

INCH-POUND

MIL-C-44031D

22 August 1989

SUPERSEDING

MIL-C-44031C

2 September 1987

## MILITARY SPECIFICATION

### CLOTH, CAMOUFLAGE PATTERN: WOODLAND, COTTON AND NYLON

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

#### 1. SCOPE

1.1 Scope. This specification covers blended cotton and nylon twill cloth which is dyed and overprinted with a 4-color camouflage print.

1.2 Classification. The cloth shall be of the following classes as specified (see 6.2).

Class 1 - Camouflage printed

Class 2 - Camouflage printed and Quarpel treated

#### 2. APPLICABLE DOCUMENTS

##### 2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Natick Research, Development, and Engineering Center, Natick, MA 01760-5014 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 8305

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

MIL-C-44031D

SPECIFICATIONS

FEDERAL

- P-S-683 - Sour, Laundry (Fluoridated)
- PPP-P-1134 - Packaging of Cotton and Cotton-Synthetic Fiber Blend Fabrics (Excluding Duck Fabrics)

MILITARY

- MIL-D-43362 - Detergent, Laundry (Anionic: A Standard for Testing)
- MIL-T-43548 - Thread, Polyester Core: Cotton-, Rayon-, or Polyester-Covered

STANDARDS

FEDERAL

- FED-STD-4 - Glossary of Fabric Imperfections
- FED-STD-191 - Textile Test Methods

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

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

FEDERAL TRADE COMMISSION

Rules and Regulations Under the Textile Fiber Products Identification Act

(Copies are available from the Federal Trade Commission, Pennsylvania Avenue, at Sixth Street, N.W., Washington, DC 20580.)

DRAWINGS

U.S. ARMY NATICK RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER

- 2-1-1516 - Woodland Pattern - 48 inches
- 2-1-1516B - Woodland Pattern - 60 inches

(Copies of drawings are available from the U.S. Army Natick Research, Development, and Engineering Center, ATTN: STRNC-EMSS, Natick, MA 01760-5014.)

MIL-C-44031D

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS (AATCC)

Chromatic Transference Scale

(Application for copies should be addressed to the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 1424 - Tear Resistance of Woven Fabrics by Falling-Pendulum  
(Elmendorf) Apparatus

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 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, shall supersede 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 (see 6.3) in accordance with 4.3.

3.2 Standard sample. The dyed and printed or dyed, printed, and treated cloth shall match the standard sample for shade and appearance and shall (unless otherwise indicated see 3.4.3) be equal to or better than the standard sample with respect to all characteristics for which the standard sample is referenced (see 6.4).

3.3 Material. It is encouraged that recycled material be used when practical as long as it meets the requirements of this specification.

## MIL-C-44031D

3.3.1 Cotton. The cotton shall be carded.

3.3.2 Nylon. The nylon shall be first quality, high tenacity, semi-dull staple having a nominal cut length of 1-1/2 inches and a round cross section, with a nominal denier of 2.25 to 2.5. The use of any form of nylon waste is prohibited, such as undrawn fiber, mixtures of deniers, lusters or cross sections, and waste from any stage of fiber production: whether drawn, undrawn, or mixed or garnetted fiber. The contractor shall submit the fiber producer's certification that each lot of nylon staple used conforms to the requirements specified herein. Testing shall be as specified in 4.4.4.

3.3.3 Yarns. The warp and filling yarn shall be singles made from a blend of 50 + 5 percent nylon and the remaining percentage cotton, based on the dry weight of the desized cloth when tested as specified in 4.4.4.

3.4 Color. The cloth shall be dyed to a ground shade approximating Light Green 354 (see 6.6). The Woodland camouflage pattern shall be obtained by roller or screen printing using four rollers or screens, as appropriate for Light Green 354, Dark Green 355, Brown 356, and Black 357 areas of the pattern over the ground shade (see 6.6 and 6.6.1).

3.4.1 Labile sulfur. The use of dyes and compounds containing sulfur capable of oxidation to sulfuric acid shall be chosen and applied such that the dyed cloth shall contain no more labile sulfur than shown by the standard sample when tested as specified in 4.4.4. When no standard sample is available, the dyed cloth shall show no more than a slight trace of labile sulfur when tested as specified in 4.4.4.

3.4.2 Visual match. The color and appearance of the camouflage printed finished cloth shall match the standard sample when viewed under filtered tungsten lamps that approximate artificial daylight and that have a correlated color temperature of 7500 + 200 K, with illumination of 100 + 20 foot candles, and shall be a good match to the standard sample under incandescent lamplight at 2300 + 200 K.

3.4.2.1 Instrumental match. The four colors listed below in the Woodland pattern for the printed finished cloth shall match the corresponding colors in the standard sample when measured on a spectrophotometer (see 6.9) in the visible wavelength range of the electromagnetic spectrum, 400 to 700 nanometers (nm). The following are the maximum numerical tolerances for acceptability ( $\Delta A$ ) for each of the four colors in the Woodland pattern, when tested as specified in 4.4.4:

<u>Color</u>	<u><math>\Delta A</math></u>
Light Green 354	1.60
Dark Green 355	1.60
Brown 356	1.30
Black 357	1.00

## MIL-C-44031D

3.4.3 Colorfastness. The camouflage printed finished cloth shall show fastness to light (after 40 hours), laundering (after three cycles), and perspiration equal to or better than the standard sample or equal to or better than a rating of "good" for each of the pattern areas, except Black 357 which shall be equal to or better than a rating of "fair". The finished cloth shall show fastness to crocking equal to or better than the standard sample or shall have an AATCC Chromatic Transference Scale rating not lower than 3.5 for all the pattern areas, except Black 357 which shall have an AATCC Chromatic Transference Scale rating not lower than 1.0, when tested as specified in 4.4.4.

3.5 Pattern execution. The pattern shall reproduce the standard sample in respect to design, colors, and registration of the respective areas. The pattern repeat of the camouflage printed finished cloth shall be 27.25 +1.25 - 2.5 inches. Each pattern area shall show solid coverage; skitteriness exceeding that shown by the standard sample in any of the printed areas will not be acceptable. When the standard sample is not referenced for pattern execution, a pattern drawing shall be provided, and the pattern on the finished cloth shall match that of the drawing (see 2.1.2 and 6.2).

3.5.1 Spectral reflectance. The finished cloth shall meet the spectral reflectance values (in percent) for the visible/near-infrared wavelength range, 600 to 860 nanometers (nm), when tested as specified in 4.4.4.

TABLE I. Spectral reflectance requirements

Wavelengths nanometers	Reflectance values (percent)					
	Black 357		Light Green 354		Dark Green 355 and Brown 356	
	min.	max.	min.	max.	min.	max.
600	--	10	8	18	3	10
620	--	10	8	18	3	10
640	--	10	8	18	3	9
660	--	10	8	18	3	12
680	--	10	10	22	3	14
700	--	10	18	33	5	18
720	--	10	22	45	7	20
740	--	10	30	55	12	28
760	--	10	35	65	18	36
780	--	10	40	75	26	44
800	--	10	45	80	34	52
820	--	10	50	86	42	60
840	--	10	55	88	50	68
860	--	10	60	90	56	74

3.6 Physical requirements. The finished cloth shall conform to the requirements in table II when tested as specified in 4.4.4.

## MIL-C-44031D

TABLE II. Physical requirements

Class	Wt. per sq. yd. minimum Ounces	Yarns per inch minimum		Breaking strength minimum		Tearing strength minimum		Air permea- bility (cu. ft./min./sq. ft.) max. ave. (see 6.8)
		Warp	Filling	Warp	Filling	Warp	Filling	
1	6.8	86	54	200	125	11	8	25.0
2	7.0	86	54	190	115	10	7	10.0

3.6.1 Weave. The weave shall be a 2/1 left hand twill.

3.6.2 Width. The width of the cloth shall be as specified (see 6.2) and shall be the minimum acceptable width inclusive of the selvage when fly-shuttle looms or shuttleless with tuck-in selvage are used. For all other shuttleless looms, the width measurement shall be made between the last warp yarn on each side excluding the protruding fringe(s).

3.7 Finish. The cloth shall be dyed and printed with the warp effect side as the face. The cloth shall be singed, desized, scoured, mercerized, dyed, and printed. The class 2 cloth shall be given an approved water repellent treatment (see 3.10).

3.8 Non-fibrous material. The starch and protein content including chloroform soluble and water-soluble material of the scoured and printed cloth of class 1, and the printed cloth prior to the application of water repellent of class 2 shall not exceed 2.0 percent when tested as specified in 4.4.4 or 4.4.2, as specified.

3.9 Dimensional stability. The shrinkage or elongation both in the warp and in the filling of the finished cloth shall be not greater than 3.5 percent for the individual sample unit and not greater than 3.0 percent for the lot average when tested as specified in 4.4.4.1. The preshrinkage process used shall not be identified by name or trademark on the cloth, ticket, or package.

3.10 Water repellency (class 2). The class 2 cloth shall be given an approved Quarpel type (see 6.7) water repellent treatment and shall conform to the water repellency requirements of table III and 3.10.1 when tested as specified in 4.4.4. The use of materials other than approved water repellents are prohibited. The cured fabric shall be afterwashed to remove all unreacted reagents.

## MIL-C-44031D

TABLE III. Water repellency requirements (class 2)

Hydrostatic height (centimeters) minimum	Dynamic absorption (percent) maximum
18.0	20.0

3.10.1 Spray rating (class 2). The results of the three individual determinations on the sample unit for spray rating shall be equal to or better than ratings 100, 100, 90 when tested as specified in 4.4.4.

3.11 Liquid repellency (class 2). The treated finished class 2 cloth shall show no wetting by n-dodecane after 30 seconds and no wetting by tri-ethyl phosphate, di-methyl methyl phosphonate, and bis (2 ethyl hexyl) hydrogen phosphite after 8 hours when tested as specified in 4.4.4.

3.12 pH. The pH value of the water extract of the finished cloth shall be no lower than 5.0 nor higher than 8.5 when tested as specified in 4.4.4.

3.13 Seam efficiency. The finished cloth shall have a seam efficiency of no less than 80 percent when tested as specified in 4.4.4.

3.14 Length and put-up. Unless otherwise specified (see 6.2), the cloth shall be furnished in continuous lengths, each not less than 40 yards. Each length shall be put-up on a roll as specified in 5.1.

3.15 Fiber identification. Each roll shall be labeled or ticketed for fiber content in accordance with the Rules and Regulations Under the Textile Fiber Products Identification Act.

3.16 Workmanship. The finished cloth shall conform to the quality of product established by this specification and the demerit points per 100 square yards shall not exceed the specified point values.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

## MIL-C-44031D

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Certificate of compliance. When certificates of compliance are submitted, the Government reserves the right to inspect such items to determine the validity of the certification.

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

- a. First article inspection (see 4.3).
- b. Quality conformance inspection (see 4.4).

4.3 First article inspection. When a first article is required (see 3.1 and 6.2), it shall be examined for appearance, color, and finish defects and shall be tested for the characteristics specified in table IV and 4.4.4.1. The presence of any defect or failure of any test shall be cause for rejection of the first article.

4.4 Quality conformance inspection.

4.4.1 Component and material inspection. In accordance with 4.1, components and materials shall be inspected in accordance with all the requirements of referenced documents unless otherwise excluded, amended, modified, or qualified in this specification or applicable purchase document.

4.4.2 In-process inspection (class 2 only). Prior to the application of the water repellent treatment, the cloth shall be tested for starch and protein content including chloroform-soluble and water-soluble material in accordance with Method 2611 of FED-STD-191. The sample unit for testing shall be 1/2 yard of the printed cloth. The lot shall be unacceptable if any sample unit fails to meet the requirement specified in 3.8. 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 up to and including 150,000	5



## MIL-C-44031D

4.4.3 End item examination. The maximum lot size shall be 150,000 linear yards.

4.4.3.1 Yard-by-yard examination. Each roll in the sample shall be examined on the face side only (printed side). When the total yardage in the roll does not exceed 100 yards, the entire yardage in the roll shall be examined. When the total yardage in the roll exceeds 100 yards, only 100 yards shall be examined. All defects, as defined in Section I of FED-STD-4, which are clearly noticeable at normal inspection distance (3 feet) shall be scored and assigned demerit points as listed in 4.4.3.1.1, except that only those slubs and knots which exceed the maximum limits shown on Sears Fabric Defect Scales (see 6.5), E or 3 as applicable for slubs and D for knots, shall be scored. No linear yard (increments of 1 yard on the measuring device of the inspection machine) from any one roll within the sample shall be penalized more than four points. The sample size shall be 20 rolls selected from 20 containers. The lot shall be unacceptable if the points per 100 square yards of the total yardage examined exceeds 30 points. The lot shall be unacceptable if the points per 100 square yards of two or more individual rolls exceeds 45 points. If one roll in the sample size of 20 exceeds 45 points per 100 square yards, a second sample of 20 rolls shall be examined for individual roll quality, only. The lot shall be unacceptable if one or more rolls in the second sample exceeds 45.0 points per 100 square yards. Point computation for quality and individual roll quality shall be as follows:

$$\frac{\text{Total points scored in sample} \times 3600}{\text{Contracted width of cloth (inches)} \times \text{Total yards inspected}} = \text{Points per 100 square yards}$$

4.4.3.1.1 Demerit points. Demerit points shall be assigned as follows:

For defects up to and including 3 inches in any dimension	- one point
For defects exceeding 3 inches, but not exceeding 6 inches in any dimension	- two points
For defects exceeding 6 inches, but not exceeding 9 inches in any dimension	- three points
For defects exceeding 9 inches in any dimension	- four points

The following defects, when present, shall be scored four points for each yard in which they occur:

- Objectionable odor
- Baggy, ridgy, or wavy cloth
- Width less than specified
- Edge ravel when pulled outward
- Slack or tight selvages 1/
- Overall uncleanness
- Pattern design not equal to the standard sample
- Incorrect color in any part of the pattern
- Pattern repeat not equal to the standard sample

MIL-C-44031D

Pattern repeat less than 24.75 inches or more than 28.50 inches  
Skitteriness (mottled, uneven color) of pattern exceeds that shown by standard sample  
Excessive feathering or spew (fuzziness at color boundaries) of pattern as compared to the sample  
Excessive grinning (off register, gap where ground shade shows through) of pattern as compared to the standard sample  
Excessive haloing or trapping (overlapping of colors) of pattern as compared to the standard sample  
Overall application of water repellent not uniform (class 2)  
Tackiness (sticky to touch) (class 2)  
Design not printed on face side of cloth

1/ To determine the presence of unacceptable selvage conditions, the following procedure shall be observed: During the visual examination, the perch shall be stopped a minimum of three times for each roll in the sample, the tension removed, and the finished cloth examined for the selvage conditions. A waviness in the selvage or significant ripples diagonally across the width of the fabric is an indication of slack or tight selvages.

4.4.3.2 Length examination. During the yard-by-yard examination, each roll in the sample shall be examined for length. Any length found to be less than the minimum specified or more than 2 yards less than the length marked on the ticket shall be considered a defect with respect to length. The lot shall be unacceptable if the total of the actual lengths of rolls in the sample is less than the total of the lengths marked on the tickets (see 6.18).

4.4.3.3 Shade and appearance examination. During the yard-by-yard examination, each roll in the sample shall be examined for shade and appearance. If any one component color in any roll of the sample is off shade or if any roll does not have the same appearance as the standard sample it shall be cause for rejection of the entire lot represented by the sample.

4.4.3.4 Roll identification marking. During the yard-by-yard examination, each roll in the sample shall be examined for defects listed below (see 6.18).

Preshrinking process identified by name or trademark on cloth or ticket.

Not labeled or ticketed in accordance with the Rules and Regulations Under the Textile Fiber Products Identification Act.

## MIL-C-44031D

4.4.4 End item testing. The cloth shall be tested for the characteristics listed in table IV. The methods of testing specified in FED-STD-191 whenever applicable and as listed in table IV shall be followed. All test reports shall contain the individual values utilized in expressing the final results. The sample unit shall be 3 continuous yards full width of the finished cloth (for class 1) or 4 continuous yards full width of the finished cloth (for class 2), for all physical and chemical tests except dimensional stability (see 4.4.4.1). The lot shall be unacceptable if one or more sample units or the lot average for dimensional stability fail to meet any requirement specified. The maximum lot size shall be 150,000 linear yards. 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 up to and including 150,000	5

TABLE IV. End item tests

<u>Characteristic</u>	<u>Requirement paragraph</u>	<u>Test method</u>
Material		
Cotton fiber identification	3.3.1	1200 <u>1/</u>
Nylon:		
Identification	3.3.2	1530 <u>1/</u>
Luster	3.3.2	<u>1/</u>
Denier	3.3.2	<u>1/</u>
Absence of nylon waste	3.3.2	<u>1/</u>
Fiber content:		
Cotton content	3.3.3	2530 <u>1/ 2/</u>
Nylon content	3.3.3	2530 <u>1/</u>
Presence of labile sulfur	3.4.1	2020 <u>1/</u>
Instrumental match	3.4.2.1	4.5.2
Colorfastness to:		
Light (after 40 hours)	3.4.3	5660
Laundering (after 3 cycles)	3.4.3	5610 <u>3/</u>
Perspiration	3.4.3	5680
Crocking	3.4.3	5651
Spectral reflectance	3.5.1	4.5.1
Weight	3.6	5041
Yarns per inch	3.6	5050
Breaking strength	3.6	5100
Tearing strength	3.6	ASTM D 1424
Air permeability	3.6	5450
Weave	3.6.1	Visual <u>1/</u>
Singed	3.7	<u>1/</u>

## MIL-C-44031D

TABLE IV. End item tests (cont'd)

Characteristic	Requirement paragraph	Test method
Desized	3.7	<u>1/</u>
Mercerized	3.7	<u>1/</u>
Non-fibrous material (class 1)	3.8	2611
Dimensional stability	3.9	4.4.4.1
Water repellency (class 2)	3.10	<u>4/</u>
Hydrostatic pressure (class 2)	3.10	5514
Dynamic absorption (class 2)	3.10	5500
Spray rating (class 2)	3.10.1	5526
Liquid repellency (class 2)	3.11	4.5.3
pH	3.12	2811
Seam efficiency	3.13	5110 <u>5/</u>

1/ Unless otherwise specified, a certificate of compliance shall be submitted and will be acceptable for the stated requirement.

2/ The cotton content shall be calculated as follows:

$$\text{Cotton content, percent} = \frac{R}{S} \times 100$$

R = Weight of residual fibers

S = Weight of dry desized specimen

3/ Only the stain on the nylon and cotton fibers of the color transfer cloth shall be evaluated and stain shall be equal to or better than a rating of "fair".

4/ The contractor shall report the water repellents used and certify that no other material has been added.

5/ The needle shall measure  $0.040 \pm 0.001$  inch across the blade at the eye. The thread shall be polyester/cotton, rayon or polyester covered in accordance with MIL-T-43548, ticket No. 50, 2 or 3 ply for the needle and ticket No. 70, 2 or 3 ply for the looper.

4.4.4.1 Dimensional stability testing. In addition to the testing specified in 4.4.4, the cloth shall be tested for dimensional stability in accordance with 4.5.4 through 4.5.4.6.3. The sample unit shall be 2 continuous yards full width of the finished cloth. The lot size shall not exceed 150,000 yards. The sample size shall be in accordance with the following:

## MIL-C-44031D

<u>Lot size (yards)</u>	<u>Sample size (number of sample units)</u>
10,000 or less	5
10,001 up to and including 35,000	8
35,001 up to and including 150,000	13

4.4.5 Packaging inspection. The inspection shall be in accordance with the quality assurance provisions of PPP-P-1134.

#### 4.5 Methods of inspection.

4.5.1 Spectral reflectance measurements in the visible/near-infrared. Spectral reflectance data shall be obtained from 600 to 860 nm, at 20 nm intervals, on a spectrophotometer (see 6.9) for each color in the pattern, relative to a barium sulfate standard; the preferred white reference standard. Other white reference materials may be used, provided they are calibrated to absolute white; for example, Halon, magnesium oxide, or vitrolite tiles (see 6.10). The spectral band-width at 860 nm shall be less than 26 nm. Reflectance measurements can be made by either the monochromatic or polychromatic mode of operation. When the poly-chromatic 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. Specimens shall be measured as a single layer backed with two layers of the same fabric and shade. Measurements will be taken on a minimum of two different areas, and the data averaged. The specimens shall be viewed at an angle no greater than 10 degrees from normal, with the specular component included. Photometric accuracy of the spectrophotometer shall be within 1 percent and wavelength accuracy within 2 nm. The standard aperture size used in the color measuring instrument shall be 1.0 to 1.25 inches in diameter. When the measured reflectance values for any color at four or more of the listed wavelengths do not meet the limits specified in table I, it shall be considered a test failure.

4.5.2 Colorimetric measurements for the acceptability equation. Each of the four colors from the Woodland pattern cited in 3.4.2.1 for both the standard sample and the test specimen shall be measured as specified in 4.5.1, except the spectral reflectance factor data shall be obtained in the visible wavelength range 400 to 700 nm only, and at 20 nm (or less) intervals. When the spectrophotometer is operated in the polychromatic mode, a source simulating CIE illuminant source D65 should be used. Colorimetric data (see 6.11), computed from the resulting spectral reflectance data, are applied to the equation for acceptability (see 6.12).

4.5.3 Liquid repellency test. Place a small specimen of the treated finished camouflage cloth (comprised of all four colors in the pattern) on a smooth horizontal surface, face-up. Using a pipette or eye dropper, gently deposit a drop of each liquid specified in 3.11 on the surface of each shade of the camouflage pattern. After 30 seconds, examine each color of the specimen under light at an angle. Absence of light reflectance at the cloth-drop interface for the N-dodecane drop shall be taken as evidence of wetting. The test shall be continued

## MIL-C-44031D

for 8 hours for the drops of tri-ethyl phosphate, di-methyl methyl phosphonate, and bis (2 ethyl hexyl) hydrogen phosphite. Absence of light reflectance at the cloth-drop interface for the three liquids after the 8-hour period shall be taken as evidence of wetting. Three specimens taken at various locations across the sample unit shall be tested. Evidence of wetting on any color of one or more specimens shall be considered cause for rejection of the lot represented by the sample.

#### 4.5.4 Dimensional stability test.

4.5.4.1 Test specimen. The test specimen shall be a square of cloth 24 inches by 24 inches.

4.5.4.1.1 Number of determinations for dimensional stability. Three specimens from each sample unit shall be tested in each of the warp and filling directions.

#### 4.5.4.2 Apparatus.

4.5.4.2.1 Wash wheel (see 6.14). A cylindrical wash wheel of the reversing type shall be used. The wheel (cage) shall be 20 to 24 inches inside diameter and 20 to 24 inches inside length. There shall be three fins each approximately 3 inches wide extending the full length of the inside of the wheel. One fin shall be located every 120 degrees around the inside diameter of the wheel. The wash wheel shall rotate at a speed of  $30 \pm 4$  revolutions per minute making 5 to 10 revolutions before reversing. The water inlets shall be large enough to permit filling the wheel to an 8 inch level in less than 2 minutes, and the outlet shall be large enough to permit discharge of this same amount of water in less than 2 minutes. The wash wheel shall be equipped with a pipe for injecting live steam that shall be capable of raising the temperature of water at an 8 inch level from 100° to 140°F in less than 2 minutes.

4.5.4.2.2 Wash wheel equipment. The wash wheel shall be equipped with a thermometer or other equivalent equipment for determining the temperature of the water during the washing and rinsing procedures, and with an outside water gage that will indicate the level of the water in the wheel.

4.5.4.2.3 Preheating tank or other device. A preheating device to supply water in quantity within  $\pm 4^{\circ}\text{F}$ .

4.5.4.2.4 Extractor (see 6.15). A centrifugal extractor of the laundry type with a perforated basket, approximately 11 inches deep by 17 to 20 inches in diameter with an operating speed of approximately 1500-1725 revolutions per minute.

## MIL-C-44031D

4.5.4.2.5 Drier (see 6.14). A drier of the rotary, tumble type having a cylindrical basket approximately 36 inches in diameter and 24 inches in length and rotating at  $35 \pm 2$  revolutions per minute. The drier shall be capable of maintaining a stack temperature within  $\pm 5^{\circ}\text{F}$  of the specified test temperature. The stack temperature shall be measured  $20 \pm 2$  inches from the exhaust opening of the drier.

4.5.4.2.6 Stamping device (see 6.17). A device capable of marking off an 18 inch distance with fine indelible ink lines.

4.5.4.2.7 Measuring ruler (see 6.17). An 18 inch plastic ruler or 18 inch metal tape, graduated to give percent change directly in 0.2 percent increments and read to the nearest 0.1 percent. (Based on an original 18 inch marking.)

4.5.4.2.8 Balance. Balance or scale capable of weighing the specimen to an accuracy of  $\pm 0.01$  g.

4.5.4.3 Reagents.

4.5.4.3.1 Synthetic detergent (see 6.16). Synthetic detergent shall conform to MIL-D-43362.

4.5.4.3.2 Sour. Sour shall conform to type I of P-S-683.

4.5.4.3.3 Water of not over 50 parts per million hardness.

4.5.4.4 Procedure.

4.5.4.4.1 Preparation of cloth. Prior to initial markings for determining dimensional stability and prior to determining the change after laundering, the cloth shall be brought to equilibrium under standard atmospheric conditions as defined in Section 4 of FED-STD-191. (A minimum of 4 hours is required.) A flat, open mesh screen rack is recommended for this purpose.

4.5.4.4.2 Preparation of specimens for dimensional stability.

4.5.4.4.2.1 Selection of specimens. The three specimens shall be cut from the cloth (sample unit) as follows: One specimen from each side of the cloth to within 3 inches of the selvage and one specimen from the center of the cloth. No two specimens shall contain the same filling yarns. The specimens shall be laid without tension on a flat surface, care being taken that the cloth is free from wrinkles or creases. Three distances, each 18 inches apart shall be measured and marked off parallel to each of the warp and filling directions of the specimen. The distances shall be a minimum of 6 inches apart and 2 inches from any edge of the specimen. The distances should be marked with indelible ink by a stamping device. The measured distances shall be parallel to the respective yarns. The specimen edges shall be slit by 1 inch diagonal cuts at intervals of about 6 inches on all four sides of the test specimen.

## MIL-C-44031D

4.5.4.4.2.2 Standard load. A standard load comprising the specimen under test and clean ballast of comparable size, weight and type of cloth shall be utilized. A total weight of 20 pounds consisting of specimen and ballast shall be used for the test.

4.5.4.4.2.3 Laundering procedure. Water of not over 50 parts per million hardness at the required temperature  $\pm 4^{\circ}\text{F}$  shall be introduced into the wash wheel to the designated level. The schedule of table V shall be followed. At the end of each time interval, the machine shall be stopped, drained without removing the load, and refilled to the proper level before starting again. The wheel shall be in motion a total of 22 minutes during the period of testing.

TABLE V. Laundering schedule

Operation	Composition	Water volume gallons	Water level inches <u>1/</u>	Temperature $^{\circ}\text{F}$	Time (minutes)
1. Suds	Synthetic detergent (10 g)	14.3	6	100	5
2. Suds	Synthetic detergent (6 g)	9.3	4	140	5
3. Rinse	---	20.5	8	140	3
4. Rinse	---	20.5	8	120	3
5. Rinse	Sour (24 g)	20.5	8	100	3
6. Rinse	---	20.5	8	100	3

1/ The water levels are based on a wash wheel with a 24 inch diameter and a 24 inch length and may have to be adjusted to give the specific volumes.

4.5.4.4.2.4 Drying procedure. After laundering, the standard load shall be extracted in two equivalent portions, a minimum of 3 minutes each. The specimens shall be separated, opened to full width, and dried together with the ballast at  $190 \pm 5^{\circ}\text{F}$  for 60 minutes in a rotating tumble drier.

4.5.4.5 Evaluation.

4.5.4.5.1 Evaluation of cloth for dimensional stability. Immediately after tumble drying, the specimens shall be laid out, without tension or pressing, on a flat surface in the standard atmosphere until moisture equilibrium is reached.



## MIL-C-44031D

(A minimum of 4 hours is required.) Care shall be taken that each specimen is smooth and free from wrinkles or creases. The previously measured distances marked on each specimen shall again be measured in both the warp and filling directions using the measuring ruler specified in 4.5.4.2.7.

4.5.4.5.2 Calculation of results. The dimensional stability of the cloth shall be calculated as follows:

Shrinkage, percent =

Average of percent measurements after laundering (three specimens)

4.5.4.6 Report of test results.

4.5.4.6.1 Dimensional stability.

4.5.4.6.2 Shrinkage. The shrinkage of the sample unit in the warp direction and in the filling direction shall be the average of three specimens tested from each direction, respectively, and shall be reported separately to the nearest 0.1 percent.

4.5.4.6.3 Elongation. When a test result registers elongation rather than shrinkage, each elongation result shall be prefixed with a minus sign with both the minus sign and the value inclosed in parenthesis.

## 5. PACKAGING

5.1 Put-up and preservation. Put-up and preservation shall be level A or Commercial as specified (see 6.2).

5.1.1 Levels A and Commercial. The cloth shall be put-up and preserved in accordance with the applicable requirements of PPP-P-1134.

5.2 Packing. Packing shall be level A, B or Commercial, as specified (see 6.2).

5.2.1 Levels A, B, and Commercial. The cloth shall be packed in accordance with the applicable requirements of PPP-P-1134.

5.3 Marking. In addition to any special marking required by the contract or purchase order, shipments shall be marked in accordance with PPP-P-1134.

## 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 intended for use in the combat camouflage uniform for woodland terrains.

## MIL-C-44031D

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification.
- b. Class required (see 1.2)
- c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
- d. When a first article is required (see 3.1, 4.3, and 6.3).
- e. Pattern drawing if required (see 3.5).
- f. Width of cloth required (see 3.6.2).
- g. Length if other than specified (see 3.14).
- h. Levels of preservation and packing (see 5.1 and 5.2).

6.3 First article. When a first article is required, it shall be inspected and approved under the appropriate provisions of FAR 52.209. The first article should be a preproduction sample. The contracting officer should specify the appropriate type of first article and the number of units to be furnished. The contracting officer should include specific instructions in acquisition documents regarding arrangements for selection, inspection, and approval of the first article.

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

6.5 Fabric defect scales. Fabric Defect Replica Kits are available from:

Sears Roebuck and Company  
 Department 817, (ATTN: BSC 23-29)  
 Sears Tower  
 Chicago, IL 60684

6.6 Pattern areas. The areas of the pattern have been found to be satisfactory when dyed or printed by the selection from among the following colorants:

Light Green 354

Vat Orange 2  
 Vat Green 1  
 Vat Yellow

Dark Green 355

Vat Brown 3  
 Vat Green 1  
 Vat Yellow 2

Black 357

Sulphur Black 6  
 Vat Blue 20  
 Vat Brown 3  
 Vat Black 11

Ground Shade

Acid Blue 258  
 Tectilon Orange 4R  
 Vat Orange 2  
 Vat Green 1  
 Vat Yellow 2

## MIL-C-44031D

Brown 356

Vat Brown 57  
Vat Brown 3  
Vat Yellow 2  
Vat Green 1

6.6.1 Printing. Satisfactory printing on Shades Light Green 354, Dark Green 355, and Brown 356 has been accomplished by the use of vat dyes only. Shade Black 357 has been satisfactorily printed with a combination of vat and sulfur dyes.

6.7 Quarrel water repellent (class 2). The "Quarrel type" water repellent treatment consists of the co-application of an emulsified fluorocarbon and a fluorocarbon extender. Approval of components and combinations is the responsibility of U.S. Army Natick Research, Development, and Engineering Center, Natick, MA 01760 and is based on extensive tests, including those for toxicity which are not set forth in this specification. Because of the time necessary to conduct full evaluation (approximately 6 months), only those chemical treatments already approved and so listed in the invitation for bids or request for proposals shall be considered acceptable for the related procurement.

6.8 Air permeability. Not all cloth capable of meeting class 1 air permeability requirements will be capable of meeting class 2 air permeability requirements.

6.9 Spectrophotometers. Suitable spectrophotometers for measuring spectral reflectance in the visible/near-infrared are the Diano Hardy, Diano Match Scan, Hunter D-54 P-IR, Hunter Vis/NIR Spectrocolorimeter and Macbeth 1500 with IR option (see 4.5.1).

6.10 White standard. Barium sulfate of suitable quality for use as a white reference standard is available from Eastman Kodak Company. The same source has available magnesium reagent (ribbon) and Halon. Suitable tiles can be obtained from the National Bureau of Standards or the instrument manufacturers (see 4.5.1).

6.11 CIE Tristimulus and CIE L\*a\*b\* values. The spectral reflectance values obtained from 400 to 700 nm for a color are used to compute the tristimulus values X, Y, and Z, using CIE Illuminant D<sub>65</sub> and the 1976 CIE 10° Supplementary Standard Colorimetric Observer. The tristimulus values are converted to CIE L\*a\*b\* for use in the acceptability equation (see 6.12). Most spectrophotometers are interfaced to computers that automatically compute CIE tristimulus values, and CIE L\*a\*b\* values. Derivation of tristimulus values can be found in, "Color in Business, Science and Industry", Third Edition, D.B. Judd and G. Wyszecki, John Wiley & Sons, New York, NY. Conversion of tristimulus values to CIE L\*a\*b\* values is described in CIE publication, "Recommendations of Uniform Color Spaces, Color Difference Equations, and Psychometric Color Terms", Supplement No. 2 to CIE Publication No. 15, "Colorimetry, E-1.3.1 (1971), Bureau Central de la CIE, Paris (1978).

## MIL-C-44031D

6.12 Acceptability equation. Color acceptability is determined by the following equation:

$$\Delta A = [g_{11}(\Delta a^*)^2 + 2g_{12}\Delta a^*\Delta b^* + g_{22}(\Delta b^*)^2 + g_{33}(\Delta L^*)^2]^{1/2}$$

where  $\Delta A$  is an acceptability figure, scaled according to color (see 3.4.2.1); and the quantities  $\Delta a^*$ ,  $\Delta b^*$ ,  $\Delta L^*$  are sample minus standard in CIELAB coordinates. The coefficients  $g_{11}$ ,  $2g_{12}$ ,  $g_{22}$  and  $g_{33}$  are given by the following equations, where  $a_0^*$  and  $b_0^*$  represent the CIELAB  $a^*$  and  $b^*$  values of the standard,  $c$  is the chroma tolerance,  $h$  is the hue tolerance, and  $v$  (for value) is the lightness tolerance:

$$\theta = \tan^{-1} (b_0^*/a_0^*)$$

$$g_{11} = (\cos^2\theta/c^2) + (\sin^2\theta/h^2)$$

$$2g_{12} = 2\sin\theta\cos\theta [(1/c^2) - (1/h^2)]$$

$$g_{22} = (\sin^2\theta/c^2) + (\cos^2\theta/h^2)$$

$$g_{33} = 1/v^2$$

Hue, chroma, and lightness tolerances for the  
woodland pattern, nylon/cotton twill

	<u>Lightness (v)</u>	<u>Chroma (c)</u>	<u>Hue (h)</u>
Light Green 354	2.26	1.32	1.16
Dark Green 355	2.20	1.30	1.11
Brown 356	1.88	1.28	0.74
Black 357	2.70	1.50	1.25

Specimens recording  $\Delta A$  values less than those listed for each color in 3.4.2.1 represent acceptable matches for color to the standard; those specimens with higher  $\Delta A$  values are unacceptable.

Natick TR-80/036, Investigations to Define Acceptability Tolerance Ranges in Various Regions of Color Space, E. Allen and B. Yuhas, U.S. Army Natick RD&E Center, Natick, MA 01760-5019, September 1981, is available from Natick for those interested in writing a software program for the acceptability equation. A computer program for determination of  $\Delta A$  on Applied Color System's (ACS) Spectra Sensor is currently available from ACS, P.O. Box 5800, Princeton, NJ 08540.

6.13 Heat setting. The contractors are cautioned to insure that the cloth prior to printing has been properly heat set in order that the final dimensions of the pattern will be within the limits set forth in 3.5.

6.14 Wash wheel and drier. The wash wheel and drier as described may be obtained from Ewing Division of Powercom, P.O. Box 454, Troy, NY 12181.

MIL-C-44031D

6.15 Extractor. The extractor may be obtained from Ewing Division of Powercom, P.O. Box 454, Troy, NY 12181, American Laundry Machinery Company, 5050 Section Avenue, Cincinnati, OH 45212, Troy Laundry Machinery, East Moline, IL 61244, Bock Co., 3600 Summit Street, Toledo, OH 43611 and Pellerin Milnor Corporation, Kenner, LA 70062.

6.16 Detergent. Synthetic Laundering Detergent (under the name of Igepon T-77) may be obtained from GAF Corporation, Dyestuff and Chemical Division, 140 West 51st Street, New York, NY 10020.

6.17 Measuring device, stamping device, and ink. The measuring device, stamping device and indelible ink may be obtained from the Sanforized Co., 433 River Street, Troy, NY 12180.

6.18 Acceptance criteria. It is recommended that an acceptance value of one (1) be used for each of the following examinations:

- (a) Length examination (individual roll)
- (b) Roll identification marking

The acceptance criteria as specified in the contract or purchase order shall be binding.

6.19 Subject term (key word) listing.

- Combat uniform
- Fabric
- Print pattern
- Quarrel treatment

6.20 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:  
 Army - GL  
 Navy - NU  
 Air Force - 99

Preparing activity:  
 Army - GL  
 (Project 8305-0292)

Review activities:  
 Army - MD  
 Navy - MC  
 Air Force - 11, 82  
 DLA - CT

**INSTRUCTIONS:** In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgment will be mailed to you within 30 days to let you know that your comments were received and are being considered.

**NOTE:** This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

(Fold along this line)

(Fold along this line)

DEPARTMENT OF THE ARMY

U.S. ARMY NATICK RESEARCH, DEVELOPMENT  
and ENGINEERING CENTER  
ATTN: STRNC-ES  
Natick, MA 01760-5014

OFFICIAL BUSINESS  
PENALTY FOR PRIVATE USE \$300

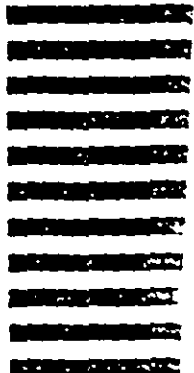


NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

**BUSINESS REPLY MAIL**  
FIRST CLASS PERMIT NO. 12062 WASHINGTON D. C.

POSTAGE WILL BE PAID BY THE DEPARTMENT OF THE ARMY

Commander  
U.S. Army Natick Research, Development  
and Engineering Center  
ATTN: STRNC-ES  
Natick, MA 01760-5014



## STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER MIL-C-44031D		2. DOCUMENT TITLE Cloth, Camouflage Pattern: Woodland, Cotton and Nylon	
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION (More than one)	
3b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER (Specify): _____	
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
6. REMARKS			
7a. NAME OF SUBMITTER (Last, First, MI) - Optional		8. WORK TELEPHONE NUMBER (Include Area Code) - Optional	
9. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional		10. DATE OF SUBMISSION (YYMMDD)	