MILITARY SPECIFICATION

CABLES, POWER, ELECTRICAL, (FLEXIBLE, FLAT, UNSHIELDED), (ROUND CONDUCTOR), GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers flexible, flat, unshielded electrical cables with either solid or stranded inner round conductors. Electrical cables covered by this specification are suitable for use in aerospace, ground, and shipboard applications to provide minimum size, weight, and space.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

TT-M-261	-	Methyl Ethyl Ketone, Technical.
TT-I-735	-	Isopropyl Alcohol.

MILITARY

MIL-T-5624	-	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-C-12000	-	Cable, Cord, and Wire, Electric; Packaging of.
MIL-L-23699	-	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base.
MIL-H-46170	-	Hydraulic Fluid, Rust Inhibited, Fire Retardant, Synthetic Hydrocarbon Base

(See supplement 1 for list of associated specification sheets).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Communications-Electronics Command, ATTN: AMSEL-ED-TO, Fort Monmouth, NJ 07703, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

STANDARDS

FEDERAL

FED-STD-228	-	Cable and Wire, Insulated; Method of Testing.

MILITARY

MIL-STD-104	-	Limits for Electrical Insulation Color.
MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129	-	Marking for Shipment and Storage.
MIL-STD-202	-	Test Methods for Electronic and Electrical *Component* Parts.
MIL-STD-454	-	Standard General Requirements for Electronic Equipment.
MIL-STD-681	-	Identification Coding and Application of Hook Up and Lead Wire.
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.
MIL-STD-1344	-	Test Methods for Electrical Connectors.
MIL-STD-45662	-	Calibration Systems Requirements.

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

B3	-	Soft or Annealed Copper Wire.
B33	-	Tinned Soft or Annealed Copper Wire for *Electrical Purposes*.
B286	-	Copper Conductors for Use in Hookup Wire for Electronic Equipment.
B298	-	Silver-Coated Soft or Annealed Copper Wire.
B355	-	Nickel-Coated Soft or Annealed Copper Wire.
D3032	-	Hookup Wire Insulation.
G21	-	Determining Resistance of Synthetic Polymetric Materials to Fungi.

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

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.1).

3.2 Qualification. Cables furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.4 and 6.2).

3.3 Materials (see 4.6.1). The materials for the principal components of the cable shall be as specified herein. Prior approval to use substitute material must be obtained from the qualifying activity. When a definite material is not specified, a material shall be used that will enable the finished products to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product. All materials used in the manufacture of cables furnished hereunder shall be of such quality and form that the finished product conforms to the requirements of this specification. All materials used shall conform to the requirements specified herein. Polyvinylchloride shall not be used as an insulating material in aerospace applications.

3.3.1 Conductors. Conductors shall be stranded, bare or coated, as specified (see 3.1). All conductors shall conform to ASTM B286 requirements.

3.3.1.1 Conductor strands.

a. Bare copper conductor. Bare copper conductors shall conform to soft or annealed copper conductor in accordance with ASTM B3.
b. Tin-coated copper conductor. Tin-coated copper conductor shall conform to the continuity and adherence coating requirements for tinned, soft or annealed copper conductor in accordance with ASTM B33.
c. Silver-coated copper conductor. Silver-coated copper conductor shall have a thickness of not less than 40 microinches of silver and meet the continuity of coating requirements of ASTM B298.
d. Nickel-coated copper conductor. Nickel-coated copper conductor shall have a thickness of not less than 50 microinches of nickel and meet the continuity of coating requirements of ASTM B355.

3.3.1.2 Stranded conductors. Stranded conductors shall be concentrically-unilay or concentrically stranded in accordance with ASTM B286. Conductors shall not be coated after stranding (no overcoating). Individual strands shall be coated before stranding and meet all the requirements of the basic wires specified in 3.3.1.1.

3.4 Design and construction (see 4.6.1). Design and construction of the cable shall be as specified herein and in the applicable specification sheet (see 3.1).

3.4.1 Conductors. The size and number of the conductors shall be in accordance with the applicable specification sheet (see 3.1).

3.4.2 Wire spacing. The acceptable spacing of the wires in the cable shall be as specified (see 3.1).

3.4.3 Finished cable. Finished cable shall conform to the configuration as specified in the applicable specification sheet (see 3.1).

3.4.3.1 Splices. All delivered cable shall be free of conductor splices. There shall be no splices of the cable as a whole unit. Unless otherwise specified in the acquisition document, the minimum acceptable finished cable lengths shall be greater than 10 feet (see 4.4.1, 6.1, and table I).

TABLE I. Finished cable lengths.

Cable width	Minimum percentage of footage in shipment with lengths greater than:			
Inches	100 ft	50 ft	25 ft	10 ft
0.5	50	80	---	100
1.0	---	50	80	100
2.0	---	50	80	100

3.4.3.2 Cable weight. Cable weight shall be tested in accordance with 4.6.1.1, the maximum cable weight per thousand feet shall be in accordance with the applicable specification sheet (see 3.1 and 4.6.1.1).

3.4.3.3 Color. The color shall be in accordance with the applicable specification sheet (see 3.1) and shall be in accordance with MIL-STD-104, class 1.

3.5 Insulation flaws. One hundred percent of the finished cable shall pass the insulation flaws test specified in 4.6.3. Test voltages shall be as specified in the applicable specification sheet (see 3.1).

3.6 Dielectric withstanding voltage. When cables are tested as specified in 4.6.4, they shall withstand the voltage specified in the applicable specification sheet (see 3.1), and there shall be no evidence of breakdown or flashover.

3.7 Insulation resistance. Insulation resistance shall be tested in accordance with 4.6.5, the insulation resistance shall be not less than 500 megohms-1,000 feet.

3.8 Conductor continuity. One hundred percent of the finished cable shall pass the conductor continuity test specified in 4.6.8. There shall be no indication of discontinuity in any conductor.

3.9 Conductor resistance. Cables shall be tested as specified in 4.6.6, the conductor direct current (dc) resistance shall not exceed the value specified in the applicable specification sheet (see 3.1).

3.10 Thermal shock. Cables shall be tested as specified in 4.6.7, they shall withstand the temperature cycles specified (see 3.1), without cracking of the insulation and with no evidence of delamination or visible change. The insulation shrinkage shall not be greater than that specified in the applicable specification sheet (see 3.1).

3.11 Flammability. Flat cables shall be tested in accordance with paragraph 4.6.9. The flat cable shall not flame for longer than one minute following any of the five 15 second applications of the flame. Burning or charring of more than 25 percent of the indicator flag or flaming drops which ignite the cotton also constitutes failure (Note: Soot that can be removed from the flag with a cloth or the fingers, and brown scorching are to be ignored).

3.12 Folding. Cables shall be tested as specified in 4.6.10, they shall withstand the folding and unfolding without indicating loss of continuity. There shall be no evidence of cracking, delamination, or fracturing. Following the test, the cable shall meet the dielectric withstanding voltage requirements in 3.6.

3.13 High-temperature aging. Cables shall be tested in accordance with 4.6.11, there shall be no cracking or separation of the insulation. The cable shall then meet the dielectric withstanding voltage requirements specified in 3.6.

3.14 Strippability. Cables shall be tested as specified in 4.6.12, the wires in the cable shall be free of stripping. Where the insulation is stripped, there shall be no evidence of conductor damage and only a trace of insulation or adhesive remaining which can be easily removed by peeling.

3.15 Solderability. Cables shall be tested as specified in 4.6.13, the dipped surface of the conductor shall be at least 95 percent covered with a continuous new solder coating. The remaining 5 percent may contain only small pin holes or rough spots. These shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability and shall be cause for failure.

3.16 Flexing endurance. Cables shall be tested as specified in 4.6.14, they shall exhibit no discontinuity and there shall be no evidence of cracking, fracturing, delamination, or rupturing.

3.17 Moisture resistance. Cables shall be tested as specified in 4.6.15, the insulation resistance shall be not less than the value specified in the specification sheet (see 3.1) and the insulation shall not exhibit any evidence of delamination.

3.18 Low pressure (maximum rated temperature). Cables shall be tested as specified in 4.6.16, the insulation shall show no evidence of shrinkage greater than 0.0625 inch at either end of the cable specimen, ballooning, bubbling, voids, or insulation weight loss greater than 1 percent. Following this exposure, the cable shall meet the requirements of dielectric withstanding voltage and insulation resistance in 3.6 and 3.7, respectively.

3.19 Fungus resistance. All nonmetallic materials shall be fungus resistant per MIL-STD-454 requirement 4, group 1, or shall be certified that the observed growth rate is 1 or less when tested in accordance with 4.6.17.

3.20 Fluid immersion. The cables shall be tested in accordance with 4.6.18, there shall be no change in cable weight greater than 5 percent, no cracking or separation of the insulation. The cable shall meet the dielectric withstanding voltage requirements specified in 3.6.

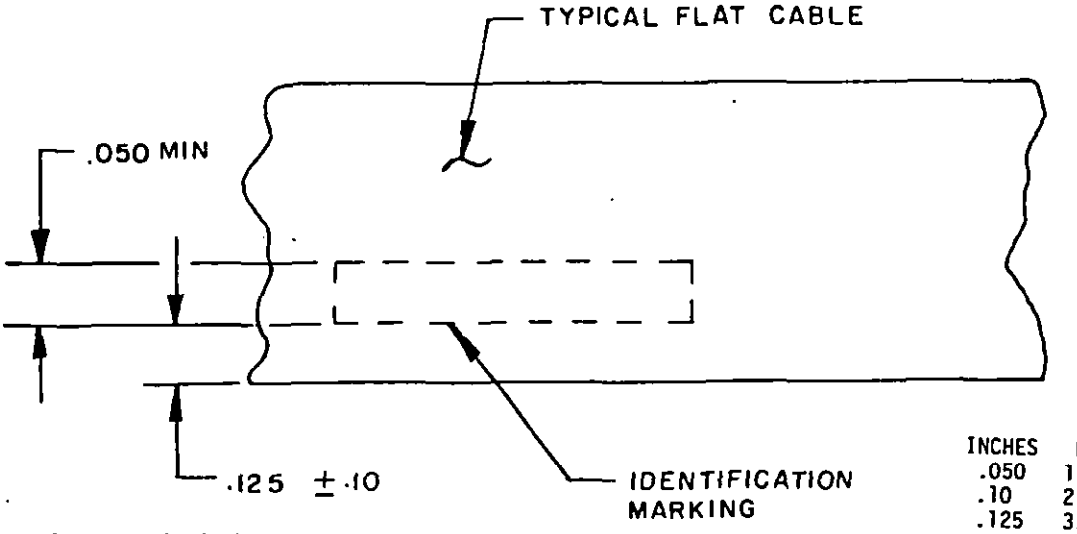
3.21 Tear groove propagation. Cables shall be tested in accordance with 4.6.19, there shall be no propagation of the tear when the load is 0.5 pound, or less. Between 0.5 and 5 pounds there may be propagation of the tear along the tear groove. When the load is 5 pounds or greater, the tear must propagate along the tear groove. There shall be no propagation of the tear into an adjacent conductor.

3.22 Marking (see 4.6.1). Unless otherwise specified (see 3.1), cables shall be marked in accordance with the following:

a. Military part number (see 3.1).
b. Manufacturer's name or symbol and the date and source code shall be in accordance with MIL-STD-1285.

The printing shall be legible and in a contrasting color. Color used for identification coding shall be in accordance with MIL-STD-681. All number 1 conductors shall be identified. The printed marking shall be located along the reference edge of the cable at 12-inch maximum repeat. Marking is required on cables with 0.050 inch or wider spacing of conductors (see figure 1).

3.23 Durability of identification. Durability of identification shall be tested in accordance with 4.6.20, the identification marking shall withstand a minimum of 125 cycles (250 strokes).



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only and are based upon 1.00 inch = 25.4 mm.

FIGURE 1. Identification marking.

3.24 Workmanship. The cable shall be constructed in a thoroughly workmanlike manner in accordance with accepted high-grade production techniques. The cable shall be free of kinks, abrasions, cracked, or peeled surfaces. The cable shall be a uniform and consistent product and shall be free from defects which will adversely affect the serviceability of the product.

3.25 Shrinkage. When tested in accordance with 4.6.21, there shall be no separation of the insulation and the insulation shall not shrink more than 0.125 inch in 12 inches.

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 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 the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

4.2 Classification of inspections. The examinations and tests of cables are classified as follows:

a. Qualification inspection (see 4.4).
b. Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the standard test conditions specified in MIL-STD-1344.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.2), on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. A sample consisting of two specimens of finished cable shall be submitted to the qualification tests of table II. Each specimen shall be a minimum of 40 linear feet of continuous unspliced cable. Qualification shall extend to all cables of the same specification sheet with fewer conductors and the same type of construction and coating.

4.4.2 Inspection routine. Samples from the two finished cable lengths shall be subjected to the tests in table II. Lengths of cable samples shall be as specified in the applicable test paragraph.

4.4.3 Failure. One or more failures shall be cause for refusal to grant qualification approval.

TABLE II. Qualification inspection.

Inspection	Requirement paragraph	Test paragraph
Group I		
Visual and mechanical inspection, cable dimensions, and construction	3.3 thru 3.4.3.3	4.6.1
Conductor resistance	3.9	4.6.7
Thermal shock	3.10	4.6.10
Folding	3.12	4.6.11
High-temperature aging	3.13	4.6.21
Strippability	3.14	4.6.14
Solderability	3.15	4.6.15
Flexing endurance	3.16	4.6.16
Moisture resistance	3.17	4.6.17
Low pressure (maximum rated temperature	3.18	4.6.18
Fungus resistance	3.19	4.6.6
Fluid immersion	3.20	4.6.12
Tear groove propagation	3.21	4.6.13
Shrinkage	3.25	4.6.19

4.4.4 Retention of qualification. To retain qualification, the contractor shall forward a report at 12- and 36-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The reporting shall be as follows:

a. Twelve-month intervals. A summary of the results of the tests performed for inspection of product for delivery, group A (see table III), indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.
b. Thirty-six month intervals. The results of tests performed for periodic inspection, group B (see table IV), including the number and mode of failures. The test report shall include results of all periodic inspection tests performed and completed during the 36-month period. If the test results indicate nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

Failure to submit the report within 30 days after the end of each reporting period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the contractor shall immediately notify the qualifying activity at any time the inspection data indicates failure of the qualified product to meet the requirements of this specificaton.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during two consecutive reporting periods, there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative cable of those covered by a single specification sheet to testing in accordance with the qualification inspection requirements.

4.5 Quality conformance inspection.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.5.1.1 Inspection lot. An inspection lot shall consist of all cables covered by a single specification sheet (see 3.1), produced under essentially the same conditions and offered for inspection at one time.

4.5.1.1.1 Unit of product. The unit of product shall be each reel, spool, or coil of cable.

4.5.1.1.2 Sample. The sample shall consist of that number of randomly selected units of product required by the applicable sampling plan in MIL-STD-105.

4.5.1.1.3 Specimens. Specimens for inspection shall be taken from each unit of product which forms part of the sample. A specimen shall be a length of cable drawn from a unit of product.

4.5.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table III, subgroups 1, 2, and 3. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. Major and minor defects shall be as defined in MIL-STD-105.

4.5.1.2.1 Subgroup 1. For subgroup 1, the acceptable quality level (AQL) shall be as specified in table III. Repetitive dimensions (such as conductor spacing) shall be checked on a random 5 percent minimum but not less than 2 spaces per specimen. Subgroup 1 inspections may be performed in any order.

4.5.1.2.2 Subgroup 2. For subgroup 2, the sample shall be 100 percent of the cable in the inspection lot and every length of cable shall be subjected to the inspection. Any portion of the cable exhibiting breakdown or nonconformity when subjected to the insulation flaws inspection shall be cut out and removed.

4.5.1.2.3 Subgroup 3. For subgroup 3, the sample shall be one length per lot. No defects shall be allowed under this subgroup.

4.5.1.2.4 Rejected lots. If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection and shall not thereafter be tenured for acceptance unless the former rejection or requirement or correction is disclosed. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.5.1.2.5 Disposition of unit of product. Units of product which have passed all the group A inspection may be delivered on the contract or purchase order if the lot is accepted.

4.5.2 Periodic inspection. Periodic inspection shall consist of group B. The delivery of products which have passed group A inspection shall not be delayed pending results of group B inspection but shall be discontinued immediately upon determination of noncompliance of the product with any group B requirement.

4.5.2.1 Group B inspection. Group B inspection shall consist of the inspections specified in table IV. Group B inspection shall be made on sample units selected from inspection lots which have passed the group A inspection.

4.5.2.1.1 Sampling plan. On a 3-year basis starting from the date of qualification, the lot shall be selected from the cable with the largest number of conductors that is covered by a single specification sheet and is in production.

4.5.2.1.1.1 Inspection. Two test lengths shall be subjected to each test.

4.5.2.1.2 Failures. If one or more specimens fail to pass group B inspection, the sample shall be considered to have failed.

4.5.2.1.3 Disposition of sample units. Units of product from which a specimen has failed shall not be delivered on the contract or order, even though the inspection lot submitted is accepted.

TABLE III. Group A inspection.

Inspection	Requirement paragraph	Test paragraph	AQL (percent defective) Major	AQL (percent defective) Minor
Subgroup 1				
Visual and mechanical inspection, cable dimensions, and construction	3.3 thru 3.4.3.3	4.6.1	1.0	4.0
Tear groove propagation	3.21	4.6.19	1.0	4.0
Marking	3.22	4.6.1	1.0	4.0
Workmanship	3.24	4.6.1	1.0	4.0
Subgroup 2				
Insulation flaws	3.5	4.6.3	See 4.5.1	2.2
Conductor continuity	3.8	4.6.8	See 4.5.1	2.2
Subgroup 3				
Conductor size	3.3.1	4.6.1	See 4.5.1	2.3
Cable color	3.4.3.3	4.6.1	See 4.5.1	2.3
Dielectric withstanding voltage	3.6	4.6.4	See 4.5.1	2.3
Insulation resistance	3.7	4.6.5	See 4.5.1	2.3
Flammability	3.11	4.6.9	See 4.5.1	2.3
Durability of identification	3.23	4.6.20	See 4.5.1	2.3

TABLE IV. Group B inspection.

Inspection	Requirement paragraph	Test paragraph
Conductor resistance	3.9	4.6.6
Thermal shock	3.10	4.6.7
Folding	3.12	4.6.10
High-temperature aging	3.13	4.6.11
Strippability	3.14	4.6.12
Solderability	3.15	4.6.13
Flexing endurance	3.16	4.6.14
Moisture resistance	3.17	4.6.15
Low pressure (maximum rated temperature)	3.18	4.6.16
Fungus resistance	3.19	4.6.17
Fluid immersion	3.20	4.6.18
Tear groove propagation	3.21	4.6.19
Shrinkage	3.25	4.6.21

4.5.2.1.4 Noncompliance. If a sample fails to pass group B inspection, the manufacturer shall notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, groups A and B inspections shall be repeated on additional sample units (all inspections, or the inspection on which the original sample

failed, at the option of the qualifying activity). Group A inspection may be reinstituted; however, final acceptance and shipment shall be withheld until the group B inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5.3 Inspection of packaging. Sample packages and packs and the inspection of the preservation, packing, and marking for shipment and storage shall be in accordance with the requirements of MIL-C-12000.

4.6 Methods of inspection.

4.6.1 Visual and mechanical inspection. The cable shall be inspected to verify that the design, construction, physical characteristics and dimensions, color, weight, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.3 thru 3.3.1.2, 3.4 thru 3.4.3.3, 3.22, and 3.24).

4.6.1.1 Cable weight (see 3.4.3.2). A specimen of cable 26.44 ±0.02 inches shall be cut and weighed in grams to the nearest 1 percent of its weight. The grams of the specimen shall be recorded as the weight in pounds per 1,000 feet.

4.6.2 Electrical tests. It shall be permissible to wind finished cable on testing spools and reels for electrical tests, and to rewind on shipping spools and reels after completion of the last test.

4.6.3 Insulation flaws (see 3.5). All cable shall be subjected to the insulation flaws test in accordance with method 6211 of FED-STD-228 with the following exceptions and conditions. The cable conductors shall be electrically tied together and grounded. A suitable fault signaling device for detection of insulation flaws shall be provided. Any flaws detected shall be removed.

4.6.4 Dielectric withstanding voltage (see 3.6). The cable shall be tested in accordance with ASTM D3032, section 8, with the following exceptions. The specimen shall be 26 ±.062 inches in length and shall be prepared for high-voltage connection by isolating adjacent conductors from each other. This may be accomplished by carefully cutting into the ends of the specimen .5 inch and 1.5 inches, respectively, so that adjacent conductors can be bent to opposite sides of the specimen. Remove .25 inch of insulation from the 1.5 inch end for electrical connections. For the first part of the test, the specified voltage (see 3.1) shall be applied between all conductors electrically connected together and the solution, and for the second part, between each conductor and its adjacent conductors. This may be accomplished by bussing together all conductors bent to one side of the specimen and connecting one high-voltage lead. The conductors bent to the other side shall be treated in a similar manner and connected to the other high-voltage lead. The specimen, the center 12 inches, shall be immersed for 1 hour. Following the test, the specimen shall be examined. Tests shall be run before and after each test specifying dielectric withstanding voltage. When dielectric withstanding voltage and insulation resistance are performed on the same samples, the test may be done in the following sequence.

a. Insulation resistance conductor to conductor in air.
b. Dielectric strength conductor to conductor in air.
c. Immerse samples in salt water solution.
d. Insulation resistance conductor to solution.
e. Dielectric strength conductor to solution.

4.6.5 Insulation resistance (see 3.7). The specimen shall be prepared in accordance with 4.6.4. A potential of 500 +50, -0 volts dc shall be applied for one minute between each conductor and its next adjacent conductor(s) in air. Following this test, the sample shall be immersed to within 6 inches of its ends in the water bath described in 4.6.4 at room temperature for a minimum of 1 hour. A voltage of 500 +50, -0 volts dc shall be applied for one minute between the conductors and water, insulation resistance shall be calculated form the following formulas:

$$\text{Wire to wire megohms-1,000 feet} = \frac{\text{Specimen resistance (megohms)} \times \text{sample length (2 feet)} \times (\text{number of conductors} - 1)}{1{,}000}$$

$$\text{Wire to water megohms-1,000 feet} = \frac{\text{Specimen resistance (megohms)} \times \text{immerse length (1 foot)} \times (\text{number of conductors})}{1{,}000}$$

4.6.6 Conductor resistance (see 3.9). The dc resistance of the individual conductors of each specimen, 36 to 48 inches long, shall be tested in accordance with method 6021 of FED-STD-228, and calculated for conformance.

4.6.7 Thermal shock (see 3.10). Cable specimens 38 to 40 inches long shall be subjected to five continuous cycles at the high and low temperatures specified (see 3.1). The specimens shall be maintained at each temperture extreme for a minimum of 30 minutes. A maximum dwell time of 2 minutes shall be allowed for transfer between test chambers. After completion of the fifth cycle, the specimens shall be removed from the test chambers, and allowed to stabilize at room temperture. The specimen shall be examined for evidence of cracking, or shrinkage of the insulation.

4.6.8 Conductor continuity (see 3.8). All cable shall be tested for conductor continuity with an ohmmeter or other suitable testing device.

4.6.9 Flammability (see 3.11).

4.6.9.1 Apparatus. The test shall be performed within a draft-free enclosure open at top and front to provide adequate ventilation for combustion, but to prevent drafts. An 18-inch (457.2 mm) flat cable specimen with its full compliment of conductors shall be secured at the ends and held taut with its longitudinal axis vertical and centered in the enclosure (see figure 2). A flat, 8- x 8-inch horizontal layer of surgical cotton is to be placed on the floor of the enclosure, and centered under the specimen so that only material drippings from the flat cable specimen shall fall upon the surgical cotton. The upper surface of the cotton is to be no more than 9.5 inches (241.3 mm) below the point at which the tip of the blue inner cone of the test flame will touch the specimen. A Tirrill gas burner with or without a gas pilot light is to supply the flame. The barrel of the burner is to extend approximately 4 inches (102 mm) above the air inlets, and its inside diameter is to be 3/8 inch (9.5 mm) nominal. While the barrel is vertical, the overall height of the flame is to be adjusted to 5 inches (127 mm). The blue inner cone is to be approximately 1.5 inches high (38 mm) and the temperature at its tip is to be 836°C (1500°F) or higher and shall be verified with an accurate measuring device. Without disturbing the adjustments for the height of the flame, the valve supplying gas to the burner flame and the separate valve supplying gas to any pilot flame are to be closed. A wedge to which the base of the burner can be secured is to be provided for tilting the barrel twenty degrees from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The burner is to be secured to the wedge and the assembly is to be placed in an adjustable support fixture.

4.6.9.2 Procedure. The fixture is to be adjusted laterally (see figure 2) to place the longitudinal axis of the barrel in the same vertical plane as the longitudinal axis of the specimen. The plane is to be parallel to the sides of the enclosure. The fixture is also to be adjusted toward the rear or front of the enclosure (see figure 2) to position the point A, which is the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel, 1.5 inches (38 mm) from the point B at which the extended longitudinal axis of the barrel meets the outer surface of the specimen. Point B is the point at which the extended longitudinal axis of the barrel meets the outer surface of the specimen. Point B is the point at which the tip of the blue inner cone will touch the center of the front of the specimen. The specimen is to be adjusted vertically to prevent point B from being any closer than 3 inches (76 mm) from the lower end of the specimen.

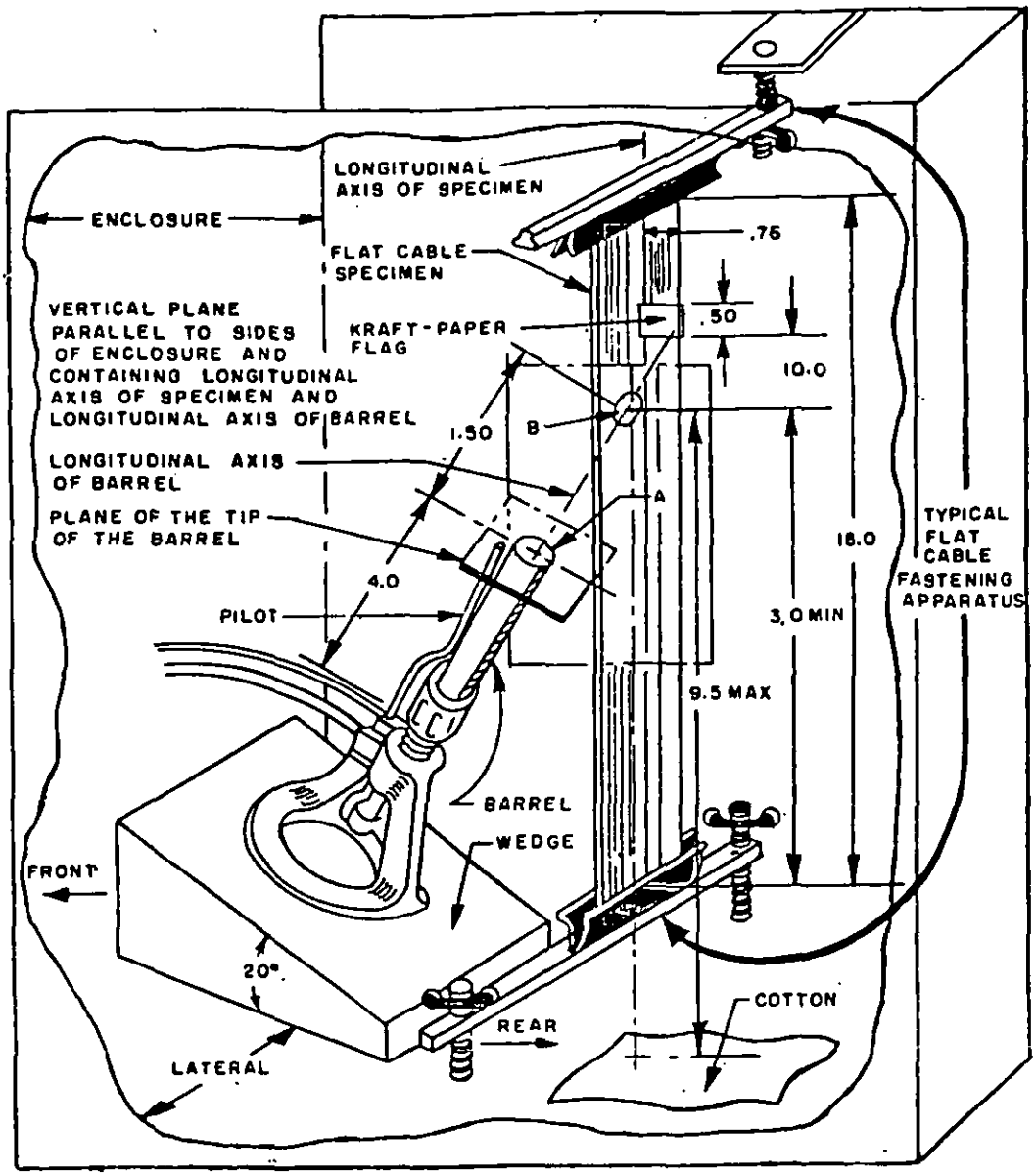


FIGURE 2. Flammability test apparatus.

In the absence of a gas pilot light on the burner, the support for the burner and wedge is to be arranged to enable the burner to be quickly removed from and precisely returned to the position described in the preceding paragraph.

A .5-inch (12.7 mm) wide strip of unreinforced 5-mil thick (approximately 0.1 mm) kraft paper that is gummed on one side is to be used to make an indicator flag. The gum is to be moistened just sufficiently to permit adhesion. With the gum toward the specimen, the strip is to be wrapped around the specimen once with its lower edge 10 inches (254 mm) above B, the point at which the blue inner cone will touch the specimen. The ends of the strip are to be pasted together evenly and trimmed to provide a flag which projects .75-inch (19 mm) from the specimen toward the rear of the enclosure (see figure 2). In the case of a flat cable, the flag is to project from the center of the rear broadface of the cable and the flame is to be applied to the front broadface.

If the burner has a gas pilot light, the valve supplying gas to the pilot is to be opened and the pilot lit. If the burner does not have a gas pilot light, it is to be supported as indicated above in a position away from the specimen and then lit. This operation and the remainder of the test are to be conducted under a forced-draft hood operating to provide adequate ventilation but avoiding drafts which affect the flame.

If the burner has a gas pilot light, the valve supplying gas to the burner is to be opened to apply the flame to the specimen automatically. This valve is to be held open for 15 seconds, closed for 15 seconds, opened for 15 seconds, etc., for a total of five 15-second applications of flame to the specimen with 15 seconds between applications. If the burner does not have a gas pilot light, the burner is to be moved into position to apply the flame to the specimen, kept there for 15 seconds, removed for 15 seconds, etc., for a total of five 15-second applications with 15 seconds between applications.

In any case, the flame is not to be reapplied until any flaming caused by the previous application ceases of its own accord, even though the time interval between applications may exceed 15 seconds.

Counting from the instant of the last removal of the burner flame, the duration of any flaming of the specimen is to be noted and recorded. Note also is to be taken and recorded of whether any flaming or glowing particles or flaming drops fall from the specimen.

4.6.10 Folding (see 3.12). A specimen of cable 26 ±.062 inches shall be folded 180° transversely and pressed between two pieces of smooth-surfaced flat metal twice the width of the cable, with a pressure of 30 ±1 pounds force per inch of cable width of the test specimen (see figure 3). After 15 ±1 minutes under pressure, the specimen shall be unfolded and the pressure reapplied to the unfolded creased portion of the cable for an additional 15 ±1 minutes. Unless otherwise specified (see 3.1), the test shall be conducted at 23°C ±5°C. This procedure constitutes one complete [illegible]. After two complete cycles of folding and unfolding on the same creased [illegible]on, the cable shall be checked for continuity and shall be examined for evidence [illegible]acking, fracturing, or rupturing. The cable shall then be subjected to the dielectric withstanding voltage test as specified in 4.6.4.

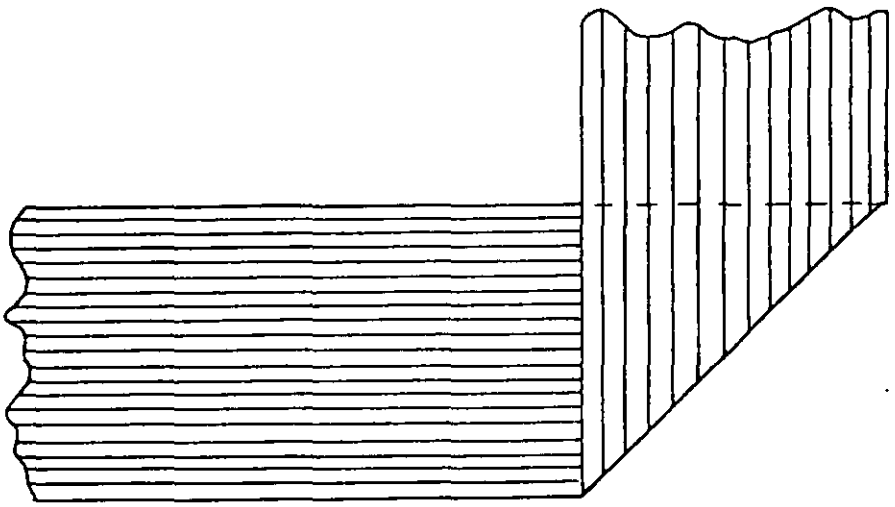


FIGURE 3. 180° transverse fold.

4.6.11 *High Temperature aging.* 0.25 ±0.10 inch of insulation shall be removed from each end of an 18 ±0.5 inches cable specimen. The central portion of the cable then shall be bent at least halfway around a horizontally placed 0.25 inch diameter stainless steel mandrel. The stripped conductor ends shall be evenly clamped together so that the weight is suspended from conductors only and the cable shall be loaded with the following weight so that the portion of insulation between the conductors and mandrel is under compression while the conductors are under tension.

Round wire size (AWG)	*Weight (lb) per conductor
24 through 28	.1 +.03, -0

*Includes the weight of the clamp.

This specimen, so prepared on the mandrel, shall be conditioned in an air-circulating oven for 7 hours ±15 minutes at the temperature specified (see 3.1).

The velocity of air past the specimen (measured at room temperature) shall be between 100 and 200 feet per minute. After conditioning, the oven shall be shut off, the door opened, and the specimen allowed to cool in the oven for at least 1 hour. When cool, the specimen shall be freed from tension, the strips shall be removed and the specimen shall be removed from the mandrel. The central portion of the cable shall be bent at least halfway around the mandrel so that the portion which was outside during conditioning is now next to the mandrel. The cable shall be loaded with the applicable weight for 1 hour ±10 minutes at high temperature (see 3.1). The cable shall then be removed from the mandrel and examined for cracking and separation of the insulation. The specimen shall then be subjected to the dielectric withstanding voltage test (see 3.6).

4.6.12 Strippability (see 3.14). The specimen of completed cable shall have the insulation removed from approximately .25 inch at each end using a cold blade stripper.

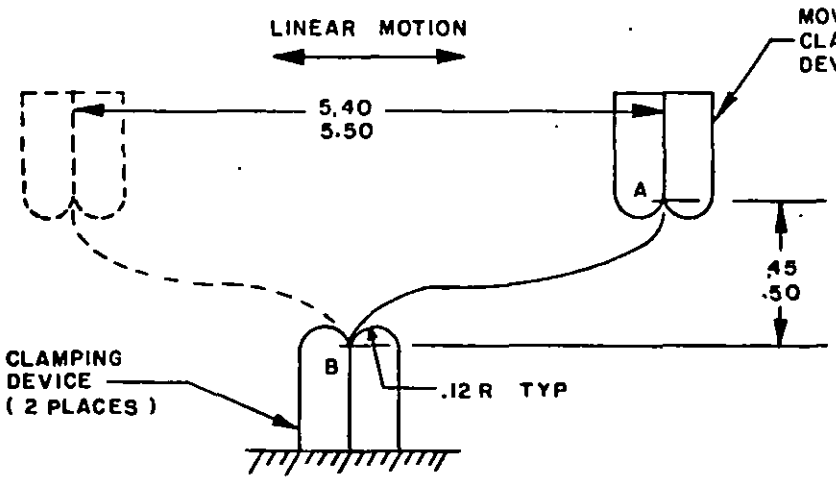
4.6.13 Solderability (see 3.15). All conductors shall be tested in accordance with MIL-STD-202, method 208 with the following exceptions:

a. Special preparations: Straighten and cut wire into convenient lengths (2 inches minimum).

b. A random of six conductors of each cable shall be tested.

c. Examination: As specified in method 208, MIL-STD-202.

4.6.14 Flexing endurance (see 3.16). A specimen of cable having a length of 6 inches minimum shall be installed in a fixture as shown on figure 4. All conductors of the test specimen shall be electrically connected in series during the test and a monitoring current of 20 ±5 milliamperes shall be applied. A continuity tester capable of indicating a current interruption of 1 microsecond shall be employed to monitor the current. One end of the cable shall be held in the fixed clamping device. The other end shall be fastened in the movable clamping device, allowing a free length of 3 to 3.05 inches between clamping devices. The movable clamping device shall be driven in reciprocating linear motion for 5.4 to 5.5 inches from one extreme position to the other extreme position. Cable and fixture shall be allowed to stabilize at the test temperature for one hour before commencing test. One cycle shall consist of travel from one extreme to the other and return. The specimen shall be subjected to a minimum of 25 cycles per minute for the number of cycles and at the temperature specified in the applicable specification sheet (see 3.1). A different cable specimen shall be used for flexing at each temperature.



INCHES	MM
.12	3.0
.45	11.4
.50	12.7
3.00	76.2
3.05	77.5
3.10	78.7
5.40	137.2
5.50	139.7

NOTES:
1. The cable length between A and B shall be 3.00 to 3.05 inches.
2. Dimensions are in inches.
3. Metric equivalents are given for general information only.

FIGURE 4. Flex test fixture.

4.6.15 Moisture resistance (see 3.17). A specimen of cable 26 inches long shall be prepared as specified in 4.6.4 and tested in accordance with method 106 of MIL-STD-202 (steps 7a and 7b shall not be required). Following the tenth cycle, and while the specimen is still at environment, the wire to wire insulation resistance shall be measured as specified in 4.6.5 with a potential of not less than 500 volts dc that shall be applied for a minimum of 1 minute between each conductor and its next adjacent conductors. Following the test, the specimen shall be examined.

4.6.16 Low pressure (maximum rated temperature((see 3.18). One specimen 26 ±.062 inches long shall be prepared by cutting both ends approximately square. The sample shall be weighed on an analytical balance. The uncoiled specimen shall be placed in a suitable open-rack (or equivalent) in a vacuum oven that has been preheated and stabilized, for not less than 10 minutes, at the maximum conductor temperature specified (see 3.1). The oven shall then be allowed to restabilize at the specified temperature (see 3.1). After temperature stabilization, the oven pressure shall be reduced to 2.0 torr, and maintained at these conditions for not less than 30 minutes. (A torr is nearly equal to the pressure of a column of mercury 1 millimeter high at 0°C and standard gravity.) On completion of the 30-minute conditioning, the heat source shall be removed and the oven shall be allowed to cool to room ambient pressure. The specimen shall then be removed from the oven. The specimen shall be weighed, checked for shrinkage, prepared per 4.6.4, then be subjected to the dielectric withstanding voltage test specified in 4.6.4, followed by the insulation resistance test as specified in 4.6.5, except the testing shall be done in air between conductors only.

4.6.17 Fungus resistance (see 3.19). A test specimen 26 ±.062 inches shall be prepared for testing of all external materials. The materials shall meet the requirements of MIL-STD-454, requirement 4, group I; materials nonnutrient to fungus or group II, shall be tested per ASTM-G21.

4.6.18 Fluid immersion (see 3.20). The specimen shall be prepared in accordance with 4.6.4. Each specimen shall then be weighed and one specimen shall be immersed to within 6 inches of its ends in each of the fluids specified in table V for 20 +0.5 hours at the temperture specified in table V. During immersion, the radius of bend of the specimen shall have a minimum diameter of 0.5 inch.

TABLE V. Test fluids and test temperatures.

Test fluid	Test temperature °C
TT-M-261 1/ TT-I-735 MIL-T-5624 (JP-4)	20 to 22
MIL-H-46170 MIL-L-23699 1/	68 to 72

1/ Not for use with polyvinylchloride insulation.

Upon removal from the fluids, the specimen shall be free of surface fluids and shall remain for 1 hour in free air at room temperature. Each specimen shall be weighed and compared with its initial weight. The specimen then shall be folded and unfolded twice in accordance with 4.6.10 and then subjected to the dielectric withstanding voltage test (see 4.6.4).

4.6.19 Tear groove propagation (see 3.21). A 16 ±0.25 inch-cable specimen containing tear grooves shall be slit for a distance of 2 ±0.25 inches along a tear groove, using a commercially available single-edge razor blade. The specimen then shall be mounted in the jaws of a tensile test machine as shown on figure 5. The specimen then shall be separated along the same tear groove for an additional 2 ±0.25 inches using a jaw separation rate of 0.50 ±0.06 inch per minute. The minimum load required for separation shall be recorded. The specimen then shall be examined.

4.6.20 Durability of identification (see 3.23). The durability of product identification shall be evaluated at room temperature as follows:

a. Test apparatus. A repeated scrape-abrasion tester, shall be used. The instrument shall be capable of rubbing a small cylindrical steel mandrel 0.025 to 0.028 inch in diameter repeatedly over the upper surface of the cable in such position that the longitudinal axis of the steel mandrel and specimen are at right angles to each other with surfaces in contact. A weight affixed to a fixture above the rubbing mandrel shall control the force exerted normal to the surface of the insulation. A motor-driven, reciprocating-cam mechanism shall be used to deliver an accurate number of abrading strokes in a direction parallel to the longitudinal axis of the specimen. The number of strokes shall be measured by a counter. The length of the stroke shall be 0.375 inch minimum and the frequency of the stroke shall be 60 cycles (120 strokes) per minute.

b. Test procedure. A test specimen shall be prepared by removing from the cable at least a 4-inch length of two adjacent conductors containing identification. The specimen shall be mounted in the specimen holder and 150 grams shall be applied through the steel mandrel to the marked surface of the specimen. The counter shall be set at zero and the drive motor started. The specimen shall be subjected to the specified number of cycles as stated in 3.23 and shall be examined. If a continuous line of identification marking has been erased or obliterated by the mandrel, the specimen shall be considered as having failed.

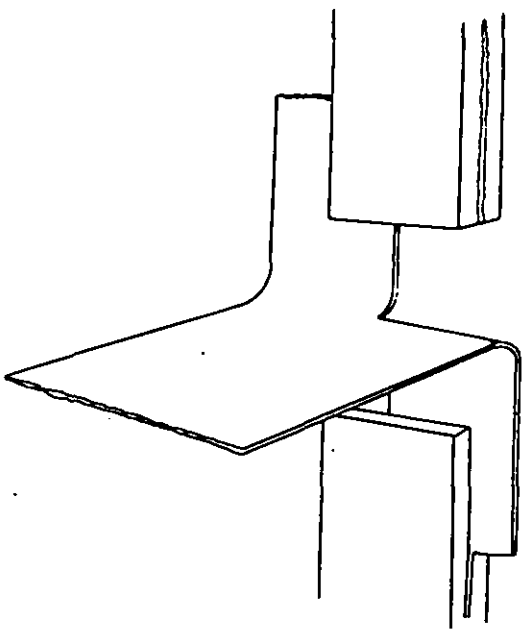


FIGURE 5. Tear groove propagation setup.

4.6.21 Shrinkage (see 3.25). A 12 ±0.5 inch-specimen of cable shall be cut so that the insulation and conductor are flush at both ends. The specimen then shall be conditioned in an air-circulating oven for 6 hours at the accelerated aging temperature of the material specified in the applicable specification sheet.

Temperature rating (°C)	Test temperature (°C) ±3°C
105	136
150	200
200	250
260	300

The velocity of air past the specimen (measured at room temperature) shall be between 100 and 200 feet per minute. After conditioning, the specimen shall be removed from the oven and allowed to cool to room temperature. The shrinkage of the insulation then shall be measured as the greatest distance which the insulation has receded from either end of the conductors; that is, the measurement obtained at the end showing the greater shrinkage shall be considered the shrinkage of the specimen.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-C-12000.

6. NOTES

6.1 Ordering data. Acquisition documents shall specify the following:

a. Title, number, and date of this specification.
b. Title, number, and date of the applicable specification sheet (see 3.1).
c. Applicable military part number (see 3.1).
d. Total number of feet and acceptable minimum continuous length (see 3.4.3.1).

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is U.S. Army Communications-Electronics Command, Attention: AMSEL-ED-TO, Fort Monmouth, NJ 07703, and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification" to DESC-EQ, 1507 Wilmington Pike, Dayton, Ohio 45444.

6.2.1 Contract supplied cable. It is understood that flat multiconductor cable supplied under the contract or purchase order shall be manufactured the same way as the sample tested and found satisfactory except for changes previously approved by the Government. Any unapproved changes from the qualification sample shall constitute cause for rejection.

6.3 Definitions.

6.3.1 Conductor. A conductor is a single conductive path in a conductive pattern.

6.3.2 Conductor diameter. the conductor diameter is the diameter of the total circular cross section of the conductor, including all metallic conductor coatings.

6.3.3 Current-carrying capacity. The current carrying capacity is the maximum current that can be continuously carried through a conductor under specified conditions.

6.3.4 Delamination. Delamination is a separation between any of the layers of the base laminate or between the laminate and the mated conductors, or both.

6.3.5 Dielectric strength. The dielectric strength is the maximum voltage that a dielectric material can withstand, under specified conditions, without rupturing; usually expressed as volts/unit thickness.

6.3.6 Flat cable. Flat cable is any cable with two or more parallel conductors in the same plane enclosed by an insulating material.

6.3.7 Insulation resistance. Insulation resistance is the electrical resistance of the insulating material, determined under specified conditions, between any pair of conductors.

6.3.8 Laminate (noun). A laminate is a product made by bonding together two or more layers of material with pressure, heat, or adhesive.

6.3.9 Margin. The margin is the distance between the edge of a flat cable and the centerline of the nearest conductor.

6.3.10 Solderability. Solderability is the property of a metal to be wetted by solder.

6.3.11 Wetting. Wetting is the free flow and spreading of solder on conductive paths and terminals to form an adherent bond.

6.4 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians:
Army - CR
Navy - AS
Air Force - 11

Review activities:
Army - AR, AV, MI
Navy - EC, OS
Air Force - 17, 99
DLA - ES, IS
NASA - MSFC

User activities:
Army - AT, ME
Navy - MC

Preparing activity:
Army - CR

Agent:
DLA - ES

(Project 6145-0893)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-C-49055B	Cables, Power, Electrical,(Flex,Flat,Unshielded) (Round Conduct)

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ 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	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426 PREVIOUS EDITION IS OBSOLETE. HISA-FM 149-85