

NOT MEASUREMENT
SENSITIVE

MIL-DTL-32149
28 April 2004

DETAIL SPECIFICATION

CLOTH, WATERPROOF, FLAME RESISTANT, MOISTURE VAPOR PERMEABLE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1. Scope. This document covers flame resistant, waterproof, and moisture vapor permeable cloth used in the ruggedized flyers' coveralls.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications. The following specification forms a part of this document to the extent specified herein. Unless otherwise specified, the issue of this document is that cited in the solicitation or contract.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division (Code 414100B120-3), Highway 547, Lakehurst, NJ 08733-5100 or emailed to Tom.Omara@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at www.dodssp.daps.mil.

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DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-83133 - Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35, and JP-8+100

(Copies of this document are available online at <http://assist.daps.dla.mil/quicksearch/> or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents and drawings. The following other Government document and drawing form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

CODE OF FEDERAL REGULATION

27 CFR 21 - Formulas for Denatured Alcohol and Rum

(Copies of this document are available online at www.gpoaccess.gov/cfr/about.html or from the Superintendent of Documents, U.S. Government Printing Office, North Capital & "H" Streets, N.W., Washington, DC 20402-0002.)

NAVAL AIR SYSTEMS COMMAND

1370AS502 - Seam Tape and Patches, Heat Sealable Anti-Exposure Coverall, CWU-74/P

(Copies of these drawings are available from Department of the Navy, Official Mail Manager, Attn: B2187 R2240 STE 1B58 TODD, NAWCAD, 48110 Shaw Road, Unit 5, Code 4631, Patuxent River, MD 20670.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

AATCC-8	- Colorfastness to Crocking: AATCC Crockmeter Method
AATCC-15	- Colorfastness to Perspiration
AATCC-16	- Colorfastness to Light
AATCC-22	- Water Repellency: Spray Test
AATCC-61	- Colorfastness to Laundering, Home and Commercial: Accelerated
AATCC-96	- Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics Except Wool
AATCC-118	- Oil Repellency: Hydrocarbon Resistance Test

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| AATCC-130 | - | Soil Release: Oily Stain Release Method |
| AATCC-135 | - | Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics |

(Copies of these documents are available from www.aatcc.org or AATCC, PO Box 12215, Research Triangle Park, NC 27709-2215.)

AMERICAN SOCIETY FOR QUALITY (ASQ)

- | | | |
|-----------|---|--|
| ASQC-Z1.4 | - | Procedures, Sampling and Tables for Inspection by Attributes (DoD adopted) |
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(Copies of this document are available from www.asq.org or the American Society for Quality, 600 Plankinton Avenue, Milwaukee, WI 53203.)

ASTM INTERNATIONAL

- | | | |
|------------|---|---|
| ASTM-D471 | - | Rubber Property – Effect of Liquids, Standard Test Method for (DoD adopted) |
| ASTM-D751 | - | Coated Fabrics, Standard Test Methods for (DoD adopted) |
| ASTM-D1776 | - | Conditioning and Testing Textiles, Standard Practice for (DoD adopted) |
| ASTM-D2582 | - | Puncture-Propagation Tear Resistance of Plastic Film, and Thin Sheeting, Standard Test Method for (DoD adopted) |
| ASTM-D3393 | - | Coated Fabrics – Waterproofness, Standard Specification for |
| ASTM-D3776 | - | Mass Per Unit Area (Weight) of Fabric, Standard Test Method for (DoD adopted) |
| ASTM-D3886 | - | Abrasion Resistance of Textile Fabrics, Standard Test Method for (Inflated Diaphragm Method) |
| ASTM-E96 | - | Water Vapor Transmission of Materials, Standard Test Method for (DoD adopted) |
| ASTM-F392 | - | Flex Durability of Flexible Barrier Materials, Standard Test Method for |
| ASTM-F903 | - | Resistance of Materials used in Protective Clothing to Penetration by Liquids, Standard Test Method for |

(Copies of these documents are available from www.astm.org or ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

- ISO 11092 - Textiles – Physiological effects – Measurement of thermal and water-vapor resistance under steady-state conditions (sweating guarded-hotplate test)

(Copies of this document are available from www.iso.ch or American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 1971 Method 6-2 - Flame Resistance Test One (Vertical Flame)
NFPA 1971 Method 6-6 - Heat and Thermal Shrinkage Resistance Test

(Copies of these documents are available from www.nfpa.org or NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471.)

SAE INTERNATIONAL

- SAE-AMS1424 - Deicing/Anti-Icing Fluid, Aircraft, SAE Type 1

(Copies of this document are available from www.sae.org or SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

- TAPPI Method T-451 - Stiffness, Preferred Procedure (1)

(Copies of this document are available from www.tappi.org or TAPPI Press, 15 Technology Parkway South, PO Box 105113, Atlanta, GA 30348-5113.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 Standard sample. The cloth shall match the standard sample (see 6.3) for shade, colorfastness, and appearance on the face side and shall be equal to or better than the standard sample with respect to all characteristics for which the standard sample is referenced.

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3.3 Cloth. The cloth shall be a laminate consisting of a nomex face, a tri-layer expanded polytetrafluoroethylene film partially impregnated with polyurethane, and a jersey knit nomex backer (see figure 1). The finished cloth shall meet the requirements specified in table I and 3.4 through 3.12 when tested as specified in 4.4.

TABLE I. Physical requirements

CHARACTERISTIC	REQUIREMENT
Weight, oz/sq yd, max	9.0
Dimensional stability, max	
1. Warp	5%
2. Fill	5%
Tear strength, kgf, min	
1. Warp	5.0
2. Fill	5.0
Hydrostatic resistance to burst, psi, min	
1. Initial	180
2. After JP-8	180
3. After aircraft fluids	180
4. After hydraulic fluids	180
5. After DEET	180
Hydrostatic resistance, sustained	
1. Initial	No leakage
2. After strength of coating	No leakage
3. After high humidity	No leakage <u>1</u> /
4. After aircraft fluids	
a. Initial	No leakage
b. After laundering	No leakage
5. After hydraulic fluid	
a. Initial	No leakage
b. After laundering	No leakage
6. After JP-8 fuel	
a. Initial	No leakage
b. After laundering	No leakage
7. After DEET	No leakage
Evaporative resistance (Ret) m ² Pa/W	11
Moisture vapor transmission rate, g/m ² /24 hr initial, min	
1. Water method (B)	700
2. Inverted water method (BW)	4500
Stiffness, warp, cm, max	
1. At 70 °F	10
2. At 0 °F	10

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TABLE I. Physical requirements – Continued.

CHARACTERISTIC	REQUIREMENT
Chemical penetration 1. JP-8 2. Hydraulic fluid	No leakage No leakage
Thermal shrinkage, max 1. Warp 2. Fill	4% 4%
Vertical flames 1. After flame – warp, seconds, max a. Initial b. After 10 launderings 2. After flame – fill, seconds, max a. Initial b. After 10 launderings 3. Char length – warp, cm, max a. Initial b. After 10 launderings 4. Char length – fill, cm, max a. Initial b. After 10 launderings	2 2 2 2 12 12 12 12
Water permeability 1. Initial 2. After synthetic perspiration a. Initial b. After laundering 3. After physical surface appearance 4. After flex (70 °F) a. Warp b. Fill 5. After cold flex (-25 °F) a. Warp b. Fill 6. After wet flex, min a. 168 hours b. 336 hours	No Leakage No Leakage No Leakage No Leakage No Leakage No Leakage 14 out of 15 have no leakage 10 out of 15 have no leakage
Sealed seams <u>2</u> / 1. Water permeability a. Initial b. After 20 laundering cycles 2. Chemical penetration a. JP-8 b. Hydraulic fluid	No Leakage No Leakage No Leakage No Leakage

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TABLE I. Physical requirements – Continued.

CHARACTERISTIC	REQUIREMENT
3. Hydrostatic resistance, sustained	
a. Initial	No Leakage
b. After JP-8	No Leakage
c. After hydraulic fluid	No Leakage
d. After aircraft fluids	No Leakage

1/ The cloth shall not become stiff and brittle nor soft and tacky and there shall be no evidence of cracking or crazing under visual examination.

2/ Unless otherwise specified in the contract or purchase order, these requirements shall be met.

3.4 Spray rating. The cloth shall have a spray rating not less than 100, 90, 90 initially and 90, 90, 90 after 5 launderings (see 4.4.10).

3.5 Resistance to organic liquids. The cloth shall show no wetting to n-tetradecane (rating 4) initially and after 5 launderings (see 4.4.10).

3.6 Physical surface appearance.

3.6.1 After laundering. After 20 laundering cycles, both sides of the cloth shall show no change in physical surface appearance when tested as specified in 4.4.4.1.

3.6.2 After continuous wash. The cloth shall exhibit no delamination greater than ¼ inch in diameter or bubbling after continuous wash as specified in 4.4.4.2.

3.7 Soil resistance. The cloth resistance to soiling by JP-8 shall be not less than 3 when tested as specified in table IV.

3.8 Color. The face side of the cloth shall be Green 3438. The backside of the laminate shall be grey.

3.9 Color matching. The color of the finished cloth shall match the standard sample when viewed under filtered tungsten lamps, which approximate artificial daylight having a correlated color temperature of 7500 ± 200 K, with illumination of 100 ± 20 foot candles, and shall be a fair match to the standard sample under incandescent lamplight at 2300 ± 200 K (see table IV).

3.10 Colorfastness. The finished cloth shall show fastness to light, laundering, and perspiration equal to or better than the standard sample when tested as specified in table IV.

3.11 Spectral reflectance. The finished cloth shall meet not less than 10 of the spectral reflectance values (in percent) for the visible/near infrared wavelength range, 600 to 860 nanometers (nm) as specified in table II, when tested as specified in 4.4.11.

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TABLE II. Spectral reflectance requirements

WAVELENGTH, nm	REFLECTANCE VALUES PERCENT	
	Minimum	Maximum
600	8	13
620	8	13
640	8	13
660	8	13
680	10	18
700	16	28
720	22	40
740	30	51
760	35	61
780	40	70
800	45	77
820	50	81
840	55	82
860	60	82

3.12 Toxicity. The finished cloth shall not present a dermal health hazard when used as intended. (see 4.4.12).

3.13 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

4. VERIFICATION

4.1 Classification of inspection. The inspection requirements specified herein are classified as follows:

- a. First article inspection (see 4.2)
- b. Conformance inspection (see 4.3)

4.2 First article inspection. When specified (see 6.2), first article inspection shall consist of the examination of 4.3.2 and all tests specified in 4.4.

4.3 Conformance inspection. Conformance inspection shall consist of all examinations and tests of this specification.

4.3.1 Conformance inspection sampling. Unless otherwise specified, sampling for conformance inspection shall be in accordance with the provisions of ASQC-Z1.4.

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4.3.2 Examination of the end item. Both sides of the cloth shall be examined for the defects specified in table III. All defects found shall be counted regardless of their proximity to each other except where two or more defects represent a single local condition in which case only the more serious defect shall be counted. A continuous defect shall be counted as one defect for each warpwise yard or fraction thereof in which it occurs.

4.3.2.1 Sample size for examination of the end item. The lot size shall be expressed in yards. The sample unit shall be 1 linear yard. The number of rolls from which the sample yardage is to be selected shall be as specified herein. The sample yardage shall be apportioned equally among the selected rolls.

Lot size in yards	Sample size in rolls
1,200 or less	3
1,201 up to and including 3,200	5
3,201 up to and including 10,000	8
10,001 up to and including 35,000	13
35,001 up to and including 150,000	20
150,001 and over	32

Lots which contain fewer than three rolls, each roll in the lot shall be examined.

TABLE III. End item visual defects

DEFECT	CLASSIFICATION	
	MAJOR	MINOR
Any hole, cut, tear or scratch, including edges	101	
Abrasion resulting in a thin or weak area	102	
Multiple floats or skips, 1/2 inch or more in either warp or filling direction of face fabric	103	
Any pit, blister, tunnel, bubbles, or delamination of components	104	
Crease or wrinkle resulting in doubling or adhesion of surfaces that cannot be corrected by manual pressure, adhesion of surfaces against each other, or any diagonal distortion of face side surface	105	
Any solid lump, defined as a slub C or 4, or knot which exceeds level C on the respective Sears Fabric Defect Scale (see 6.4)	106	
Fabric edges rolled, folded, doubled, scalloped or wavy	107	
Any spot, stain <u>1</u> /, or foreign matter <u>2</u> /	108	
Any odor other than that which is characteristic of the component materials of the cloth		201
Any color off-shade, not uniform, mottled, or spotted (face side only)	109	
Any tackiness	110	
Any pinhole	111	

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TABLE III. End item visual defects – Continued.

DEFECT	CLASSIFICATION	
	MAJOR	MINOR
Any area without waterproof finish (i.e., laminating film, where required)	112	
Any scorch or burn	113	
Multiple floats or skips, 1/2 inch or more in either warp or filling direction of face fabric	114	
Not clean	115	

1/ Clearly visible at normal inspection distance (3 ft).

2/ For the back side, any spot, stain, off-shade area, or discoloration that is a result of the distortion of a backing fabric (if used) or a result of uneven dyeing of a backing fabric shall not be scored for this condition. Foreign matter shall include waste, fly, or extraneous material that has been formed into the fabric system.

4.3.3 End item testing. The cloth shall be tested as specified in 4.4

4.3.3.1 Sample size for end item testing. The sample unit for testing shall be 15 continuous yards full width of the finished cloth, put up in a manner to prevent folding and creasing, or both. The lot shall be unacceptable if any sample unit fails to meet any requirement specified. The sample size shall be in accordance with the following:

<u>Lot size (yards)</u>	<u>Sample size (sample units)</u>
800 or less	2
801 up to and including 22,000	3
22,001 and over	5

4.4 Test methods. The tests of this specification shall be conducted in accordance with the test methods specified in table IV.

TABLE IV. Test methods

TESTS	TEST METHODS	REQUIREMENT PARAGRAPH
Weight	ASTM-D3776 (Option C)	3.3
Dimensional stability	AATCC-96 & 4.4.10	3.3
Tear strength	ASTM-D2582 & 4.4.1	3.3
Hydrostatic resistance (to burst):		3.3
Initial	<u>1/</u> ASTM-D751 procedure A	
After JP-8	<u>1/</u> ASTM-D751 procedure A & 4.4.9	
After aircraft fluids	<u>1/</u> ASTM-D751 procedure A & 4.4.9.1	
After hydraulic fluid	<u>1/</u> ASTM-D751 procedure A & 4.4.9	
After abrasion	<u>1/</u> ASTM-D751 procedure A & 4.4.2.2	

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TABLE IV. Test methods – Continued.

TESTS	TEST METHODS	REQUIREMENT PARAGRAPH
After contamination with DEET	<u>1</u> / ASTM-D751 procedure A & 4.4.2.4	3.3
Hydrostatic resistance, sustained:		3.3
Initial	ASTM-D3393 & 4.4.2.1	
After strength of coating	ASTM-D751, section 54-58, 20 lb stretch	
After high humidity	ASTM-D3393 & 4.4.2.3	
After aircraft fluids	ASTM-D3393 & 4.4.2.1, 4.4.9.1, 4.4.10	
After hydraulic fluid	ASTM-D3393 & 4.4.2.1, 4.4.9, 4.4.10	
After JP-8 fuel	ASTM-D3393 & 4.4.2.1, 4.4.9 & 4.4.10	
After contamination with DEET	ASTM-D3393 & 4.4.2.1, 4.4.2.4	
Evaporative Resistance (Ret) <u>2</u> /	ISO 11092	3.3
Moisture vapor transmission rate:		3.3
Water method (B)	ASTM-E96 & 4.4.6.1	
Inverted water method (BW)	ASTM-E96 & 4.4.6.2	
Stiffness		3.3
At 70 °F	TAPPI Method T-451 & 4.4.3.1	
At 0 °F	TAPPI Method T-451 & 4.4.3.2	
Chemical penetration:		3.3
JP-8	ASTM-F903	
Hydraulic fluid	ASTM-F903	
Thermal shrinkage	NFPA 1971, Method 6-6	3.3
Vertical flames	NFPA 1971, Method 6-2	3.3
Water permeability:		3.3
Initial	ASTM-D751 & 4.4.5	
After synthetic perspiration	ASTM-D751 & 4.4.8, 4.4.10, 4.4.5	
After physical surface appearance	ASTM-D751 & 4.4.4.1, 4.4.4.2, 4.4.5	
After flex (70 °F)	ASTM-D751 & 4.4.5.1	
After cold flex (-25 °F)	ASTM-D751 & 4.4.5.2	
After wet flex	ASTM-D751 & 4.4.5.3	

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TABLE IV. Test methods – Continued.

TESTS	TEST METHODS	REQUIREMENT PARAGRAPH
Sealed seams: <u>3/</u> Water permeability Initial After 20 laundering cycles Chemical penetration JP-8 Hydraulic fluid Hydrostatic resistance (sustained) Initial After JP-8 After hydraulic fluid After aircraft fluids	ASTM-D751 & 4.4.5 ASTM-D751 & 4.4.5, 4.4.10 ASTM-F903 ASTM-F903 ASTM-D3393 & 4.4.2.1 ASTM-D3393 & 4.4.2.1, 4.4.9 ASTM-D3393 & 4.4.2.1, 4.4.9 ASTM-D3393 & 4.4.2.1, 4.4.9.1	3.3
Spray rating	AATCC-22	3.4
Resistance to organic liquids	AATCC-118	3.5
Physical surface appearance	4.4.4.1 & 4.4.4.2	3.6
Soil resistance:	<u>4/</u> AATCC-130	3.7
Color matching	4.4.11	3.9
Colorfastness to: Laundering Light Perspiration Crocking	AATCC-61, Test 1A & 4.4.7.1 AATCC-16, Option A or E 4.4.8 & AATCC-15 AATCC-8	3.10
Spectral reflectance	4.4.11	3.11
Toxicity	4.4.12	3.12

1/ Knit side facing water.

2/ First article evaluation only

3/ Construct a seam using stitch type 301, 6-8 stitches per inch, SSa-1 seam type of ASTM-D6193. Tape the seam using seam sealing tape as specified in 1370AS502. The entire width of the seam tape shall be hot air sealed over the width of the seam and stitching.

4/ The sample size shall be five 8- x 8-inch samples.

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4.4.1 Tear strength. Testing shall be as specified in ASTM-D2582 with exceptions as follows: Five warp and five filling specimens shall be tested. Specimen size shall be 8 inches by 8 inches. The test shall be conducted using carriage #6 and only one tear shall be made on a single specimen. The specimen shall be positioned with the face side toward the probe and with the designated yarns of the face fabric at right angles to the direction of tear. The test shall be conducted using the standard drop height of 508 ± 2 mm. If the tear is not straight on face side of the laminate, the result shall be considered invalid and another specimen shall be tested. The thickness of the specimen shall not be measured.

4.4.2 Hydrostatic resistance.

4.4.2.1 Sustained. Testing shall be as specified in ASTM-D3393 except that a water pressure of 40 psi (25 psi shall be used for testing after contamination with DEET) shall be used and applied to the face side of the test specimens. Sealed seams shall follow the same procedure as specified except that water pressure shall be 10 psi for one sustained period of 10 minutes with no ramping cycles, and the seams shall be centered in the test area of the testing apparatus.

4.4.2.2 After abrasion. Testing shall be as specified in ASTM-D3886 except that the test shall be conducted in the multidirectional mode as specified herein. The face side of the cloth shall be abraded for 10,000 cycles using the face side of the test material as the abradant and a load of 6 pounds. The specimens shall then be tested for hydrostatic resistance in accordance with table IV.

4.4.2.3 After high humidity. Three specimens 4 by 4 inches shall be laid flat, face side up, on a supporting plate and the assembly placed in a desiccator containing water in the lower portion. The water level shall be 1 inch below the specimens. The lid of the desiccator shall be put in place and the desiccator placed in a circulating air oven having a temperature of 125 ± 2 °F for a period of 7 days. At the end of the aging period, each specimen shall be removed from the desiccator and then immediately examined for colorfastness. The specimens shall then be tested for hydrostatic resistance in accordance with table IV.

4.4.2.4 After diethyltoluamide (DEET). Five specimens shall be laid flat, face side up, on a glass plate 4 by 4 by 1/4 inches thick. Three drops of diethyltoluamide solution as specified in 4.4.2.4.1 shall be applied to the center of each specimen. A glass plate of the same dimensions shall be placed on the specimen and a pressure of 0.0625 pounds per square inch of glass plate contact area shall be applied to the assembly. After 16 hours the specimens shall be removed from between the glass plates and tested immediately for hydrostatic resistance in accordance with table IV.

4.4.2.4.1 Diethyltoluamide (DEET insect repellent) solution. The diethyltoluamide solution shall be a minimum of 75 percent by weight of diethyltoluamide and the remainder denatured alcohol. The diethyltoluamide shall be a technical grade and contain N, N-diethyl-metatoluamide of not less than 95 percent purity and the remainder shall consist of entirely or a mixture of ortho or para isomers of N, N-diethyltoluamide. The denatured alcohol shall be ethanol, U.S.P. 94.9 percent by volume and denatured in accordance with The Code of Federal

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Regulations 27 CFR 21, Formula 40. The insect repellent shall be registered with the U.S. Environmental Protection Agency in accordance with the Federal Insecticide, Fungicide and Rodenticide (see 6.7).

4.4.3 Stiffness.

4.4.3.1 Stiffness at 70 °F. Stiffness shall be tested as specified in TAPPI Method T-451, Preferred Procedure (1), except that five test specimens with the long dimension parallel to the warp direction of the cloth shall be tested. The standard textile test conditions as specified in ASTM-D1776 shall be used.

4.4.3.2 Stiffness at 0 °F. Stiffness shall be tested as specified in TAPPI Method T-451, Preferred Procedure (1), except that five test specimens with the long dimension parallel to the warp direction of the cloth shall be tested. The samples shall be conditioned in a controlled cooling chamber for 30 minutes. Testing shall then be performed in accordance with table IV.

4.4.4 Physical surface appearance.

4.4.4.1 After laundering. Conduct 20 laundering and drying cycles in accordance with 4.4.10. Each sample, 48 inches in length by full width shall be cut in half across the width of the cloth. One half of the sample (24 inches in length) shall be laundered and the remaining half retained as the unlaundered portion for the final evaluation, as necessary. After each drying cycle, visually examine both sides of the cloth for changes in physical surface appearance when compared to the unlaundered sample.

4.4.4.2 After continuous wash. Three 14-inch by full width (54-58 inch) samples shall be cut from the sample unit. Sample edges shall be serged or sewn prior to washing. The samples shall be subject to 96 hours of wash in accordance with AATCC-135, without soap. The wash shall run in a continuous manner in 24 hour increments, detangling the samples every 24 hours. Samples shall be inspected for signs of delamination or bubbling.

4.4.5 Water permeability. Water permeability shall be tested as specified in ASTM-D751, Hydrostatic Resistance, Procedure B, Procedure 2, with a fixed hydrostatic head of 1 psi applied to the face side of the test specimen for 10 minutes. Five specimens shall be tested. Measure for the appearance of water droplets. Leakage is the appearance of one or more droplets of water within the 4-1/2 inch diameter test area. For sealed seams, a 28-inch sealed specimen shall be tested in three areas across the sample, with each site centered on the sealed area. The specimen shall be tested at 1 psi for 3 minutes. Leakage is the appearance of one or more droplets of water within the 4-1/2 inch diameter test area, or any wicking through the sealed seam area. Wicking leaks can be checked by blotting sample area with a paper towel.

4.4.5.1 Water permeability after flex at 70 °F. One warp and one fill specimen, 8 by 12 inches, shall be cut from the sample unit with the 8-inch dimension in the indicated direction (warp or filling, as applicable). The specimen shall be conditioned and flexed as specified in

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ASTM-F392, except that the specimen shall not be aged, the short edges shall not be heat sealed or otherwise joined, and the specimen shall be flexed for 1500 full flex cycles. Two 6- by 8-inch specimens shall be cut from the 8- by 12-inch flexed specimen and tested for water permeability in accordance with table IV.

4.4.5.2 Water permeability after cold flex at -25 °F. One warp and one fill specimen, 8 by 12 inches, shall be cut from the sample unit with the 8-inch dimension in the indicated direction (warp or filling as applicable). The specimen shall be conditioned and flexed as specified in ASTM-F392 except the specimen shall not be aged, the short edges shall not be heat sealed or otherwise joined. The 8- by 12-inch specimen shall be mounted on the flex test apparatus, placed in a test chamber at the specified temperature for 1 hour, and then flexed for 1500 full flex cycles in the test chamber at the specified temperature. At the end of the flexing cycle, two 6- by 8-inch specimens shall be cut from the 8- by 12-inch flexed specimen and conditioned prior to testing for water permeability in accordance with table IV.

4.4.5.3 Water permeability after wet flex. Three 14-inch by full width samples shall be cut from the sample unit. Sample edges shall be serged or sewn prior to wash. The samples shall be subject to 168 hours of wash in accordance with AATCC-135, without soap and run in a continuous manner detangling the samples every 24 hours. After washing for 168 hours, the samples shall be hung to air dry, until fully dry, and then conditioned for 4 hours at 65 percent RH and 23 °C. The samples shall be subsequently subject to water permeability testing at 5 sites spread equally along the width of each sample in accordance with 4.4.5. Suter areas shall be marked and the three samples from the sample unit shall be washed an additional 168 hours (total of 336 hours on the samples) of continuous wash. After the additional 168 hours of continuous wash, water permeability shall be conducted on five sites per sample as specified above.

4.4.6 Moisture vapor transmission rate.

4.4.6.1 Water method (B). Five specimens per sample unit shall be tested for each of the moisture vapor transmission rate (MVTR) methods. The back side of the laminated cloth shall face the water and the specimens shall be sealed by any means which prevents leaking or wicking of water around the specimen. The tests shall be performed in an area with a controlled temperature of 73.4 ± 1 °F and a controlled relative humidity of 50 ± 2 percent. The water method for determining MVTR shall be conducted as specified in ASTM-E96, with the test dish in the upright position (Procedure B). The free stream air velocity shall be 550 ± 50 FPM as measured 2 inches above the cloth specimen. The air flow shall be measured at least 2 inches from any other surface. The test shall run for 24 hours and weight measurements shall be taken only at the start and the completion of the test. At the start of the 24 hour period, the air gap between the water surface and the back of the specimen shall be 3/4 inch. The minimum value shall be obtained by averaging all of the determinations obtained from the individual specimens taken from all of the sample units as a group. No single specimen determination shall be less than 350 grams/meter²/24 hours.

4.4.6.2 Inverted water method (BW). The inverted water method for determining MVTR shall be conducted as specified in ASTM-E96 with the test dish in the inverted position

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(Procedure BW). The free stream air velocity shall be 550 ± 50 FPM as measured 2 inches below the cloth specimen. The air flow shall be measured at least 2 inches from any other surface. The test shall be run for 2 hours and weight measurements shall be taken only at the start and completion of the test. The minimum value shall be obtained by averaging all of the determinations obtained from the individual specimens taken from all of the sample units as a group. No single specimen determination shall be less than 2500 grams/meter²/24 hours.

4.4.7 Colorfastness.

4.4.7.1 Laundering. Laundering shall be tested as specified in AATCC No. 61, Test 1A, 3 cycles except that 1993 AATCC Standard Reference Detergent (non-phosphate) without optical brighteners shall be used.

4.4.8 Synthetic perspiration test. The specimen, 8 by 8 inches, shall be cut and exposed to synthetic perspiration as follows: the synthetic perspiration solution shall be made by combining 3.0 grams sodium chloride, 1.0 gram trypticase soy broth powder, 1.0 gram normal propyl propionate, 0.5 gram of liquid lecithin and 500 ml of distilled water. Cover the solution and heat to 50 °C, stirring frequently while heating. Continue until all ingredients are dissolved. Then, cool the solution to 35 °C, remove cover and dispense it immediately with a pipette or other measuring device. Dispense 2 ml of perspiration solution at 35 °C, onto the center of an 8- by 8- by 1/4 inch glass plate. Place the specimen on the glass plate with the back side contacting the glass. Dispense an additional 2 ml of the synthetic perspiration solution onto the center of the specimen. Place a second 8- by 8- by 1/4-inch glass plate on top of the specimen and then place a 4 pound weight on top of the assembly in the center. After 16 hours, remove the specimen (do not rinse) and air dry the specimen before testing the specimen as specified in AATCC-15.

4.4.9 Contamination procedure. The specimen (or specimen area) shall be laid flat, face side up, on a glass plate. Three drops (1mL for sealed samples) of a test liquid, either hydraulic fluid or JP-8 conforming to MIL-T-83133, shall be applied to the center of the specimen (or specimen area). A glass plate of the same dimensions shall be placed on the specimen (or specimen area) and a pressure of 0.0625 pounds per square inch (1 pound per square inch for seam sealed samples) of glass plate contact area shall be applied to the assembly. After 16 hours (2 hours for seam sealed samples), remove the specimen (or specimen area) from the assembly and test immediately for the required performance property in the center of specimen (or specimen area). For testing the initial condition, the test specimen shall be as specified by the applicable test method. For testing hydrostatic resistance and leakage after laundering, one laundering sample 48 inches by the full width of the cloth shall be used for each test liquid specified above. Three drops of the test liquid shall be applied to each laundering sample. The face side of the laundry sample shall be marked using a laundry marker pen. The laundering test shall then be conducted in accordance with 4.4.10 for one laundering and drying cycle. After laundering, the specimen areas may be cut from the laundering sample to facilitate performance property testing. Ten specimens shall be tested for each of the initial and the after laundering conditions.

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4.4.9.1 Contamination procedure after aircraft fluids. The specimen (or specimen area) shall be laid flat, face side up, on a glass plate. One milliliter of JP-8 fuel conforming to MIL-T-83133 shall be spread over the middle of the sample, followed by 1 mL of de-icing fluid conforming to SAE-AMS1424. The samples shall then be placed flat in an air-circulating oven at 50 °C for 30 minutes. Remove immediately and test as specified in table IV.

4.4.10 Laundering procedure. Place 2.0 ± 0.2 pounds of the cloth in an automatic washing machine set on permanent press cycle, high water level, and a wash temperature of 100 °F. The tolerance for the warm wash temperature shall be +10 °F and -0 °F. A ballast may be added to equal 2 pounds of cloth. Place 0.5 ounce (14 grams) of AATCC-135, Standard Reference Detergent (non-phosphate) without optical brighteners into the washer. The duration of each laundering cycle shall be 30 ± 5 minutes. After laundering, place sample and ballast in an automatic tumble dryer set on permanent press cycle that has a temperature of 155 ± 5 °F, and dry for 30 minutes or until dry. The washer and dryer shall be in accordance with AATCC-135.

4.4.11 Spectral reflectance. Spectral reflectance shall be determined on the face side and shall be obtained from 600 to 860 nanometers (nm) at 20 nm intervals on a spectrophotometer (see 6.5) relative to the barium sulfate standard, the preferred white standard. Other white reference materials may be used. If other white reference materials are used, they shall be calibrated to absolute white, e.g. magnesium oxide or vitrolite tiles (see 6.6). The spectral band width shall be less than 26 nm at 860 nm. Reflectance measurements shall be made by either the monochromatic or polychromatic mode of operation. When the polychromatic mode is used, the spectrophotometer shall operate with the specimen diffusely illuminated with the full emission of a source that simulates either CIE source A or CIE source D65. The specimen shall be measured as a single layer, backed with six layers of the same fabric and shade. Measurements shall be taken on a minimum of two different areas and averaged. The measured areas shall be at least 6 inches away from the selvage. The specimen shall be viewed at an angle no greater than 10 degrees from the normal, with the specular component included. Photometric accuracy of the spectrophotometer shall be within 1 percent and wavelength accuracy within 2 nm. Spectral reflectance values obtained shall meet the requirements specified in 3.11.

4.4.12 Toxicity assessment. A primary dermal irritation study in laboratory animals and a repeated insult human patch test (Modified Draize Procedure), under the supervision of a qualified dermatologist, using at least 100 free living individuals shall be conducted. The results shall meet the requirement of 3.12.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing

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Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The cloth is military unique based on its use in the fabrication of the continuous wear coverall and components which are worn during overwater flights to protect the aircrewmembers from hypothermia in the event of immersion in cold water.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number and date of this specification.
- b. Quantity required.
- c. When first article inspection is required (see 3.1).
- d. Packaging requirements (see 5.1)

6.3 Standard sample. For access to standard samples, contact the contracting activity issuing the invitation for bids.

6.4 Defect replica kits. Fabric defect replica kits are available from Sears Roebuck and Company, Department 817, (ATTN: BSC 23-29), Sears Tower, Chicago, IL 60684.

6.5 Spectrophotometer. Suitable spectrophotometers for measuring spectral reflectance in the visible/near spectral include the Data Color CS-5, Diano Hardy, Diano Match Scan, Hunter D54P-IR, and the MacBeth 1500 with IR options.

6.6 White standard. Barium sulfate acceptable for use as a white reference standard is available from the Eastman Kodak Company. The same source has available magnesium reagent (ribbon). Acceptable tiles can be obtained from the National Institute of Standards and Technology or the instrument manufacturers.

6.7 Insect repellent. DEET insect repellent conforming to Type II, Concentration A of O-I-503 has been used successfully as a reagent in testing.

6.8 Subject term (key word) listing.

Physical surface appearance

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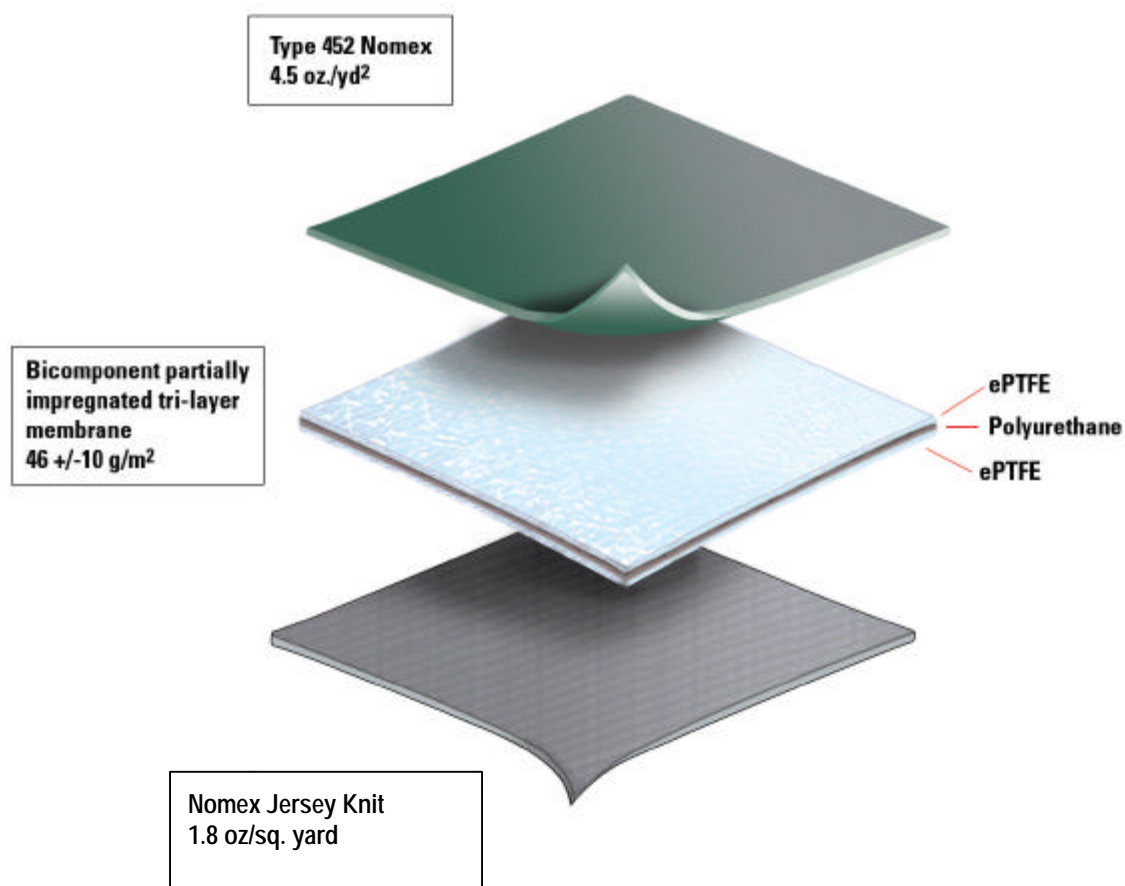


FIGURE 1. Film composition

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Custodians:

Navy-AS

DLA-CT

Preparing activity:

Navy - AS

(Project 8305-N841)

Review activity:

Navy-NU

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using ASSIST Online database at <http://www.dodssp.daps.mil>.