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LIGHTWEIGHT INSULATED FOOTWEAR FOR COLD-WET CONDITIONS

T. A. Pietraszek

Uniroyal, Incorporated

Prepared for:

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December 1973

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TECHNICAL REPORT

74-10-CE

LIGHTWEIGHT INSULATED FOOTWEAR FOR COLD-WET CONDITIONS

by

T. A. Pietraszek

Uniroyal, Inc.

Naugatuck, Conn.

Contract No. DAAG17-72C-0058

December 1973

Approved for public release; distribution unlimited.

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY TROOP SUPPORT COMMAND

Clothing & Personal Life Support Equipment Laboratory

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13. ABSTRACT

A procurement of a fixed number (450 pair) of lightweight insulated footwear was completed.

The construction was based on a design developed under recently completed contracts and optimized during Phase I of efforts reported herein.

It was demonstrated that the item could be taken from the laboratory bench and produced in a repetitive manner utilizing skills and techniques not unlike factory operations except on a reduced scale.

Of particular note was the application of the outerskin by means of an electrocoating system which permitted a control of spray deposition not possible heretofore.

Significant improvements in closure, surface bloom, adhesion of outerskin and larger socklinings for easier fitting were noted.

A ski shelf and groove in heel design was developed, but not applied to product at this time.

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Processing						
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Boots						

AD________________

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BY

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UNIROYAL, INCORPORATED
NAUGATUCK FOOTWEAR PLANT
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06770

CONTRACT NO. DAAG 17-72C-0058

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Clothing and Personal Life Support Equipment Laboratory
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

FOREWORD

The objective of improving the mobility and efficiency of the combat soldier under Arctic conditions requires the development of a new concept in insulated footwear. The footwear must retain necessary insulation properties and physical characteristics and at the same time be lightweight. The present standard black insulated U. S. Army boots developed for cold-wet conditions weigh approximately 80-86 ounces per pair. Studies of energy consumption of the combat soldier indicate that one ounce of weight carried on the foot is equivalent to six ounces carried on the back and therefore a pair of 80 ounce boots are equivalent to 30 pounds. In view of this, the development of new lightweight insulated footwear is essential. The boots should be in the weight range of 24-26 ounces per boot (size 9R), be durable and flexible, and offer environmental protection at temperatures as low as -30°C.

This report describes the work performed during the 12 month period from 3 November 1971 to 2 November 1972 under continuation of a program previously initiated with UniRoyal Incorporated. Under the supervision of Project Officer Joseph E. Assaf, U. S. Army Natick Laboratories, the materials and processing studies and the development of fabrication procedures culminating in the production of lightweight polyurethane insulated footwear were performed by UniRoyal, Incorporated, Naugatuck, Connecticut under Project Reference 1J662713DJ40, through Contract No. DAAG 17-72C-0058.

The Project Officer wishes to acknowledge Dr. Malcolm C. Henry. Deputy Director of the Clothing and Personal Life Support Equipment Laboratory (C&PLSEL) for his valued suggestions and the aid and guidance of Mr. Douglas S. Swain, Footwear Technologist at NLABS relative to design considerations.

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ABSTRACT

A procurement of a fixed number (450 pair) of lightweight insulated footwear was completed.

The construction was based on a design developed under recently completed contracts and optimized during Phase I of efforts reported herein.

It was demonstrated that the item could be taken from the laboratory bench and produced in a repetitive manner utilizing skills and techniques not unlike factory operations except on a reduced scale.

Of particular note was the application of the outerskin by means of an electrocoating system which permitted a control of spray deposition not possible heretofore.

Significant improvements in closure, surface bloom, adhesion of outerskin and larger socklinings for easier fitting were noted.

A ski shelf and groove in heel design was developed, but not applied to product at this time.

INTRODUCTION

The main objective of the contract was to fabricate 450 pair, 150 pair each in sizes 8, 9 and 10 of lightweight, insulated polyurethane footwear utilizing and updating all previous knowledge developed on this item.

In essence, this was a continuation of work performed under Contract No. DAAG-17-70C-0003, but specifically related to the further development and optimizing of a prototype boot designed and identified as Model Number R-3007.

The subject contract was composed of two sections. Phase I for material and processing studies intended for improving the overall quality of the previous boots, and preparing prototypes for the ultimate fabrication of the 450 pair under Phase II of this contract.

Work was directed toward the following goals:

(1) Development of a new puncture resistant skin.

(2) Increasing thickness of outerskin below the ankle.

(3) Modifying processing techniques for an improved skin.

(4) Improvement in adhesion of outerskin to boot proper i.e. outsole edge.

(5) Modifying closure to improve wearability.

(6) Eliminating bloom on boot surfaces upon storage.

(7) Preparing preproduction samples.

(8) Developing a ski-shelf and groove in heel design for application to this footwear.

Phase II consisted of producing the specified 450 pair of boots according to the best knowledge and information available on this item.

I. MATERIALS AND DESIGNS

Phase I portion of the contract consisted of efforts in improving materials, formulations, constructions and boot designs developed under the past contract, and finalizing the construction to produce an optimum product as delineated in this report.

Mutual accord was reached with Natick Laboratories on all pre-production data, and approval to proceed with the Phase II portion of the contract was received following agreement on some specific areas covering boot constructions as follows:

A. Outsole density to remain as specified with the upper adjusted to bring boot within overall weight.

B. No reduction in density at the sacrifice of upper strength and appearance.

C. The use of Adiprene L-42 prepolymer skin on the basis of Gehman low temperature tests and processing characteristics.

D. Snow collar to be of lightweight construction without a cotton net backing.

1. Boot Composition

The formulations listed herein for the outsole and upper represent boots produced under the Phase II portion of the contract.

Boot compositions given below were based on Vibrathane B-602, a polyether urethane prepolymer which is a reaction product of polytetramethylene ether glycol (PTMEG) and toluene diisocyanate (TDI). Included were the curative, meta phenylene diamine (mPDA); a nitrogen gas producing blowing agent, Nitrosan; a silicone surfactant (SF-1079) and a black color dispersion. Both upper and outsole were basically the same compound with the blowing agent and Santicizer S-140 as the main significant difference. Fuel oil Additive #2 is a dispersant.

BOOT FORMULATION

	Outsole	Upper
Vibrathane B-602	100	100
mPDA	4	4
Nitrosan	1.5	9
Santicizer S-140	18	25
SF-1079 Silicone Surfactant	1	1
3041 Black	0.5	0.5
Fuel Oil Additive #2	.007	.045

Note: Parts By Weight

2. Socklining and Collar

The socklining (standard) used in constructing the boot was a nylon/rubber/cotton laminate developed under the previous contract. However, an improvement in the adhesion of the nylon to the natural rubber was necessary, and this was obtained by the application of an adhesive coating to the nylon prior to laminating it to the natural rubber. The base compound for making this cement consisted of 100 parts of natural rubber and 9 parts of SRF-HS carbon black. The mixture was then dissolved in solvent to form a cement with the following composition:

Ingredients	Parts
Basic Compound	100
Denatured Alcohol	17
Gasoline	178

By spreading one coat of the above cement on the nylon fabric prior to laminating it to the natural rubber gum, the adhesion of the nylon to the natural rubber was increased significantly (from 0.5-1.5 pounds/2 in. to 7.0 pounds/2 in.). The adhesion of the cotton to the natural rubber increased to 5-10 pounds/2 in. and was considered good.

A further improvement was made in the construction of the socklining. This included the remaking of the dies used in cutting the parts of the socklining before they were stitched together. The dies were made slightly larger so that when the completed socklining was hooded over the last prior to the making of the boot, the socklining was not excessively stretched but extended just enough to fit the last with no wrinkles or sags. This development reduced tendencies for the boot to pull in or shrink when the socklining relaxed to its normal state after the boot was made and removed from the last.

Tables I and II show physical properties obtained on the above standard sockl ining versus a new experimental urethane coated nylon tricot material (Hygrade Shoe Findings Company), which has lightweight features.

Two different submissions of Hygrade material were made and the second sample was a marked improvement over the first. In view of the late receipt of the "Hygrade" fabric, decision was made to use the UniRoyal 3 ply material as standard for the contract.

Original collar requirements specified use of the standard sockl ining fabric as the closure material, but subsequent review of water absorption characteristics of the boot suggested elimination of the cotton laminate from this construction to reduce water pick-up and overall boot weight. This resulted in adoption of a 2 ply laminate of rubber and nylon with a comparative weight reduction from 38 grams to 26 grams (average) per collar.

3. Outerskin Composition

In extending the studies developed under the previous contract to improve the overall durability of the outerskin, a formulation utilizing Adiprene L-42 (DuPont) a polyether prepolymer based on PTMEG and toluene diisocyanate (TDI) was compared to Vibrathane B-605, a polyether prepolymer based on PTMEG and 4, 4-dimethylmethane diisocyanate (MDI).

FORMULATIONS

	Outer Skin (Vibrathane)	Outer Skin (Adiprene)
Vibrathane B-605	100	
Adiprene L-42		100
mPDA	3.6	3.4
Santicizer S-140	40	
SF 69 Silicone Surfactant	1.4	1.3
3041 Black	5	4.3
THF	56.5	106.5
Cyclohexanone	106.5	100
Toluene	86.5	86.5

Note: Parts by Weight

Physical tests on the above indicated that the L-42 formulation had essentially similar tensile strength, slightly higher elongation and somewhat better tear and low temperature flexibility. Refer to Table III for data. The difference between the two formulations, other than the prepolymers was the presence of 40 parts of Santicizer S-140 plasticizer (cresyl diphenyl phosphate) in the B-605 skin coating.

TABLE I

PHYSICAL PROPERTIES OF SOCKLINING MATERIAL

Type Test	Spec.	Standard	Hygrade #1 (Original)	Hygrade #2 (UniRoyal Fabric)
Weight (Oz./Sq. Yd.)	-	15.8	3.7	4.5
Gauge (Inches)	-	.031	.012	.013
Breaking Strength (Ball burst-Lbs.)	-	182	113	175
Tear (Elmendof)				
Wales - Grams	2400 Min.	3200+	1344	3200+
Courses - Grams	-	2800	800	2096

TABLE I I

PHYSICAL PROPERTIES OF SOCKLININGS

Physical Property	Test Method Fed. Std. No. 191	Sock-lining Spec.	UniRoyal Nylon/Cotton/ Rubber	Hygrade Nylon/ Polyurethane
Adhesion, Lbs./2 In. (Wales direction)	Method 5950	2.0 Min.	Nylon to rubber 7.0 Cotton to rubber 7.4	Nylon to urethane 7.0
Tear (Grams) (Wales direction)	Method 5132	2400 Min.	2633	765
Weight (Oz./Yd.^{2})	-	None	16.1	3.9
Gauge (In.)	-	None	.037	.012
No. of Plies (Fabric)	-	None	2	1
Weight (Size 10) (Grams)	-	None	75	19.5

UniRoyal Laminate Composition -
Nylon - Tricot Net #1826 (2.7 Oz./Sq. Yd.)
Gum - Natural Rubber
Cotton- 300 Cotton Net (3.6 Oz./Sq. Yd.)

TABLE III

PHYSICAL TESTING DATA - OUTERSKIN

	Vibrathane B-605	Adiprene L-42
100% Modulus (lbs./sq. in.)	375	620
300% Modulus (lbs./sq. in.)	740	810
Tensile Strength (lbs./sq. in.)	4430	4270
Percent Elongation (%)	660	870
Tear - Die C (lbs./in.)	330	415
Tear - Trouser (lbs./in.)	50	-
Gehman - Low Temperature (°F)		
T_2	+9	-2
T_5	-39	-59
T_{10}	-67	-62
T_{100}	-100	-93

The decision to use the L-42 prepolymer was primarily based on its slightly superior low temperature properties, and the fact that no plasticizer was required to obtain the properties. It should be noted that plasticized films would be more apt to change over extended storage especially at higher temperatures, than would non-plasticized films, even though the high boiling point of this plasticizer (390°C) would minimize volatility, if any. No tests were conducted to prove or disprove this belief other than generally accepted knowledge of performance of liquid plasticized compositions.

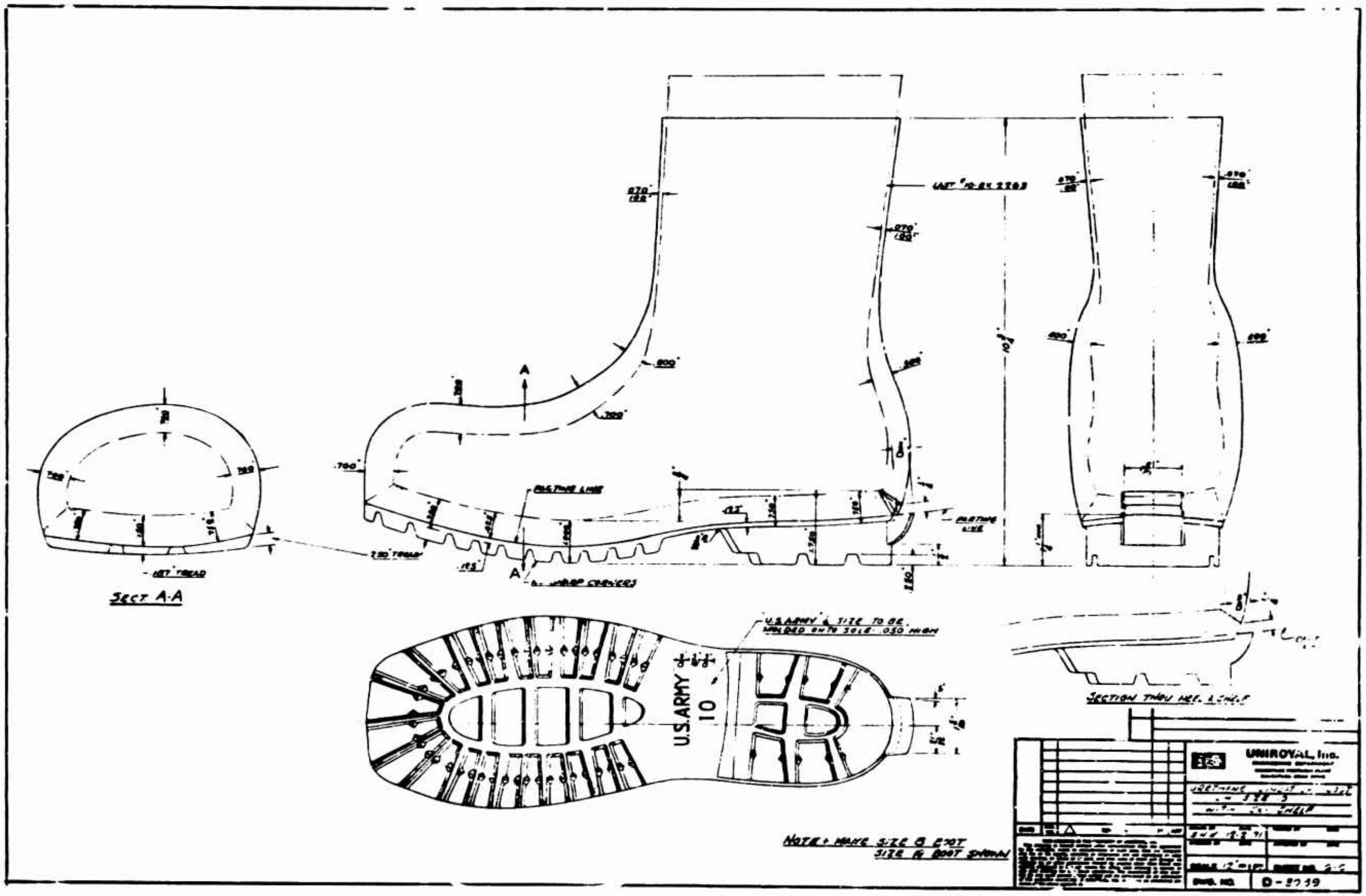
In addition to material selection, methods were developed to improve the adhesion of the outerskin to the upper foam and the outer edge of the outsole. This included buffing of the outsole edge and complete washing of the boot exterior surface with toluol solvent. The solvent acted not only as a cleaning agent for removal of foreign matter contamination but also as a solvent for any possible post cure blowing agent residues which may have been present on the surface.

4. Last and Mold Design

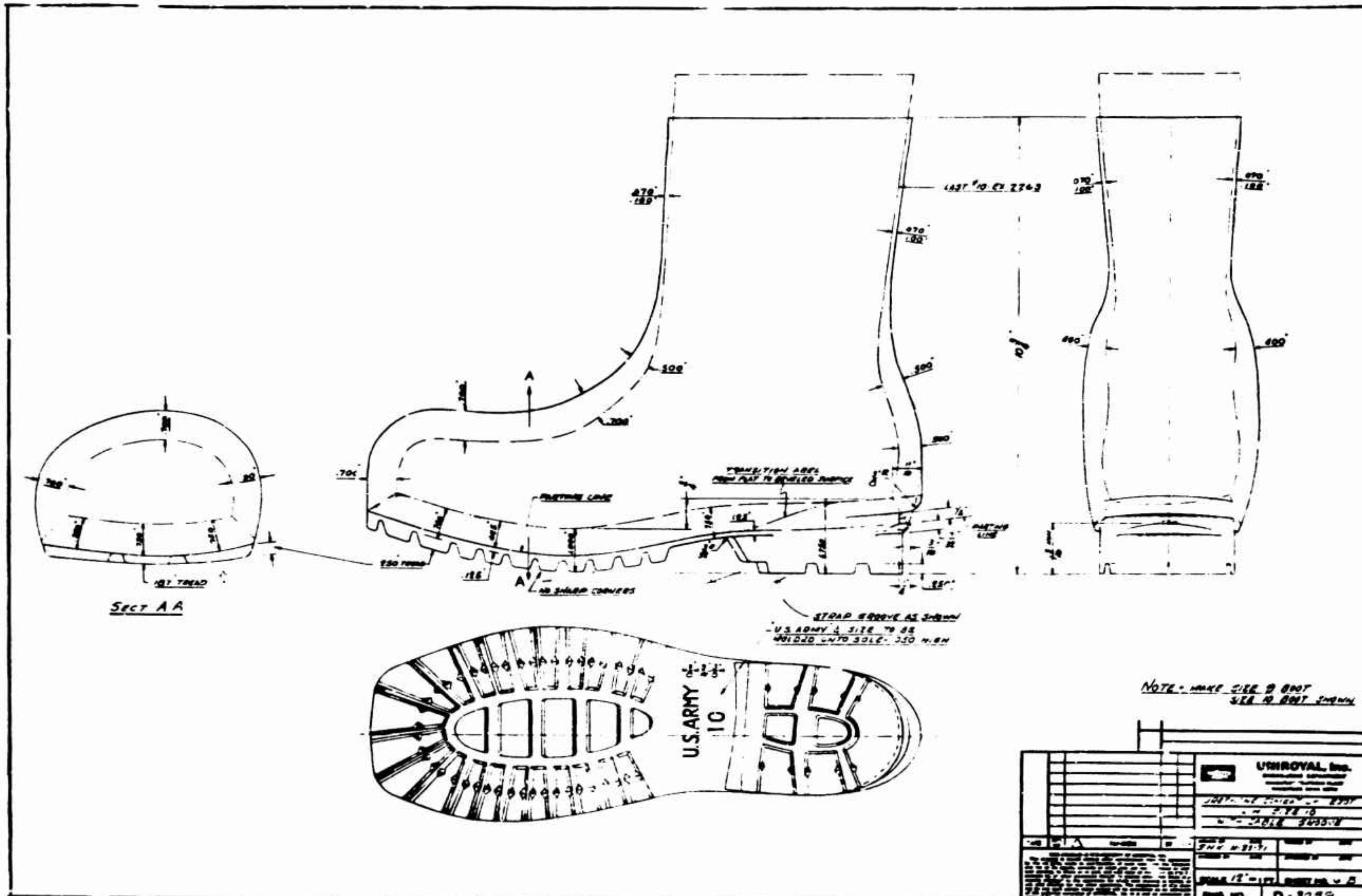
Two preliminary boot design objectives were part of this contract, (1) design a size 8, lightweight, insulated polyurethane boot with a shelf above the heel at the rear of the boot to accommodate a ski cable, and (2) design a size 9 lightweight, insulated polyurethane boot with a groove extending around the rear of the heel to also accommodate a ski cable. These objectives were worked on by footwear designers and preliminary drawings were produced to meet the requirements.

Drawing number D-3089, Sheet number 6C, illustrated the boot design with a ski shelf and drawing number D-3089, sheet number 6B, depicted the boot with a groove in the heel; both designs could incorporate a ski cable binding. These drawings were forwarded to the project officer. It was determined by the U. S. Army Natick Laboratories that further effort in designing of boots with either ski shelves or heel grooves for accommodating ski cable bindings was not feasible at this time and UniRoyal was instructed to design a size 8 and size 9 lightweight, insulated, polyurethane boot identical to the existing size 10 boot (R-3007) developed under the previous contract. Also, it was determined that the outsole design of all boots produced in sizes 8, 9 and 10 be outsole Design E which was also developed under the past contract and is depicted in current drawing (No. D-3089-6A).

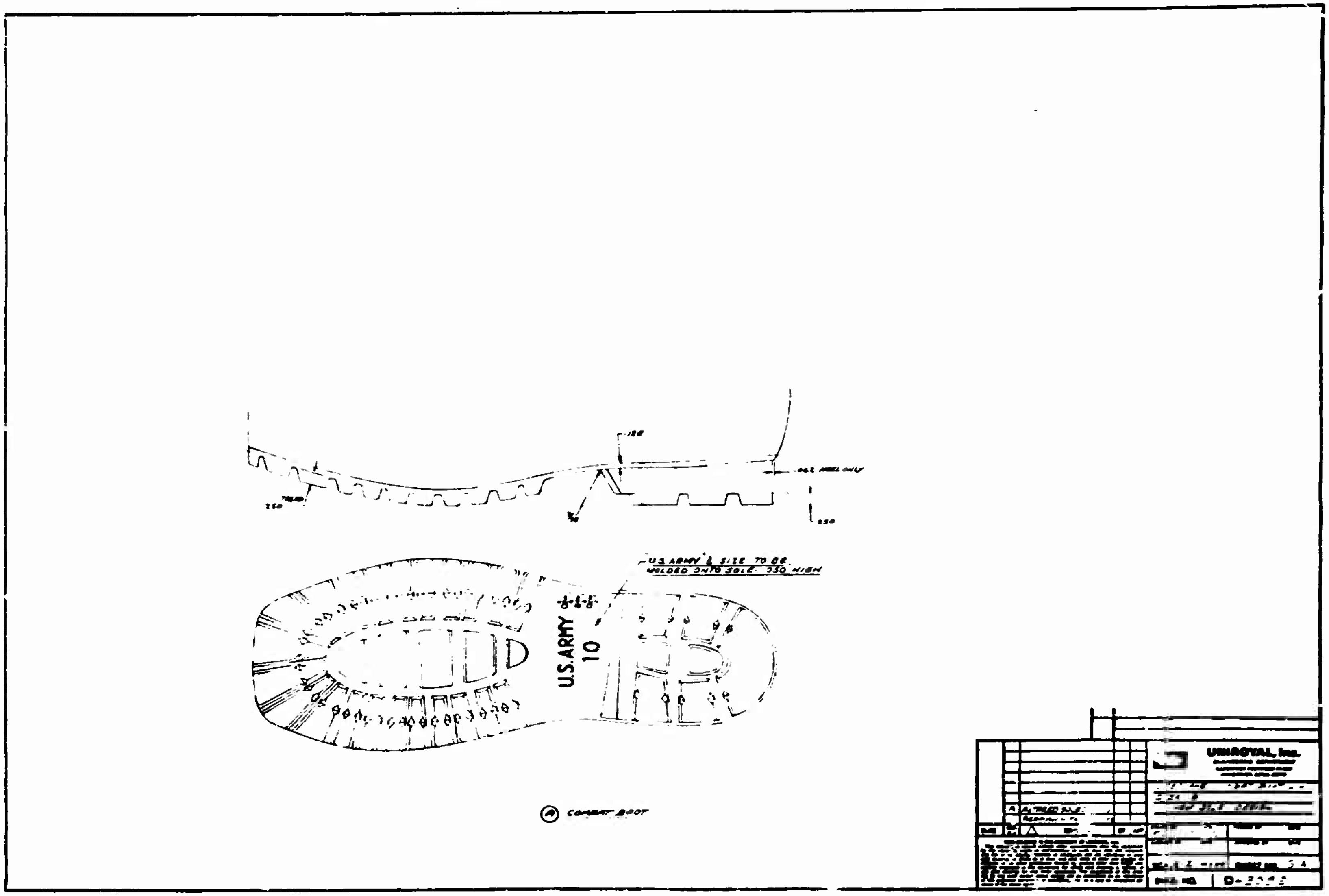
The size 10 last and molds were then graded down and reproduced in sizes 8 and 9. Refer to drawings No. D-3089 and E-3089 for details. The lasts were completed and the molds delivered in March 1972. The molds were inscribed in the shank area of the outsole with "U.S. Army" and the boot size.



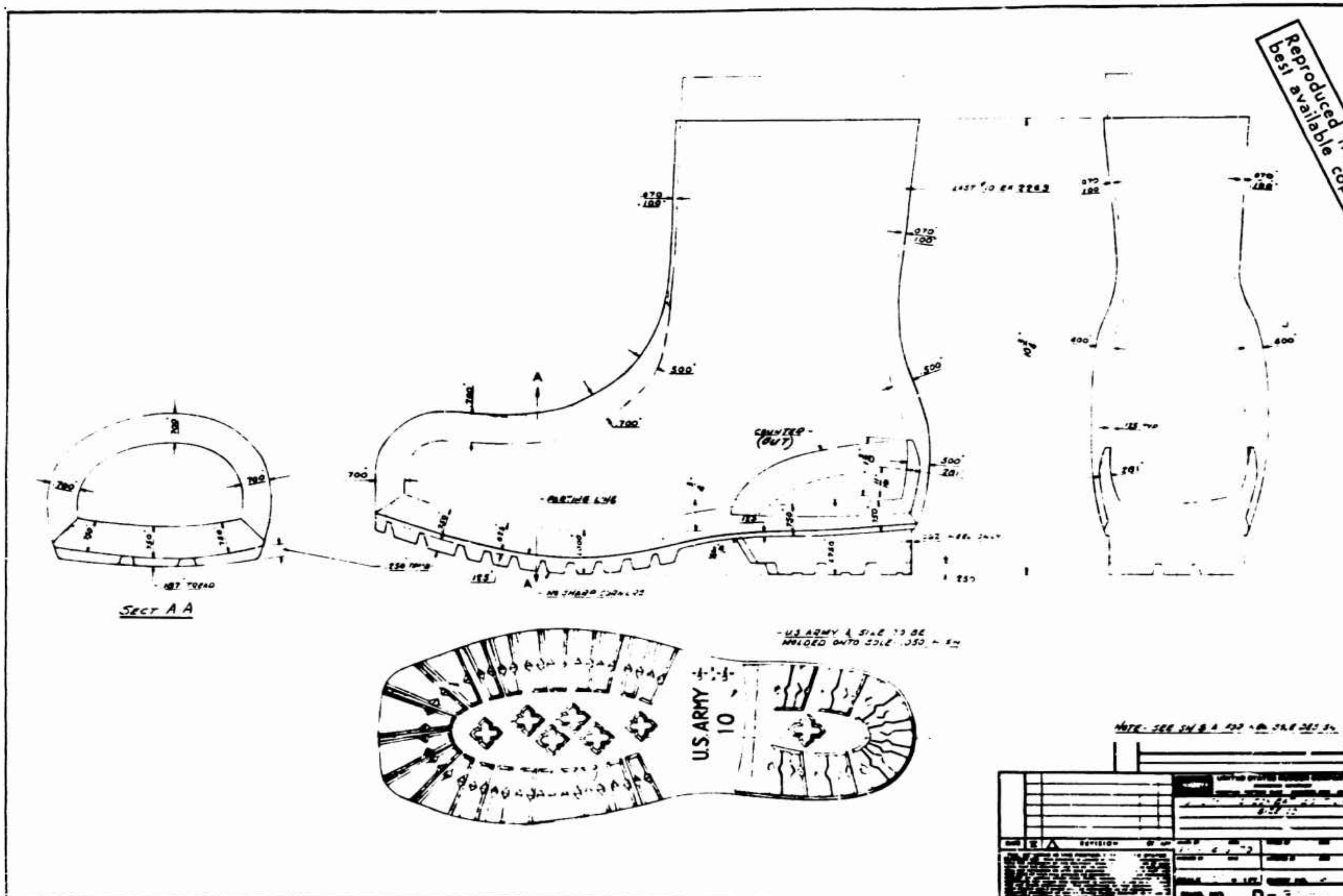
BOOT DESIGN WITH SKI SHELF
D 3089-6C



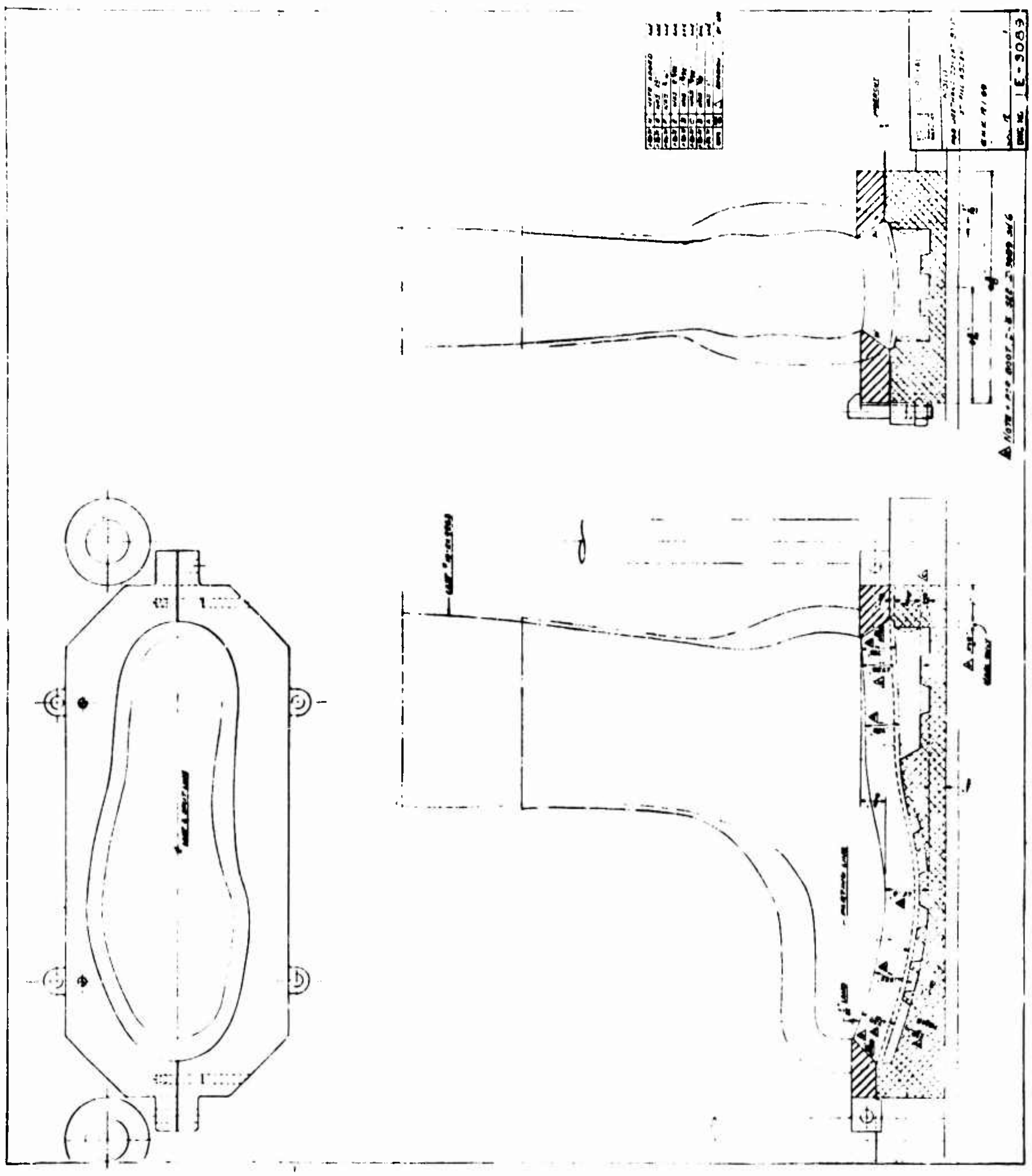
BOOT DESIGN WITH GROOVE
IN HEEL D 3089 - 6B



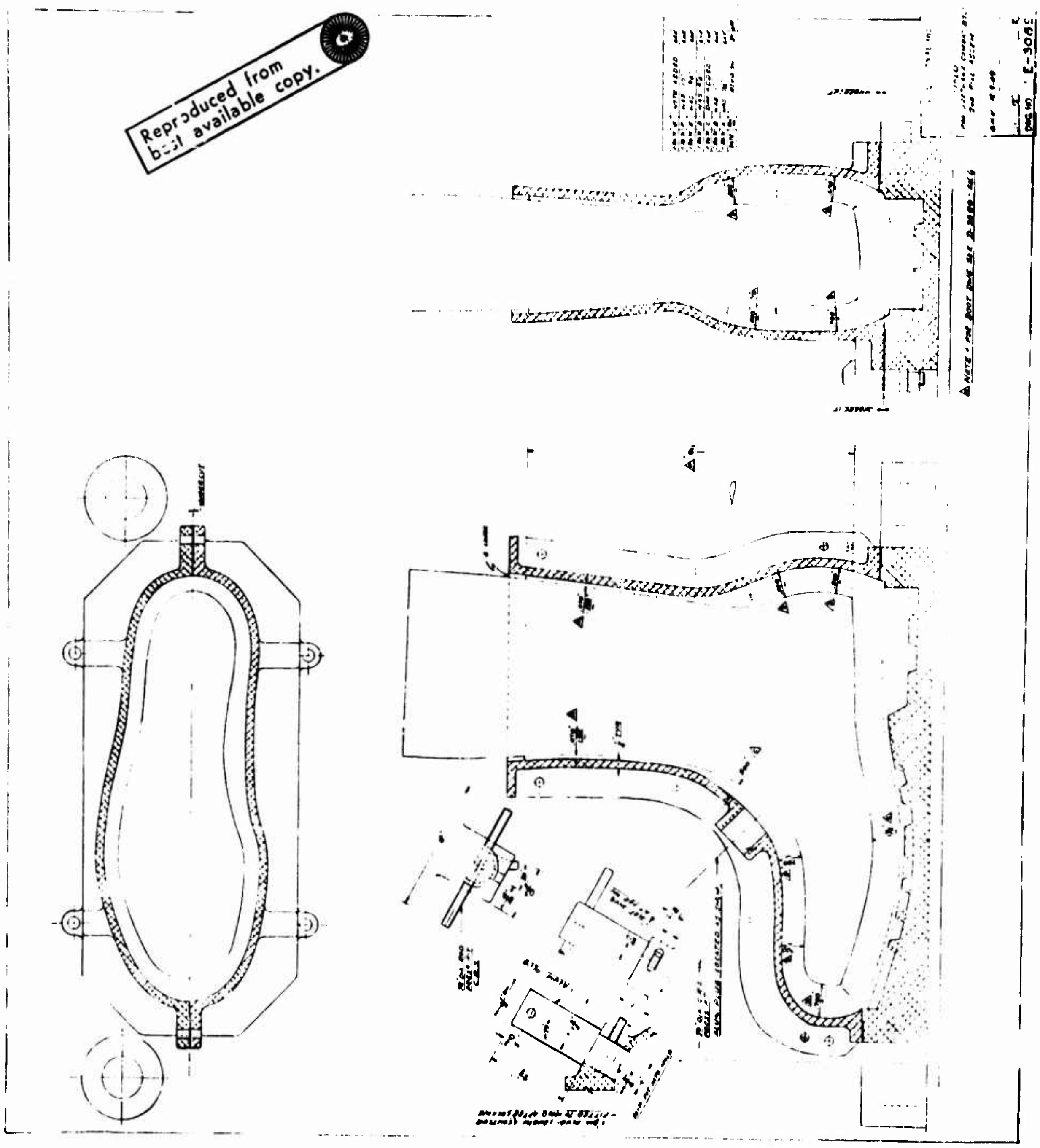
DESIGN E WITH SHANK IDENTITY
D 3089-6A



ORIGINAL SIZE 10 MOLD
D 3089-6



MOLD FOR FIRST FILL ASSEMBLY
E 3089-1



MOLD FOR SECOND FILL ASSEMBLY

E 3089-2

II. PROCESSING CONDITIONS

The most important aspects of processing studies during Phase I were to duplicate approved laboratory processes on pilot equipment capable of producing the 450 pairs of boots at a rate of 75 pair per month. This study included the proper positioning of equipment so that each operation necessary in constructing the boot followed a sequential order.

Techniques for casting the outsole and the upper of the boot were established using a Viking-Chase mixing/metering machine. The boots fabricated on this equipment were tested to determine capability of meeting the physical property requirements set in the contract.

Perhaps the most significant improvement in boot processing was the development of electrostatic coating of the outerskin. Systems under investigation included Graco-Fischer and Ransburg. Outerskins were sprayed onto boots and on test plates for complete physical testing before decision as to adoption of a system. The Ransburg electrocoating system was chosen for spraying the boots because deposition and uniformity could be readily controlled. The equipment was time leased at Parva Buckle Company, Mt. Carmel, Connecticut for performance of this phase of operations.

Standard footwear buffing equipment was utilized for removing the flash lines and buffing the outsole edge prior to the spraying of the outer skin. This prepared the edge surface and promoted better adhesion of the sprayed outer skin without destroying any of the foam structure.

Processing conditions played a major part in the manufacture of a satisfactory boot. This was true in both the casting and spraying operations. Temperatures were reduced on the outsole molds to produce higher density outsoles resulting in increased durometer and better wearing soles. However, higher temperatures were required on the last and shells in order to realize a lighter upper foam. and meet weight requirements.

Post curing was also extended from two hours at 180°F to two hours at 250°F in order to assure complete Nitrosan crystal bloom dissipation and optimum relaxation of stresses to arrive at adequate size fit.

As regards electrostatic coating, it was necessary to clean the gun and dismantle the apparatus after each use. Solvent flushing did not necessarily guarantee a clean system because of the tendency of components to either settle, partially crosslink from humidity, gel, etc.

The pumping system was pressurized to assure flow control on the prepolymer component. Other improvements and/or changes were adopted as needed to assure reliability. Of note was brushing coated boots prior to the last pass through the spray system to minimize pock marks which looked like pinholes.

Fabrication of boots was controlled by daily checks on vital statistics and data was recorded on production travel cards. Problems were encountered with Nitrosan blowing efficiency. It was difficult to compensate for ambient temperature variations since standards were set for quantitative delivery of Nitrosan. This accounted for the variability in low density upper foam as noted on some of the early boots. In order to improve the performance and control of this area, a pressure balance system for the Nitrosan component was adopted. This was a means of equalizing the dispense and recirculating pressure to ensure output consistency.

A maintenance program was introduced to periodically clean both the casting and spraying equipment and this extended the performance of the machines. Unfortunately, experience was required in order to improve operational skills and produce a better product.

Another significant step was the complete revamping of all molds, dowel pins, mold holders, clamping mechanisms, for better fit. It should be noted that looseness did develop in the mold assemblies because molds were made of aluminum, dowel pins were steel and the system of alignment was subject to wear.

A further move in improving our processing, was the purchase of 24 more lasts (4 pair each size 8, 9 and 10) for the electrostatic spraying operations. This was required in order to maintain a continuous controlled system without the variables associated in stop-and-go methods using only a few lasts.

To get more uniformity in temperature control of molds and related equipment, a new larger oven was obtained for the casting process. This step minimized variations previously noted when two ovens were used for the same operation.

A layout of the area and equipment utilized in implementing these processes is shown in Figure 1. A process flow chart (Figure 2) with built in quality control points was developed for adaptation to the pilot plant. Production travel cards (In-Process Control Sheets - see Appendix B) attached to boot lots were marked each time the boots approached the next step in the manufacturing process as indicated by the process flow chart. Finally, manufacturing procedures were written for the critical aspects of operations. These were prepared in the form of separate documents (Appendix B) in outline style for easy reading, orientation and understanding by the operators.

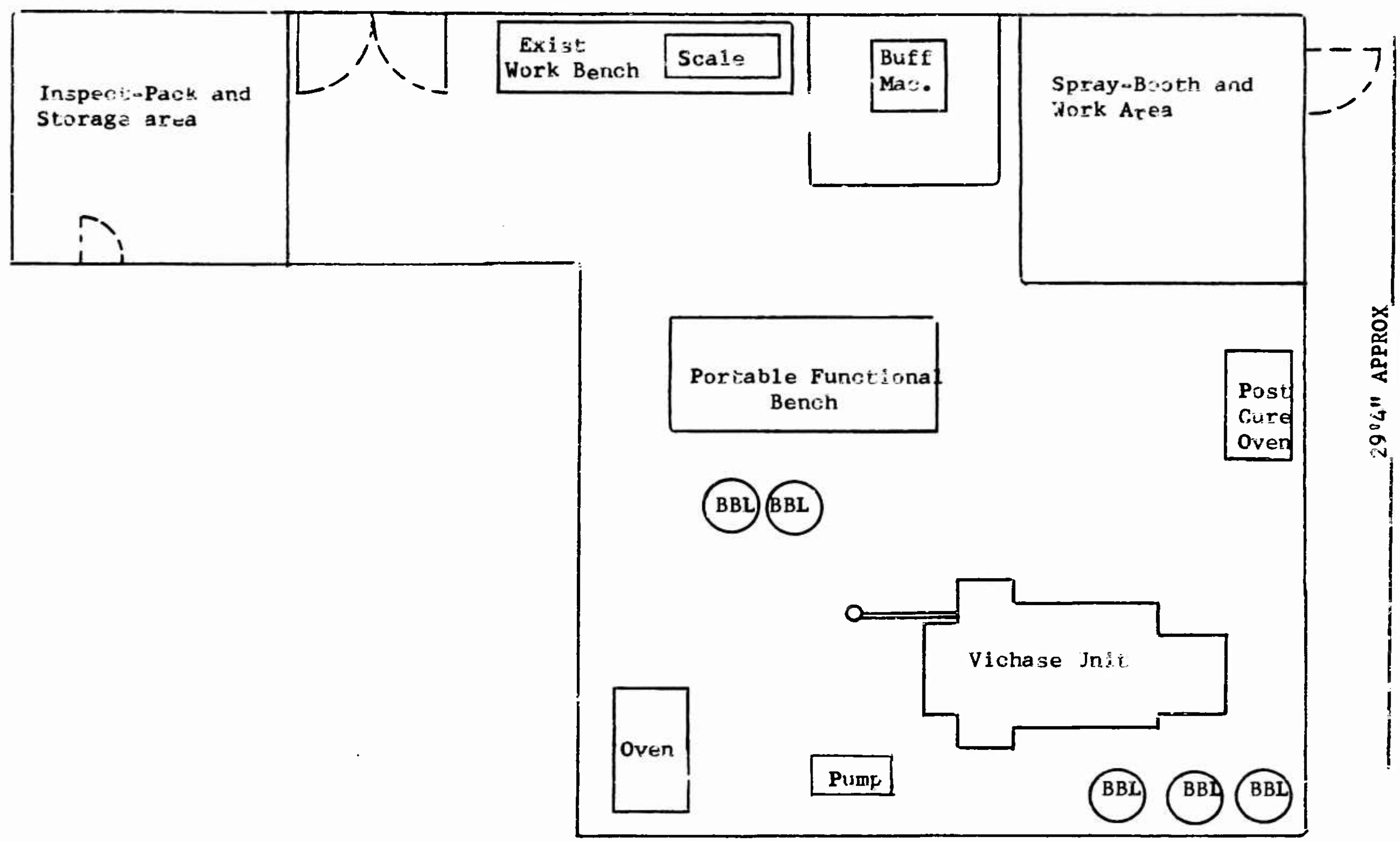


FIGURE 1

PROPOSED PILOT PLANT LAYOUT

Lot	MONDAY 8	10	12	2	4	TUESDAY 8	10	12	2	4	WEDNESDAY 8	10	12	2	4	THURSDAY 8	10	12	2	4	FRIDAY 8	10	12	2	4
1	Vichase Cast			Post Cure Buff		Inspect						Hold					Hold				Parva-Electro Coat				
2				Vichase Cast		Post Cure Buff			Inspect			"					"				"		"		"
3						Vichase Cast			Post Cure Buff		Inspect			Hold			"				"		"		"
4									Vichase Cast		Post Cure Buff			Inspect			"				"		"		"
5											Vichase Cast			Post Cure Buff		Inspect			Hold		"		"		"
6														Vichase Cast		Post Cure Buff			Inspect			Hold			
7																Vichase Cast			Post Cure Buff		Inspect			Hold	
8																			Vichase Cast		Post Cure Buff			Inspect	
9																					Vichase Cast			Post Cure Buff	
10																								Vichase Cast	

1	Sew	Mark	Inspect		Pack							
2	"	"	"		"							
3	"	"	"		"							
4	"	"	"		"							
5	"	"	"		"							
6	Hold			Hold		Parva Electro Coat			Sew	Mark	Inspect	Pack
7	"			"		"	"	"	"	"	"	"
8	"			"		"	"	"	"	"	"	"
9	Inspect	Hold		"		"	"	"	"	"	"	"
10	Post Cure Buff	Inspect		"		"	"	"	"	"	"	"

FIGURE 2
PILOT PLANT FLOW CHART

III. PHYSICAL PROPERTIES AND WEAR TESTS

A. Initial Production

Table IV lists the physical properties obtained from test slabs. Table V through VIII lists the results derived from cut up boots. The data reported for the outerskin in Table IV was for the original formulation based on the Vibrathane B-602 and shows that the physical properties exceeded specified minimums.

In Table V some of the results noted on boot parts do not conform to tentative guidelines presented in the contract. The outsole density was slightly lower than expected. Compression deflection at room temperature was somewhat higher for both the sole and upper foam insulation. Water absorption for the outsole probably reflected lower density and this was corrected subsequently. All other physical properties were within requirements. On the basis of these results no change in specification would be made until more data was available.

Table VI lists the boot thicknesses as measured on size 8, 9 and 10 boots. Most of the measurements were within expectations, however, points No. 7, 8, 9, 10, 11 and 12 deviated somewhat from the listed requirements and consideration was given toward revisions in the values since the deviations were common to all sizes. Similar consideration was given to points No. 17,18 19 and 20.

Based on these and subsequent random checks of boot dimensions, the following recommendations for changes were made for this production of boots.

Location	From	To
7-8-9-10	.500"-.700"	.400"-.700"
11-12	.400"-.600"	.300"-.600"
17-18-19-20	.700"-.900"	.500"-.800"

The reason for increasing the range of the larger thicknesses was that low density foam was not as dimensionally stable as firm density type which possesses only minor amounts of blowing agent. This was confirmed by data obtained on the outsole section.

Table VII depicts actual weight of the various components of the preproduction boots. These figures show that the boots tended to be on the heavy side and modification was required in processing conditions to bring the weight within anticipated limits. This was accomplished by temperature and blowing agent adjustment.

TABLE IV

PHYSICAL PROPERTIES OF SLABS

Physical Properties	Test Method	Outsole Spec.	Outsole Actual	Upper Foam Spec.	Upper Foam Actual	Outerskin Spec.	Outerskin Actual
Color		Black	Black	Black	Black	Black	Black
Thickness (Inches)		None	.075"	None	.0375"	None	.010"-.040"
Density Lbs./Ft.^{3}	ASTM D2406-65T Prs. 62-67	25 Min. 30 Max.	22.2	10.0 Min. 15.0 Max.	17.3	-	
Tensile Strength(PSI)	ASTM D412-66	-		-		2700 Min.	4523
Ultimate Elongation %	ASTM D412-66	-		-		500 Min.	653
Compression Defl. @25% At Room Temp.(PSI)	ASTM D1056-67T Prs. 17-20	35 Max.	41	6 Max.	17	-	
At -20°F (Increase from Original)		[illegible]0% Max.	7.3	50% Max.	5.5		
Compression Set at 50% Deflection at R.T. (%)	ASTM D1056-67T Prs. 21, 22 & 23	15 Max.	3.5	10 Max.	8.5	-	
% at 158°F		60 Max.	68.9	70 Max.	89.8	-	
Cut Growth 50,000 Flexes-Original %	ASTM D1052-55	200%	7600 cy (1) No Crack (2)	-	-	-	
After 70 Hrs.@212°F-%	ASTM D573-67T	200%	No Crack (2)	-	-	-	
Gehman Test T_{10}	ASTM D1053-65	-65°F	-76°F	-		-65°F	-82°F
Water Absorption % 6" Head 48 Hrs.	Fed. Std. 601 Method 12411	8 Max.	2.6	50 Max.	3.9	-	

TABLE IV (Continued)

PHYSICAL PROPERTIES OF SLABS

Physical Properties	Test Method	Outsole		Upper Foam		Outerskin	
		Spec.	Actual	Spec.	Actual	Spec.	Actual
Tear Resistance Die C (PPI)	ASTM D624-54	-		-		250	426
Hardness Shore A (Original)	ASTM D2240-64T	45-65	39	-		-	
Hardness After 70 Hrs. @212°F. Change from Original	ASTM D573-67T	10 pts. Max.	-6	-		-	
Hardness at -20°F Change from Original		15 pts. Max.	+4	-		-	

(1) Testing conducted on full thickness of slabs.

(2) Testing conducted on specified thickness.

TABLE V

PHYSICAL PROPERTIES OF BOOTS*

Physical Properties	Test Method	OUTSOLE Spec.	OUTSOLE Actual Size 8	OUTSOLE Actual Size 9	UPPER FOAM Spec.	UPPER FOAM Actual Size 8	UPPER FOAM Actual Size 9
Color	-	Black	Black	Black	Black	Black	Black
Density	ASTM D2406-65T Prs. 62-67	25 Min. 30 Max.	22.8	20.8	10 Min. 15 Max.	11.0	10.7
Compression Deflection @ 25% at Room Temp.(PSI)	ASTM D1056-67T Prs. 17-20	35 Max.	36.2	21.8	6 Max.	8.2	7.9
at $-20^{o}F$ (Increase from Original)		30% Max.	-6.1	+210%	50% Max.	-14.5	+14
Compression Set at 50% Deflection at	ASTM D1056-67T Prs. 21, 22 & 23						
Room Temp. - %		15 Max.	9.7	9.3	10 Max.	14.8	10.8
at $158^{o}F$		60 Max.	72.2	73.0	70 Max.	79.9	83.1
Cut Growth 50,000 Flexes	ASTM D1052-55						
Original %		200%	76,000 cy	No Crack	-		
After 70 Hrs. @$212^{o}F$-%	ASTM D573-67T	200%	No Crack	No Crack	-		
Gehman Test T_{10}	ASTM D1053-65 (ex. Prs. 8&9)	$-65^{o}F$	$-75^{o}F$	$-80^{o}F$	-		
Water Absorption % 6" Head 48 Hrs. at R.T.	Fed. Std. 601 Method 12411	8 Max.	11.2	10.8	50 Max.	42.2	38.8

* Preproduction Units

TABLE V (Continued)

PHYSICAL PROPERTIES OF BOOTS*

Physical Properties	Test Method	OUTSOLE			UPPER FOAM		
		Spec.	Actual		Spec.	Actual	
			Size 8	Size 9		Size 8	Size 9
Hardness Shore A Original	ASTM D2240-64T	45-65	59	47	-		
Hardness After 70 Hrs. @212^{0}F Change from Original	ASTM D573-67T	10 pts. Max.	-8	+4	-		
Hardness Change at -20^{0}F Change from Original		15 pts. Max.	+10	+24	-		

*Preproduction Units

TABLE VI

BOOT DIMENSIONS AND THICKNESSES

Upper Section		Size 10		Size 9		Size 8	
Point Loc.	Spec.	Right	Left	Right	Left	Right	Left
1	.100"-.200"	.105	.150	.110	.130	.105	.110
2	" "	.100	.150	.105	.150	.105	.115
3	.100"-.200"	.140	.150	.140	.110	.150	.150
4	" "	.130	.140	.135	.105	.155	.150
5	.100"-.200"	.130	.150	.130	.135	.140	.130
6	" "	.120	.145	.145	.130	.125	.140
7	.500"-.700"	.450	.500	.500	.550	.525	.525
8	" "	.550	.500	.500	.500	.475	.525
9	.500"-.700"	.475	.450	.475	.475	.500	.475
10	" "	.475	.450	.450	.475	.500	.475
11	.400"-.600"	.400	.300	.375	.475	.600	.400
12	" "	.475	.400	.550	.550	.500	.600
13	.500"-.700"	.550	.450	.500	.475	.500	.500
14	" "	.475	.425	.475	.450	.550	.500
15	.600"-.800"	.600	.800	.775	.700	.675	.750
16	" "	.600	.800	.775	.700	.675	.700
17	.700"-.900"	.650	.550	.700	.800	.700	.700
18	" "	.575	.550	.500	.650	.725	.700
19	.700"-.900"	.700	.800	.775	.650	.750	.750
20	" "	.650	.800	.775	.650	.700	.775
Upper Size Determination	Cut Edges	Fits Size 10 Last		Fits Size 9 Last		Fits Size 8 Last	
Outsole Section							
1 Heel	a) 1.75"-1.85"	1.75	1.85	1.75	1.72	1.80	1.75
	b) " "	1.75	1.80	1.75	1.70	1.80	1.75
2 Ball	a) 1.00"-1.10"	1.10	1.05	1.05	1.05	1.10	1.05
	b) " "	1.10	1.05	1.06	1.05	1.05	1.06
3 Arch	a) .75"-.85"	.85	.80	.775	.825	.85	.80
	b) " "	.85	.80	.80	.80	.85	.80
4 Cleats	a) .20"-.30"	.25	.25	.25	.25	.25	.25
	b) " "	.25	.26	.26	.25	.25	.25
Outsole Size Determination	Conforms to Last Bottom	Fits Size 10 Last		Fits Size 9 Last		Fits Size 8 Last	

Note: Dimensions are in Inches

TABLE VII

BOOT WEIGHT COMPOSITION

Serial No.	1		1		1		2	
Size	10L	10R	9L	9R	8L	8R	10L	10R
Weight (as coated) Grams	686	737	766	806	731	702	743	660
Weight of Collar Grams	38	40	38	38	37	36	37	36
Weight of Lace Grams	4	4	4	4	4	4	4	4
Weight (Molded) Grams	570	621	600	662	585	560	625	557
Weight of Coating Grams	116	116	166	144	146	142	118	123
Weight of Sockliningy Grams	20*	20*	73	73	69	69	20*	20*
Weight of Outsole & Upper Grams	550	601	527	599	516	491	605	537
Weight (Final) Ozs.	25.8	27.6	28.1	29.7	27.3	26.3	27.7	25.5
Grams	628	781	708	346	772	742	784	720

*Lightweight sock

B. Subsequent Production

Table VIII presents physical test data obtained on typical boots from Phase II production. The contract specified two pair each size (total six pair) to be tested during period of production, and these were used to develop this data.

In general, the results showed conformance to requirements with some exceptions. Compression deflection in the outsole differs from the earlier data because composition (density) was modified. Likewise, cutgrowth resistance was not up to expectations in aged tests.

At this point, there is some doubt that a good reproducible or meaningful flex test exists for polyurethane outsoles.

Hardness data showed conformance to specifications.

It was significant that water absorption values on the upper were within specifications, considering reduction in density of this foam. The outsole figures were good.

Actual wear tests were also conducted on boots representing lots to be shipped. Initial results showed that the outerskin had a tendency to crack. Deficiencies were investigated, and after exhaustive review, it was concluded that the electrostatic coating system gradually deteriorated as spraying progressed.

Physical tests conducted on our preproduction and initial production films showed good results but mechanical problems and feed flow plugging led to off-ratios on curing agent - prepolymer combinations, resulting in premature skin cracking.

The first designated shipment was throughly scrutinized and the boots held back because of questionable wear potential. After correcting the problem, boots from new lots were wear tested and found to show exceptional resistance to skin cracking and abrasion and these were shipped. There was no outsole cracking or chunking on any boots represented by any of the shipments.

Table IX showed that wear was poor until test No. 6 and 7, when high mileages were accumulated. After corrections of the spraying problems, sample films obtained from sprayed plates coated at the same time were tested and these met the guideline requirements as outlined in the contract. It should be noted however, that the mileages showed lower values as wear tests progressed (No. 8, 9, 10). This could possibly have been caused by the gradual reduction in seasonal temperatures. Testing was started in July and continued into very late fall including walking on snow.

TABLE VIII

PHYSICAL PROPERTIES OF BOOTS

Physical Property	Test Method	Outsole			Upper Foam		
		Spec.	Actual Test 1	Actual Test 2	Spec.	Actual Test 1	Actual Test 2
Color		Black	Black	Black	Black	Black	Black
Density	ASTM D2406-65T Prs. 62-67	25 Min. 30 Max.	27.6	29.4	10 Min. 15 Max.	9.8	9.7
Compression Deflection @25% At Room Temp. (PSI)	ASTM D1056-67T Prs. 17-20	35 Max.	52.5	53.5	6 Max.	2.5	2.5
At $-20^{\circ}F$ (Increase from Original)		30% Max.	+6.3	-3.2	50% Max.	+48	+24
Compression Set At 50% Deflection at	ASTM D1056-67T Prs. 21, 22 and 23						
Room Temp. - %		15 Max.	4.3	4.6	10 Max.	7.8	7.5
At $158^{\circ}F$		60 Max.	9.5	8.2	70 Max.	79.4	69.9
Cutgrowth 50,000 Flexes	ASTM D1052-55						
Original %		200%	65	95	-		
After 70 Hrs. @ $212^{\circ}F$-%	ASTM D573-67T	200%	10	440			
Gehman Test T_{10}	ASTM D1053-65 (ex. Prs. 8 & 9)	$-65^{\circ}F$	$-80^{\circ}F$	$-78^{\circ}F$	-		
Water Absorption % 6" Head 48 Hrs. at R. T.	Fed. Std. 601 Method 12411	8 Max.	1.5	4.1	50 Max.	22.6	27.8

TABLE VIII (Continued)

PHYSICAL PROPERTIES OF BOOTS

Physical Property	Test Method	Outsole Spec.	Outsole Actual Test 1	Outsole Actual Test 2	Upper Foam Spec.	Upper Foam Actual Test 1	Upper Foam Actual Test 2
Hardness Shore A Original	ASTM D2240-64T	45-65	63	65	-		
Hardness After 70 Hrs. @ 212°F Change from Original	ASTM D573-67T	10 pts. Max.	-1	-3			
Hardness -20°F Change from Original		15 pts. Max.	+5	+7	-		

Note: Phase II Production

TABLE VIII (Continued)

PHYSICAL PROPERTIES OF BOOTS

Physical Property	Test Method	Outerskin Spec.	Outerskin Actual
Color	-	Black	Black
Tensile Strength (PSI)	ASTM D412-66	2700 Min.	3910
Ultimate Elongation (%)	ASTM D412-66	500 Min.	650
Gehman Test T_{10}	ASTM D1053-65 (except prs. 8 & 9)	$-65^{o}F$	$-75^{o}F$
Tear Resistance Die C (PPI)	ASTM D624-54	250 Min.	363

Note: Phase II Production

TABLE IX

BOOT FORCED WEAR TESTS

Test No.	Code	Size	I.D./Lot	Mileage	Comments
1	328A	10L	6-8	9.8 Miles	Start of Skin Crack
	328A	10R	6-8	28 Miles	Stopped Test
2	328B	9L	72-2	143 Miles	Skin Cracked
	328B	9R	72-2	143 Miles	Stopped Test
3	328C	9L	Ex-49	39 Miles	B-605 Skin OK(Dropped Test)
	328C	9R	Ex-49	39 Miles	L-42 Skin OK(Experimental)
4	328D	9L	6-5	38 Miles	Skin Cracked
	328D	9R	72-9	38 Miles	Stopped Test
5	328E	8L	72-14	14 Miles	Skin Cracked
	328E	8R	6-13	14 Miles	Stopped Test
6	328F	8L	7-1	369 Miles	Skin Cracked
	328F	8F	7-1	369 Miles	Stopped Test
7	328G	10L	C-1	405 Miles	O.K.-(Stopped Test)
	328G	10R	6-16-A	405 Miles	*O.K.-(No Skin Cracks)
8	328H	9L	7-10-A	274 Miles	Start of Skin Crack
	328H	9R	7-17-A	274 Miles	Stopped Test
9	328I	8L	8-18	250 Miles	Soft Upper - Heel Skin Crack
	328I	8R	8-13	316 Miles	Firm Upper - Toe Skin Crack
10	328J	9L	9-17	194 Miles	Skin Crack at Repair- Skin Buffed off sole
	328J	9R	9-8	242 Miles	O.K.-Skin on sole buffed

*Skin Puncture - Chain Link Fence

Boots were cross-mated to determine effect of variables, i.e. boot upper densities (firm vs. soft) repairs, partial or complete outsole buff, etc. Of interest was test No. 9 which showed a 1/4" skin split at the heel after 250 miles but did not increase in size when worn up to 316 miles. On the other hand, the firm upper showed a 2" split on vamp after 316 miles, when test was stopped. Of further note was pair No. 10 coded 328J. These were deliberately included to determine the effect of skin wear on the outsole. Periodic inspections disclosed that there was a significant advantage of keeping partially buffed skin on the bottom versus complete removal of same. The boot without skin exhibited more wear but this could not be detected by weight loss. Both boots weighed within 1 gram of the original figure after this test period. There was absolutely no cleat chunking on any of the wear tests, but there was one incident of puncture. Of note also was the fact that there was no peeling of outerskin from buffed outsole edges or solvent washed uppers.

The forced wear tests were conducted on pavement (concrete, asphalt) around the perimeter of the UniRoyal plant. There were no areas of rough terrain, wooded or unprepared ground. This walking course is the standard used for commercial footwear testing at contractor's facility.

Table X was provided in order to show that the skin films representing Phase II boots passed physical test requirements. Obviously, these results were not a measure of skin durability as regards flex cracking, puncture resistance, etc. Likewise a sprayed foam panel was evaluated for machine flex crack resistance (Polyair flex tester) to determine possible skin-over upper foam characteristics, and perhaps evolve a more realistic test for predictions, but no cracking was observed after 25,000 cycles on this test. This again confirmed the opinion that there was no realistic flexing test applicable to polyurethane end product performance other than wear of the product itself.

C. Special Testing

The following data depicted checks made on finished boots to determine water pick-up when completely immersed for 16 hours.

Test No.	Size	Type	Weight Pick-Up%
1. (Preproduction)	8L	No Collar	3.8
	8R	No Collar	2.8
2. (Preproduction)	9L	No Collar	2.1
	9R	No Collar	1.1
3. (Production)	10R	No Collar	2.95
	10L	With Collar	6.4*
Requirements		No Collar	5.0 Max.

*It should be noted that eyelets permitted water to enter the collar, but most was drained out before weighing.

TABLE X

PHYSICAL PROPERTIES OF SKIN FILMS

No.	Spray Period	Tensile	Elongation	Tear
1	July	4755	635	375
2	August	4060	635	358
3	September	5085	650	387
4	September	5600	600	427
5	October	5100	670	430
6	November	4900	610	425
7	December	4600	610	310
Requirements		2700 Min.	500 Min.	250 Min.

Note:

Phase II - L-42 Compound

The test with the collar was primarily of incidental interest, but one could conclude that it did significantly effect weight increase of the boot and would be of interest to the military.

Tables XI-XII-XIII showed results obtained in a nondestructive analysis of boots produced during Phase II. This data could be considered as a typical cross-section of boot characteristics during the producing period. Of specific interest were the figures for outsole hardness values and the variation in weights of coating. No study was made of the effect of thickness on flex crack resistance of skin, but thickness would have a significant bearing on puncture resistance. The optimum skin thickness was not known, and suffice it to say, further work in this area would be recommended.

D. Boot Maintenance and Upkeep

There has not been any formal program developed for the purpose of establishing instruction for protection, cleaning and/or repair of polyurethane insulated boots. However, some observations and procedures have been noted on wear tested boots and these are offered below:

1. Soiled boots could be readily washed with soap and water while using a bristle scrubbing brush on the cleats.
2. When used cautiously and judiciously, THF (tetrahydrofuran) and/or Toluol could restore gloss by wiping outerskin only with a lintless cotton cloth dampened with the solvent.
3. Silicone spray could also impart gloss to a clean boot and provide a slip finish.
4. Boots should be stored as close as possible to their original shape, otherwise permanent set will adversely affect usefulness.
5. Exposure to hot plates, radiators, exhaust steam and other forms of high heat source or pressure would likewise produce deleterious effects on the foam structure and ultimate boot life.

IV. QUALITY CONTROL AND SHIPMENTS

Utilizing basic requirements for control, inspection and acceptance of product as delineated in the contract, steps were taken to implement these directives into workable documents. This was accomplished by developing the following procedures:

TABLE XI

BOOT DATA ON GROUP NO. 1

Size	8	9	10
Style	Collar	Collar	Collar
Type of Sock	Standard	Standard	Standard
No. of Boots	12 (6 Pair)	12 (6 Pair)	12 (6 Pair)
Duro A (Outsole-Av.)	65	67	67
Weight (Final)			
Grams (Av.)	696	738	743
Ozs. (Av.)	24.6	26.1	26.3
Weight of Collar Grams (Av.)	26	26	26
Weight of Lace Grams (Av.)	4	4	4
Weight (Molded) Grams (Av.)	580	623	620
Weight of Coating (1) Grams (Av.)	86	85	93
Weight of Sock (Sealed) Grams (Av.)	75	75	75
Weight of Outsole & Upper Grams (Av.)	505	548	545

(1) Loses approximately 10% Weight Due to Gradual Solvent Loss.

TABLE XII

BOOT DATA ON GROUP NO. 2

Size	8	9	10	8	9	10
Style	Collar	Collar	Collar	No Collar	No Collar	No Collar
Type Sock	Standard	Standard	Standard	Standard	Standard	Standard
No. of Boots	12 (6 Pr.)	12 (6 Pr.)	12 (6 Pr.)	24 (12 Pr.)	24 (12 Pr.)	24 (12 Pr.)
Duro A (Outsole - Av.)	59	55	59	59	61	60
Weight (Final) Grams (Av.)	745	772	770	714	745	765
Ozs. (Av.)	26.3	27.2	27.2	25.2	26.3	27
Weight of Collar Grams (Av.)	26	26	26	-	-	-
Weight of Lace Grams (Av.)	4	4	4	-	-	-
Weight (Molded)	594	622	624	600	635	653
Weight of Coating (1) Grams (Av.)	121	120	116	114	110	112
Weight of Sock (Sealed)	75	75	75	75	75	75
Weight of Outsole & Upper Grams (Av.)	519	547	549	525	560	578

(1) Loses Approximately 10% Weight Due to Gradual Solvent Loss.

TABLE XIII

BOOT DATA ON GROUP NO. 3

Size	8	9	10	8	9	10
Style	Collar	Collar	Collar	No Collar	No Collar	No Collar
Type of Sock	Standard	Standard	Standard	Standard	Standard	Standard
No. of Boots	24(12 Pr.)	24(12 Pr.)	24(12 Pr.)	24(12 Pr.)	24(12 Pr.)	24(12 Pr.)
Duro A (Outsole-Av.)	61	62	63	62	63	64
Weight (Final)						
Grams (Av.)	748	772	786	732	761	778
Oz. (Av.)	26.4	27.3	27.8	26.9	26.9	27.5
Weight of Collar Grams (Av.)	26	26	26	-	-	-
Weight of Lace Grams (Av.)	4	4	4	-	-	-
Weight (Molded) Grams (Av.)	594	621	635	607	638	665
Weight of Coating(1) Grams (Av.)	124	126	121	126	123	123
Weight of Sock (Sealed) Grams (Av.)	75	75	75	75	75	75
Weight of Outsole & Upper Grams (Av.)	519	546	560	532	553	580

(1) Loses Approximately 10% Weight due to Gradual Solvent Loss.

1. A Process Flow Chart
2. In Process Control Travel Card
3. Standard Quality Control Travel Card
4. Final Visual Inspection Form
5. Quality Assurance Data Form
6. Shipment Schedule Form

There was a 100% visual inspection of boots. Furthermore, each one received at least three inspections before shipment. The first after molding, the second after buffing and precoating, and the third after coating. A fourth inspection was conducted on collared boots.

This phase of our performance probably received more attention than any other after production commenced. There was a detailed review of quality levels and all areas of such control were tightened significantly.

Initially, there was a question of boot creasing in packaged boxes, but after some comprehensive testing at Naugatuck, boots were packed to rest on back side when stored upright in cases and this largely resolved the problem of fold and crease formation.

In order to establish the AQL (Acceptance Quality Level), all boots sent to Natick were reinspected, documented, categorized and the information used to upgrade our Standard Quality Control Procedure. Further to this, new safeguards were adopted in the form of final visual inspection, both detailed and comprehesive. Additionally, many boots were checked and go-no-go samples established to determine acceptable visual quality. Finally, the Quality Assurance Group over-inspected ready to go shipments before sealing cartons. This control of quality eliminated the problems experienced on early deliveries.

Additional controls were instituted on each pair of boots by means of serial number, which could be traced back to lots and date of manufacture as documented in the Travel Cards. Included, was the weight of each boot (in ounces) branded indelibly on the instep outsole.

All documents and forms used in the fabrication operations are attached to this report, and constitute a total package which includes detailed procedures for material preparations and equipment operations. These are:

1. Preparation of curing agent compound
2. Preparation of Nitrosan dispersion
3. Preparation of outerskin compound
4. Procedure for casting boots on Viking-Chase Machine
5. Procedure for electrostatic coating

V. CONCLUSIONS

1. Production of lightweight insulated polyurethane footwear by the casting process was possible on a repetitive basis.
2. Application of an outerskin by electrostatic coating method was a prime processing development of the project.
3. Adhesion of outerskin to total boot was markedly improved by buffing outsole surface edge and solvent washing boot prior to spraying.
4. Nitrosan surface bloom was essentially eliminated by raising post curing time and temperature from 180°F to 250°F.

APPENDIX A

LIST OF MATERIALS

MATERIAL (Trade Name)	CHEMICAL NAME	SOURCE
Adiprene L-42	Polyether, Urethane Prepolymer	E. I. DuPont DeNemours, Inc.
3041 Black	Furnace Black dispersed in DOP	Inmont Corp.
mPDA	Meta Phenylene Diamine	E. I. DuPont DeNemours, Inc.
Nitrosan	N,N'-Dinitroso-N,N'-Dimethyl Terephthalamide	E. I. DuPont DeNemours, Inc.
SF-1079	Silicone Surfactant	General Electric Co.
SF-69	Silicone Surfactant	General Electric Co.
Santicizer S-140	Cresyl Diphenyl Phosphate	Monsanto Chemical Co.
THF	Tetrahydrofuran	Quaker Chemical Co.
Toluene	Toluene	AMSCO, Div. of Union Oil Co.
Vibrathane B-602	Polyether, Urethane Prepolymer	UniRoyal Chemical Div.
Vibrathane B-605	Polyether, Urethane Prepolymer	UniRoyal Chemical Div.
Cyclohexanone	Cyclohexanone	Phillips Bros., Holbrook, Mass.
FOA-2 (Fuel Oil Additive #2)	50% Organic Compound Copolymer in Kerosine	E. I. DuPont DeNemours, Inc.

FABRICS	DESCRIPTION	SOURCE
300 Cotton Net	Single Thread Ribbed net - 3.6 oz./sq. yd.	UniRoyal Inc., Mishawaka, Ind.
1828 Nylon Tricot Net	Two Bar Jersey Tricot Net - 2.7 oz./sq. yd.	Gehring Textile Co.

APPENDIX B

PROCEDURES, COMPOUNDS

AND

CONTROL DATA

PREPARATION OF NITROSAN DISPERSION

This procedure delineates the operations to be followed for the preparation of Nitrosan dispersion as used for polyurethane microcellular compositions viz. U. S. Army - LIF boots.

I. Materials and Equipment

1. Scale (Sauter metric or equal)
2. Hobart mixer (model N-50, H.P. 1/6) (Size - 1 gal.)
3. Tri-Homo Disperser Homogenizer (type-Champion) (Size 2½) (variable speed motor - explosion proof - watercooled)
4. Basic Nitrosan compound (See below)
5. Methylene Chloride solvent
6. Supply cans with handles (1 gal. with vented cover)
7. Polyethylene bags, cover film
8. Spatula, strainer, handy wipes (paper towels) etc.
9. Safety gear - (goggles and/or shield) (lab. coat) (eye wash, etc.)
10. Safety area (remote tin shed - explosion proof design)
11. Refrigerator (dispersion storage)

II. Compound - Weighing and Mixing

1. Recipe:

Nitrosan	1000	grams
Santicizer S-140	2000	"
Fuel Oil Additive #2	5	"
Black #3041 Disp.	300	"

2. Mixing Procedure (Hobart)

a. Weigh Nitrosan separately and carefully into a polyethylene bag.
b. Weigh the liquid ingredients (except fuel oil additive) in the stainless steel Hobart mixing bowl.
c. Add the Nitrosan to the liquid slowly, using spatula for incorporation.
d. Place mixing bowl on Hobart mixer, turn speed to one (1) and start mixing.
e. After 10 minutes of blending on Hobart, add the fuel oil additive #2 (weighed separately in a paper cup).
f. Mix an additional 10 minutes.
g. Transfer to 1 gallon can (vented top) or feed directly to homogenizer if machines are in same area.

3. <u>Dispersing Procedure</u>

a. Start cooling water through homogenizer at least 15 minutes before using machine.
b. Turn on Tri-Homo machine.
c. Set motor at 3 RPM (setting on Tri-Homo).
d. Set head impeller at six (6).
e. Run a small amount of Nitrosan by head into discard can to check flow.
f. Place clean 1 gallon can under head at material discharge nozzle.
g. Pour 1/3 of the Nitrosan blend mixture into the funnel above head, and observe operation to assure proper conditions (no smoke, odor grinding noises, etc.).
   Note: Check for heat build up in the filling can and stir fresh dispersion gently with spatula.
h. Complete addition of rest of the Nitrosan mixture through the homogenizer.
i. When finished, cover can with vented cover. Set aside into polyethylene bag.
j. Clean up machine and utensils by pouring small amounts of methylene chloride through system into discard can and wipe equipment with paper towel.
k. Turn off homogenizer.
l. Place polyethylene cover film over machine, (funnel head, etc.) to keep clean.
m. Turn off water cooling system.
n. Clean area. Dispose of Nitrosan contaminated items.

4. <u>Storage and Handling</u>

a. Nitrosan prespersion is stored in refrigerator to assure optimum strength. Store at 45°F ± 10°F.
b. Carry or transfer Nitrosan containers in polyethylene bags to keep dry and hold level but close to ground. Be sure covers are vented, and cans have handles.
   Note: Never put warm or smoking Nitrosan into refrigerator. Cool off to room temperature before storing.
c. When using cold stored Nitrosan dispersion, stir well with spatula and pass thru a household sieve strainer (20 mesh approximate) before use.

5. <u>Safety</u>

It is important that each operator working with Nitrosan read the DuPont brochure on the material and be apprised of the dangers involved in handling this blowing agent. (See Pilot Plant materials notebook).

5. <u>Safety</u> (Continued)

When running Nitrosan through any equipment, be prepared for localized heat build up, possible smoking or unusual odor emanating from the mixture. Back away and evacuate area. Be prepared to use CO_2 extinguisher to cool off or water to put out fire if it develops. Explosion is possible, therefore area at homogenizer must have automatic fire control system.

Note: Do not inhale Nitrosan smoke. It is dangerous and toxic.

PREPARATION OF CURING AGENT COMPOUND

This procedure outlines the operations to be followed for the preparation of mPDA (meta phenylene diamine) composition as used in the lightweight boot polyurethane formulations. (Component of boot casting system)

I. Materials and Equipment

1. Scale (Sauter metric or equal)
2. Hot plate (temperature 800°F high)
3. Supply cans with handles i.e. 1 gal.
4. Spatula, Handy Wipes (paper towels), gloves, etc.
5. Safety gear - (glasses, goggles or shield) (lab coat) (eye wash, etc.)
6. Safety area - exhaust hood
7. Cleaning solvent - methylene chloride
8. Basic compounds (see below)

II. Compound - Weighing and Mixing

1. Recipe:

	Batch		100 Parts (Wt.)
mPDA	600	grams	20
Santicizer S-140	2250	"	75
Silicone Fluid SF-1079	150	"	5
TOTAL	3000	grams	100

2. Mixing Procedure (Manual)

a. Weigh mPDA into 1 gallon can.
b. Weigh silicone fluid separately and add to mPDA. Stir in with spatula.
c. Heat on hot plate (high 800°F) until the mPDA liquifies (approximately 10 minutes) and stir with spatula.
d. Weigh Santicizer S-140 separately and add to the liquified mixture. (Remove from hot plate) Stir with spatula.
e. Place back on hot plate for approximately 5 minutes. Stir with spatula.
   Note: Do not leave mixture on hot plate unattended. Excessive heating will decompose material.
f. Keep compound at 150°F until ready for use. Use up within 24 hours.

III. Safety

1. mPDA is a dangerous and powerful chemical which combines with organic matter causing discoloration (yellowing) i.e. skin.

2. Contents must be kept in closed containers in ventilated and/or hood exhausted areas.

3. Do not inhale fumes which are poisonous to human body.

PREPARATION OF OUTERSKIN COMPOUNDS

This procedure outlines the operations to be followed for the preparation of polyurethane compounds used in electrostatic coating of lightweight polyurethane footwear. This is a two component system emerging as one in final spray.

I. Materials and Equipment

1. Scale (Sauter metric or equal)
2. Supply cans - 1 gal., 5 gal.
3. Spatula, Handy Wipes (paper towels), gloves, safety glasses, lab. coats, etc.
4. Air stirrer (Lightnin Mixer)
5. Viscosimeter (Zahn #2 and #5)
6. Stop watch, thermometer, test plates
7. Oven (to liquify prepolymer)
8. Basic compounds (see below)
9. Nitrogen gas

II. Compounds - Weighing and Mixing

1. Recipes:

Component A (Prepolymer)

	Batch	100 Parts (wt.)
Adiprene L-42	2000 grams	66.7
THF (Tetrahydrofuran)	500 "	16.7
Cyclohexanone	500 "	16.6
TOTAL	3000 grams	100.0

a. Weigh out ingredients in order noted by additive method into 1 gal. can.

Note: Adiprene L-42 must be liquified by overnight heating in oven at 150°F, allow to cool before mixing with solvents.

b. Stir materials on air stirrer until well dispersed and homogeneous.

c. Check viscosity using Zahn #5 viscosimeter. Record temperature. Spec. - 17 ± 2 sec. @ R.T.

Note: If temperature is over 90°F, allow to cool and recheck viscosity. Keep covered.

d. Component A must not be made sooner than 24 hours before use. Moisture effects prepolymer and properties will change.

Note: Keep unused portions of Adiprene L-42 under a cover of nitrogen gas in well closed containers.

2. Component B (Curing Agent)

	Batch		100 Parts (Wt.)
mPDA (meta phenylene diamine)	205.2	grams	6.8
THF (Tetrahydrofuran)	780.0	"	26.0
Cyclohexanone	1650.0	"	55.0
Silicone Fluid (SF-69)	64.8	"	2.2
RHB #3041 Black Dispersion	300.0	"	10.0
TOTAL	3000.0		100.0

a. Weigh mPDA into 1 gal. can.
b. Add THF and cyclohexanone and stir mixture with spatula until mPDA is dissolved.
c. Weigh silicone fluid and black dispersion and add to above mixture. Stir until color is uniformly dispersed. (approximately 15 minutes)
d. Check viscosity using Zahn #2 viscosimeter. Record temperature and results on travel card. Specs. - 16.5 ± 1.0 sec. @ R.T.

3. Final Compound (Cast Film)

	Batch		100 Parts (Wt.)
Component A	150	grams	75
Component B	50	"	25
TOTAL	200	grams	100

Control Test

a. Weigh above amounts into paper cup by additive method in order shown.
b. Stir mixture quickly, and thoroughly with spatula.
c. Pour this final compound into well-type test plate evenly. Plate must be on level setting.
d. Allow to set until totally reacted. Either overnight at ambient temperature or 1 hour @ 150°F after initial solvent dissipation time of 1 to 2 hours at R.T.
e. Test film for physical properties to the following specifications:

Tensile strength (PSI)	2700 min.
Elongation %	500 min.
Tear Resistance (Graves) PPI	250
Gehman Test T_{10}	-65°F

Note: Components must be kept separate until final usage when mixed in the Ransburg electrocoating system. Pot life is approximately 5 minutes.

4. Safety

Observe care in handling these materials which are strong chemicals and solvents. Use with adequate ventilation and personal protection.

PROCEDURE FOR CASTING BOOTS ON VIKING-CHASE MACHINE

This procedure outlines the process utilized in fabrication of lightweight polyurethane boots under U. S. Army Contract DAAG-17-72C-0058 dated 3 November 1971. The operations are essentially covered by In Process Control Travel Card #2-272 (attached).

I. Materials and Equipment

1. Viking Chase mixing-metering machine Serial No. VEM-1664.
2. Compounds - 3 component formulation prepared and dispensed separately for ultimate final mixing in machine.
   a. Prepolymer - Vibrathane B-602
   b. Curing Agent - mPDA
   c. Blowing Agent - Nitrosan

   Note: For preparation of each component, refer to individual procedures for making same.
3. Flushing solvent - methylene chloride
4. Ovens (Grieve or equal) 400°F max. capacity.
5. Supply cans, Handy Wipes (paper towels) gloves, etc.
6. Viscosimeters (Zahn #2 and #5).
7. Stopwatch, thermometer.
8. Veedol #77 oil (heat exchanger medium)
9. Paper cups. tools, auxiliary supplies.
10. Tilting table.
11. Nitrogen gas.
12. Buffing machine.
13. Safety supplies, coats, glasses, etc.

II. Parameters for Viking Chase Operation

A. Machine Start-up

1. Plug in machine and set temperature controls for prepolymer and mPDA components at 100°C.
2. Turn on oil pumps for heat transfer medium in reservoir tanks.
3. Turn on circulating system when temperature reaches 75°C to heat all lines.
4. Nitrosan tank - oil circulating - room temperature control.

B. Machine Loading

1. Prepolymer tank - fill clean tank with 5 gals. of prepolymer and pressurize system with nitrogen to 10 PSI.
2. mPDA tank - fill clean tank with sufficient curing agent compound (1 gal.) for the period run (8 hours).
3. Nitrosan tank - fill clean tank with sufficient blowing agent compound (1 gal.) for a period run (8 hours)

Note: Pots and lines are usually full with compat[illegible] diluent or carrier (Santicizer S-140 or BC[illegible] (Butyl cellosolve acetate) and must be emptied via return line so as not to contaminate components. This requires 3 operators - 2 to fill and 1 to operate controls. Allow components to circulate 10-15 minutes before dispensing.

4. Check temperatures of each component at head level and record on Travel Card.

C. Dispense Check

1. Remove and clean the 3 feed orifices.
2. After reinserting, pressure balance each stream by turning hand screw in head system of machine until dispense pressure coincides with tank pressure gauge.
3. Tare weight three paper cups and hold under each orifice to check dispense rate. Set times for 8 second flow.
4. Check weight materials to determine ratio of components to each other. Optimum ratio for prepolymer to curing agent is 5.85 to 1 for the upper foam and a 5.5 to 1 for the outsole foam. Optimum ratio for prepolymer to blowing agent is 4.5 to 1 for the upper and 20 to 1 for the outsole.
5. When above is complete, insert impeller and close housing head.
6. Settings for outsole are as follows:

   a. mPDA 14.5
   b. Nitrosan (dial) 155
   c. Prepolymer (RPM) 40

   Dispense a 3 second shot into cup to check foam compositions. Density should be firm for outsole with a durometer reading of 35 min.
7. Settings for upper are as follows:

   a. mPDA 15.5
   b. Nitrosan (dial) 20
   c. Prepolymer (RPM) 40

7. Dispense a 3 second shot into cup to check foam rise and composition. Density should be uniform for upper with a durometer reading of 10 min. Cut cup through cross section vertically to check foam quality. Note: Machine head must be flushed with methylene chloride after each dispense mix. Record results on Travel Card.

III. Parameters for Mold Conditions

A. Preheat Ovens

1. Temperature for outsole casting requires oven controls at 150 ± 10°F.
2. Temperatures for shells and lasts require oven controls at 260 ± 10°F.

B. Last Socklining

1. Socklinings are prepared ahead and consist of a nylon tricot/rubber/cotton laminate.
2. Material is die cut, sewed as sock to fit last, and seams are sealed with a 20% Estane 5707 solution in THF (Tetrahydrofuran).
3. Lasts are donned with socklining and latter is taped down with pressure sensitive tape at upper extremity to keep taut.

C. Mold Rigging

1. Assemble each size mold complete with last and sock, outsole rings and shells into mold carrier rig to assure correct allignment.
2. Disassemble shells and outsole molds and place into respective ovens for correct temperature requirements. The last and mold rig for the basic molding assembly structure are also placed in oven (260°F).

IV. Casting Operation

1. Outsoles

a. When temperatures of mold assemblies reach optimum, prepare for pouring.

b. Set process conditions as follows:

1. mPDA	14.5
2. Nitrosan	155
3. Pump (RPM)	40

c. Set pour cycle timer as follows:

		Total
1. Size 8 (preshot/pour)	1/13	14
2. Size 9 (preshot/pour)	1/14	15
3. Size 10 (preshot/pour)	1/15	16 (time in seconds)

d. Dispense compound into outsole mold and place unit into mold rig. Assemble outsole rings and fit last into place. Lock all component fittings.

e. Place into oven and cure 20' @ 260°F.

IV. 2. Upper

a. After outsole curing, remove mold rigs, and prepare for pouring of upper. Remove rings, assemble shells.
b. Set process conditions as follows:

1.	mPDA	15.5
2.	Nitrosan	20
3.	Pump (RPM)	40

c. Set pour cycle times as follows:

		Total	
1.	Size 8 (preshot/pour) 2/8	10	(time in seconds)
2.	Size 9 (preshot/pour 2/9	11	" " "
3.	Size 10 (preshot/pour 2/10	12	" " "

d. When ready, dispense compound into upper shells thru pour hole. Tilt assembly to permit complete dispersal and fill of molds.
e. After foam reaches top, place entire rig into oven for cure 20' @ 260°F.
f. After cure, remove from oven, allow to cool to handling temperature and demold. This is done in the reverse manner.

Note: This completes the casting operation.

V. Boot Finishing

1. Trim flash from boot with scissors as closely as possible and identify by lot.
2. Post cure in oven 2 hours @ 250°F to fully crosslink compound and decompose spent Nitrosan crystals.
3. Allow to cool to room temperature.
4. Buff flashlines and outsole edge. The latter to improve adhesion of coating to hard skin outsole.
5. Store in clean bulk boxes neatly stacked to prevent creasing, crushing, and/or permanent set damage to upper foam.

VI. Securing Vichase Machine

1. Lower temperatures on prepolymer and mPDA tanks to 25°C.
2. Add new supply of prepolymer to tank and cap with nitrogen (10 PSI).
3. Allow mPDA to remain in tank for short layover period, (overnight), but discard next day when adding new supply.

Note: For extended non use, drain immediately and replace with Santicizer S-140 flushing agent.

4. Drain and remove Nitrosan dispersion and replace with Santicizer S-140 flushing agent.
5. Allow system to operate for approximately 30 minutes to assure complete circulation of contents.
6. Shut down machine.

VII. Safety

It is important that safety be uppermost in operators minds. Proper clothing (lab coats) safety glasses, insulating gloves, light gloves, proper tools, etc.

When filling and draining dangerous materials, flexible exhaust vent hose should be directed to area in order to remove dangerous amine and isocyanate fumes. Be sure all exhausting systems are in operation. Fire equipment, eye flushing solutions, blankets, extinguishers must be available for emergency use.

PROCEDURE FOR ELECTROSTATIC COATING

This outlines the process followed in coating lightweight polyurethane boots with a two component spray system utilizing the Ransburg Electrocoating Process.

I. Materials and Equipment

1. Basic Materials - Component A - Prepolymer
   Component B - Curing Agent

   Note: Refer to section covering preparation of the coating compositions.
2. Ransburg electrostatic system, including conveyor and oven drying capability (Parva Buckle Company, Mt. Carmel, Conn.).
3. Pump motor system assembly (standard motor 1450 RPM)
   a. Zenith B-4407 size 3 pump - prepolymer
   b. Zenith B-4407 Size 1 pump - curing agent
   c. Solvent flush - THF (tetrahydrofuran)
   d. Variable drive motor - pump assembly
4. Kenics control gun (Graco)
5. Boots and lasts of appropriate size
6. Pressure pots for solvent and spray components
7. Supply cans, spatula, Handy Wipes (paper towels), brushes, gloves, lab. coats, etc.
8. Spray plates, boot hangers, boxes, etc.

II. Preparation of Spray System

A. Supply and pump delivery
   1. Fill pressure pot with Component A (prepolymer) and pressurize to 30 PSI.
   2. Fill other supply pot with Component B (curing Agent) and pressurize as needed.
   3. Fill pressure pot with flush solvent (THF-tetrahydrofuran) and pressurize to 10 PSI.

   Note: Be sure all lines have been thoroughly preflushed with THF before filling pots with components.
   4. Set up the Kenics control gun to both component lines and tie in with one exit line to Ransburg disc well.
   5. Flush feed lines from pump to gun to disc with solvent to assure full flow.
   6. Start Component B (curing agent) pumping and wait until coming through on disc.
   7. Flush and switch to Component A (prepolymer) to pump through lines.
   8. Switch control gun to mix and allow to run a few minutes collecting sample material on well plate to form a cast film.
   9. Fill deep well of disc to 1/2" from top to keep "pot time" of mixed components to a minimum. Allow well to set. (approximately 20 min.).

10. Tie in all feed lines and systems to operating position.
11. Set up the vertical recipricating hydraulic motion of disc coating system to position of a sample boot on conveyor.
12. Adjust for dwell at lower boot portion to allow for more deposit of coating (approximately 2 sec.) in this critical area.
13. Set conveyor speed at approximately 3.5 ft./min.
14. Turn on oven to 250°F.

III. Spraying Operation

1. Load boots on lasts and hang on conveyor with sufficient clearance between boots to allow for good coverage.
2. Hang metallic (conductive) grids (3 to 4) in advance of boot flow thru booth. Repeat at end of run.
3. Turn on power to start spraying operation.
4. Each cycle of boots consists of 7 or 8 units allowing 1 space for a steel plate to build up a test film for subsequent physical testing.
5. Each group of boots is put through 3 times to assure sufficient coating build up. Adjust variable pump drive to obtain optimum coverage.

Note: Prior to the last pass, boot is brushed with solvent moistened paint brush to cover surface imperfections if any (pinholes, uneveness, etc.).

6. After 3 passes through spray booth, the boots are carried on conveyor for passage through drying oven to dissipate solvent fumes and dry the coating to allow handling.
7. Time in air (R.T.) prior to oven - approximately 15 minutes.
8. Time in oven - approximately 13 minutes @ 250°F.
9. Time out of oven before removing boots off lasts - approximately 15 minutes.
10. Allow boots to cool to room temperature before bulk packing.

Note: Exercise care in handling because coating is tender and subject to easy damage.

11. Repeat cycle of boots lasting and feed conveyor.
12. To shut down, reverse operation outlined in Part II.

IV. Safety

1. Extreme safety precautions must be exercised in operation of the high voltage electrostatic coating system. Dangers are inherent from electrical shock, overspray, solvents and mechanical power equipment. Laboratory coats, gloves, glasses should be worn to assure personal safety and nondamage of personal garments (clothes, shoes, etc.).

2. Maintenance of equipment in clean condition is mandatory because the two component system tends to clog and build up in lines and pumping system. It is imperative that Kenics control gun be dismantled and cleaned after each usage and the pumping system also periodically dismantled for thorough cleaning.

Cov't. Boot - Natick
Cont. DAAG 17-72C-0058

LIF-PILOT PLANT
IN-PROCESS CONTROL - CHECK-OFF SHEET

Date ____________
Lot No. ____________

I. Viking Chase

I. Viking Chase	Spec.	Actual
A. Prepolymer		
1. Oil Bath Temp.	100°±5°C	
2. Prepolymer Temp	212±10°F	
3. " Vis.(Z-5)	30±3	
B. Curing Agent		
1. Oil Bath Temp.	100°±5°C	
2. Cur.Agt.Temp.	212±10°F	
3. " " Vis(Z-2)	15±2	
C. Blowing Agent		
1. Oil Bath Temp.	105±5°F	
2. Blow.Agt.Temp.	90±10°F	
3. " "Vis(Z-5)	10± 2	
D. Dispense Check		
1. Tank A	Ok	
2. Tank B	Ok	
3. Tank C	Ok	
4. Flush	Ok	
E. Pre Shot Test (Cup)		
1. Expansion (3 sec.)	Out-1/3Cup	
	Up-1"over cup	
2. Color	Blk-Gray	
3. Density/Duro		
Outsole	35 min.	
Upper	10 min.	

OK________ Hold________ Oper.________

F. Process Comments

II. Mold Conditions

II. Mold Conditions	Spec.	Actual
A. Preheat Ovens		
1. Outsole Temp.	150±10F	
2. Last Temp.	260°±10F	
3. Exhausts	ON	
B. Outsole Molds		
1. Temp.	140±10	
C. Shell Molds		
1. Temp.	240±10	
2. Plug	Clean	
D. Last-Sock		
1. Socklining	Std.	
- do -	Hi Grade	
2. Sock Seal	100%	
3. Last Temp.	250±10	

OK________ Hold________ Oper.________

III. Process Conditions

III. Process Conditions		Spec.	Actual
A. Outsole			
1. MPDA set		14.5	
2. Nitrosan set		155	
3. Pump (RPM)		40	
4. Preshot/Pour	S8	1/13	
" "	S9	1/14	
" "	S10	1/15	
5. Cure Time		20'@260°F	
B. Upper			
1. MPDA set		15.5	
2. Nitrosan set		20	
3. Pump (RPM)		40	
4. Preshot/Pour	S8	2/8	
" "	S9	2/9	
" "	S10	2/10	
5. Cure Time		20'@260°F	

OK________ Hold________ Oper.________

IV. Boot Prep

IV. Boot Prep	Spec.	Actual
A. Post Cure	2hrs@250±10°F	
B. Trim (Top)	10 3/4"+½"	
C. Buff (sole/edge)(Emery Wheel) (flash/plug)	(2"x1")	

OK________ Oper.________

Hold________ Date________

V. Production Data

Pr#	Size	I.D.No.	OK	Rej.	Repair	Comment
1	8L					
	8R					
2	9L					
	9R					
3	10L					
	10R					
4	8L					
	8R					
5	9L					
	9R					
6	10L					
	10R					

	Of Date	No.ToDate	Tot.ToDate
Total Cast			
No. OK			
No. Repaired			
No. Scrapped			
Yield (%)			

Oper.________ Date________

Product Comments:

Rev. - 2-772
Style - US ARMY (NATICK)
Contract - DAAG-17-72C-0058

UNIROYAL, INC. - NAUGATUCK, CONN.
BOOT, BLACK, COLD WEATHER INSULATED
QUALITY ASSURANCE DATA

Date ____________
Lot No. ____________

VI. Inspection - Before Coating

No.	Size	I.D. No.	Duro 1	Duro 2	Duro 3	Wgt. Gms.	Sock OK	Sock Rej.	Outsole OK	Outsole Rej.	Upper OK	Upper Rej.	Comment
1	8L												S
2	8R												O
3	9L												L
4	9R												V
5	10L												E
6	10R												N
7	8L												T
8	8R												
9	9L												W
10	9R												A
11	10L												S
12	10R												H

Date ________ OK ________ HOLD ________ INSP. ________

After Coating

Coat Date	Wgt. Plain Gms.	Weight Final (Collar) Gms.	Weight Final (Collar) Ozs.	OK	Rej.	Rep.	Gov't. Ser. No.	Comment
	P							
	O							
	S							
	T							
	C							
	U							
	R							
	E							
	15'							
	@							
	250°F							

Insp. ________ Date ________

VII. Coating

	Spec.	Actual		Spec.	Actual
A. Prepolymer Vis.(Zahn 5)			D. Boots/Cycle		
B. Curing Agt. Vis.(Zahn 2)			E. No.Of Passes		
C. Pump Setting			F. Coat.Time (Total)		
			G. Usage(Pre.) Ratio(C.A.)		
			H. Comment		

Date ________ Oper. ________

X. Repairs

ID. ... Section Type Comment

OK ________ Rej. ________ Oper. ________ Date ________

VIII. Collar and Lace Attachment

Date ________ Oper. ________

XI. Packaging and Making

________ One pair/box - 6 boxes per carton
________ Box and carton markings (per MIL-SID-129)

OK ________ Rej. ________ Insp. ________ Date ________

IX. Final Visual Inspection - 100%

________ Irregularity imparing function, voids, depression, poorfill
________ Component parts missing, punctured or malformed
________ Excessive buffing of heel/outsole to remove runs or lumps
________ Loose sock lining or easy to peel off
________ Improperly attached closure
________ Boot markings, size, serial no. and weight

OK ________ Rej. ________ Insp. ________ Date ________

XII. Final Acceptance

These units conform to specification, drawings and contract requirements.

Date ________ Quality Assurance ________

STANDARD QUALITY CONTROL PROCEDURE

Commodity:	U. S. Army-LIF Boots	Naugatuck Plant No.	72-1
Contract No.	DAAG 17-72C-0058	Effective Date:	October 17, 1972
Issued by:		Making Obsolete	June 20, 1972
		Sheet 1 of 3 Sheets	

ACCEPTANCE STANDARDS - VISUAL EXAMINATION

	Major	Minor
I. FIRST INSPECTION - Cast Boot - 100%		
A. Socklining		
1. Missing, loose or torn	X	
2. Wrinkled or creased, but not folded		X
3. Depressions or ridges on insole	X	
4. Seams not glued	X	
5. Strike thru (glue or foam)		X
B. Outsole		
1. Cleats not formed	X	
2. Poor blow (irregular or none)	X	
3. Incomplete fill toe and heel	X	
4. Small voids 1/8"		X
C. Upper		
1. Short upper 10 1/2"	X	
2. Poor blow (irregular or none)	X	
3. Poor adhesion to outsole	X	
4. Voids or blisters 1/2"		X
5. Flashline groove (void)		X
6. Surface irregularities		X
D. Complete Boot		
1. Weight (665 gms. max.)	X	
II. PRECOATING INSPECTION - 100%		
A. Socklining		
1. Loose, torn or delaminated	X	
2. Inside bloom		X
3. Sharp or rough stitchline		X

STANDARD QUALITY CONTROL PROCEDURE

Commodity:	U. S. Army-LIF Boots	Naugatuck Plant No.	72-1
Contract No.	DAAG-17-72-C-0058	Effective Date	October 17, 1972
Issued by:		Making Obsolete:	June 20, 1972
		Sheet 2 of 3 Sheets	

ACCEPTANCE STANDARDS - VISUAL EXAMINATION (Continued)

II. PRE COATING INSPECTION (Continued)	Major	Minor
B. Outsole		
1. Not trimmed or buffed (edge)	X	
2. Excessive or gouged buff (unrepairable)	X	
3. Cuts, damage	X	
4. Buffing dust		X
5. Not clean		X
C. Upper		
1. Unbuffed flashline (inc. pour hole)	X	
2. Cuts, damage	X	
3. Not clean (solvent washed)		X
D. Repairs		
1. Missed or incomplete	X	
2. Workmanship	X	
III. FINAL INSPECTION - 100%		
A. Coating		
1. Uncoated or missed area	X	
2. Damaged or broken skin	X	
3. Pinholes or flecks (notthru skin)		X
4. Discernable mold lines and pour holes		X
5. Blisters, bubbles or depressions 7½"	X	
6. Smoothness of coating		X
7. Blushing and/or discoloration of skin	X	
8. Ridges, sags or drips on outsole (unbuffed)	X	
B. Closure (when specified)		
1. Improper attachment	X	
2. Torn or cut	X	
3. Missing laces or non functional	X	
4. Height 3" min.		X
5. Folds		X
6. Incorrect stitching		X

STANDARD QUALITY CONTROL PROCEDURE

Commodity:	U. S. Army-LIF Boots	Naugatuck Plant No.	72-1
Contract No.	DAAG 17-72-C-0058	Effective Date :	October 17, 1972
Issued By:		Making Obsolete:	June 20, 1972
		Sheet 3 of 3 sheets	

ACCEPTANCE STANDARDS - VISUAL EXAMINATION (Continued)

	Major	Minor
III. FINAL INSPECTION - (Continued)		
C. Marking		
1. Size missing	X	
2. Serial number missing	X	
3. Weight missing 28 oz. Max.	X	
4. Legibility		X
D. Complete Boot		
1. Creased or wrinkled	X	
2. Mishaped (damaged or compressed foam)	X	
3. Soft upper (foam density)	X	
4. Gauge of upper Wall		X
E. Packing and Shipping		
1. Incorrect packing	X	
2. Mixed sizes in box	X	
3. Mixed styles		X
4. Tissue and cardboard insert missing		X
5. Box label legibility		X
6. Correct count in box	X	
7. Incorrect address on shipping box	X	
8. Shipping container marking legibility		X
IV. OVER INSPECTION - MIL-STD-105		
A. Overall Boot		
1. Level II		
2. AQL - 2.5	X	
3. AQL - 6.5		X

UNIROYAL INCORPORATED, NAUGATUCK, CONNECTICUT

BOOT, BLACK, COLD WEATHER, INSULATED

QUALITY ASSURANCE DATA

FINAL VISUAL INSPECTION (COMPREHENSIVE)

Style-

US ARMY (NATICK)

Contract-DAAG-17-72C-0058

Shipment No. ____________

Pair No.	1	2	3	4	5	6
Serial No.						
Size	L R	L R	L R	L R	L R	L R
Lot. No.						
Irregularity impairing function, voids, depressions, poor fill						
Component parts missing, punctured or malformed						
Excessive buffing of heel/outsole to remove runs or lumps						
Loose sockl ining or easy to peel off						
Improperly attached closure						
Boot markings, size serial No. and weight						
Rating 1.........OK						
2.........Passable						
3.........Reject						

OK__________ Rej.__________ Inspect__________ Date__________

FINAL VISUAL INSPECTION - (DETAILED)

CONTRACT NO. DAAG-17-72C-0058

BOOT							COATING					SEAMS				OUTSOLE		SOCKLINING			CLOSURE		FINAL	
Pr No	Size	Ser No	Lot No	App	Foam Den	Cr	App	Pin Hole	Lump	Blister	Run	Ft	Back	Hole	Out Sole	App	Buff	App	Seam	Cr	App	Lace	Wt	Rate Val
1	L																							
	R																							
2	L																							
	R																							
3	L																							
	R																							
4	L																							
	R																							
5	L																							
	R																							
6	L																							
	R																							

Legend: OK..............1
Passable........2
Reject..........3

Date Inspected ____________

Shipment No. ____________

Inspector ____________

SHIPMENT SCHEDULE

Commodity: U. S. Army-LIF Boots

Naugatuck Plant: 72-1

Contract No. DAAG 17-72-C-0058

Effective Date: May 30, 1972

Issued by: ____________

Making Obsolete: New

Sheet ____ of ____ Sheets

Shipment No: Date:

Carton	Size	# Prs.	SOCK Std	SOCK Hy	COLLAR Yes	COLLAR No	SLIP SOLE Yes	SLIP SOLE No	INSP.-PACK Oper	INSP.-PACK Date
1	8									
2	9									
3	10									
4	8									
5	9									
6	10									
7	8									
8	9									
9	10									
10	8									
11	9									
12	10									
13	8									
14	9									
15	10									
TOTAL	8									
FOR	9									
SHIP.	10									
TOTAL	8									
TO	9									
DATE	10									

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