THE NEW NAVY FLIER'S FIRE-RESISTANT BLUE COVERALL

DEPARTMENT OF THE NAVY
SUPPLY SYSTEMS COMMAND

NAVY CLOTHING AND TEXTILE RESEARCH FACILITY
NATICK, MASSACHUSETTS

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The Navy Clothing & Textile Research Facility, at the request of the Naval Air Systems Command.has developed a flyer's blue aramid coverall. NAVAIR's objective was to develop a unique blue flight coverall to enhance morale and the retention levels of Naval aviators. NAVAIR requested the coverall be similar to the Air Force CWU-27/P coverall but have a pencil pocket flap and shoulder epaulets for attachment of the Navy's soft shoulder boards. The fabric used for the coverall is a 95/5 Nomex/Kevlar piece-dyed material. Off-the-shelf piece-dyed material was purchased and tested in the NCTRF laboratory

to the same criteria as the solution-dyed fabric used in the Air Force coverall. Although the fabric did not pass all tests, NCTRF felt that a purchase document could be written for an "off the shelf" fabric that meets the critical requirements. NCTRF then procured 500 new coveralls for NAVAIR and distributed these, as directed, to Navy, Air Force and Coast Guard installations. Twelve coveralls underwent fire pit testing at NADC. The fire pit testing showed that the coveralls did provide satisfactory protection for the conditions in which they would be used. (U)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

THE NEW NAVY FLYER'S FIRE-RESISTANT BLUE COVERALL

INTRODUCTION

The Navy Clothing and Textile Research Facility (NCTRF), at the request of the Naval Air Systems Command (NAVAIR), has developed a flyer's blue aramid coverall. NAVAIR's objective was to develop a unique blue flight coverall to enhance the morale and the retention levels of Navy aviators. NAVAIR requested the coverall be similar to the Air Force CWU-27P coverall (Flyer's Summer Fire-Resistant Coveralls, MIL-C-83141) in design but have a pencil pocket flap and shoulder epaulets for attachment of the Navy's soft shoulder boards. The fabric used for the coverall is a 95/5 Nomex/Kevlar piece-dyed material. Two thousand yards of "off the shelf" piece-dyed fabric were purchased and tested in the NCTRF laboratory to the same criteria as the solution-dyed fabric (Plain and Basket Weave Aramid Cloth, MIL-C-83429) used in the Air Force CWU-27/P coverall. Although the fabric did not pass all tests, NCTRF felt that a purchase document could be written for an "off the shelf" fabric that meets the critical requirements. NCTRF then procured 500 new blue coveralls for NAVAIR and distributed these, as directed, to Navy, Air Force, and Coast Guard installations. Twelve of the coveralls underwent fire pit testing at the Naval Air Development Center (NADC), Warminster, PA. The fire pit testing showed that the coveralls did provide satisfactory protection for the conditions in which they would be used. This report describes the fabric and the garment and discusses the laboratory and fire pit testing.

DESCRIPTION OF FABRIC

The fabric chosen for use in the new coverall was a 4.3 oz/yd^2, 95/5 Nomex/Kevlar blend, plain weave material that was piece dyed to Navy Color No. Blue 3374. This fabric had already been selected by a joint effort of NAVAIR and NADC (1). The task of NCTRF was to refine this fabric so that it would conform to the coverall requirements but still be considered an "off the shelf" fabric.

To construct the 500 coveralls, NCTRF procured 2,000 yards of this material, which were delivered as 19 rolls of fabric. A 1-yard length from each roll was taken for test purposes.

LABORATORY TEST PROCEDURES AND RESULTS

Since this was a new fabric, no test criteria had been established. Initial testing was based on the criteria established for the solution-dyed fabric used in the Air Force CWU-27/P coverall. Table I lists the various test methods and results for the fabric.

(1) Fabric requirement supplied by NAVAIR Speedletter, dated 6 May 1982.

TABLE I. INITIAL TEST PROCEDURES AND RESULTS

Characteristics	Test Methods*	Results	Air Force Requirements
1. Width	5020	62-7/16 inches	45 inches
2. Yarns/Inch	5050	Warp: 64 Filling: 41	Warp: 70 Filling: 47
3. Air Permeability	5450	208 $ft^3/min/ft^2$	25 $ft^3/min/ft^2$
4. Weight	5041	4.3 oz/yd^2	4.3 $oz./yd^2$
5. Colorfastness to Light	5660	Poor	Equal to std sample
6. Seam Efficiency	5110	100%	80%
7. Shrinkage	5556	Warp: 2.8% Filling: 1.4%	Warp: 4.0% maximum Filling: 1.5% maximum
8. Breaking Strength	5100	Warp: 152 lbs Filling: 113 lbs	Warp: 180 lbs minimum Filling: 100 lbs minimum
9. Nonfibrous Content	2611	3.1%	1.0% maximum
10. Tearing Strength	5132	Warp: 10.1 lbs Filling: 6.9 lbs	12 lbs minimum 8 lbs minimum
11. Acidity (pH)	2811	4.5	5 - 8
12. Colorfastness to Laundering	5610	Sample - Good Transfer Cloth - Good	Equal to std sample

TABLE I. INITIAL TEST PROCEDURES AND RESULTS (CONT'D)

Characteristics	Test Methods*	Results	Air Force Requirements
13. Electrical Resistivity	Initial - 5930 After Five Mobile Launderings 5556 & 5930	Side A - 4.1×10^{16} ohms Side B - 4.1×10^{16} ohms After Laundering Side A - 5.3×10^{16} ohms Side B - 4.1×10^{16} ohms	3.0×10^{11} ohms 8.0×10^{11} ohms
14. Flame Resistance	Initial - 5903 After Weathering (40 hrs.) - 5804 & 5903	See Appendix A	Flame time, 2 seconds Glow time, 25 seconds Char length, 3.5 inches
15. Weave	Visual	Plain weave	Plain weave
16. Yarn Ply	Visual	2 - ply warp & filling	2 - ply warp & filling
17. Staple Length	Visual	1-1/2 to 2-inch staple length	1-1/2 to 2-inch staple length
18. Curling	MIL-C-83429	Warp; No curling Filling: No curling	Warp: No curling Filling: No curling

*The test methods used to measure fabric characteristics 1 through 14 are contained in Federal Test Methods Standard 191A.

DISCUSSION OF LABORATORY TEST RESULTS

The following is an explanation of the test areas where the new fabric failed to pass the test criteria for the Air Force fabric.

Test #2 - Yarns/Inch - In this test, both warp and filling yarns tested out as 6 less than the Air Force standard fabric. NCTRF feels that this is not detrimental to the fabric as long as the minimum weight per square yard is achieved.

Test #5 - Colorfastness to Light - In this test, the sample was rated as "poor," whereas the minimum Air Force requirement was "good." Since this fabric is a piece-dyed material and not solution dyed like the Air Force fabric, we expected that it would have poorer lightfastness. When piece-dyed fabrics are used, the poor fastness to light is a condition that must be accepted.

Test #11 - Acidity - Although the test sample failed to meet the minimum pH of 5, it is felt that 4.5 pH is not detrimental to the end use of the fabric.

Test #13 - Electrical Resistivity - In this test, the sample failed both initial and after-laundering electrical resistivity. In the case of electrical resistivity, NCTRF believes that the Air Force specification requirement should be maintained. The Air Force requirement for resistivity before laundering is a maximum of 3.0×10^{11} ohms; after five launderings, the maximum is 8.0×10^{11} ohms. A fabric manufacturer can easily treat his fabric with a durable anti-static finish to comply with this requirement.

Test #14 - Flame Resistance - A total of 19 samples were tested in both the warp and filling direction for flame resistance before and after weathering. In the before-weathering test, 12 of the 38 samples tested failed the char length by an average of 5%. Since this was a critical area for a fabric intended for use in flyer's coveralls, NCTRF felt that this criterion,that is, a maximum char length of 3.5 inches must be maintained. A fabric manufacturer can meet this minimum requirement when the fabric is dyed and finished properly.

Since this coverall fabric is piece dyed, the problem is that the piece dyeing process uses a flammable dye carrier. If the dye carrier is not fully washed out when this coverall fabric is dyed and finished, the dye carrier would contribute to the fabric's being flammable. Because the dye carrier used in the dyeing process is odoriferous by nature, one of the ways to guard against procuring flammable fabrics would be to eliminate fabrics with an odor. Therefore, the purchase document covering this fabric states that the fabric would be defective if it has "any odor caused by the dyeing process." Table II lists the physical requirements for the flyer's-blue-coverall fabric, which NCTRF established after evaluating our laboratory tests using the Air Force requirements.

TABLE II. PHYSICAL REQUIREMENTS FOR THE FLYER'S BLUE COVERALL FABRIC

CHARACTERISTICS	REQUIREMENTS
Width (inches minimum)	62
Yarns/Inch	
Warp	64
Filling	40
Air Permeability (cu. ft/min/ft^2)	
Minimum	130
Maximum	190
Colorfastness to Light	Equal to or better than standard sample
Seam Efficiency (minimum)	80%
Shrinkage	
Warp (maximum)	4%
Filling (maximum)	2%
Breaking Strength (lbs. minimum)	
Warp	140
Filling	100
Nonfibrous Content (minimum)	4%
Tearing Strength (lbs. minimum)	
Warp	9
Filling	5.5
Acidity (pH)	
No less than	4.5
No greater than	8.0
Colorfastness to Laundering	Equal to or better than standard sample
Electrical Resistivity (ohms maximum)	
Initial	3.0×10^{11}
After 5 launderings	8.0×10^{11}
Flame Resistance	
Flame time (seconds maximum)	2
Glow time (seconds maximum)	8
Char length (inches maximum)	3.5
Weave	Plain
Yarn Ply	2 ply
Staple Length (inches)	1-1/2 to 2
Curling	No curling

DESIGN OF COVERALL

The blue coverall design shown in Figure 1 is the same as that of the Air Force CWU-27/P coverall, except that a flap was added to the left arm pencil pocket (see Figures 2 & 3) as an improvement. When the pencil pocket flap was designed, consideration had to be given to the end use of the garment. Because the coverall is to be used by air crew personnel, a looping type of flap had to be avoided since this would catch on critical areas of the aircraft. Therefore, the flap was designed with two hook and pile fasteners, thus keeping it as near to the wearer's body as possible but still allowing for ease in using the pencil pocket.

Shoulder epaulets, added to accommodate the Navy's soft shoulder boards, are shown in Figure 4.

CONSTRUCTION OF COVERALL

Once NCTRF decided upon the design of the coverall, we developed a set of Navy patterns with a size range of 32 short through 48 long. Five hundred coveralls were then manufactured commercially for testing the patterns with the new material, for fire pit testing, and for service evaluation at various military facilities.

As directed by NAVAIR, about 200 coveralls were distributed to various activities of the Coast Guard, Air Force and Navy for service evaluation. Because information from this distribution was to be forwarded directly to NAVAIR (Code 5311D), no information regarding this evaluation was yet available for inclusion in this report.

FIRE PIT TESTING - PROCEDURE

Twelve garments were tested for protection against fire at the NADC fuel fire test facility. A manikin dressed in the coverall was carried through the flames on a rotary crane with a 2-second traverse over the fire pit. The fire pit measured 20 feet x 30 feet x 8 inches deep. It was filled with water to just below the height of a grid of aluminum angle that divided the surface into 20 cells. Each cell had a fuel nozzle through which fuel was pumped. The procedure was that JP-4 fuel was pumped underground from a holding tank, it rose to the surface, and spread in the cells. About 20 seconds later, it was ignited and the flames were allowed to reach maximum height and temperature when the manikin was sent over the fire pit. The operation was controlled from behind a concrete block wall so that the passage through the flames could not be seen by the operators.

The manikins were dressed in summer underwear, shorts and T-shirts, and the test coverall. The manikin surface was provided with 26 sensor sites, each containing seven sensor strips by which the temperature was measured. These strips were fabricated to change colors at the temperature printed on its face. The temperatures were 220, 230, 240, 250, 260, 270 and 280 degrees F, and the sensor strips were mounted on leather patches that were placed at

(Text continued on page 11.)

Figure 1. Navy Flyer's Fire-Resistant Blue Coverall.

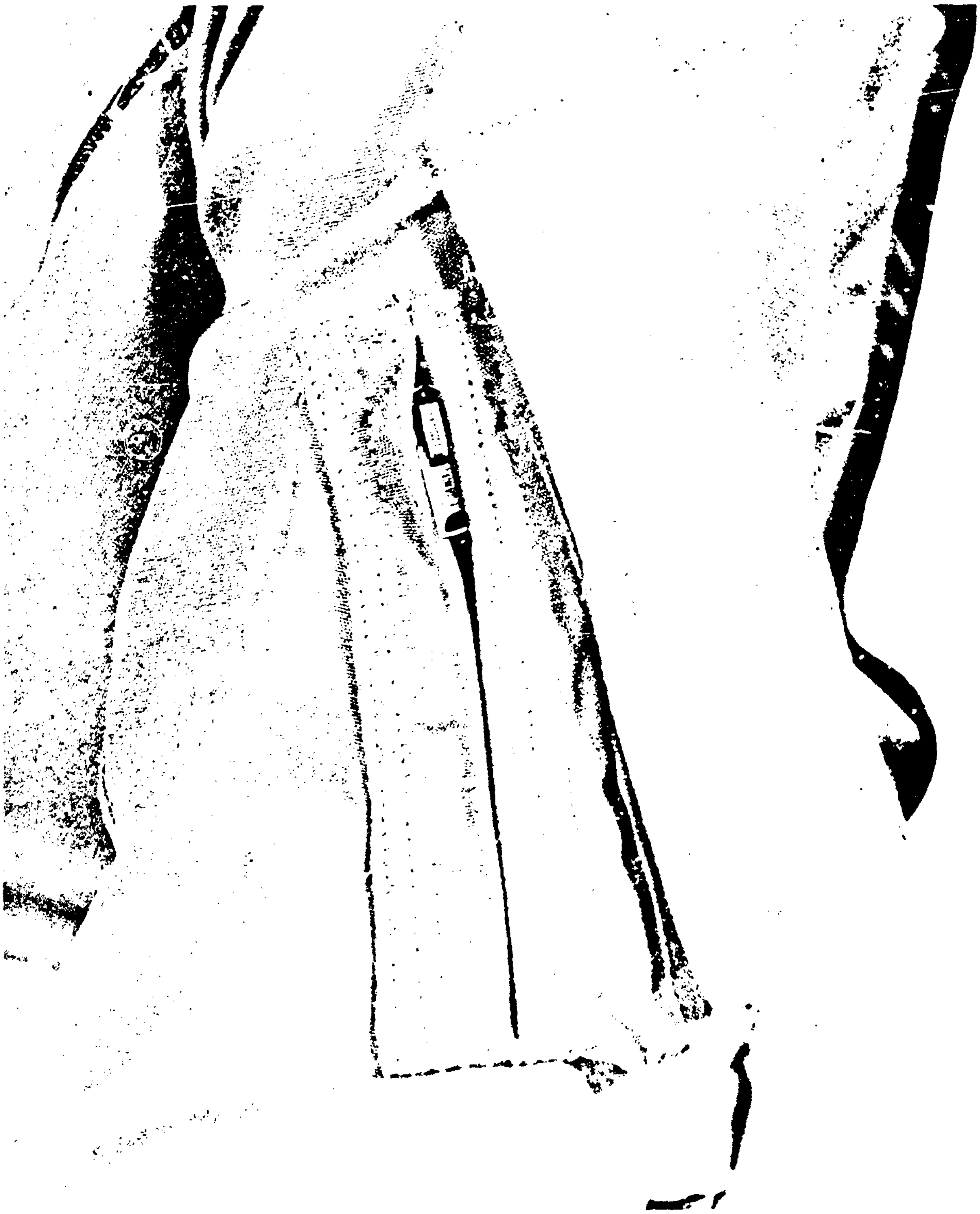

Figure 2. Pencil Pocket with Flap Closed.

Figure 3. Pencil Pocket with Flap Open.

Figure 4. Shoulder Epaulets.

the 26 sites. Ten sites were distributed on the torso, eight on the arms, and eight on the legs--a distribution that covered 81% of the total body surface (see Table III).

TABLE III. LOCATION OF SENSORS

1.	Upper Torso Front, left breast
2.	Upper Torso Back
3.	Upper Torso Front, right breast
4.	Upper Torso Back
5.	Upper Torso Front, navel
6.	Upper Torso Back
7.	Lower Torso Front, pelvic area right
8.	Lower Torso Back
9.	Lower Torso Front, pelvic area left
10.	Lower Torso Back
11.	Right Arm Upper Front
12.	Right Arm Upper Back
13.	Right Arm Lower Front
14.	Right Arm Lower Back
15.	Left Arm Upper Front
16.	Left Arm Upper Back
17.	Left Arm Lower Front
18.	Left Arm Lower Back
19.	Right Leg Front, thigh
20.	Right Leg Back, thigh
21.	Right Leg Front, lower leg
22.	Right Leg Back, lower leg
23.	Left Leg Front, thigh
24.	Left Leg Back, thigh
25.	Left Leg Front, lower leg
26.	Left Leg Back, lower leg

Heat flux was measured by a transducer that was carried through the flames at the manikin's waist, and the signal was printed on a strip chart recorder. The heat flux was obtained by integrating the trace with a planimeter.

Two movie cameras viewed the emergence of the manikin from the flames beyond the wall - one running at normal speed (24 frames/sec), the other at slow motion speed (100 frames/sec). A hand-held video camera recorded the manikin as it came from behind the wall. The manikin was then viewed from the front, back, and sides by the video camera, which zoomed in and out for detail. Still photographs and video views were also made of the front, back, and sides of the dressed manikin before the flame exposure.

The percentage of the body burned was calculated based on predetermined data for the division of body surface. The data allocate 35% of the body surface to the torso. Since there are 10 sensors on the torso in these tests, each would cover 3.5% of the body surface. In the same manner, the arms having eight sensors are allocated 14% of the body surface, or 1.75% for each arm sensor. The legs with eight sensors are allocated 32% of the body surface, or 4% for each leg sensor.

In these tests the sensors were evaluated at 250 degrees F for a third degree burn.

FIRE PIT TESTING - RESULTS AND DISCUSSION

Appendix B shows the sensor data in which sites are represented by rows with seven temperatures. If a sensor got hot enough to be triggered (change color), the temperature was written out; if not, a zero appeared. Heat flux in cal/cm^2 appears on the line with the sample identification. Table IV shows results of calculations for the percentage of body burned for the three body areas--torso, arms, and legs--and the total for each test. Observations from the photography and video coverage are shown in Table V.

TABLE IV.
PERCENTAGE OF BODY BURNED
AT 250^{o}F

SAMPLE	HEAT FLUX (Cal/cm^2)	PERCENTAGE OF BODY BURNED TORSO	ARMS	LEGS	TOTAL PERCENTAGE BURNED
1	4.64	0.0	3.5	4.0	7.5
2	8.07	0.0	8.8	20.0	28.8
3	5.29	3.5	5.3	12.0	20.8
4	4.49	0.0	7.0	24.0	31.0
5	5.08	0.0	3.5	16.0	19.5
6	7.36	7.0	10.5	32.0	49.5
7	5.85	0.0	12.3	16.0	28.3
8	7.53	0.0	10.5	12.0	22.5
9	6.72	0.0	8.8	20.0	28.8
10	5.66	7.0	8.8	16.0	31.8
11	9.86	7.0	7.0	16.0	30.0
12	3.45	0.0	0.0	4.0	4.0

MEAN AND STANDARD DEVIATION OF HEAT FLUX 6.07 / 1.27
MEAN AND STANDARD DEVIATION OF PERCENT BODY BURN 26.83 / 10.79

TABLE V.
RESULTS OF VIDEO AND PHOTOGRAPHIC COVERAGE

SAMPLE	HEAT FLUX	TOTAL % BODY BURN	FLAMING RESULTS					REMARKS
			AFSE	AFPO	AFGL	FFL	CC	
1	4.64	7.5	-	-	-	-	X	COLOR CHANGE ON BACK, SMOKED SLIGHTLY
2	8.07	28.8	X	-	-	-	X	COMPLETELY AFLAME, BUT SELF-EXTINGUISHED QUICKLY
3	5.29	20.8	X	-	-	-	X	FRONT LEGS AND ALL OF BACK ASHED
4	4.49	31.0	X	-	-	-	X	FLAMED BACK AND BACK OF LEGS
5	5.06	19.5	X	-	-	-	X	SOME OF BURNED AREAS TEAR EASILY
6	7.36	49.5	X	-	-	-	X	TOTAL COVERALL ASHED AND SHRUNK
7	5.85	28.3	X	-	-	-	X	ASHED FRONT AND BACK
8	7.53	22.5	X	-	-	-	X	ASHED FRONT AND BACK, LEGS SHRUNK
9	6.72	28.8	X	-	-	-	X	ASHED FROM WAIST DOWN, LEGS SHRUNK
10	5.66	31.8	X	-	-	-	X	ASHED FRONT AND BACK
11	9.86	30.0	X	-	-	-	X	ASHED FRONT AND BACK, SHRUNK ALL OVER
12	3.45	4.0	-	-	-	-	-	SINGED ONLY AT ENDS OF LEGS

AFSE - AFTER FLAMING, SELF-EXTINGUISHED
AFPO - AFTER FLAMING, MANUALLY EXTINGUISHED
AFGL - AFTER GLOW
FFL - FURTHER FLAMING (FROM AFTER GLOW)
CC - COLOR CHANGE, BLUE TO BEIGE

As shown in Table V, all but one of the coveralls was flaming as they emerged from the fire pit, and all quickly self-extinguished but smoked for the next few seconds. The heat caused a dramatic color from royal blue to beige, which allowed us to see what parts of the suit were heated. Although the light beige progressed to a darker beige when ashing took place, the first color change seemed not to have affected the integrity of the material as indicated by its resistance to ripping by hand. It was not possible to tear it in the light beige state. In the next stage, dark beige, it was brittle and would disintegrate with light squeezing. (This ashing was limited to small areas of some of the coveralls in these tests.) This observation raises the question as to what was burning. Since the fabric appears unaffected and the dye is absent, the implication is that it may have been the dye.

The mean percentage of the body burned at 250° F for the 12 coveralls was 26.83%. (See Table IV.) With a range of 4.0 and 49.5%, the coverall would offer average, if not desirable, protection from fuel fires. Moreover, the flight coverall is only one part of the overall protection from fire that the airman wears. Since it is usually covered by any number of additional pieces of equipment and an outer garment, the actual protection would be the result of the entire system of protection, which would certainly be greater than that offered by the coverall alone. Consequently, the flyer's blue coverall would seem to offer adequate flame-resistance protection when worn with the entire system of flight clothing.

Also, these suits were constructed from "off the shelf" material which may contain flammable dye carriers. After testing this material, we determined that a safeguard must be put into the material purchase document to prohibit material being used that contains the "odor of dyeing." This safeguard should prohibit the use in the coveralls of material with flammable dye carriers.

CONCLUSION AND RECOMMENDATION

Based on the results of testing, the flyer's blue coverall seems to offer adequate flame-resistance protection when worn with the entire system of flight clothing. Therefore, NCTRF recommends adoption of the new Navy flyer's fire-resistant blue coverall as an option to the current sage green garment.

APPENDIX A
FLAME RESISTANCE RESULTS

SAMPLE A

Before Weathering Warp*	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.2	AFG - 1.8	AFG - 2.0	AFG - 2.0
CL - 2-3/8	CL - 2-3/8	CL - 3-1/8	CL - 3-1/8

SAMPLE B

Before Weathering Warp	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 1.8	AFG - 2.0	AFG - 2.0
CL - 2-1/8	CL - 2-1/8	CL - 3-1/8	CL-3-5/8**

SAMPLE C

Before Weathering Warp	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 1.8	AFG - 2.0	AFG - 2.0
CL - 2-1/8	CL - 2-1/8	CL - 3-3/8	CL - 3-3/8

SAMPLE D

Before Weathering Warp	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-3/8	CL - 2-1/8	CL - 2-7/8	CL - 2-4/8

SAMPLE E

Before Weathering Warp	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-3/8	CL - 2-2/8	CL - 3-5/8**	CL - 3-3/8

SAMPLE F

Before Weathering Warp	Before Weathering Filling	After Weathering Warp	After Weathering Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-3/8	CL - 2-1/8	CL - 3-4/8	CL - 3-2/8

*Legend:
AFT = after flame time in seconds.
AFG = after glow time in seconds.
CL = char length in inches.
**Does not meet Air Force test requirement of 3.5 inches.

APPENDIX A (CONT'D)

SAMPLE G

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT* - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFT - 2.0
CL - 2-5/8	CL - 2-3/8	CL - 3-1/8	CL - 3-4/8

SAMPLE H

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AGT - 2.0	AFG - 2.2	AFG - 2.0	AFG - 2.0
CL - 2-4/8	CL - 2-3/8	CL - 3-3/8	CL - 3-4/8

SAMPLE I

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.2	AFG - 2.0	AFG - 2.0
CL - 2-4/8	CL - 2-4/8	CL - 3-4/8	CL - 3-2/8

SAMPLE J

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-4/8	CL - 2-4/8	CL - 2-6/8	CL - 3-3/8

SAMPLE K

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	ATG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-4/8	CL - 2-5/8	CL - 3-5/8**	CL- 3-5/8**

SAMPLE L

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-4/8	CL - 2-3/8	CL - 3-6/8**	CL -3-6/8**

*Legend:
AFT = after flame time in seconds.
AFG = after glow time in seconds.
CL = char length in inches.
**Does not meet Air Force test requirement of 3.5 inches.

APPENDIX A (CONT'D)

SAMPLE M

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT* - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFT - 2.0	AFT - 2.0
CL - 2-5/8	CL - 2-2/8	CL - 3-1/8	CL - 3-4/8

SAMPLE N

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 1.8	AFG - 2.0	AFT - 2.0
CL - 2-4/8	CL - 2-2/8	CL - 3-5/8**	CL -3-5/8**

SAMPLE O

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 1.8	AFG - 2.0
CL - 2-5/8	CL - 2-2/8	CL - 3-6/8**	CL- 3-7/8**

SAMPLE P

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-5/8	CL - 2-2/8	CL - 2-5/8	CL - 2-6/8

SAMPLE Q

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2-5/8	CL - 2-5/8	CL - 3-2/8	CL - 3-4/8

*Legend:
AFT = after flame time in seconds.
AFG = after glow time in seconds.
CL = char length in inches.
**Does not meet Air Force test requirement of 3.5 inches.

APPENDIX A (CONT'D)

SAMPLE R

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT* - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 1.8	AFG - 2.0
CL - 2-2/8	CL - 2-2/8	CL - 3-5/8**	CL- 3-5/8**

SAMPLE S

Before Weathering		After Weathering	
Warp	Filling	Warp	Filling
AFT - 0	AFT - 0	AFT - 0	AFT - 0
AFG - 2.0	AFG - 2.0	AFG - 2.0	AFG - 2.0
CL - 2.0	CL - 2-1/8	CL - 2-4/8	CL - 2-7/8

*Legend:
AFT = after flame time in seconds.
AFG = after glow time in seconds.
CL = char length in inches.
**Does not meet Air Force test requirement of 3.5 inches.

APPENDIX B. SENSOR DATA

SAMPLE (1) 2 SEC. 4.64 CAL/CM^2

	1	2	3	4	5	6	7
TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	260	270	280
RA1B	0	0	0	0	0	0	0
RA2F	220	230	0	0	0	0	0
RA2B	0	0	0	0	0	0	0
LA1F	0	0	0	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	0	0	0
LA2B	0	0	0	0	0	0	0
LEGS							
RL1F	220	230	240	250	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	0	0	0	0	0	0	0
RL3B	220	0	0	0	0	0	0
LL1F	0	0	0	0	0	0	0
LL1B	0	0	0	0	0	0	0
LL3F	0	0	0	0	0	0	0
LL3B	220	230	0	0	0	0	0

SAMPLE (2) 2 SEC. 8.07 CAL/CM^2

	1	2	3	4	5	6	7
TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	260	270	280
RA1B	220	230	240	250	260	270	280
RA2F	220	230	240	250	260	270	280
RA2B	220	230	240	250	260	270	280
LA1F	0	0	0	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	260	270	0
LA2B	0	0	0	0	0	0	0
LEGS							
RL1F	220	230	0	0	0	0	0
RL1B	220	230	240	250	260	270	280
RL3F	220	230	240	250	0	0	0
RL3B	0	0	0	0	0	0	0
LL1F	220	230	240	250	260	0	0
LL1B	220	230	240	250	260	270	280
LL3F	220	230	240	250	0	0	0
LL3B	220	0	0	0	0	0	0

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE.
IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO — LT = LOWER TORSO
RA = RIGHT ARM — LA = LEFT ARM
RL = RIGHT LEG — LL = LEFT LEG
F = FRONT — B = BACK

SENSOR DATA (cont'd)

SAMPLE (3) 2 SEC. 5.29 CAL/CM^2

			TORSO				
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	220	230	240	250	0	0	0
			ARMS				
RA1F	220	230	240	250	260	270	280
RA1B	0	0	0	0	0	0	0
RA2F	220	230	240	250	260	270	0
RA2B	0	0	0	0	0	0	0
LA1F	0	0	0	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	260	270	0
LA2B	0	0	0	0	0	0	0
			LEGS				
RL1F	0	0	0	0	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	220	230	240	250	260	270	280
RL3B	0	0	0	0	0	0	0
LL1F	220	230	240	250	260	270	280
LL1B	0	0	0	0	0	0	0
LL3F	220	230	240	250	0	0	0
LL3B	220	230	0	0	0	0	0

SAMPLE (4) 2 SEC. 4.49 CAL/CM^2

			TORSO				
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	220	230	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
			ARMS				
RA1F	0	0	0	0	0	0	0
RA1B	0	0	0	0	0	0	0
RA2F	220	230	240	250	260	270	0
RA2B	220	230	240	250	260	270	280
LA1F	0	0	0	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	0	0	0
LA2B	220	230	240	250	260	270	280
			LEGS				
RL1F	220	230	240	250	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	220	230	240	250	260	270	280
RL3B	220	230	240	250	260	270	280
LL1F	220	230	240	250	260	270	280
LL1B	0	0	0	0	0	0	0
LL3F	220	230	240	250	260	270	280
LL3B	220	230	240	250	260	270	280

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE.
IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO   LT = LOWER TORSO
RA = RIGHT ARM   LA = LEFT ARM
RL = RIGHT LEG   LL = LEFT LEG
F = FRONT   B = BACK

SENSOR DATA (cont'd)

SAMPLE (5) 2 SEC. 5.08 CAL/CM^2

TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	220	230	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	220	230	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	0	0	0	0
RA1B	0	0	0	0	0	0	0
RA2F	0	0	0	0	0	0	0
RA2B	220	0	0	0	0	0	0
LA1F	220	230	0	0	0	0	0
LA1B	220	230	240	250	260	270	280
LA2F	220	230	240	250	260	270	280
LA2B	220	230	240	0	0	0	0
LEGS							
RL1F	0	0	0	0	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	220	230	240	250	260	270	280
RL3B	220	230	240	250	260	270	280
LL1F	0	0	0	0	0	0	0
LL1B	220	230	240	250	260	270	280
LL3F	220	230	240	250	260	270	280
LL3B	0	0	0	0	0	0	0

SAMPLE (6) 2 SEC. 7.36 CAL/CM^2

TORSO							
UT2F	220	230	0	0	0	0	0
UT2B	220	230	240	250	260	270	280
UT3F	220	0	0	0	0	0	0
UT3B	220	230	240	250	260	270	280
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	260	270	280
RA1B	220	230	240	0	0	0	0
RA2F	220	230	240	250	260	0	0
RA2B	220	230	240	250	260	270	280
LA1F	220	230	240	250	260	270	280
LA1B	220	230	0	0	0	0	0
LA2F	220	230	240	250	260	270	280
LA2B	220	230	240	250	260	270	280
LEGS							
RL1F	220	230	240	250	260	270	280
RL2B	220	230	240	250	260	270	280
RL3F	220	230	240	250	260	270	280
RL3B	220	230	240	250	260	270	280
LL1F	220	230	240	250	260	270	280
LL1B	220	230	240	250	260	270	280
LL3F	220	230	240	250	260	270	280
LL3B	220	230	240	250	260	270	0

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE.
IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO   LT = LOWER TORSO
RA = RIGHT ARM   LA = LEFT ARM
RL = RIGHT LEG   LL = LEFT LEG
F = FRONT   B = BACK

SENSOR DATA (cont'd)

SAMPLE (7) 2 SEC. 5.85 CAL/CM^2

TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	0	0	0
RA1B	220	230	240	250	0	0	0
RA2F	220	230	240	250	260	270	280
RA2B	220	230	240	250	260	0	0
LA1F	220	0	0	0	0	0	0
LA1B	220	230	240	250	0	0	0
LA2F	220	230	240	250	260	270	280
LA2B	220	230	240	250	260	270	280
LEGS							
RL1F	220	230	0	0	0	0	0
RL1B	220	230	240	250	0	0	0
RL3F	220	230	240	250	260	270	280
RL3B	220	230	240	0	0	0	0
LL1F	220	230	240	250	260	270	280
LL1B	220	230	240	250	260	270	280
LL3F	0	0	0	0	0	0	0
LL3B	220	230	0	0	0	0	0

SAMPLE (8) 2 SEC. 7.53 CAL/CM^2

TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	0	0	0
RA1B	220	230	0	0	0	0	0
RA2F	220	230	240	250	260	270	280
RA2B	220	230	240	250	260	270	280
LA1F	220	230	240	250	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	0	0	0
LA2B	220	230	240	250	260	0	0
LEGS							
RL1F	0	0	0	0	0	0	0
RL1B	220	230	240	250	0	0	0
RL3F	220	230	0	0	0	0	0
RL3B	220	230	240	250	0	0	0
LL1F	220	230	240	250	260	0	0
LL1B	0	0	0	0	0	0	0
LL3F	0	0	0	0	0	0	0
LL3B	220	230	0	0	0	0	0

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE. IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO　　LT = LOWER TORSO
RA = RIGHT ARM　　LA = LEFT ARM
RL = RIGHT LEG　　LL = LEFT LEG
F = FRONT　　B = BACK

SENSOR DATA (cont'd)

SAMPLE (9) 2 SEC. 6.72 CAL/CM^2

Site	1	2	3	4	5	6	7
TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	260	270	280
RA1B	220	0	0	0	0	0	0
RA2F	220	230	240	250	260	0	0
RA2B	220	230	240	250	260	270	280
LA1F	220	230	240	250	260	270	280
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	0	0	0
LA2B	0	0	0	0	0	0	0
LEGS							
RL1F	220	230	240	250	260	270	280
RL1B	220	230	0	0	0	0	0
RL3F	0	0	0	0	0	0	0
RL3B	0	0	0	0	0	0	0
LL1F	220	230	240	250	260	270	280
LL1B	220	230	240	250	260	0	0
LL3F	220	230	240	250	260	270	280
LL3B	220	230	240	250	260	270	280

SAMPLE (10) 2 SEC. 5.66 CAL/CM^2

Site	1	2	3	4	5	6	7
TORSO							
UT2F	220	230	0	0	0	0	0
UT2B	220	230	240	250	260	270	280
UT3F	0	0	0	0	0	0	0
UT3B	220	230	240	250	260	270	280
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	220	230	240	250	0	0	0
RA1B	220	230	240	250	260	270	0
RA2F	220	230	240	250	260	0	0
RA2B	220	230	240	250	260	270	280
LA1F	220	230	240	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	220	230	240	250	260	270	280
LA2B	0	0	0	0	0	0	0
LEGS							
RL1F	0	0	0	0	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	220	230	240	250	260	270	280
RL3B	220	0	0	0	0	0	0
LL1F	220	230	240	250	260	270	280
LL1B	220	230	240	0	0	0	0
LL3F	220	230	240	250	260	270	280
LL3B	220	230	240	250	0	0	0

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE.
IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO LT = LOWER TORSO
RA = RIGHT ARM LA = LEFT ARM
RL = RIGHT LEG LL = LEFT LEG
F = FRONT B = BACK

SENSOR DATA (cont'd)

SAMPLE (11) 2 SEC. 9.86 CAL/CM^2

TORSO							
UT2F	220	230	240	250	0	0	0
UT2B	220	230	240	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	220	230	240	250	260	270	280
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	0	0	0	0	0	0	0
RA1B	220	230	240	250	260	270	280
RA2F	0	0	0	0	0	0	0
RA2B	220	230	240	250	260	270	280
LA1F	0	0	0	0	0	0	0
LA1B	220	230	240	250	260	270	280
LA2F	0	0	0	0	0	0	0
LA2B	220	230	240	250	260	270	280
LEGS							
RL1F	220	230	240	0	0	0	0
RL1B	220	230	240	250	260	270	280
RL3F	220	230	240	250	0	0	0
RL3B	220	230	240	0	0	0	0
LL1F	220	230	240	250	260	270	280
LL1B	220	230	0	0	0	0	0
LL3F	220	230	240	250	0	0	0
LL3B	0	0	0	0	0	0	0

SAMPLE (12) 2 SEC. 3.45 CAL/CM^2

TORSO							
UT2F	0	0	0	0	0	0	0
UT2B	0	0	0	0	0	0	0
UT3F	0	0	0	0	0	0	0
UT3B	0	0	0	0	0	0	0
UT6F	0	0	0	0	0	0	0
UT6B	0	0	0	0	0	0	0
LT1F	0	0	0	0	0	0	0
LT1B	0	0	0	0	0	0	0
LT2F	0	0	0	0	0	0	0
LT2B	0	0	0	0	0	0	0
ARMS							
RA1F	0	0	0	0	0	0	0
RA1B	0	0	0	0	0	0	0
RA2F	0	0	0	0	0	0	0
RA2B	0	0	0	0	0	0	0
LA1F	0	0	0	0	0	0	0
LA1B	0	0	0	0	0	0	0
LA2F	0	0	0	0	0	0	0
LA2B	0	0	0	0	0	0	0
LEGS							
RL1F	0	0	0	0	0	0	0
RL1B	0	0	0	0	0	0	0
RL3F	220	230	240	250	0	0	0
RL3B	0	0	0	0	0	0	0
LL1F	0	0	0	0	0	0	0
LL1B	0	0	0	0	0	0	0
LL3F	220	230	240	0	0	0	0
LL3B	0	0	0	0	0	0	0

THE SEVEN NUMBERED COLUMNS REPRESENT THE SEVEN SENSORS AT EACH SITE.
IF ZERO, ITS TEMPERATURE WAS NOT REACHED.

UT = UPPER TORSO
RA = RIGHT ARM
RL = RIGHT LEG
F = FRONT
LT = LOWER TORSO
LA = LEFT ARM
LL = LEFT LEG
B = BACK