0	
869526	LSA	4,000				0	
859623	LSA	4,000				0	
856182	LSA	4,000			7	7	FFS-3354-3355-3356-3792-3794-3796-3798

The ambient air temperatures during this sequence ranged from 13°F to -7°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber
FFS - Failure to fire semiautomatically

TABLE 7.--M16A1 Malfunctions of Fifth 1,000 Rounds
Utilizing Ammunition Loaded With IMR Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FJ	BOB	COEC	DF	Total Malfunctions	Remarks
866691	Dry	5,000	2	10	5		17	FJ-4001-4003 BOB-4521-4541-4561-4844-4854-4921-4922-4941-4942-4974 COEC-4022-4024-4026-4062-4064
860077	Dry	5,000		2	19		21	BOB-4002-4003 COEC-4022-4024-4028-4062-4064-4082-4122-4252-4256-4276-4302-4304-4502-4506-4510-4544-4546-4772-4794
864508	Dry	5,000	2	4	14		20	FJ-4020-4021 BOB-4002-4004-4006-4008 COEC-4026-4030-4043-4045-4262-4268-4272-4313-4315-4526-4548-4855-4972-4982
864206	Dry	5,000			4		4	COEC-4164-4166-4168-4170
855743	Dry	5,000				1	1	DF-4164
863298	A	5,000			5		5	COEC-4671-4673-4675-4677-4679
862999	A	5,000		1	12		13	BOB-4003 COEC-4021-4025-4094-4108-4110-4262-4264-4312-4316-4572-4962-4982
864353	A	5,000			7		7	COEC-4252-4258-4260-4282-4312-4971-4982
855194	A	5,000					0	
859386	A	5,000					0	
808612	LSA	5,000	1		7		8	FJ-4532 COEC-4022-4024-4026-4042-4045-4063-4066
861465	LSA	5,000					0	
869526	LSA	5,000					0	
859623	LSA	5,000					0	

TABLE 7.--M16A1 Malfunctions of Fifth 1,000 Rounds
Utilizing Ammunition Loaded With IMR Powder (Cont'd)

Gun Number	Type Lube	Cumulative Rounds Fired	FJ	BOB	COEC	DF	Total Malfunctions	Remarks
856182	LSA	5,000			22		22	COEC-4044-4006-4024-4028-4034-4038 4055-4059-4062-4064-4071-4075-4752-4754-4756-4758-4760-4762-4764-4766-4968-4970

The ambient air temperatures during this sequence ranged from 12°F to 6°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FJ - Failure to eject
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber
DF - Double feed

TABLE 8.--M16A1 Malfunctions of Sixth 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	BOB	FFR	DF	Total Malfunctions	Remarks
866691	Dry	6,000						0	
860077	Dry	6,000						0	
864508	Dry	6,000	2	1	1	2		6	FBL-5460-5461 FJ-5754 BOB-5068 FFR-5350-5351
864206	Dry	6,000						0	
855743	Dry	6,000						0	
863298	A	6,000						0	
862999	A	6,000			1			1	BOB-5419
864353	A	6,000			1			1	BOB-5329
855194	A	6,000						0	
859386	A	6,000						0	
808612	LSA	6,000		2	1			3	FJ-5412-5489 BOB-5002
861465	LSA	6,000						0	
869526	LSA	6,000					2	2	DF-5138-5158
859623	LSA	6,000						0	
856182	LSA	6,000						0	

The ambient air temperatures during this sequence ranged from 35°F to 3°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
FJ - Failure to eject
BOB - Bolt overrides the base of the round
FFR - Failure to fire
DF - Double feed

TABLE 9.--M14 Malfunctions of First 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBR	BOB	COEC	Total Malfunctions	Remarks
442906	Dry	1,000				0	
577704	Dry	1,000				0	
12504	Dry	1,000			1	1	COEC-142
1531194	Dry	1,000				0	
436037	Dry	1,000			1	1	COEC-422
538578	A	1,000				0	
105136	A	1,000			1	1	COEC-94
340062	A	1,000				0	
544772	A	1,000		2		2	BOB-420-421
55751	A	1,000	1			1	FBR-640
456708	LSA	1,000				0	
1166701	LSA	1,000				0	
1513788	LSA	1,000				0	
443691	LSA	1,000				0	
391288	LSA	1,000			1	1	COEC-90

The ambient air temperatures during this sequence ranged from -46°F to -58°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBR - Failure of the bolt to remain to the rear after the last round is fired
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber

TABLE 10.--M14 Malfunctions of Second 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FJ	COEC	BOB	FFR	Total Malfunctions	Remarks
442906	Dry	2,000					0	
577704	Dry	2,000		3			3	COEC-1921-1922-1981
12504	Dry	2,000	1	1			2	FJ-1780 COEC-1775
1531194	Dry	2,000					0	
436037	Dry	2,000		7		1	8	COEC-1835-1838-1867-1879-1924-1929-1972 FFR-1831
538578	A	2,000					0	
105136	A	2,000					0	
340062	A	2,000					0	
544772	A	2,000					0	
55751	A	2,000					0	
1156708	LSA	2,000					0	
1166791	LSA	2,000					0	
1513788	LSA	2,000					0	
443691	LSA	2,000					0	
391288	LSA	2,000			5		5	BOB-1252-1254-1256-1280-1340

The ambient air temperatures during this sequence ranged from -46°F to -58°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FJ - Failure to eject
COEC - Bolt closes on an empty chamber
BOB - Bolt overrides the base of the round
FFR - Failure to fire

TABLE 11.--M14 Malfunctions of Third 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	COEC	FFR	Total Malfunctions	Remarks
442906	Dry	3,000	6	3		1	10	FBL-2258-2267-2305-2386-2401-2406 FJ-2304-2385-2386 FFR-2042
577704	Dry	3,000	4	5			9	FBL-2326-2327-2328-2329 FJ-2253-2265-2312-2314-2325
12504	Dry	3,000	4	4			8	FBL-2322-2335-2398-2406 FJ-2253-2321-2338-2402
1531194	Dry	3,000					0	
436037	Dry	3,000				2	2	FFR-2121-2664
538578	A	3,000					0	
105136	A	3,000					0	
340062	A	3,000	1				1	FBL-2042
544772	A	3,000					0	
55751	A	3,000					0	
456708	LSA	3,000			1		1	COEC-2325
1166791	LSA	3,000					0	
1513788	LSA	3,000					0	
443691	LSA	3,000					0	
391288	LSA	3,000					0	

The ambient air temperatures during this sequence ranged from -28°F to -46°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
FJ - Failure to eject
COEC - Bolt closes on an empty chamber
FFR - Failure to fire

TABLE 12.--M14 Malfunctions of Fourth 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	BOB	COEC	FFR	Total Malfunctions	Remarks
442906	Dry	4,000		6			3	9	FJ-3533-3534-3535-3536-3979-3980 FFR-3002-3543-3544
577704	Dry	4,000						0	Selector switch came off
12504	Dry	4,000					1	1	FFR-3162
1531194	Dry	4,000						0	
436037	Dry	4,000	5		3	5		13	FBL-3333-3335-3337-3339-3353 BOB-3762-3784-3786 COEC-3258-3262-3764-3966-3968
538578	A	4,000						0	
105136	A	4,000						0	
340062	A	4,000						0	
544772	A	4,000						0	
55751	A	4,000						0	Broken firing pin-3611
1156708	LSA	4,000				7		7	COEC-3001-3003-3005-3006-3007-3009-3010
1166791	LSA	4,000						0	
1513788	LSA	4,000						0	Broken extractor-3592
443691	LSA	4,000						0	
391288	LSA	4,000						0	

The ambient air temperatures during this sequence ranged from 13°F to -7°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
FJ - Failure to eject
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber
FFR - Failure to fire

TABLE 13.--M14 Malfunctions of Fifth 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	BOB	COEC	Total Malfunctions	Remarks
442906	Dry	5,000	1	8			9	FBL-4022 FJ-4002-4004-4508-4754-4512-4768-4962-4982
577704	Dry	5,000	5				5	FBL-4591-4613-4617-4633-4666
12504	Dry	5,000					0	
1531194	Dry	5,000					0	
436037	Dry	5,000	7			5	12	FBL-4002-4004-4006-4020-4023-4035-4065 COEC-4252-4271-4275-4311-4962
538578	A	5,000					0	
105136	A	5,000			1		1	BOB-4376
340062	A	5,000			2		2	BOB-4526-4528 Broken firing pin-4810
544772	A	5,000					0	
55751	A	5,000					0	
1156708	LSA	5,000		7	1		8	FJ-4671-4673-4674-4675-4676-4677-4678 BOB-4585
1166791	LSA	5,000					0	
1513788	LSA	5,000					0	
443691	LSA	5,000					0	
391288	LSA	5,000			1		1	BOB-4774

The ambient air temperatures during this sequence ranged from 12°F to 6°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of the bolt to lock
FJ - Failure to eject
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber

TABLE 14 --M14 Malfunctions of Sixth 1,000 Rounds
Utilizing Ammunition Loaded With Ball Powder

Gun Number	Type Lube	Cumulative Rounds Fired	FBL	FJ	BOB	COEC	FFR	DF	Total Malfunctions	Remarks
442906	Dry	6,000		9	6				15	FJ-5004-5005-5006-5007-5008-5251-5253-5255-5257 BOB-5832-5838-5854-5857-5896-5966
577704	Dry	6,000	6			3	3		12	FBL-5422-5424-5426-5428-5430-5432 COEC-5508-5510-5512 FFR-5330-5331-5962
12504	Dry	6,000	1	3	2				6	FBL-5874 FJ-5852-5853-5854 BOB-5851-5962
1531194	Dry	6,000	2						2	FBL-5974-5976
436037	Dry	6,000	3		1		3	2	9	FBL-5460-5462-5463 BOB-5083 FFR-5468-5469-5470 DF-5440-5963
538578	A	6,000							0	
105136	A	6,000							0	Selector came off-5506
340062	A	6,000					2		2	FFR-5254-5255
544772	A	6,000							0	
55751	A	6,000							0	
1156708	LSA	6,000							0	
1166791	LSA	6,000							0	
1513788	LSA	6,000							0	
443691	LSA	6,000							0	
391288	LSA	6,000							0	

The ambient air temperatures during this sequence ranged from 35°F to 3°F.

The numbers in the "Remarks" column refer to the round number when the malfunction occurred.

Abbreviations

FBL - Failure of bolt to lock
FJ - Failure to eject
BOB - Bolt overrides the base of the round
COEC - Bolt closes on an empty chamber
FFR - Failure to fire
DF - Double feed

TABLE 15.--Summary of Malfunctions

Gun Number	Type Lube	Total Rounds Fired	FBL		FBR		FJ		BOB		COEC		FFS		FFR		FFA		DF		Total Malfunctions		Grand Total
			IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	IMR	Ball	
M16A1	Dry	30,000	0	2	1	4	4	2	22	2	44	2	0	0	0	7	0	0	1	0	72	19	91
M16A1	A	30,000	3	1	0	0	3	2	12	7	30	0	0	13	0	0	0	5	0	0	48	28	76
M16A1	LSA	30,000	0	0	0	13	3	2	2	2	29	0	7	0	0	0	0	0	0	2	41	19	60
																					161	66	227
M14	Dry	30,000	44		0		39		12		26		0		14		0		2		137		
M14	A	30,000	1		1		0		5		1		0		2		0		0		10		
M14	LSA	30,000	0		0		7		7		9		0		0		0		0		23		
																					170		

The ambient air temperatures during all the sequences ranged from 35°F to -5° F.

Abbreviations

FBL - Failure of bolt to lock
FBR - Failure of bolt to remain to rear after last round
FJ - Failure to eject
BOB - Bolt overrides the base of the round
COEC - Bolt closes on empty chamber
FFS - Failure to fire semiautomatically
FFR - Failure to fire
FFA - Failure of forward assist assembly to lock the bolt
DF - Double feed

TABLE 16.--Rates of Fire for M16A1 Rifle

Serial Number	Type Lube	IMR 1	IMR 1000	Ball 1001	Ball 2000	Ball 2001	Ball 3000	IMR 3001	IMR 4000	IMR 4001	IMR 5000	Ball 5001	Ball 6000
866691	Dry	720	720	750	710	710	700	630	600		570	690	750
860077	Dry	660	600	600	600	660	630	630	600			666	750
864508	Dry	690	660	600	600	760	800	720	690			600	825
864206	Dry	630	630	630	630	630	640	720	690	666	690	750	857
855713	Dry	720	720	670	670	720	720	720	660	632	690	750	857
863298	A	720	690	670	670	670	670	750	720	705	570	720	750
862999	A	660	600	630	630	710	710	660	600			600	705
864353	A	720	690	600	600	720	720	690	600	600		705	750
855194	A	690	630	670	670	690	690	720	660	710	570	635	750
859386	A	720	690	600	630	710	710	750	660	771	600	666	720
808612	LSA	660	660	670	630	660	630	810	720	705	690	760	800
861465	LSA	690	660	710	710	750	750	750	720	666	600	750	750
869526	LSA	660	660	710	710	760	760	750	690	632	570	666	825
859623	LSA	660	660	630	630	630	640	810	780	750	705	800	800
856182	LSA	720	690	600	600	720	720	750	720			623	780

NOTE: 1. Blank squares denote that rate of fire could not be determined due to weapon malfunction.

2. Rates of fire taken up to and including 3,000 rounds are not considered valid since the recorders were run off of generator power which was not constant.

TABLE 17.--Rates of Fire for M14 Rifle (Ball Powder Ammunition)

Serial Number	Type Lube	1	1000	1001	2000	2001	3000	3001	4000	4001	5000	5001	6000
442906	Dry	870	870	710	710	810	810	690	750				
577704	Dry	720	720	670	630	830	830	750	780	750		720	
12504	Dry	840	840	670	670	840	840	720	780	760	760	770	
1531194	Dry	840	840	670	670	670	670	750	750	750	750	750	714
436037	Dry	840	810	670	670	870	840	720		750		690	
538578	A	840	840	670	670	720	720	780	840	800	705	854	800
105136	A	780	840	710	710	810	780	810	810	800	800	800	800
340062	A	780	760	670	630	750	750	780	780	800	780	854	800
544772	A	870	870	750	710	790	790	840	840	857	800	923	800
55751	A	810	840	670	670	750	750	840	810	800	705	800	825
1156708	LSA	840	810	670	630	810	830		780	857	800	857	825
1166791	LSA	840	840	670	710	780	750	780	750	854	814	857	825
1513788	LSA	900	870	710	670	840	840	810	810	800	800	830	800
443691	LSA	750	750	670	670	670	670	840	870	857	800	830	800
391288	LSA	870	840	600	600	810	780	780	870	800	800	890	800

NOTE: 1. Blank squares denote that rate of fire could not be determined due to weapon malfunction.

2. Rates of fire taken up to and including 3,000 rounds are not considered valid since the recorders were run off of generator power which was not constant.

TABLE 18.--Analysis and Correction Times

Malfunction*	Times	
	M14	M16A1
FFS	----	50.7 seconds
BOB	8.5 seconds	11.2 seconds
FFR	22.0 seconds	28.0 seconds
FJ	4.5 seconds	4.0 seconds
COEC	26.2 seconds	24.0 seconds
FBL	30.8 seconds	----
Replace broken firing pin	8 minutes	----
Replace selector	3.5 minutes	----
Maintenance "A"	16 minutes	20 minutes

*See explanations of abbreviations on tables 3 through 15.

NOTE: Times are averages taken of two or more malfunctions.

APPENDIX II ARCTIC WINTER UNIFORM

The year-round temperature variation peculiar to the arctic prohibits the prescribing of a particular uniform for any season. The clothing which is comfortable at -50°F becomes uncomfortable at -10°F and vice versa. Since this large fluctuation is experienced on an hour-by-hour, day-by-day basis, some degree of flexibility in uniform requirements is necessary.

Since materiel tested under arctic conditions is expected to function under the most adverse conditions, the uniform worn by operating personnel must also be suitable for the most adverse conditions. Accordingly, the "arctic winter uniform" referred to in this report is defined as follows:

a. Shirt, wool, OG 108.

b. Trousers, field, OG 107, with liner.

c. Undershirt, winter.

d. Drawers, winter.

e. Socks, wool cushion sole.

f. Boots, vapor barrier, white.

g. Suspenders.

h. Cap, pile.

i. Parka with liner and hood.

j. Mitten set, arctic, with liners.

APPENDIX III REFERENCES

a. RDT&E Project No. 1C024401A10701.

b. AMCMC Code 5672.12.499.

c. Report, U. S. Army Arctic Test Center, STEAC-TA, 17 July 1967, Engineer Design Test for Preservative Lubricants, USATECOM Project No. 8-5-0060-01.

d. TM 9-1005-223-12, Operator and Organizational Maintenance Manual with Repair Parts and Special Tool Lists for Rifles, 7.62mm, M14 and M14E2, and Bipod, Rifle, Mz, 8 February 1965.

e. TM 9-1005-249-14, Operation, Maintenance, Repair and Replacement Parts, Rifle, 5.56mm, M16; Rifle, 5.56mm, XM16E1; and Launcher, Grenade, 40mm, XM148, 1 August 1966.

f. TM 9-207, Operation and Maintenance of Ordnance Material in Extreme Cold Weather 0°F to -65°F, September 1959.

g. Plan, U. S. Army Arctic Test Center, STEAC-TA, 2 November 1967, Service Test of Lubricants for M14 and M16E1 Rifles, Under Arctic Winter Conditions, USATECOM Project No. 8-8-0060-03.

h. Approved USAATC Revised Test Plan, STEAC-TA, 25 January 1968, Service Test of Lubricants for M14 and M16A1 Rifles, Under Arctic Winter Conditions, USATECOM Project No. 8-8-0060-03.

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U. S. Army Test and Evaluation Command

13. ABSTRACT

An arctic service test of lubricant MIL-L-46000A (LSA) and experimental lubricant "A" was conducted by the U. S. Army Arctic Test Center, Fort Greely, Alaska, from 29 January to 6 April 1968. The purpose of the test was to evaluate the lubricants when applied to weapons that were operated and maintained under arctic winter field conditions and to evaluate the performance of weapons operated without lubrication and with minimum maintenance under arctic winter conditions. After approval of the plan of test, another objective was added to the test by USATECOM, this being to compare the performance of the M16A1 rifle when using extruded grain (IMR) powder and ball powder ammunition under arctic winter conditions.

Testing was conducted in ambient temperatures of 35°F to -58°F using soldiers representative of those who would normally use the lubricants.

Due to the late arrival of ball powder ammunition for the M16A1 rifle, testing was not initiated until 29 January 1968. Two 1,000-round sequences were fired in ambient temperatures of -46°F to -58°F. One 1,000-round sequence was fired in ambient temperature range of -25°F to -45°F. All other sequences were fired in temperatures which ranged from 35°F to -7°F.

It was concluded that LSA was a better lubricant in temperatures of -28°F to -58°F. In temperatures of 35°F to -58°F both "LSA" and "A" lubricants were highly comparable; however, these results are not conclusive due to the wide variation in temperatures at which the different ammunitions were fired.

It was further concluded that ball powder ammunition was superior to IMR powder ammunition in M16A1 rifles.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Arctic Lubricants Lubricants for M14 and M16A1 Rifles IMR Powder Ammunition Ball Powder Ammunition						

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DD Form 1473, Item 13, Abstract (Cont'd)

It was recommended that (1) The test lubricants be returned for further testing under arctic winter conditions; (2) All test and support items be sent to the U. S. Army Arctic Test Center prior to 15 October 1968 to insure completion of testing during the FY 69 test season; (3) Only ball powder ammunition be used in the M16A1 rifle.