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SUPERSEDING
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MILITARY SPECIFICATION

FUNGUS-RESISTANT TREATMENT FOR SANDBAGS; COPPER PROCESSES

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

1. SCOPE

1.1 Scope. This specification covers the processing of sandbags with copper compounds for protection against fungus attack. These processes are not intended for application to materials which will come into frequent contact with a person's skin.

1.2 Classification. The processing shall be of the following types, grades, and methods as specified:

Type I - Copper naphthenate.
  Grade A - Copper deposit 0.8 percent.
  Grade B - Copper deposit 0.55 percent.
  Method 1 - Solvent application.
  Method 2 - Oil-in-water emulsion application.
  Method 3 - Ammonia application.
Type II - Cuprammonium salts.
Type III - Copper 8-quinolinolate.
  Method 1 - Solvent application.
  Method 4 - Emulsion dispersion application.
  Method 5 - Two-bath aqueous precipitation application.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein:

STANDARDS

Federal

FED. TEST METHOD STD.
No. 191 - Textile Test Methods.

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(Copies of the standard required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Description. The fungus-inhibiting compounds shall be combined with such solvents - emulsifying, stabilizing, wetting, or bonding agents - as are necessary to insure that the fungus-inhibiting compounds can be uniformly applied and retained by the fabric being treated.

3.1.1 Type I, copper-naphthenate treatment. The copper naphthenate used in this treatment shall consist of a clear, green-colored liquid containing no sediment and manufactured from naphthenic acid occurring in petroleum. The naphthenic acid shall have an acid number of not less than 180 and shall contain not more than 25 percent unsaponifiable matter. Application to the fabric shall be effected by the applicable method as specified herein.

3.1.2 Type II, cuprammonium treatment. The active ingredient shall be carbonate of copper solubilized by means of aqueous ammonia.

3.1.3 Type III, copper 8-quinolinolate treatment.

3.1.3.1 Method 1, solvent application. The copper 8-quinolinolate shall be compounded into a formulation which will result in a stable, clear, single-phase solution free of visible solid particles when diluted with organic solvents.

3.1.3.2 Method 4, emulsion dispersion application. The copper 8-quinolinolate shall be compounded into a formulation which will form a stable emulsion of either oil-in-water or water-in-oil.

3.1.3.3 Method 5, two-bath aqueous precipitation. The copper 8-quinolinolate processing shall be accomplished as follows: The fabric shall be treated with an aqueous solution of 8-hydroxyquinoline in the presence of acetic acid and a suitable wetting agent, such as dodecyl benzene sodium sulfonate, at 85° C. plus or minus 3° C. and then squeezed to remove the excess solution. Then the fabric in wet condition shall be treated at room temperature with an aqueous solution of a cupric salt, preferably normal cupric acetate. The fabric shall be washed to remove any free copper salt or 8-hydroxyquinoline and then dried.

3.2 Materials. Materials used shall conform to standard commercial technical grades.

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3.3 Processing.

3.3.1 Penetration. The processing shall thoroughly impregnate the fa

3.3.2 Crocking. The crocking resistance of the treated fabric shall not less than "good" when tested as specified in table III.

3.3.3 Weight increase. The processing shall not increase the weight the fabric by more than 15 percent.

3.3.4 Uniformity. The processing shall provide a uniform deposit wit tar spots, bare spots, tackiness, streaks, or discoloration in the treat fabric.

3.4 Durability and flexibility. The treated fabric shall not crack, dust or flake when tested as specified in 4.3.2.2.

3.5 Burning time. The processing shall not decrease the burning time the treated fabric by more than 40 percent from the untreated fabric.

3.6 Spontaneous heating. When the treated fabric is heated in a Mack apparatus, the temperature of the treated fabric shall not exceed 105° C

3.7 Stability.

3.7.1 Acidity. After 48 hours of accelerated aging, as specified in table III, the treated fabric shall have a pH value numerically not less than 5.5.

3.7.2 Breaking strength. The processed fabric after 48 hours of acce erated aging, as specified in table III, shall have a breaking strength less than 90 percent of the breaking strength of unprocessed fabric aged the same manner.

3.8 Copper content. The copper content of the treatment applied to t fabric as received shall not exceed the concentration specified in table The copper content of the fabric after leaching shall not be less than t minimum concentrations specified in table I when tested as specified in table III.

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Table I. Copper Content of Treated Fabric

Type	Grade	Percent copper1/
I	A	1.0 ± 0.2
I	B	0.55 ± 0.05
II		1.75 ± 0.25
III		0.25 ± 0.10

1/ The percentage calculated as metallic copper shall be based on the dry weight of the treated fabric.

3.9 Fungus resistance. The uniformity of the fungus resistance imparted to type I and type II treated fabrics shall be such that the fabric will show no visible growth of fungus when tested as specified in 4.3.2.3.1. For type III treated fabrics the loss in breaking strength shall be not more than 10 percent when the fabric is tested as specified in 4.3.2.3.2, 4.3.2.3.2.2 and 4.3.2.3.2.3, when compared with identically treated cloth tested as specified in 4.3.2.3.2.

3.10 Sewability. The treatment shall not adversely affect the sewing quality of the fabric, and the seam efficiency shall be not less than 80 percent.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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 assure supplies and services conform to prescribed requirements.

4.2 Quality conformance inspection.

4.2.1 Unit of product. The unit of product shall be 1 linear yard, full width of the fabric.

4.2.2 Sample piece. The sample piece for examination and test shall be 2 linear yards, full width of the fabric.

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4.2.3 Sampling. Sampling for examination and test shall be in accordance with table II.

4.2.4 Examination. Samples selected in accordance with 4.2.3 shall be examined for the defects specified in 4.3.1. AQL shall be 1.5 defects per 100 units of product.

Table II. Sampling

Lot size in yards	Sample size in pieces	1.5 AQL		4.0 AQL	
		Ac.	Re.	Ac.	Re.
Up to 1,300 1/	5	0	1	0	1
1,301 to 3,200	7	0	1	0	1
3,201 to 8,000	10	0	1	1	2
8,001 to 22,000	15	0	1	1	2
22,001 to 110,000	25	1	2	2	3
110,001 and up	50	2	3	2	3

1/ If a lot contains fewer than five pieces, each piece in the lot shall be examined.

4.2.5 Tests. Samples selected in accordance with 4.2.3 shall be tested as specified in 4.3.2.1 through 4.3.2.3.2.3. AQL shall be 4.0 defects per 100 units of product.

4.3 Inspection procedure.

4.3.1 Examination. Fabric shall be examined as specified herein for the following defects. All defects 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 of yard in which it occurs.

101. Tar spots or stains.
102. Unevenly treated or thin area.
103. Bare spot.
104. Oil spots caused in treating.
105. Cut, hole or tear.
106. Incorrectly dried or tacky.
107. Hard crease.
108. Unclean overall.
109. Shaded end to end, side to center, side to side, or throughout the sample.

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110. Mottled, cloudy, or streaky throughout.
111. Discolorization.

4.3.2 Tests.

4.3.2.1 Physical and chemical properties. The physical and chemical properties of the treated fabric shall be determined in accordance with table III. The average of the determinations made in any test shall be used as the criteria for conformance or nonconformance to the applicable referenced paragraph. Specimens for the spontaneous heating test shall be 6 linear inches, full width of the material, shall be taken as soon as the material leaves the drying operation, and shall be hermetically sealed immediately in a suitable container and kept in the sealed container until required for the spontaneous heating test. Nonconformance to the reference paragraph in table III for the applicable test being conducted shall constitute failure of that test.

4.3.2.2 Durability and flexibility. Bend the sample through an angle of 180 degrees over a 1/4-inch diameter mandrel and run back and forth five times. Remove sample from the mandrel and shake by hand. Nonconformance to 3.4 shall constitute failure of this test.

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Table III. Tests

Test	Test Method 1/	Paragraph Reference	No. of determ. per unit of product.	Results reported each unit of product:
Sewability	5110	3.10	10	Average of 10 determinations to nearest 1.0 percent.
Weight increase	5041	3.3.3	5 2/	Average of 5 determinations to the nearest 0.10.
Accelerated aging	5850	3.7.2	10	See test for breaking strength.
Acidity	2811	3.7.1	2	Average of 2 determinations to nearest 0.10 pH.
Breaking strength	5100 or 5104	3.7.2	10 3/ 4/	Average of 10 determinations to nearest 1.0 pounds.
Leaching	5831	3.8	--	
Burning time	5906	3.5	5	Average of 5 determinations of the burning time in seconds, for test specimens to burn 10 inches 5/
Spontaneous heating	5920	3.6	2	Average of 2 determinations to nearest 1.0° C.
Crocking	5651	3.3.2	3	Not less than "good".
Copper Analysis				
(a) Types I and II	2050	3.8	2	Average of 2 determinations to the nearest 0.01 percent.
(b) Type III	2060	3.8	2	Average of 2 determinations to the nearest 0.01 percent.

1/ Test methods referenced herein are contained in FED. TEST METHOD STD. No. 191.

2/ All test results on the weight of basic untreated cloth and the finished cloth shall be averaged separately to determine the respective average weights. These values shall then be utilized in calculating the percent increase in the finished cloth weight. Results shall be calculated to the nearest 0.1 percent.

3/ Except that the breaking strength reported shall be the average of the results obtained from testing a minimum of 10 specimens in the warp direction. Method 5100 shall be used for loosely woven fabric; method 5104 for closely woven fabric.

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4/ Change in breaking strength shall be computed on the basis of the average breaking strengths of the treated and untreated fabrics as determined after accelerated aging.

5/ Calculate percent decrease in burning time as follows:

$$\frac{U-T}{U} \times 100 = \text{percent decrease in burning time.}$$

where: U = average of 5 determinations of burning time of untreated fabric.
T = average of 5 determinations of burning time of treated fabric.

4.3.2.3 Fungus resistance (see 6.3).

4.3.2.3.1 Chaetomium globosum.

4.3.2.3.1.1 Culture medium. The culture medium shall have the following composition:

NH_4HO_3	3.0 gm.
K_2HPO_4	1.0 gm.
$MgSO_4 \cdot 7H_2O$	0.5 gm.
KCl	0.25 gm.
Agar	15.0 gm.
Distilled water, to make	1000 ml.

The pH shall be 5.5 to 6.5; if otherwise, adjust to that range with HCl or NaOH. After mixing, the above ingredients shall be sterilized by autoclaving for 15 minutes at 15 psig (121° C.). Under sterile conditions, the medium shall be poured into Petri dishes or other suitable containers for culturing and allowed to harden.

4.3.2.3.1.2 Test organism. The organism used in this test shall be Chaetomium globosum, A.T.C.C. 6205. Stock cultures of this organism shall be carefully maintained on strips or squares of sterile porous filter paper or blotting paper on the test agar medium specified in 4.3.2.3.1.1, and promptly renewed if there is evidence of contamination. The cultures may be kept for not more than 4 months in a refrigerator at a temperature between 3° to 10° C. Subcultures incubated at 28° to 30° C. for 7 to 21 days shall be used in preparing the inoculum.

4.3.2.3.1.3 Inoculum. To a culture of the test organism in a ripe-fruiting condition add about 10 ml of sterile, distilled water containing about 0.005 percent of a nontoxic wetting agent. Force the spores into suspension by brushing with a sterile camel's hair brush (or other suitable means) and dilute to 100 ml with sterile water.

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4.3.2.3.1.4 Preparation of test specimens. Five specimens of 1-1/2 inches square selected at random shall be cut from the treated fabric sampl Specimens shall be leached for 24 hours as specified in table III.

4.3.2.3.1.5 Inoculation. Under aseptic conditions, immerse each test specimen in distilled water and place it firmly on the surface of the culture medium. With a sterile pipette or other suitable means distribute approximately 1.5 ml of inoculum over the surface of the specimen and surrounding medium.

4.3.2.3.1.6 Controls. Three untreated specimens of fabric shall be test along with the treated specimens to test the viability of the inoculum. At the end of the incubation period, the controls shall be well covered with the fungus growth.

4.3.2.3.1.7 Incubation. The period of incubation shall be 14 days at a temperature of 28° to 30° C. and a relative humidity of not less than 90.0 percent.

4.3.2.3.1.8 Failure criteria. Evidence of any fungus growth on the specimen shall constitute failure of this test.

4.3.2.3.2 Microbiological (type III). Unless otherwise specified herein fabric processed using type III treatment shall be tested as specified in 4.3.2.3.2.1. When specified, fabric processed using type III treatment shall be tested as specified in 4.3.2.3.2.2 or as specified in 4.3.2.3.3.

4.3.2.3.2.1 Aspergillus niger. This test shall be performed in accordance with the procedure specified in 4.3.2.3.1, except for the culture medi and the test organism.

4.3.2.3.2.1.1 Culture medium. The culture medium used in this test shal have the same composition as that specified in 4.3.2.3.1.1 with the excepti that 30 gm of dextrose shall be added to the other ingredients.

4.3.2.3.2.1.2 Test organism. The test organism used in this test shall be Aspergillus niger A.T.C.C. 6275. Stock cultures of this organism shall be carefully maintained on a potato-dextrose agar medium and promptly renew if there is evidence of contamination. The cultures may be kept for not more than 4 months in a refrigerator at a temperature between 3° to 10° C. Subcultures incubated at 28° to 30° C. for 10 to 14 days shall be used in preparing the inoculum.

4.3.2.3.2.1.3 Failure criteria. Evidence of any fungus growth on the specimens shall constitute failure of this test.

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4.3.2.3.2.2 Mixed culture. Test the fabric in accordance with FED. TEST METHOD STD. No. 191, method 5104 except that the specimens shall be prepared as specified in 4.3.2.3.2.2.4.

4.3.2.3.2.2.1 Culture medium. The culture medium used in this test shall be the same as that specified in 4.3.2.3.1.1.

4.3.2.3.2.2.2 Test organisms. The test organisms used in this test shall be Chaetomium globosum, A.T.C.C. 6205, Myrothecium verrucaria, A.T.C.C. 9095, and Aspergillus terreus, A.T.C.C. 10690. Stock cultures of these test organisms shall be carefully maintained and promptly renewed if there is evidence of contamination. Stock cultures of Chaetomium globosum and Myrothecium verrucaria will be maintained as specified in 4.3.2.3.1.2, and cultures of Aspergillus terreus will be maintained as specified in 4.3.2.3.2.1.2.

4.3.2.3.2.2.3 Inoculum. A suspension of spores of each of the organisms specified in 4.3.2.3.2.2.2 shall be prepared as described in 4.3.2.3.1.3. The three separate suspensions of spores shall be combined under sterile conditions and thoroughly mixed.

4.3.2.3.2.2.4 Preparation of test specimens. A total of 20 strips, 1.5 by 12 inches, selected at random, from the treated fabric shall be prepared and leached as specified in table III. Ten strips shall be cut in the direction of the warp, and 10 similar strips shall be cut in the fill direction. Each strip shall be given a designation number which shall be clearly marked on each end and then raveled to 1 inch by pulling approximately the same number of threads from each side. After leaching, each raveled strip, 1 by 12 inches, shall be cut into two specimens, 1 by 6 inches, one of which shall be subjected to the fungus test followed by a breaking strength test, and the other shall be subjected to the breaking test only.

4.3.2.3.2.2.5 Inoculation. Inoculation shall be performed as specified in 4.3.2.3.1.5.

4.3.2.3.2.2.6 Viability controls. One piece of sterile, untreated twine or cord, 2 inches in length, shall be placed 1 inch away from the test specimen in each dish to test the viability of the inoculum.

4.3.2.3.2.2.7 Incubation. The incubation period shall be 14 days at 29° C. plus or minus 1° C. and a relative humidity of not less than 90 percent. Upon completion of the incubation period, the specimens shall be subjected to the breaking strength test specified in 4.3.2.3.2.2.

4.3.2.3.2.2.8 Failure criteria. Nonconformance to 3.7.2 shall constitute failure of this test.

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4.3.2.3.2.3 Soil burial. The treated cloth shall be tested in accordance with FED. TEST METHOD STD. No. 191, method 5762, except the test fabric shall be leached according to FED. TEST METHOD STD. No. 191, method 5831 and buried vertically or horizontally, as specified, in soil varying in pH from 5.5 to 7.0. Nonconformance to 3.9 shall constitute failure of this test.

5. PREPARATION FOR DELIVERY

5.1 This section is not applicable to this specification.

6. NOTES

6.1 Intended use. This specification covers the copper processes which have been found to impart a high degree of fungus resistance to sandbag fabric.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) Type, grade, and method required (see 1.2).
(c) When type III processed fabric should be tested in accordance with 4.3.2.3.2.2 or 4.3.2.3.3 (see 4.3.2.3.2).
(d) Whether treated cloth will be buried vertically or horizontally (see 4.3.2.3.2.3).

6.3 Fungus test organisms. The organisms used in the fungus resistance test specified may be obtained from the American Type Culture Collection, 12301 Parklawn Drive, Rockville, MD 20852, or for Service use, from the Mycology Group, Pioneering Research Laboratories, U. S. Army Natick Laboratories, Natick, MA 01760.

Custodians:

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Air Force - 11

Review activities:

Army - MU, GL

User activities:

Army - MI

Preparing activity:

Army - ME

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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	b. WORK TELEPHONE NUMBER *(In Code)* – Optional
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