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RDT&E PROJECT NO. 1J643303D54712D

USATECOM PROJECT NO. 8-3-7020-06

ENGINEERING TEST OF BOOT, COMBAT, MOUNTAIN AND SKI

FINAL REPORT

BY

EDWIN W. MANGUM

JUNE 1968

U S ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-BC

2 JUL 1968

SUBJECT: Final Report of Engineering Test of Boot, Combat, Mountain and Ski, RDT&E Project No. 1J643303D54712D, USATECOM Project No. 8-3-7020-06

Commanding General
US Army Materiel Command
ATTN: AMCRD-JI
Washington, D. C. 20315

1. Subject report has been approved. Copies are forwarded for information.

2. The Service Test is in progress at the US Army Arctic Test Center with the summer phase of testing nearing completion. The report of that testing is scheduled for distribution in September 1968.

FOR THE COMMANDER:

LeROY S. STANLEY
Colonel, GS
Dir, Inf Mat Test Dir

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as (2 cys)

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RDT&E PROJECT NO. 1J643303D54712D

USATECOM PROJECT NO. 8-3-7020-06

ENGINEERING TEST OF BOOT, COMBAT, MOUNTAIN AND SKI

TEST REPORT

BY

EDWIN W. MANGUM
Engineering Test Directorate

JUNE 1968

U. S. ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

USATECOM 8-3-7020-06

Final Report of Engineering Test of Boot, Combat, Mountain and Ski

Conducted at Fort Lee, Virginia

June 1968

Abstract

An Engineering Test of the Boot, Combat, Mountain and Ski was conducted from 26 January through 24 May 1968, to: evaluate the Model No. 1070 boot through laboratory techniques in consideration of certain Technical Characteristics for Boot, Combat, Mountain and Ski, April 1966, as included in the QMR for the System of Lightweight Individual Clothing and Equipment (LINCLOE); evaluate the sizing and fitting characteristics in consideration of the Technical Characteristics; and provide technical assistance to the U. S. Army Arctic Test Center (USAATC) in the initial fitting and issue of the test item in that phase of the Service Test.

It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

FOREWORD

The U. S. Army General Equipment Test Activity (USAGETA), Fort Lee, Virginia, was responsible for preparing the test plan, executing the test, and preparing the report for the Engineering Test.

The authorization for this test was letter, AMSTE-BC, Headquarters, USATECOM, 18 August 1967, subject: "Test Directive, Engineering and Service Test of Boot, Combat, Mountain and Ski, USATECOM Project Numbers 8-3-7020-05/06. (Ref. 1, App. III)

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

1.1 BACKGROUND

The U.S. Army Natick Laboratories, during the Fiscal Year 1964 Development Program, attempted to develop a boot which would overcome several pertinent deficiencies in the present standard boot, combat, ski and mountain (MIL-B-1710A, 6 August 1962) which rendered the boot unsatisfactory for U.S. Army use. These deficiencies are:

a. Lack of desired environmental protection.

b. High individual logistic support requirements (two pairs of ski socks and one pair each of cushion sole socks and felt insoles).

c. Poor water resistance properties.

d. Design precludes procurement.

Based on test results obtained during this program the present test item, a leather boot with cellular sponge insulation was selected for continued development and testing.

1.2 DESCRIPTION OF MATERIEL

The Boot, Mountain and Ski, hereinafter referred to as Model Number 1070, is a blucher-style boot with full quarters, rolled cushioned top, short vamp, and full gusset. The quarters are closed at the back and reinforced with a full back stay that is looped at the top. The upper leather is black, full grain, chrome tanned, and oil filled. The boot is fully lined with a tan color, chrome tanned, glove type leather that is lapstitched on the sides and closed at the back of the boot. The leather insole, 5 1/2 to 6 1/2 irons thick, is chrome tanned. The bottom is of "Goodyear Welt" construction with five iron thick leather midsole, a three iron thick rubber midsole and a five iron thick leather shank wedge. The outsole and heel are black rubber (Styrene Butadiene Rubber) with a cleated "Vibram" design and are contact bonded to the midsole and reinforced with brass nails. The toe is formed with a number 125 Celastic Band Box. The boot has three chrome eyelets and four chrome stud-type hooks on each quarter for closure with a round braided nylon lace. The boot is fully insulated with 1/8-inch unicellular foam between the outside upper and leather lining and an additional 1/8 inch thickness in the toe area. A 3/8-inch felt slip sole is used for bottom insulation. The overall height of the boot is seven inches. A size 8D boot weighs 34 ounces.

The boot is intended to be worn with one pair of cushion sole socks. The boot is designed to provide a capability for military operations in mountainous areas with temperatures down to minus 20°F. See Figure 1 for identification view of the Model No. 1070 boots.

1.3 TEST OBJECTIVES

a. To evaluate the Model No. 1070 boot through laboratory techniques in consideration of the Technical Characteristics (pars. B1, B3, and B4) for Boot, Combat, Mountain and Ski, April 1966, as included in the QMR for the System of Lightweight Individual Clothing and Equipment (LINCLOE).

b. To evaluate the sizing and fitting characteristics in consideration of the Technical Characteristics (par. B13) and to provide technical assistance to USAATC in the initial fitting and issue of the test item in that phase of the Service Test.

1.4 SUMMARY OF RESULTS

a. Participants wearing the test ski boots were able to maintain a great toe temperature of 48 ± 5°F. with no further significant temperature drop while active in the environmental chamber when exposed to an ambient temperature of -20°F. While inactive under the same conditions, toe temperatures showed continued drop to 42°F. at which point participants were removed as a safety precaution.

b. The test boots heated to 100°F. and then subjected to a -20°F. ambient temperature showed a 2.92°F./min. rate of heat loss internally.

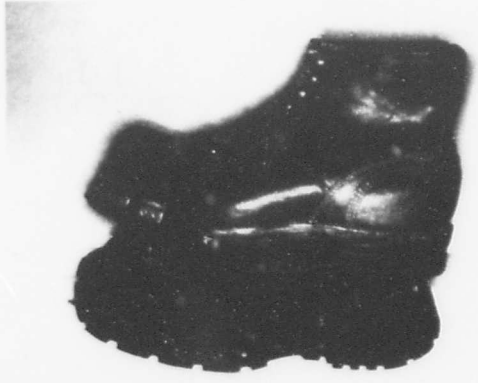
c. The test boots provided protection against an internal 12.6°F. temperature rise for approximately 2 1/2 minutes after ignition of Napalm and Mogas and for approximately 1 1/2 minutes after ignition of yellow phosphorous on outer surface.

d. Results of tests of protection against thermal effects of atomic weapons will be included in a subsequent supplemental report.

e. Observations during the limited wear periods of this test indicated maintenance requirements are nominal and similar to those for leather combat boots and other leather footwear items with the exception that the felt insole should be removed periodically for drying and airing.

Model No. 1070

Model No. 990



Standard

Identification Views

Figure 1

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FORT LEE, VA.

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NEGATIVE _____

f. Fifty-one participants were fitted with the Model 1070, Model 990, and standard ski boots for participation in the Service Test. The same size is required for proper fit in the Models 1070 and 990. No definite correlation of sizes could be established between the Models 1070 and 990 sizes and those for the standard ski boot because of the lack of a full tariff of sizes in the standard boots and the limited number of personnel available for fitting. In addition, the extra sockgear, two pairs of ski socks, used in the standard boot permits and requires less sophisticated fitting of the standard boot. A slight difference was noted in the sizing of the Model 990 and Model 1070 boots; the Model 1070 is slightly wider in the toe area than the Model 990 in each given size. The size tariff for the Models 1070 and 990 boots was comprised of whole sizes only in three widths. This size tariff was adequate for the fitting of the personnel available.

1.5 CONCLUSIONS

The Model 1070 mountain and ski boot is satisfactory as to the technical characteristics (pars. B1, B4, and B13) included in the QMR for the System of Lightweight Individual Clothing and Equipment (LINCLOE).

1.6 RECOMMENDATIONS

None.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

This test was conducted during the period 26 January through 24 May 1968, utilizing the USAGETA laboratory facilities at Fort Lee, Virginia, where studies were made of the insulation characteristics and the protective qualities against high intensity flash and flame. Studies of the protective qualities against the thermal effects of nuclear weapons will be conducted at the U.S. Army Natick Laboaratories, (USANL) Natick, Massachusetts. Sizing and fitting operations were accomplished in support of the Service Test conducted by the U.S. Army Arctic Test Center at Fort Greely, Alaska.

2.2 INITIAL INSPECTION

2.2.1 Objective

To determine the presence of any visible defects in material or workmanship which might affect test operations or results.

2.2.2 Method

Each boot was carefully inspected prior to use for evidence of defects or variations in material or workmanship.

2.2.3 Results

No defects or pertinent variations in material or workmanship were found in the 25 pairs of boots provided as a test sample.

2.2.4 Analysis

Not applicable.

2.3 INSULATION

2.3.1 Objective

To determine if the test boots provide protection against cold effects to an active user at temperatures as low as -20°F.

2.3.2 Method

a. A group of 6 men were properly fitted with the Model 1070 mountainous ski boots. Thermocouples were attached at the tip of the great toes of each participant. The participants then donned their socks and ski boots and the standard cold-wet uniform portions suitable for the ambient temperatures at the time of operations outside the environmental chamber. The complete uniform was donned prior to the entry into the chamber with the interior ambient temperature set at -20°F. The participants completed four exposure periods at the -20°F. ambient temperature inside the chamber; two periods during which the participants were inactive and two periods during which they walked about and performed calisthenics. One period of inactive exposure and one period with activity were each preceded by a 1-hour period of inactivity. The other periods of exposure, one each without and with activity, were preceded by a 1-hour period of marching and calisthenics. Toe temperatures were obtained and recorded electronically at 20-second intervals during each exposure period. Exposure periods were terminated and participants withdrawn when one toe temperature reached the minimum safety limit, +42°F., or when the temperatures reached a plateau, i.e., no further temperature drop over an extended period of reading.

b. One of the Model 1070 boots had a thermocouple attached to the inner surface of the boot. The boot was then laced and an approximately 2-inch thick layer of floam insulation was inserted in the ankle area and sealed to inner lining with silicon rubber. The thermocouple was attached to an electronic recorder for semi-continuous observation of the changes in the inner air temperatures during the pre-heating of the boots to 100°F. and subsequent exposure to -20°F. ambient temperature in the environmental chamber. An infrared optical thermometer was used to observe heat changes on the outer surfaces of the boot. Several trials and detailed persual of the outer surface of the boot were made to determine the rate of heat loss as well as definite heat leakage points in the boot.

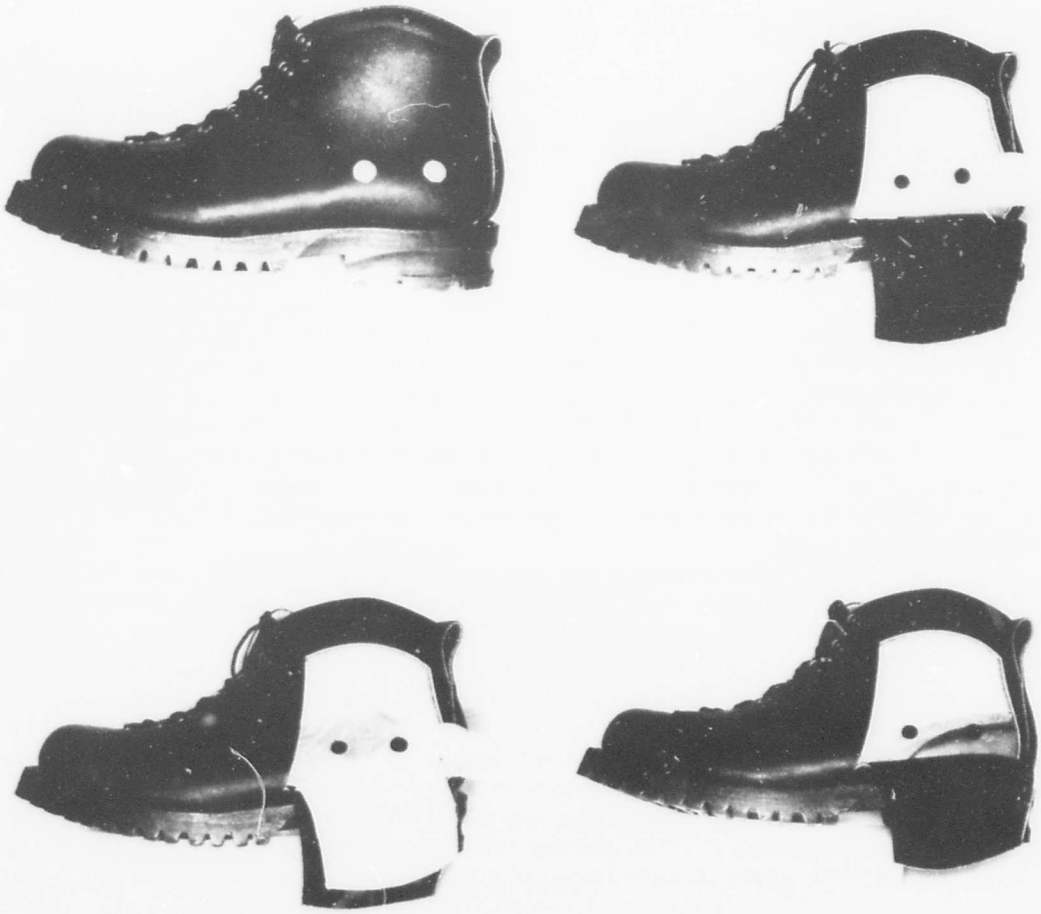
c. Thermograms of the test boot were obtained with an infrared scanner equipped with a polaroid camera attachment. A high intensity lamp with shield was used as the heat source inside the boot. The thermal image of the boot as projected on an oscilloscope screen was photographed to obtain the thermograms for study of the character and configuration of the insulation. Thermal transmission ranges were read from the temperature meter in the scanner console.

2.3.3 Results

a. The temperature at the tip of the great toes of the six individuals wearing the test boots reached a plateau at 48 ± 5°F., when the participants were active during periods of exposure to -20°F. ambient temperature in the environmental chamber, regardless of pre-exposure conditioning, activity or inactivity. When activity preceded exposure, the time to reach the temperature plateau ranged from 73 to 107 minutes; when inactivity preceded exposure times ranged from 69 to 112 minutes. When the participants were inactive during exposure, great toe temperature of each individual reached the minimum temperature prescribed for safety, 42°F. and each individual was withdrawn from exposure. The time ranges were 42 to 68 minutes when inactivity preceded exposure and 52 to 77 minutes when activity preceded exposure. The average rates of temperature drop were approximately the same 0.7 ± 0.1°F., during periods of exposure, with participants active and inactive, irrespective of pre-exposure conditioning.

b. The test boot showed heat loss rates in °F. per min. of 2.92° on the inside, and 1.00° on the outer surface at the side and 1.23° at the lacing area when static heat loss studies made with the boot heated to 100°F. and exposed to a -20°F. ambient temperature. Examinations were made to determine possible reasons for the more rapid rate of heat loss from the inside. The optical thermometer detected very small "hot spots" in the inner and outer heel areas along the line of the top of the counter which indicated convection of inner warm air to the outside of the boot. These spots were approximately 15°F. warmer than the rest of the boot outer surface in the general area. Photographs showing the location of two such spots of heat leakage are shown in Figure 2.

c. Near maximum output for the 0-50°C. (32-122°F.) range was indicated by the gray scale block seen in the upper right corner of the thermograms. Being the last block of an eight-block gray scale, maximum temperature detection of 47 + 3°C. (117 + 5°F.) was denoted in the highlights of the thermal images. The high block level required for removing ambient air interference inhibited imaging of the rest of the scale. The gray scale divisions are indicated in Table I:



Views of Locations of Heat Leakage Points

Figure 2

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NEGATIVE _____

FRONT

EFFECTIVENESS OF INSULATION IN DESCENDING ORDER 1 THRU 3.

X-DENOTES SOLE OR OUTER LAYERS.

SIDE

DIAGRAMS SHOWING DISTRIBUTION AND GRADATIONS OF INSULATION

Figure 3

TABLE I

GRAY SCALE DIVISIONS FOR THERMOGRAMS OF SKI BOOTS

(TEMPERATURE RANGE 0-50°C.)									
°F.	3	9	15	22	28	35	51	47	±3
°C.	37	48	59	71	82	95	106	117	±5

Diagrams of the distribution and gradations of insulation as obtained through thermograms are shown in Figure 3.

2.3.4 Analysis

Not applicable.

2.4 PROTECTION AGAINST THERMAL EFFECTS

2.4.1 Objective

To determine if the test boots will provide protection against the thermal effects of atomic weapons to the extent that no more than first degree burns are received as a result of exposure to the equivalent of 10 calories per square centimeter from a 30 KT yield weapon.

2.4.2 Method

Samples of the boot upper stock will be subjected to tests by U S. Army Natick Laboratories utilizing the solar furnace at USANL.

2.4.3 Results

Tests have not been completed and the results will be reported in a supplemental report at a later date.

2.4.4 Analysis

Not applicable.

2.5 PROTECTION AGAINST HIGH INTENSITY FLASH AND FLAME

2.5.1 Objective

To determine if the test boots will provide protection against high intensity flash or flame of 30 seconds duration and from burning gels, other fuels, and phosphorous for a period of several minutes outside the fire ball area.

2.5.2 Method

Thermocouples were placed on the sides and soles of samples of the test boots with millivolt readouts made to a Honeywell Electronic 19 recorder. Approximately 25 cubic centimeters of Napalm; or a stick of yellow phosphorous, 1 1/2 inches long, approximately 5/8 inches diameter were placed on the outer surface of the boots immediately above the location of a thermocouple and ignited. Records were made of the time required for a 12.6°F. temperature rise and the time to reach the criterion temperature rise on the inside surface of the boot and in the hottest point in the fuel burning areas during the burning periods. A rise of 12.6°F. in material adjacent to the skin is considered necessary to produce initial skin tissue damage.

2.5.3 Results

The test boot upper side material withstood a 12.6°F. rise for approximately 2 1/2 minutes when Mogas and Napalm were ignited on the outer surface and for approximately 1 1/2 minutes when phosphorous was ignited. The sole resisted such a temperature rise throughout the burning period when Napalm and phosphorous were ignited. No trials were conducted with Mogas on the sole because Mogas could not be retained on the relatively flat surfaces of the outsole for sufficient time for ignition or in quantities practical for study purposes. In addition, the outsole is inverted in normal position and does not retain any appreciable quantities of liquids. A summary of the data obtained in the series of trails is shown in Table II.

TABLE II

SUMMARY OF DATA OBTAINED IN STUDIES OF
BOOT PROTECTION AGAINST IGNITED MOGAS, NAPALM, AND PHOSPHOROUS

	MATERIAL IGNITED					
	NAPALM		MOGAS		PHOSPHOROUS	
	BOOT AREA		BOOT AREA		BOOT AREA	
	SIDE	SOLE	SIDE	SOLE	SIDE	SOLE
INSIDE BOOT:						
Max Temp Rise (°F.)	102	65	108	a	124	65
Time to Max Temp Rise (Sec)	181	257	209	a	261	180
Time to 12.6°F. Rise (Sec)	150	b	145	a	81	b
OUTSIDE BOOT:	1708		1323		1266	
Max Temp Rise (°F.)	104		67		130	
Time to 12.6°F. Rise (Sec)	c		c		14	

a. Mogas not ignited on sole.
b. 12.6°F. temperature rise not obtained.
c. 12.6°F. almost instantaneous; time not obtained.

2.5.4 Analysis

Not applicable.

2.6 FITTING AND SIZING CHARACTERISTICS

2.6.1 Objectives

To determine the fitting and sizing characteristics of the Model 1070 test boots as compared with the Model 990 and standard boots used as control items when fitted to the participants in the service test; and to evaluate the fitting tariff including three widths, whole sizes only, as provided in the tariff of test boots.

2.6.2 Method

Fifty-one participants in the Service Test were fitted with one pair each of the test boots, Model 1070, and the two control boots, Model 990 and standard. Records were made of the properly fitted size in each boot type. All fitting was accomplished with participants wearing proper sockgear: Models 1070 and 990 boots, each with one pair of standard wool cushion sole socks; the standard boots with one pair of standard wool cushion sole socks and two pairs of standard ski socks in graduate sizes over the cushion sole socks. All boots included one pair of felt insoles.

2.6.3 Results

The fitting and issue operations conducted in support of the Service Test showed: the Model 1070 boot is slightly wider than the Model 990 control boot in the same given size; the same size in each of these two boot models are required for proper fitting of given individuals; the two models were provided in a full-size tariff only in three widths, B, D, and EE; and that this tariff was adequate for fitting the personnel available for participation in the Service Test. No definite correlation could be established between the Models 1070 and 990 and the standard boots due to the limited number of sizes available in the standard boots as well as the limited number of personnel fitted, 51. In addition, the extra sockgear used in the standard boot does not permit nor require fitting as sophisticated as that for the Models 1070 and 990 boots. The distribution of the fitted sizes of the Model 1070 and 990 boots and the correlated sizes in the standard boots is shown in Table III.

2.6.4 Analysis

Not applicable.

2.7 VALUE ANALYSIS

2.7.1 Objective

To determine if the test boots have any unnecessary, costly, or nice-to-have features which may be eliminated without adversely affecting the essential performance requirements, reliability, quality, or safety (USATECOM Reg 700-1).

2.7.2 Method

TABLE III

DISTRIBUTION OF FITTED SIZES FOR STANDARD SKI BOOTS FOR GIVEN SIZES OF NO. 1070 AND NO. 990 INSULATED SKI BOOTS

STD BOOTS	EXPERIMENT #1070 & #990 BOOTS													
	7D	7EE	8D	8EE	9B	9D	9EE	10B	10D	10EE	11B	11D	12B	12D
7EE	1													
7½E	2													
8½E		1	4	1	2	1								
9½C					2	7		1						
9½E						1								
10D						1								
10½C						1		1						
9½EE							1							
10D						1	3	3						
11½C								3		3	1	1		
11D									1					
11½E										1	2			
11½EE										1		3	1	
12½E														

The test boots were carefully examined and observances made during test operations for data relative to value improvement and features that could be eliminated.

2.7.3 Results

No unnecessary, costly, or nice-to-have features were observed.

2.7.4 Analysis

Not applicable.

SECTION 3. APPENDICES

APPENDIX	I	-	FINDINGS
APPENDIX	II	-	REFERENCES
APPENDIX	III	-	DISTRIBUTION LIST

APPENDIX I. FINDINGS

Paragraph Reference	Qualitative Materiel Requirements	Met	Not Met	Remarks
7. Technical Characteristics				
a.	The Boot, Combat, Mountain and Ski will protect an active user in temperatures as low as -20°F.	X		Paragraph 2.3.3
b.	The Boot, Combat, Mountain and Ski will provide protection against thermal effects of atomic weapons for the areas covered to the extent that no more than first degree burns are received as a result of exposure to the equivalent of 10 cal/cm^2 from a 30 KT yield weapon.		X	Tests at USAN Labs not completed at time of this report. Results to be included in a subsequent supplemental report.
c.	The Boot, Combat, Mountain and Ski will provide protection for the areas covered against high intensity flash or flame of 30 seconds duration and from burning gels, other fuels, and phosphorous for a period of several minutes outside the fireball area.	X		Paragraph 2.5.3
d.	The Boot, Combat, Mountain Ski lend themselves to a sizing system in the minimum number of tariff sizes, whole and half sizes in three widths.	X		Paragraph 2.6.3

APPENDIX II. REFERENCES

1. Letter, AMSTE-BC, Headquarters, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland, 18 August 1967, subject: "Test Directive, Engineering and Service Test of Boot, Combat, Mountain and Ski, USATECOM Project Nos. 8-3-7020-05/06."

2. Final Report of Engineering Design Test of Boot, Combat, Mountain and Ski, under Arctic Winter Conditions, USATECOM Project No. 8-3-7020-02. November 1965, U.S. Army Arctic Test Center.

3. Proposed Annex B LINCLOE QMR, Item 3, 14 April 1967.

4. AMCTC Agenda Item 4749, Meeting 8-66, Technical Characteristics for Boot, Combat, Mountain and Ski.

5. CDOG 1439 (2) II-System of Lightweight Individual Combat Clothing and Equipment (LINCLOE).

6. RDT&E Project 1J643303D54712D, Individual Combat Protective Clothing and Equipment Development.

7. Letter, AMXRE-COP, U.S. Army Natick Laboratories, 7 August 1967, subject: "ET/ST of Boots, Combat, Mountain and Ski".

8. Letter, TECOM 8 Sep 67, Engineering and Service Test of Boot, Combat, Mountain and Ski, USATECOM Project No. 8-3-7020-05/06.

AD

Accession No.

U.S. Army General Equipment Test Activity, Fort Lee, Virginia

ENGINEERING TEST OF BOOT, COMBAT, MOUNTAIN AND SKI by Edwin W. Mangum June 1968, 25p. -tables, -illus., 3 Appendices p. 19 - 25 (TECOM Proj. No. 8-3-7020-06) Unclassified Report

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It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

UNCLASSIFIED

1. FOOTWEAR - COMBAT
2. BOOTS - MOUNTAIN
I. Mangum, Edwin W.
II. Title: Engineering Test of Boot, Combat, Mountain and Ski, Final Report
III. USATECOM 8-3-7020-06

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It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

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It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

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It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

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An Engineering Test of the Boot, Combat, Mountain and Ski was conducted from 26 January through 24 May 1968, to evaluate the Model No. 1079 boot through laboratory techniques in consideration of certain Technical Characteristics for Boot, Combat, Mountain and Ski, April 1966, as included in the QMR for the System of Lightweight Individual Clothing and Equipment (LINCLOE), evaluate the sizing and fitting characteristics in consideration of the Technical Characteristics, and provide technical assistance to the U.S. Army Arctic Test Center (USAATC) in the initial fitting and issue of the test item in that phase of the Service Test.

It was concluded that the Model 1070 Mountain and Ski Boot is satisfactory as to the Technical Characteristics included in the QMR for the system of Lightweight Clothing and Equipment (LINCLOE) for which tests were conducted.

UNCLASSIFIED

1. FOOTWEAR - COMBAT
2. BOOTS - MOUNTAIN

I. Mangum, Edwin W.
II. Title: Engineering Test of Boot, Combat, Mountain and Ski, Final Report
III. USATECOM 8-3-7020-06

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Combat Boot						
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Military Footwear						
Ski Boot						
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