

AD-A258 412



2

# THE NEW NAVY FLIER'S FIRE-RESISTANT BLUE COVERALL

**S** DTIC  
ELECTE  
DEC 24 1992 **D**  
**A**



20030221029

NAVY CLOTHING AND TEXTILE RESEARCH FACILITY  
NATICK, MASSACHUSETTS

Approved for public release;  
distribution unlimited.

TECHNICAL REPORT NO. 155

92 12 23 093

92-32736



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>155                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                 |
| 4. TITLE (and Subtitle)<br>THE NEW NAVY FLYER'S FIRE-RESISTANT BLUE COVERALL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final Report                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 6. PERFORMING ORG. REPORT NUMBER                                                              |
| 7. AUTHOR(s)<br>Leonaud G. Boutin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 9. CONTRACT OR GRANT NUMBER(s)                                                                |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Navy Clothing & Textile Research Facility<br>21 Strathmore Road<br>Natick, MA 01760                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>64264N, WR31254,<br>32-5-23 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Naval Air Systems Command<br>AIR-5311D<br>Washington, DC 20361                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 12. REPORT DATE<br>August 1984                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 13. NUMBER OF PAGES<br>27                                                                     |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)<br>-----                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                 |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                               |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)<br><br>Same as 16.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                               |
| 18. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                               |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br><br>Flyer's Fire-Resistant Blue Coverall; Fire-Resistant Fabric; Piece-Dyed Fabric;<br>Flight Clothing; Military Protective Clothing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                               |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>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 |                       |                                                                                               |

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

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)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

# TABLE OF CONTENTS

|                                                | <u>PAGE</u> |
|------------------------------------------------|-------------|
| List of Illustrations.....                     | iv          |
| List of Tables.....                            | v           |
| Introduction.....                              | 1           |
| Description of Fabric.....                     | 1           |
| Laboratory Test Procedures and Results.....    | 1           |
| Discussion of Laboratory Test Results.....     | 4           |
| Design of Coverall.....                        | 6           |
| Construction of Coverall.....                  | 6           |
| Fire Pit Testing - Procedure.....              | 6           |
| Fire Pit Testing - Results and Discussion..... | 12          |
| Conclusion and Recommendation.....             | 14          |
| Appendix A. Flame Resistance Results.....      | A-1         |
| Appendix B. Sensor Data.....                   | B-1         |

|                    |                      |
|--------------------|----------------------|
| Accession For      |                      |
| NTIS CRA&I         | DTIC                 |
| DTIC TAB           |                      |
| Unannounced        |                      |
| Justification      |                      |
| By                 |                      |
| Distribution/      |                      |
| Availability Codes |                      |
| Dist               | Avail. or<br>Special |
| A-1                |                      |

DTIC QUALITY INSPECTED 1

---

## LIST OF ILLUSTRATIONS

| <u>Figure</u> |                                                | <u>Page</u> |
|---------------|------------------------------------------------|-------------|
| 1             | Navy Flyer's Fire-Resistant Blue Coverall..... | 7           |
| 2             | Pencil Pocket with Flap Closed.....            | 8           |
| 3             | Pencil Pocket with Flap Open.....              | 9           |
| 4             | Shoulder Epaulets.....                         | 10          |

## LIST OF TABLES

| <u>Table</u>                                                       | <u>Page</u> |
|--------------------------------------------------------------------|-------------|
| I Initial Test Procedures and Results.....                         | 2           |
| II Physical Requirements for the Flyer's Blue Coverall Fabric..... | 5           |
| III Location of Sensors.....                                       | 11          |
| IV Percentage of Body Burned at 250°F.....                         | 12          |
| V Results of Video and Photographic Coverage.....                  | 13          |

## 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<sup>2</sup>, 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<br>Filling: 41                  | Warp: 70<br>Filling: 47                           |
| 3. Air Permeability             | 5450          | 208 ft <sup>3</sup> /min/ft <sup>2</sup> | 25 ft <sup>3</sup> /min/ft <sup>2</sup>           |
| 4. Weight                       | 5041          | 4.3 oz/yd <sup>2</sup>                   | 4.3 oz./yd <sup>2</sup>                           |
| 5. Colorfastness to Light       | 5660          | Poor                                     | Equal to std sample                               |
| 6. Seam Efficiency              | 5110          | 100%                                     | 80%                                               |
| 7. Shrinkage                    | 5556          | Warp: 2.8%<br>Filling: 1.4%              | Warp: 4.0% maximum<br>Filling: 1.5% maximum       |
| 8. Breaking Strength            | 5100          | Warp: 152 lbs<br>Filling: 113 lbs        | Warp: 180 lbs minimum<br>Filling: 100 lbs minimum |
| 9. Nonfibrous Content           | 2611          | 3.1%                                     | 1.0% maximum                                      |
| 10. Tearing Strength            | 5132          | Warp: 10.1 lbs<br>Filling: 6.9 lbs       | 12 lbs minimum<br>8 lbs minimum                   |
| 11. Acidity (pH)                | 2811          | 4.5                                      | 5 - 8                                             |
| 12. Colorfastness to Laundering | 5610          | Sample - Good<br>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<br>After Five Mobile<br>Launderings 5556<br>& 5930 | Side A - $4.1 \times 10^{16}$ ohms<br>Side B - $4.1 \times 10^{16}$ ohms<br>After Laundering<br>Side A - $5.3 \times 10^{16}$ ohms<br>Side B - $4.1 \times 10^{16}$ ohms | $3.0 \times 10^{11}$ ohms<br><br><br>$8.0 \times 10^{11}$ ohms            |
| 14. Flame Resistance       | Initial - 5903<br>After Weathering<br>(40 hrs.) - 5804<br>& 5903  | See Appendix A                                                                                                                                                           | Flame time, 2 seconds<br>Glow time, 25 seconds<br>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<br>staple length                                          |
| 18. Curling                | MIL-C-83429                                                       | Warp: No curling<br>Filling: No curling                                                                                                                                  | Warp: No curling<br>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-laundrying 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 laundrying is a maximum of  $3.0 \times 10^{11}$  ohms; after five laundryings, the maximum is  $8.0 \times 10^{11}$  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 <sup>2</sup> ) |                                         |
| 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                                        | $3.0 \times 10^{11}$                    |
| After 5 launderings                            | $8.0 \times 10^{11}$                    |
| 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.

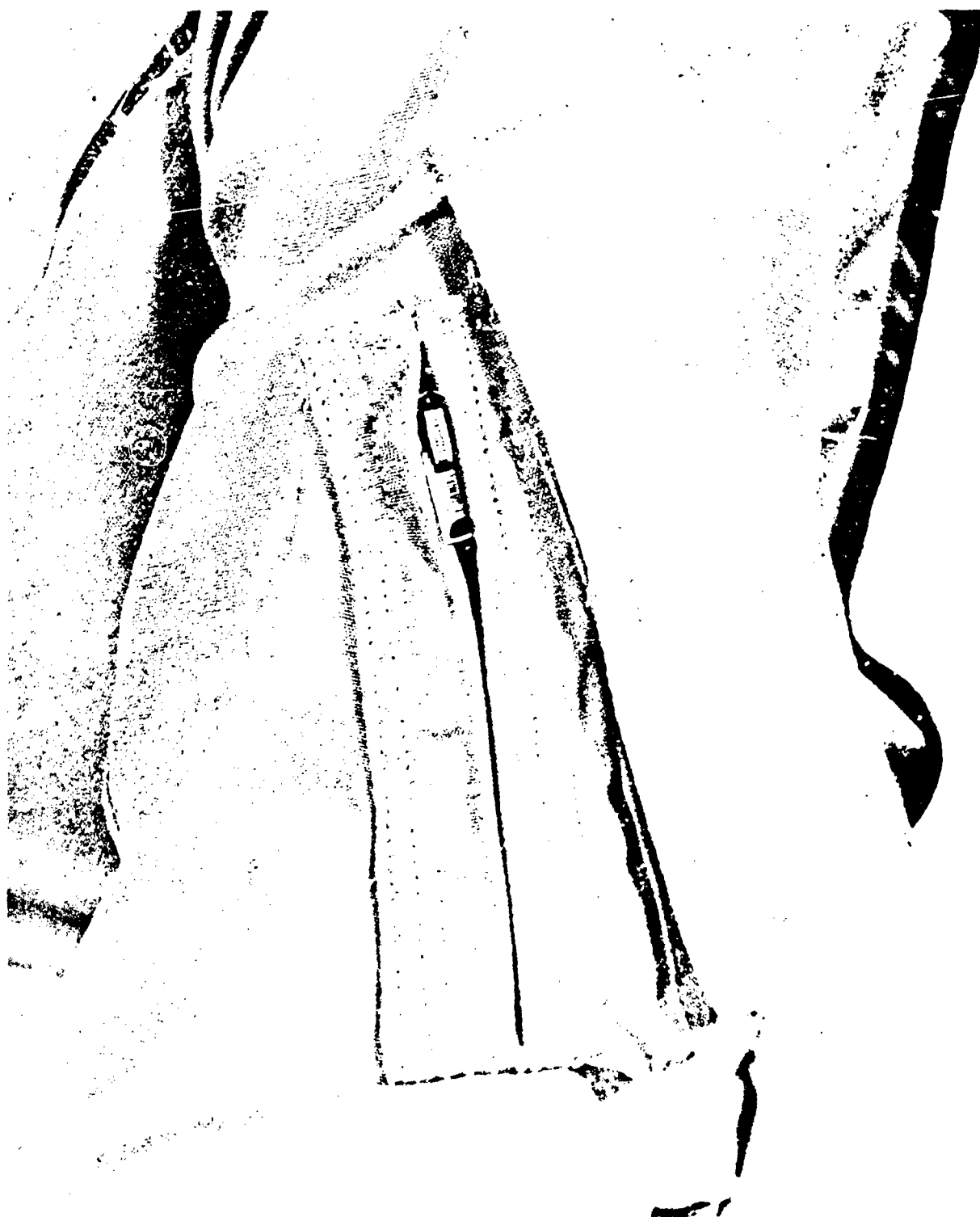


Figure 2. Pencil Pocket with Flap Closed.



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<sup>2</sup> 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°F

| SAMPLE | HEAT<br>FLUX<br>(Cal/cm <sup>2</sup> ) | PERCENTAGE OF BODY BURNED |      |      | TOTAL PERCENTAGE BURNED |
|--------|----------------------------------------|---------------------------|------|------|-------------------------|
|        |                                        | TORSO                     | ARMS | LEGS |                         |
| 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<br>FLUX | TOTAL %<br>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 \*      Filling  
AFT - 0      AFT - 0  
AFG - 2.2      AFG - 1.8  
CL - 2-3/8      CL - 2-3/8

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

## SAMPLE B

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

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

## SAMPLE C

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

After Weathering  
Warp      Filling  
AFT - 0      AFT - 0  
AFG - 2.0      AFG - 2.0  
CL - 3-3/8      CL - 3-3/8

## SAMPLE D

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

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

## SAMPLE E

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

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

## SAMPLE F

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

After Weathering  
Warp      Filling  
AFT - 0      AFT - 0  
AFG - 2.0      AFG - 2.0  
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

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT* - 0   | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| CL - 2-5/8 | CL - 2-2/8 |

### After Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFT - 2.0  | AFT - 2.0  |
| CL - 3-1/8 | CL - 3-4/8 |

## SAMPLE N

### Before Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 1.8  |
| CL - 2-4/8 | CL - 2-2/8 |

### After Weathering

|              |              |
|--------------|--------------|
| Warp         | Filling      |
| AFT - 0      | AFT - 0      |
| AFG - 2.0    | AFT - 2.0    |
| CL - 3-5/8** | CL - 3-5/8** |

## SAMPLE O

### Before Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| CL - 2-5/8 | CL - 2-2/8 |

### After Weathering

|              |              |
|--------------|--------------|
| Warp         | Filling      |
| AFT - 0      | AFT - 0      |
| AFG - 1.8    | AFG - 2.0    |
| CL - 3-6/8** | CL - 3-7/8** |

## SAMPLE P

### Before Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| CL - 2-5/8 | CL - 2-2/8 |

### After Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| CL - 2-5/8 | CL - 2-6/8 |

## SAMPLE Q

### Before Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| CL - 2-5/8 | CL - 2-5/8 |

### After Weathering

|            |            |
|------------|------------|
| Warp       | Filling    |
| AFT - 0    | AFT - 0    |
| AFG - 2.0  | AFG - 2.0  |
| 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 <sup>2</sup> |     |     |     |     |     |   | SAMPLE (2) |     | 2 SEC. 8.07 CAL/CM <sup>2</sup> |     |     |     |     |     |   |
|------------|-----|---------------------------------|-----|-----|-----|-----|-----|---|------------|-----|---------------------------------|-----|-----|-----|-----|-----|---|
|            |     | TORSO                           |     |     |     |     |     |   |            |     | TORSO                           |     |     |     |     |     |   |
| UT2F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT2F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| UT2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| UT3F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT3F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| UT3B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT3B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| UT6F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT6F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| UT6B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | UT6B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| LT1F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | LT1F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| LT1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | LT1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| LT2F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | LT2F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
| LT2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 | LT2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   | 0 |
|            |     | ARMS                            |     |     |     |     |     |   |            |     | ARMS                            |     |     |     |     |     |   |
| RA1F       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   | RA1F       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| RA1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | RA1B       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| RA2F       | 220 | 230                             | 0   | 0   | 0   | 0   | 0   |   | RA2F       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| RA2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | RA2B       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| LA1F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LA1F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   |
| LA1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LA1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   |
| LA2F       | 220 | 230                             | 240 | 250 | 0   | 0   | 0   |   | LA2F       | 220 | 230                             | 240 | 250 | 260 | 270 | 0   |   |
| LA2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LA2B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   |
|            |     | LEGS                            |     |     |     |     |     |   |            |     | LEGS                            |     |     |     |     |     |   |
| RL1F       | 220 | 230                             | 240 | 250 | 0   | 0   | 0   |   | RL1F       | 220 | 230                             | 0   | 0   | 0   | 0   | 0   |   |
| RL1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | RL1B       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| RL3F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | RL3F       | 220 | 230                             | 240 | 250 | 0   | 0   | 0   |   |
| RL3B       | 220 | 0                               | 0   | 0   | 0   | 0   | 0   |   | RL3B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   |
| LL1F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LL1F       | 220 | 230                             | 240 | 250 | 260 | 0   | 0   |   |
| LL1B       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LL1B       | 220 | 230                             | 240 | 250 | 260 | 270 | 280 |   |
| LL3F       | 0   | 0                               | 0   | 0   | 0   | 0   | 0   |   | LL3F       | 220 | 230                             | 240 | 250 | 0   | 0   | 0   |   |
| LL3B       | 220 | 230                             | 0   | 0   | 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  
RA = RIGHT ARM  
RL = RIGHT LEG  
F = FRONT  
LT = LOWER TORSO  
LA = LEFT ARM  
LL = LEFT LEG  
B = BACK

SENSOR DATA (cont'd)

| SAMPLE (3) |     | 2 SEC. 5.29 CAL/CM <sup>2</sup> |     | SAMPLE (4) |     | 2 SEC. 4.49 CAL/CM <sup>2</sup> |     |
|------------|-----|---------------------------------|-----|------------|-----|---------------------------------|-----|
|            |     | TORSO                           |     |            |     | TORSO                           |     |
| UT2F       | 0   | 0                               | 0   | 0          | 0   | 0                               | 0   |
| UT2B       | 0   | 0                               | 0   | 0          | 0   | 0                               | 0   |
| UT3F       | 0   | 0                               | 0   | 220        | 230 | 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                            |     |            |     | 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                            |     |            |     | 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        | 260 | 270                             | 280 |
| 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  
RA - RIGHT ARM  
RL - RIGHT LEG  
F - FRONT  
LT - LOWER TORSO  
LA - LEFT ARM  
LL - LEFT LEG  
B - BACK

SENSOR DATA (cont'd)

| SAMPLE (5) 2 SEC. 5.08 CAL/CM <sup>2</sup> |     |     |     | SAMPLE (6) 2 SEC. 7.36 CAL/CM <sup>2</sup> |     |     |     |
|--------------------------------------------|-----|-----|-----|--------------------------------------------|-----|-----|-----|
| TORSO                                      |     |     |     | 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                                       |     |     |     | ARMS                                       |     |     |     |
| RA1F                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| RA1B                                       | 0   | 0   | 0   | 0                                          | 0   | 0   | 0   |
| RA2F                                       | 0   | 0   | 0   | 0                                          | 0   | 0   | 0   |
| RA2B                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LA1F                                       | 220 | 230 | 0   | 220                                        | 230 | 240 | 250 |
| LA1B                                       | 220 | 230 | 260 | 220                                        | 230 | 240 | 250 |
| LA2F                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LA2B                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LEGS                                       |     |     |     | LEGS                                       |     |     |     |
| RL1F                                       | 0   | 0   | 0   | 0                                          | 0   | 0   | 0   |
| RL1B                                       | 0   | 0   | 0   | 0                                          | 0   | 0   | 0   |
| RL3F                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| RL3B                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LL1F                                       | 0   | 0   | 0   | 0                                          | 0   | 0   | 0   |
| LL1B                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LL3F                                       | 220 | 230 | 240 | 220                                        | 230 | 240 | 250 |
| LL3B                                       | 0   | 0   | 0   | 220                                        | 230 | 240 | 250 |

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 <sup>2</sup> |     |     |     |     |     |         | SAMPLE (8) 2 SEC. 7.53 CAL/CM <sup>2</sup> |     |     |     |     |     |         |
|--------------------------------------------|-----|-----|-----|-----|-----|---------|--------------------------------------------|-----|-----|-----|-----|-----|---------|
| TORSO                                      |     |     |     |     |     |         | TORSO                                      |     |     |     |     |     |         |
| UT2F                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT2F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| UT2B                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT2B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| UT3F                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT3F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| UT3B                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT3B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| UT6F                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT6F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| UT6B                                       | 0   | 0   | 0   | 0   | 0   | 0       | UT6B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LT1F                                       | 0   | 0   | 0   | 0   | 0   | 0       | LT1F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LT1B                                       | 0   | 0   | 0   | 0   | 0   | 0       | LT1B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LT2F                                       | 0   | 0   | 0   | 0   | 0   | 0       | LT2F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LT2B                                       | 0   | 0   | 0   | 0   | 0   | 0       | LT2B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| ARMS                                       |     |     |     |     |     |         | ARMS                                       |     |     |     |     |     |         |
| RA1F                                       | 220 | 230 | 240 | 250 | 0   | 0       | RA1F                                       | 220 | 230 | 240 | 250 | 0   | 0       |
| RA1B                                       | 220 | 230 | 240 | 250 | 0   | 0       | RA1B                                       | 220 | 230 | 0   | 0   | 0   | 0       |
| RA2F                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | RA2F                                       | 220 | 230 | 240 | 250 | 260 | 270 280 |
| RA2B                                       | 220 | 230 | 240 | 250 | 260 | 0       | RA2B                                       | 220 | 230 | 240 | 250 | 260 | 270 280 |
| LA1F                                       | 220 | 0   | 0   | 0   | 0   | 0       | LA1F                                       | 220 | 230 | 240 | 250 | 0   | 0       |
| LA1B                                       | 220 | 230 | 240 | 250 | 0   | 0       | LA1B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LA2F                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | LA2F                                       | 220 | 230 | 240 | 250 | 0   | 0       |
| LA2B                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | LA2B                                       | 220 | 230 | 240 | 250 | 260 | 0       |
| LEGS                                       |     |     |     |     |     |         | LEGS                                       |     |     |     |     |     |         |
| RL1F                                       | 220 | 230 | 0   | 0   | 0   | 0       | RL1F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| RL1B                                       | 220 | 230 | 240 | 250 | 0   | 0       | RL1B                                       | 220 | 230 | 240 | 250 | 0   | 0       |
| RL3F                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | RL3F                                       | 220 | 230 | 0   | 0   | 0   | 0       |
| RL3B                                       | 220 | 230 | 240 | 0   | 0   | 0       | RL3B                                       | 220 | 230 | 240 | 250 | 0   | 0       |
| LL1F                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | LL1F                                       | 220 | 230 | 240 | 250 | 260 | 0       |
| LL1B                                       | 220 | 230 | 240 | 250 | 260 | 270 280 | LL1B                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LL3F                                       | 0   | 0   | 0   | 0   | 0   | 0       | LL3F                                       | 0   | 0   | 0   | 0   | 0   | 0       |
| LL3B                                       | 220 | 230 | 0   | 0   | 0   | 0       | LL3B                                       | 220 | 230 | 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

# SENSOR DATA (cont'd)

| SAMPLE (9) |     | 2 SEC. 6.72 CAL/CM <sup>2</sup> |     | SAMPLE (10) |     | 2 SEC. 5.66 CAL/CM <sup>2</sup> |     |
|------------|-----|---------------------------------|-----|-------------|-----|---------------------------------|-----|
|            |     | TORSO                           |     |             |     | 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                            |     |             |     | 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                            |     |             |     | 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 |

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

# SENSOR DATA (cont'd)

| SAMPLE (11) 2 SEC. 9.86 CAL/CM <sup>2</sup> |     |     |                     | SAMPLE (12) 2 SEC. 3.45 CAL/CM <sup>2</sup> |     |         |       |
|---------------------------------------------|-----|-----|---------------------|---------------------------------------------|-----|---------|-------|
| TORSO                                       |     |     |                     | TORSO                                       |     |         |       |
| UT2F                                        | 220 | 230 | 240 250             | 0                                           | 0   | 0       | 0     |
| UT2B                                        | 220 | 230 | 240                 | 0                                           | 0   | 0       | 0     |
| UT3F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| UT3B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| UT6F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| UT6B                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LT1F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LT1B                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LT2F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LT2B                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| ARMS                                        |     |     |                     | ARMS                                        |     |         |       |
| RA1F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| RA1B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| RA2F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| RA2B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| LA1F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LA1B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| LA2F                                        | 0   | 0   | 0 0 0               | 0                                           | 0   | 0       | 0     |
| LA2B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| LEGS                                        |     |     |                     | LEGS                                        |     |         |       |
| RL1F                                        | 220 | 230 | 240 0 0 0           | 0                                           | 0   | 0       | 0     |
| RL1B                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0     |
| RL3F                                        | 220 | 230 | 240 250 0 0 0       | 220                                         | 230 | 240 250 | 0 0 0 |
| RL3B                                        | 220 | 230 | 240 0 0 0           | 0                                           | 0   | 0       | 0 0 0 |
| LL1F                                        | 220 | 230 | 240 250 260 270 280 | 0                                           | 0   | 0       | 0 0 0 |
| LL1B                                        | 220 | 230 | 0 0 0               | 0                                           | 0   | 0       | 0 0 0 |
| LL3F                                        | 220 | 230 | 240 250 0 0 0       | 220                                         | 230 | 240     | 0 0 0 |
| LL3B                                        | 0   | 0   | 0 0 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