

INCH-POUND

MIL-DTL-28781C
10 November 2000
SUPERSEDING
MIL-C-28781B (EC)
18 January 1977

DETAIL SPECIFICATION

CABLE, ELECTRICAL, SPECIAL PURPOSE SHORE USE

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

1. SCOPE

1.1 Scope. This specification describes twisted-pair, multiconductor, shielded cables for use within shore communication stations and facilities.

1.2 Classification. Cables will be of the following number of pairs, as specified in the Invitation for Bids (IFB) or order (see 6.2):

1 pair
3 pairs
6 pairs
16 pairs
26 pairs
52 pairs
104 pairs

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 requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of these documents are those listed in the specific 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 that may be of use in improving this document should be addressed to: Defense Logistics Agency, Defense Supply Center, Columbus (DSCC-VAI), P.O. Box 3990, Columbus, OH 43216-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 6145

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SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-DTL-16878
MIL-DTL-16878/1

Wire, Electrical, Insulated, General Specification for
Wire, Electrical, Polyvinyl Chloride (PVC) Insulated, 105
°C, 600 Volts (Not for Navy Shipboard Use)

STANDARDS

FEDERAL

FED-STD-228

Cable and Wire, Insulated; Methods of Testing

(Unless otherwise indicated, copies of the above specifications and standards are available from the Document Automation and Production Service, DoDSSP, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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 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 SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B33

Wire, Tinned Soft or Annealed Copper, For
Electrical Purposes (DoD adopted).

ASTM D470

Wire and Cable, Crosslinked Insulations and Jackets
(DoD adopted).

ASTM D2240

Rubber Property-Durometer Hardness (DoD adopted).

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.)

INSULATED CABLE ENGINEERING ASSOCIATION (ICEA)

ICEA S61-402
(NEMA WC 5)

Thermoplastic-Insulated Wire and Cable for the
Transmission and Distribution of Electrical Energy (DoD
adopted).

(Application for copies should be addressed to the Insulated Cable Engineering Association, South Yarmouth, MA 02664)

MUNSELL COLOR COMPANY, INC.

Munsell Color Charts for Plastic Cable and Wire

(Application for copies should be addressed to the Munsell Color Company, Inc., 2441 N. Calvert Street, Baltimore, MD 21218).

3. REQUIREMENTS

3.1 First article sample. Prior to starting production of a particular class, a sample shall be tested unless otherwise directed by the contract (see 6.2 and 6.3). First article samples shall be fabricated by the manufacturer with tools and methods that, as far as practicable, are the same as those which will be used for quantity production of the product.

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3.2 Materials.

3.2.1 Conductors. The conductors shall utilize number 24 American Wire Gauge (AWG) (nominal diameter .0201 inch (.5105 millimeter)), tinned solid copper wire, in accordance with ASTM B33.

3.2.1.1 Joining conductors. Joints made in conductors may be brazed using a silver alloy solder and a non-acid flux, or welded. Joints shall be butted and shall be free from lumps and sharp projections. The tensile strength of any section of a conductor joint that was brazed or welded shall be not less than 85 percent of the tensile strength of an adjacent section without a joint.

3.2.1.2 Conductor resistance. The direct current (dc) resistance of each conductor shall not exceed 30 ohms per 1,000-foot (304.8-meter) length, when measured at, or corrected for, 68° F.

3.2.2 Insulation material. The insulation material shall be .010±.002-inch (.254±.051 millimeters) thick polyvinyl chloride, in accordance with MIL-DTL-16878 and MIL-DTL-16878/1, M16878/1BEA. A jacket of polyamide material .002±.001 inch (.508±.025 millimeter) thick shall be placed over the insulation. The outside diameter of the conductor, including insulation and polyamide material, is to be not greater than .0502 inch (1.275 millimeters) to permit application of commercially available cable connector devices.

3.2.2.1 Insulation defects. The insulation shall be smooth and free from holes, splits, blisters, and other imperfections.

3.2.2.2 Cold bend. The finished conductor insulation shall show no evidence of cracking or fracturing when cold bend tested in accordance with 4.6.4.

3.2.2.3 Color coding of insulation. The color coding shall be as shown in table I to identify each pair in the completed cable.

TABLE I. Color coding.

Pair Number	Color	Pair Number	Color
1	Blue and white (or natural)	27	Orange-white (stripe) and white (or natural)
2	Orange and white (or natural)	28	Green-white (stripe) and white (or natural)
3	Green and white (or natural)	29	Brown-white (stripe) and white (or natural)
4	Brown and white (or natural)	30	Slate-white (stripe) and white (or natural)
5	Slate and white (or natural)	31	Blue-white (stripe) and red
6	Blue and red	32	Orange-white (stripe) and red
7	Orange and red	33	Green-white (stripe) and red
8	Green and red	34	Brown-white (stripe) and red
9	Brown and red	35	Slate-white (stripe) and red
10	Slate and red	36	Blue-white (stripe) and black
11	Blue and black	37	Orange-white (stripe) and black
12	Orange and black	38	Green-white (stripe) and black
13	Green and black	39	Brown-white (stripe) and black
14	Brown and black	40	Slate-white (stripe) and black
15	Slate and black	41	Blue-white (stripe) and yellow
16	Blue and yellow	42	Orange-white (stripe) and yellow
17	Orange and yellow	43	Green-white (stripe) and yellow
18	Green and yellow	44	Brown-white (stripe) and yellow
19	Brown and yellow	45	Slate-white (stripe) and yellow
20	Slate and yellow	46 ^{1/2}	Blue-white (stripe) and violet
21	Blue and violet	47	Orange-white (stripe) and violet

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TABLE I. Color coding - Continued.

Pair Number	Color	Pair Number	Color
22	Orange and violet	48	Green-white (stripe) and violet
23	Green and violet	49	Brown-white (stripe) and violet
24	Brown and violet	50	Slate-white (stripe) and violet
25	Slate and violet	51	Red and white (or natural)
26	Blue-white (stripe) and White (or natural)	Spare ^{1/} (For 52 or 104 pair)	Red and Black

NOTE:

1/ At the manufacturer's option, pair number 46 and the Spare pair may be used to assure the required number of (non-defective) pairs.

3.2.2.3.1 Color standards. The colored insulation shall match the centroid colors of table II, within the limits of standards for colors as defined in Munsell Color Charts for Plastic Cable and Wire. The color pigments shall be chosen to yield uniform dielectric constant between colors and shall have no deteriorating effects on the insulation.

TABLE II. Munsell centroid colors.

		Tolerance Limits					
		Hue		Value		Chroma	
Color	Centroid	H-	H+	V-	V+	C-	C+
Red	2.5R 4/12	1.25R 4/12	3.75R 4/12	2.5R 3/12	2.5R 4.5/12	2.5R 4/10	None
Orange	2.5YR 6/14	1.25R 6/14	3.75YR 6/14	2.5YR 5/14	2.5YR 6.5/14	2.5YR 6/12	None
Brown	2.5YR 3.5/6	10R 3.5/6	5YR 3.5/6	2.5YR 3/6	2.5YR 4/6	2.5YR 3.5/4	2.5YR 3.5/7
Yellow	5Y 8.5/12	2.5Y 8.5/12	7.5Y 8.5/12	5Y 8/12	None	5Y 8.5/10	None
Green	2.5G 5/12	1.25 G5/12	3.75G 5/12	2.5G 4/10	2.5G 5.5/12	2.5G 5/9	None
Blue	2.5PB 4/10	10B 4/10	5PB 4/10	2.5PB 3.5/10	2.5PB 4.5/10	2.5PB 4/9	None
Violet	2.5P 4/10	1.25P 4/10	3.75P 4/10	2.5P 3/10	2.5P 4.5/10	2.5 4/8	None
Neutral Colors							
White	N 9/	Value Tolerances: V- is N 8.75; no V+ limit. Chromaticity Tolerances: 5R 9/1 5G 9/5 5YR 9/1 5B 9/5 5Y 9/1 5P 9/5					
Slate	N 5/	Value Tolerances: V- is N 4.5/; V+ is N 5.5/ Chromaticity Tolerances: 5R 5/5 5B 5/5 5Y 5/5 5P 5/5 5G 5/5					
Black	N 2/	Value Tolerances: No V- limit; V+ is N 2.3 Chromaticity Tolerances: 5R 2/5 5B 2/5 5Y 2/5 5P 2/5 5G 2/5					

3.2.2.3.2 Insulation stripes. Striping shall be such as to provide readily discernible stripes on the conductor insulation. These stripes may be integral of the insulation or the striping may be provided as an internal plastic coating. Striping shall firmly adhere to the insulation and remain intact through the life

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of the conductor insulation. Insulation striping in accordance with method 1 of ICEA S61-402 is acceptable.

3.2.2.4 Twisting of pairs. The insulated conductors shall be twisted into pairs. The average length of pair twists in any pair in the finished cable, when measured on any 10-foot (3.05-meter) length, shall not exceed 6 inches (152.4 millimeters).

3.2.2.4.1 Crosstalk loss. The root mean square (rms) output-to-output far-end crosstalk loss, as measured on the completed cable at a test frequency of 150-kilohertz (kHz), shall not be less than 70 dB per 1,000 feet (304.8 meters).

3.2.2.5 Heat resistance. The insulation shall exhibit no cracking or delamination and no readily visible defects in any of the wire components after being subjected to the heat conditions of MIL-DTL-16878/1.

3.2.2.6 Shrinkage. When subjected to contact with molten solder, the insulation shall not flare away from the conductor, open up over the bent portion called for in the test, nor shrink back more than .125 inch.

3.2.3 Cable forming. The twisted pairs shall be assembled to form a substantially cylindrical core. Adjacent layers may be stranded in the same direction or in opposite directions. For a 104-pair cable, the cable shall be formed in two 52-pair concentric units or four 26-pair units.

3.2.3.1 Binder. A colored binder shall be applied around the units for separation. The colors shall be readily recognizable. Bindings shall be applied with a lay of not more than 4 inches. The binder may be either a non-hygroscopic thread or tape.

3.2.3.2 Binder colors. The colors for each unit binder shall be as follows:

<u>Unit</u>	<u>Color of Binding</u>
1	Blue-White
2	Orange-White
3	Green-White
4	Brown-White
5	Slate-White

3.2.4 Core covering. The core covering shall be completely covered with Mylar® (Mylar is a registered trademark of E.I. DuPont Co.), polyethylene, or Mylar backed SBR (Styrene-Butadiene Rubber) or equivalent, which shall be non-hygroscopic and shall be applied with an overlap. The core covering shall provide a sufficient heat barrier to prevent visible evidence of conductor insulation deformation or adhesion between conductors caused by adverse heat transfer during the jacketing operation.

3.2.4.1 Dielectric strength. In each length of completed cable, the insulation between conductors, and between conductors and shield, shall withstand the dielectric dc potential for 3 seconds as follows:

	<u>dc volts</u>
Between conductors	3,600
Between conductors and shield	1,800

3.2.5 Shield. An overall tinned copper braid shield shall be applied over the core-covering. The shield shall cover 90 percent of the cable core.

3.2.5.1 Shield resistance. The dc resistance of the shield for a 1000-foot (304.8-meter) length of completed cable shall not exceed the values shown below:

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<u>No. of pairs</u>	<u>dc resistance</u>
1	5.75 ohms
3	4.00 ohms
6	3.50 ohms
26	2.10 ohms

3.2.6 Jacket material. The jacket material shall be black colored polyvinyl chloride containing a minimum of 1 percent of carbon black, or similar material, to resist ultraviolet light. The jacket material shall conform to the physical (finished cable) requirements outlined in 3.2.6.1 through 3.2.6.4. The cable jacket shall have a Type A durometer hardness of 80±5.

3.2.6.1 Tensile strength. The cable jacket shall have a minimum tensile strength of 2000 pounds per square inch (psi).

3.2.6.2 Elongation. The cable jacket shall have a minimum elongation of 250 percent.

3.2.6.3 Jacket thickness and outside cable diameter. The jacket thickness and outside cable diameter shall be as specified in table III. The minimum spot thickness of the jacket shall not be less than 70 percent of the specified thickness. The average thickness at any cross-section of the jacket material shall be not less than 90 percent of the specified thickness.

TABLE III. Jacket thickness and outside diameter (OD).

No. of pairs	Nominal jacket thickness		Approx. OD	
	inches	Millimeters	inches	millimeters
1	.050	1.270	.227	5.765
3	.050	1.270	.315	8.001
6	.050	1.270	.388	9.855
16	.062	1.5748	.506	12.852
26	.062	1.5748	.615	15.621
52	.062	1.5748	.781	19.837
104	.070	1.778	1.137	28.900

3.2.6.4 Cold bend for jacket material. A sample of the finished cable shall show no evidence of cracking or fracturing.

3.2.7 Cable marking. A tape shall be permanently marked and inserted between the jacket and shield. The length shall be marked every 12 inches (30.48 centimeters). The tape shall be marked at least every 24 inches (60.96 centimeters) with the following:

- a. Manufacturer's name (or symbol designation).
- b. Date of manufacture.
- c. Contract number.
- d. Specification number.

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3.3 Electrical requirements.

3.3.1 Mutual capacitance. The average mutual capacitance of all pairs in a completed reel of cable of three or more pairs shall not exceed .152 microfarad (μF) per 1 mile (1.609 kilometers). The average mutual capacitance of all pairs also shall not exceed .160 μF per 1 mile for cables of less than three pairs. The mutual capacitance test shall be performed in accordance with 4.6.2. Note: The objective is the lowest practical average mutual capacitance with all individual pair mutual capacitances as close as practical to the average value for the reel.

3.3.2 Capacitance unbalance.

3.3.2.1 Pair-to-pair capacitance unbalance. The pair-to-pair capacitance unbalance for a 1000-foot (304.8-meter) length of completed cable measured at $1,000 \pm 100$ Hz shall not exceed the following:

Less than 16 pairs	100 picofarads (pF) max individual
16 or more pairs	40 pF rms

For lengths of cable other than 1000 feet (304.8 meters), the value shall be converted to 1000-foot (304.8-meter) values by dividing the unbalance of the length measured by the square root of the ratio of the length measured to 1,000 feet. In cables with 52 pairs and less and in each group of multigroup cables, the unbalances to be considered shall be:

- a. Between pairs adjacent in a layer.
- b. Between pairs in centers of four pairs or less.
- c. Between pairs in adjacent layers, when the number of pairs in the inner (smaller) layer is six or less. In this, the center is counted as a layer.

3.3.2.2 Pair-to-shield capacitance unbalance. The pair-to-shield direct capacitance unbalance for a 1000-foot (304.8-meter) length of completed cable, when measured at $1,000 \pm 100$ Hz, shall conform to the following: (a) The conductor-to-shield capacitances of the two conductors of the pair under test shall balance within 6 percent of the value of the lowest conductor-to-shield capacitance of the pair; and (b) the maximum deviation of any pair difference shall not exceed the average of the differences of all pairs of the cable by more than 500 pF. Note: "Pair difference" is the difference between the conductor-to-shield capacitances of the two conductors of the pair.

3.3.3 Continuity. In each length of cable, the conductors shall be free from grounds (contacts between a conductor and shield), short circuits, and open circuits. The shielding shall be free from open circuits.

3.4 Cable put-up. Cable shall be put-up on reels in lengths-per-reel as specified in the solicitation (see 6.2).

4. VERIFICATION

4.1 Requirements cross-reference matrix. Table IV provides a cross-reference matrix of the section 3 requirements tested or verified in the paragraphs below.

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TABLE IV. Requirements cross-reference matrix.

Requirement	Verification	Requirement	Verification
3.1	4.4	3.2.3.2	4.6.1
3.2	4.6.1	3.2.4	4.6.1
3.2.1	4.6.1	3.2.4.1	4.6.6
3.2.1.1	4.6.1, 4.6.8	3.2.5	4.6.1
3.2.1.2	4.6.7	3.2.5.1	4.6.7
3.2.2.1	4.6.1	3.2.6	4.4, 4.6.10
3.2.2.2	4.6.4	3.2.6.1	4.6.5
3.2.2.3	4.6.1	3.2.6.2	4.6.5
3.2.2.3.1	4.5.2.3, 4.6.1	3.2.6.3	4.6.1
3.2.2.3.2	4.6.1	3.2.6.4	4.6.4, 4.6.4.1, 4.6.4.2
3.2.2.4	4.6.1	3.2.7	4.6.1
3.2.2.4.1	4.6.9	3.3.1	4.6.2
3.2.2.5	4.6.12	3.3.2.1	4.6.3.1
3.2.2.6	4.6.12	3.3.2.2	4.6.3.2
3.2.3	4.6.1	3.3.3	4.6.11
3.2.3.1	4.6.1	3.4	4.6.1

4.2 Responsibility for inspection. Unless otherwise specified in the contract or purchase order (see 6.2), 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 the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2.1 Government verification. All inspections performed by the supplier will be subject to Government verification at any time. Verification will consist of the following:

- a. Surveillance of the operations to determine that practice, methods, and procedures of the written inspection system are being properly applied.
- b. Government product inspection to measure contract parameters of a product to be offered for acceptance.
- c. Government inspection of delivered items to assure compliance with this specification and as specified in the contract or order.

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

- a. First article (see 4.4).
- b. Conformance inspection (see 4.5).

4.4 First article inspection. First article inspection shall be performed on 500 feet (152.4 meters) of cable specified in the IFB (see 6.2). Certification of compliance for the basic materials may be obtained from the supplier of the material, providing that such certification contains actual test, examination, or other verifiable data (see 6.3).

4.4.1 Test methods. The first article samples shall be subjected to the tests listed in table V. No failures will be permitted.

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TABLE V. First article inspection.

Examination and test	Requirement paragraph	Test method paragraph
Visual and dimensional	3.2.1, 3.2.1.1, 3.2.2, 3.2.2.1, 3.2.2.3, 3.2.2.3.1, 3.2.2.3.2, 3.2.2.4, 3.2.3, 3.2.3.1, 3.2.3.2, 3.2.4, 3.2.5, 3.2.6, 3.2.6.3, 3.2.7, 3.4	4.6.1
Continuity	3.3.3	4.6.11
Conductor resistance	3.2.1.2	4.6.7
Mutual capacitance	3.3.1	4.6.2
Capacitance unbalance	3.3.2	4.6.3
Insulation:		
Material	3.2.2	4.6.1
Defects	3.2.2.1	4.6.1
Cold bend	3.2.2.2	4.6.4
Tensile strength and elongation	3.2.2	4.6.5
Striping (if applicable)	3.2.2.3.2	4.6.1
Color coding	3.2.2.3	4.6.1
Color standards	3.2.2.3.1	4.6.1
Heat resistance	3.2.2.5	4.6.12
Shrinkage	3.2.2.6	4.6.12
Twisting of pairs	3.2.2.4	4.6.1
Binder thread or tapes	3.2.3.1, 3.2.3.2	4.6.1
Core covering	3.2.4	4.6.1
Crosstalk	3.2.2.4.1	4.6.9
Shield:		
Resistance	3.2.5.1	4.6.7
Jacket:		
Hardness	3.2.6	4.6.10
Cold bend	3.2.6.4	4.6.4
Tensile strength	3.2.6.1	4.6.5
Elongation	3.2.6.2	4.6.5
Dielectric strength	3.2.4.1	4.6.6

4.5 Conformance inspection.

4.5.1 Inspection lot. Cable of the same size (number of pairs) and color coding, offered for delivery at one time, shall be considered a lot for purposes of sampling and inspection.

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4.5.2 Group A inspection. The Group A inspection shall consist of the tests shown in table VI.

Table VI. Group A inspection.

Examination and tests	Requirement paragraph	Test method paragraph
Visual and dimensional	3.2.1, 3.2.2, 3.2.1.1, 3.2.2.1, 3.2.2.3, 3.2.2.4, 3.2.3, 3.2.3.1, 3.2.4, 3.2.5, 3.2.3.2	4.6.1
Continuity	3.3.3	4.6.11
Jacket thickness and OD	3.2.6.3	4.6.1
Insulation defects	3.2.2.1	4.6.1
Insulation striping	3.2.2.3.2	4.6.1
Insulation colors: Pre-mixed (mixed in plant)	3.2.2.3.1	4.3
Mixed (Mixed by material manufacturer)	3.2.2.3.1	4.3
Dielectric	3.2.4.1	4.6.6

4.5.2.1 Sampling for visual and dimensional examination. Each reel shipping length shall be examined to verify conformance to 4.6.1 and the requirements in table VI. The number of pairs to be examined shall be as follows:

<u>Pairs in the cable</u>	<u>Pairs to be examined</u>
1	1
3	2
6	3
16	5
26	8
52	13
104	20

Any defect in a sample shall cause rejection of the shipping length. In the event that a defect or error is found at any inspected end, the other end of that length shall be examined for the same defect. The reel that contains the adjacent section of cable shall also be examined for the same defect.

4.5.2.2 Sampling for insulation and continuity tests. In each shipping length of cable, tests shall be performed on the number of pairs specified in 4.5.2.1. Each of the selected pairs shall be subjected to all of the tests necessary to verify conformance to 3.2.2, 3.2.2.1 and 3.3.3, respectively. If any pair fails in any test, the entire length of cable shall not be offered for delivery. The same pair on the adjacent reels shall be subjected to the same test in which the failure occurred.

4.5.2.3 Sampling for measurement of colors. In each shipping length of cable, pairs shall be selected at random for verification of the color in accordance with 3.2.2.3 by comparison with Munsell color cards. The number of pairs so examined shall be the same as specified in 4.5.2.1. If any pair is found not having color as specified, every pair in that cable length shall be compared with the Munsell color card. Also, the reels of cable preceding and following shall be examined to determine the extent of the incorrect coloring. If the colored insulation does not conform to the requirements of 3.2.2.3, the lot shall not be offered for delivery.

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4.5.3 Group B inspection. The Group B inspection shall consist of tests shown in table VII.

TABLE VII. Group B inspection.

Examination and tests	Requirement paragraph	Test method paragraph
Mutual capacitance	3.3.1	4.6.2
Capacitance unbalance	3.3.2	4.6.3
Conductor resistance	3.2.1.2	4.6.7
Shield resistance	3.2.5.1	4.6.7
Crosstalk	3.2.2.4.1	4.6.9

4.5.3.1 Sampling for Group B tests. The sample size (number of reels) of each lot of prepared cable to be tested under Group B tests listed in table VII shall be in accordance with the sample sizes stated below in table VIII for the cable construction (number of pairs) involved. If one or more defects are found in the inspection sample, then the production lot shall be inspected for that particular defect and the defects removed. A second inspection sample shall be selected from the production lot and all sampling tests again performed. If one or more defective items are found in the second inspection sample, the production lot shall be rejected and shall not be supplied to this specification.

TABLE VIII. Sample sizes.

Number of pairs in Assembled cable	Sample Size
1	1
3	2
6	2
16	5
26	5
52	5
104	5

Any test failures in any sample reel for any test listed in table VII of this specification shall be cause for rejection of the entire lot of the cable size represented by the sample reel under test on the basis of the parameters being tested.

4.5.4 Rejected lots. If any inspection lot is rejected, the supplier may replace it with a new lot, rework it to correct the defects, or screen out the defective units, and reinspect the lot. Such lots shall be inspected using table IX below. Reinspected lots shall be kept separate from new lots and shall be clearly identified as reinspected lots.

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TABLE IX. Reinspected lots.

Number of pairs in assembled cable	Sample	Sample Size
1	First	1
	Second	1
3	First	2
	Second	2
6	First	2
	Second	2
16	First	3
	Second	3
26	First	3
	Second	3
52	First	3
	Second	3

4.6 Methods of inspection.

4.6.1 Visual and dimensional examination. Finished wire shall be examined to determine that the materials, physical dimensions, construction, splices, marking, and workmanship conform to the applicable requirements. The color coding, shielding, core covering, binder marking, pair twist rate, cable forming, and jacket thickness shall be examined at the ends of the shipping length of cable on the reel. The cable shall be examined for jacket imperfections on all of the surface which is visible without unwinding the cable from the reel.

4.6.2 Mutual capacitance test. The mutual capacitance test shall be performed on the cable shipping length in place on the reel. Mutual capacitance is the effective capacitance between the two wires of a pair. Mutual capacitance may be measured on individual pairs, or the average mutual capacitance may be on a number of pairs in groups. The mutual capacitance shall be measured by using a suitable capacitance or impedance bridge with a test frequency of 1000 ± 100 Hz. Where group measurements of mutual capacitance are performed with cables exceeding 26 pairs in size, these measurements should be made on individual groups rather than on all pairs of the cable grouped together for a single average measurement. In any reel of 12 pairs or more, the rms deviation of mutual capacitance of all the pairs tested from the average mutual capacitance of that reel shall not exceed four percent.

4.6.3 Capacitance unbalance test. The capacitance unbalance test shall be performed on the cable shipping length in place on the reel.

4.6.3.1 Pair-to-pair capacitance unbalance. The capacitance involved and test methods are shown in figure 1. One and two represent the two conductors of a pair. Three and four represent the two conductors of a second pair. The capacitances, namely C_{13} , C_{14} , C_{23} , C_{24} , C_{12} , and C_{34} are the direct capacitances between conductors.

The capacitances C_{1g} , C_{2g} , C_{3g} , and C_{4g} are the direct capacitances between wires 1 through 4, respectively, and all other conductors in the cable connected to the shield and ground. The pair-to-pair capacitance unbalance is: $(C_{14} + C_{23}) - (C_{13} + C_{24})$

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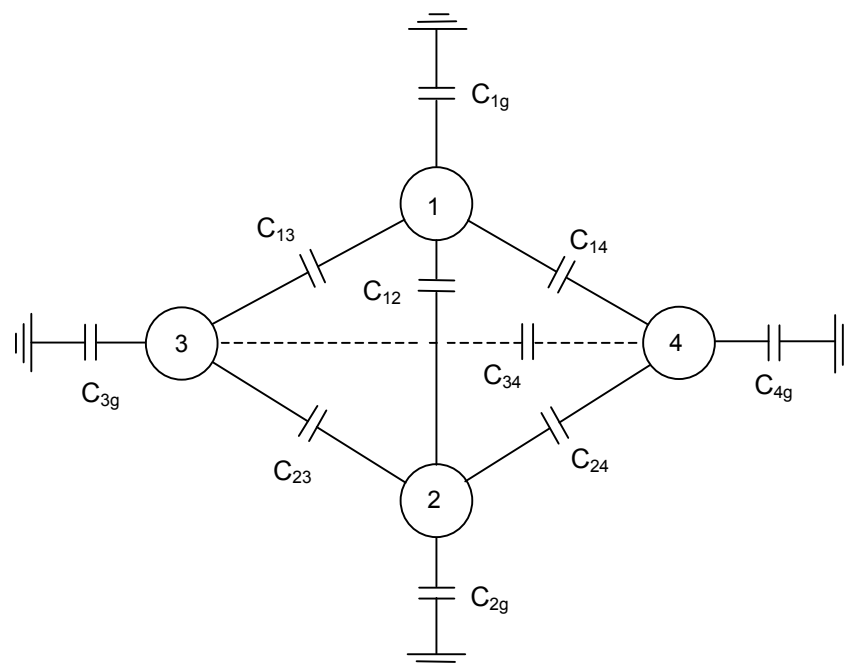


Figure 1. Test method for determining capacitance unbalance of pair-to-pair.

4.6.3.2. Pair-to-shield capacitance unbalance. In figure 2, S indicates all wires (except conductors 1 and 2) bunched together. Wires 1 and 2 have a direct capacitance between them as well as a direct capacitance to the shield. Wires 1 and 2 also have direct capacitance to S, and S has a direct capacitance to the shield.

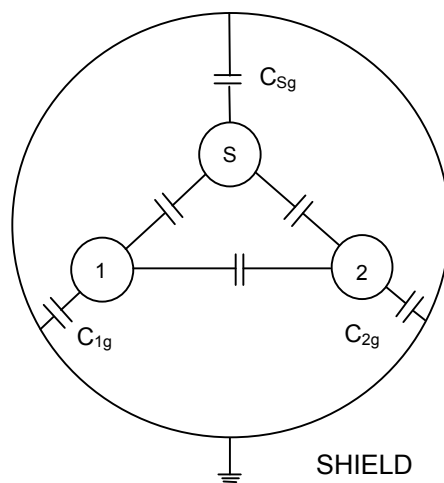


Figure 2. Test method for determining capacitance unbalance of pair-to-shield.

The pair-to-shield direct capacitance unbalance for pair 1-2 is $C_{1g} - C_{2g}$. The measurement of this difference shall be made in such a way that the measured value is not appreciably affected by the direct capacitances of wires 1 and 2 to other wires. A schematic of a form of measuring bridge often used to measure $C_{1g} - C_{2g}$ at 1,000 Hz, is shown in figure 3.

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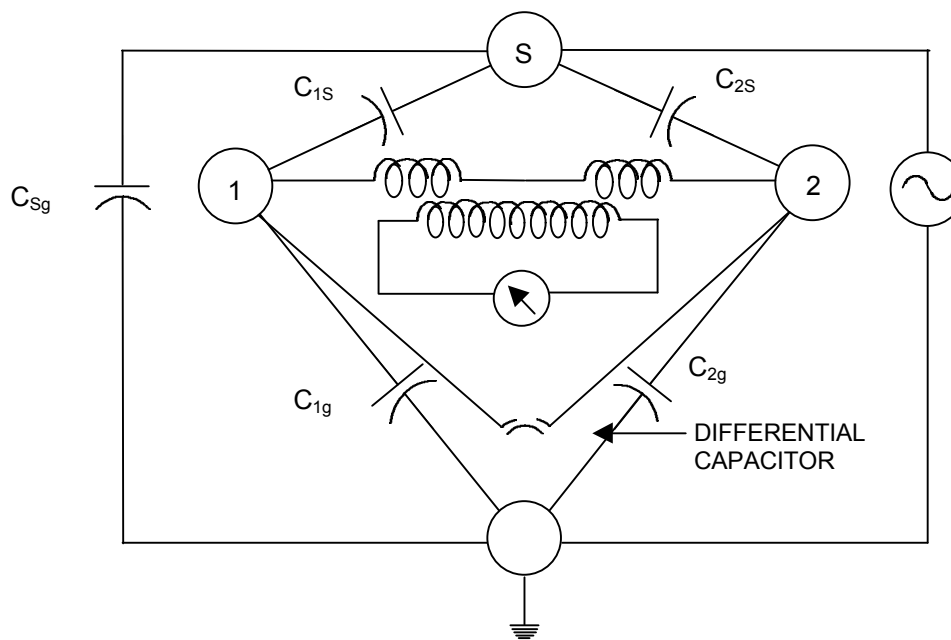


Figure 3. Test method for determining capacitance unbalance of pair-to-shield.

S indicates all wires (except conductors 1 and 2) bunched together. If a group or subgroup is always separated from the shield (by other groups or subgroups) the wires of a pair in the separated group have very small direct capacitances to the shield and their difference is negligible.

4.6.4 Cold bend test. The cold bend test for the insulation material and jacket material shall be performed as specified in 4.6.4.1 and 4.6.4.2.

4.6.4.1 Specimens. For cables with an overall diameter of less than .5 inch (12.70 millimeters), the test specified in 4.6.4.2 shall be conducted on three specimens of cable; the length of each specimen shall be at least 150 times the diameter. For cable of .5 inch (12.70 millimeters) and greater nominal diameter, the test specified in 4.6.4.2 shall be conducted on two specimens of cable. The length of each specimen shall be at least 120 times the diameter of the cable.

4.6.4.2 Procedure. One end of the test specimen shall be clamped circumferentially at two points, approximately 45 degrees apart, to a mandrel whose diameter is 10 times that of the test specimen. The specimen shall then be conditioned for 20 hours at -40 ± 4 °F (-40 ± 2 °C) except for cable .250 inch (6.35 millimeters) overall nominal diameter and smaller, which shall be conditioned for 20 hours at -58 ± 4 °F (-50 ± 2 °C). During this conditioning period, the specimens shall be kept reasonably straight. After this conditioning, but while the specimens are still in the cold chamber at the conditioning temperature, the specimens shall be wrapped for three close turns (two close turns for cables having a diameter .5 inch (12.70 millimeters) and greater) around the mandrel. This shall be done at a uniform rate of 15 ± 3 revolutions per minute, preferably by means of an electrically driven motor. The cable shall be guided by a free moving sheave or transversing device, in intimate contact with the cable at the initial point of bend. The cable shall be removed from the cold chamber and shall satisfactorily meet the dielectric withstanding voltage requirement of 3.2.4.1. The cable shall be visually examined for evidence of cracks or flaws in the insulation material or jacket.

4.6.5 Tensile strength and elongation test. Samples of the conductor insulation or the jacket material, removed from the finished cable or conductor, shall be tested in accordance with standard ASTM D470 for the conductor insulation and jacket. The tensile strength of the cable jacket shall be

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tested in accordance with FED-STD-228, method 3021, or ASTM D470. The cable jacket elongation shall be tested in accordance with FED-STD-228, method 3031, or ASTM D470.

4.6.6 Dielectric test. The cable shall be subjected to the dielectric test as specified in Method 6111 of FED-STD-228.

4.6.7 Resistance test. The resistance of the conductors and shield shall be measured as specified in Method 6031 of FED-STD-228.

4.6.8 Joining conductors test. The tensile strength of any section of a conductor joint that was brazed or welded shall be tested to determine conformance to 3.2.1.1.

4.6.9 Crosstalk loss test. The rms crosstalk loss calculation shall be based on the combined total of all adjacent and alternate pair combinations within the same layer and center-to-first layer pair combinations. The rms crosstalk loss is the number of dB corresponding to the rms crosstalk voltage ratio. If the crosstalk loss is K_o dB at a frequency of f_o for a length L_o , it can be determined for any other length L or frequency f by:

$$K_{\frac{f}{L}} \text{ loss} = K_o - 20 \log_{10} \frac{f}{f_o} - 10 \log_{10} \frac{L}{L_o}$$

4.6.10 Jacket hardness test. Samples of the conductor jacket shall be tested for hardness in accordance with ASTM D2240.

4.6.11 Continuity test. Test continuity of all conductors with a low dc voltage and an appropriate indicating meter. Using a minimum test voltage of 100 V dc, test each conductor individually to verify that each conductor is free of any contact with the shield or any of the other conductors that may be bunched together.

4.6.12 Heat resistance and solder shrinkage. Heat resistance and solder shrinkage tests of MIL-DTL-16878 shall be performed on the finished insulated conductor.

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 material is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

6.1 Intended use. The cable described in this specification is intended for use in shore stations and facilities.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. Number of pairs in cable (see 1.2).
- c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).

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- d. If a first article inspection should not be performed (see 3.1).
- e. Length of first article samples, if other than as specified in 4.4.
- f. Number of feet of cable required on each reel (see 3.4 and 6.5.1).
- g. Inspection conditions, if other than as specified (see 4.2).
- h. Packaging, packing, and marking requirements other than those required by 5.1 and 6.5.

6.3 First article. Invitations for bids should provide that the Government reserves the right to waive the requirement for first article samples for those bidders offering a product which has been previously procured or tested by the Government. Also, bidders offering such products who wish to rely on such production or test must furnish evidence with the bid that prior Government approval is presently appropriate for the pending procurement (see 4.4).

6.3.1 Size of cable. The invitations for bids should specify the size (number of pairs) of cable to be tested under first article test requirements. (If all constructions are procured, the 26-pair construction should normally be specified.)

6.4 Changes from previous issue. Due to the extent of the changes, marginal notations are not used in this revision to identify changes with respect to the previous issue.

6.5 Packaging. MIL-C-12000 has been used in the past to specify requirements for the preservation, packing, unitization, and marking of cable, cord, and wire for storage and domestic and overseas shipments.

6.5.1 Reels. Cables should be furnished on non-returnable reels which should contain lengths as specified in 6.2. The cable lengths should have both ends brought out so that cable can be readily tested without unreeling. The reels should be constructed with flanges of sufficient thickness to protect the cable from damage during handling, shipment, and storage. The diameter of the reel core should be not less than 20 times the diameter of the cable.

6.5.2 Marking. In the past, both flanges of each reel have been marked in accordance with MIL-STD-129 with the following information:

- a. Reel number
- b. Number of pairs in cable
- c. Length and location of each piece in feet for reels of multi-lengths

Where practicable, metal tags, stencil, or paper labels containing the information specified above should be securely attached to the reels. Where paper labels are used, they should be securely attached and protected by a transparent compound to prevent deterioration of the markings.

6.6 Subject term (key word) listing.

Capacitance unbalance
 Crosstalk loss
 Heat resistance
 Munsell color
 Multiconductor
 Mutual capacitance
 Polyamide
 Polyethylene

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Polyvinyl chloride
Shielded cables
Shore communication

CONCLUDING MATERIAL

Custodians:
Navy - EC
DLA - CC
Army - AV

Preparing Activity:
DLA - CC
(Project 6145-2241)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of 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.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-DTL-28781C	2. DOCUMENT DATE (YYYYMMDD) 20001110
3. DOCUMENT TITLE Cable, Electrical, Special Purpose, Shore Use		
4. NATURE OF CHANGE <i>(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)</i>		
5. REASON FOR RECOMMENDATION		
6. SUBMITTER		
a. NAME <i>(Last, First, Middle Initial)</i>		b. ORGANIZATION
c. ADDRESS <i>(Include zip code)</i>	d. TELEPHONE <i>(Include Area Code)</i> (1) Commercial (2) DSN <i>(if applicable)</i>	7. DATE SUBMITTED (YYYYMMDD)
8. PREPARING ACTIVITY		
a. NAME Defense Logistics Agency Defense Supply Center, Columbus (DSCC-VAI)		b. TELEPHONE <i>(Include Area Code)</i> (1) Commercial 614-692-0538 (2) DSN 850-0538
c. ADDRESS <i>(Include Zip Code)</i> P.O. Box 3990 Columbus, OH 43216-5000		IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6621 Telephone (703) 767-6888 DSN 427-6888