

MILITARY SPECIFICATION

CABLE, TELEPHONE WF-16()/U

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

1. SCOPE

1.1 Scope.- This specification covers two (2) pairs of parallel stranded conductors, each pair commonly insulated with high density polyethylene; the pairs twisted together to form a four (4) wire voice/frequency telephone cable designated as Telephone Cable WF-16()/U. (See 6.5).

2. APPLICABLE DOCUMENTS

2.1 Documents.- 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.

SPECIFICATIONS

FEDERAL

QQ-S-781 Strapping, Flat: Steel.
PPP-F-320 Fiberboard; Sheet Stock (Container Grade) and Cut Shapes.

MILITARY

MIL-P-116 Preservation, Methods of.
MIL-C-572 Cords, yarns, and monofilaments - Organic Synthetic Fiber.
MIL-Y-1140 Yarn, Cord, Sleeving, Cloth, and Tape - Glass.
MIL-R-3241 Reels, Cable (Reels, DR-5, DR-7, DR-15-B, RL-159/U).
MIL-P-22748 Plastic, Polyethylene and Copolymers, High Density,
Molding and Extrusion Material.

STANDARDS

FEDERAL

FED-STD-228 Cable and Wire, Insulated, Methods of Testing.
FED-STD-595 Colors.

MILITARY

MIL-STD-105 Sampling Procedures and Tables for Inspection by
Attributes.
MIL-STD-129 Marking for Shipment and Storage.

(Copies of specifications, standards and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Both the title and number or symbol should be stipulated when requesting copies.)

2.2 Other documents. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

B-105 Hard-Drawn Copper Alloy Wires for Electrical Conductors.
D-470 Methods of Testing Rubber and Thermoplastic Insulated Wire and
Cable.
D-573 Method of Test for Accelerated Aging of Vulcanized Rubber by the
Oven Method.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19106.)

3. REQUIREMENTS

3.1 First article. - When specified in the contract, the contractor shall furnish first article units in accordance with 4.3.

3.2 Materials. -

3.2.1 Strands. - The conductor strands shall be bare, hard-drawn wire, copper alloy #85, in accordance with ASTM B-105. Each strand shall be 0.0085 inch \pm 0.0001 inch in diameter.

3.2.2 Insulating compound.- The insulating compound shall be high density (linear) polyethylene, per MIL-P-22748, Class B, Grade 1. The insulating compound used on one pair of conductors shall be brown, Color No. 30117, per FED-STD-595. Both colors of the insulating compound shall contain 1 + 2% of titanium dioxide ultraviolet inhibitor. - 0

3.2.3 Code markers.- One conductor of a pair shall contain the manufacturer's code marker and the other conductor of the same pair the marker for the year of manufacture. The yarn used for marker threads shall be one of the following:

(a) Glass yarn, form 1, class C, yarn numbers ECE450-1/0, ECE450-1/2 or ECD900-1/2, in accordance with MIL-Y-1140.

(b) One end of 30 denier, 40 filament type SAR, for Y yarn in accordance with MIL-C-572.

3.3 Construction.-

3.3.1 Conductors.- Each conductor shall be composed of 7 copper alloy strands as specified in 3.2.1.

3.3.1.1 Stranding.- The maximum length of lay of the concentric stranded conductor shall be one half (0.5) inch, and the direction of lay shall be left hand. The outside strands shall lie evenly and smoothly around the central strand without crowding.

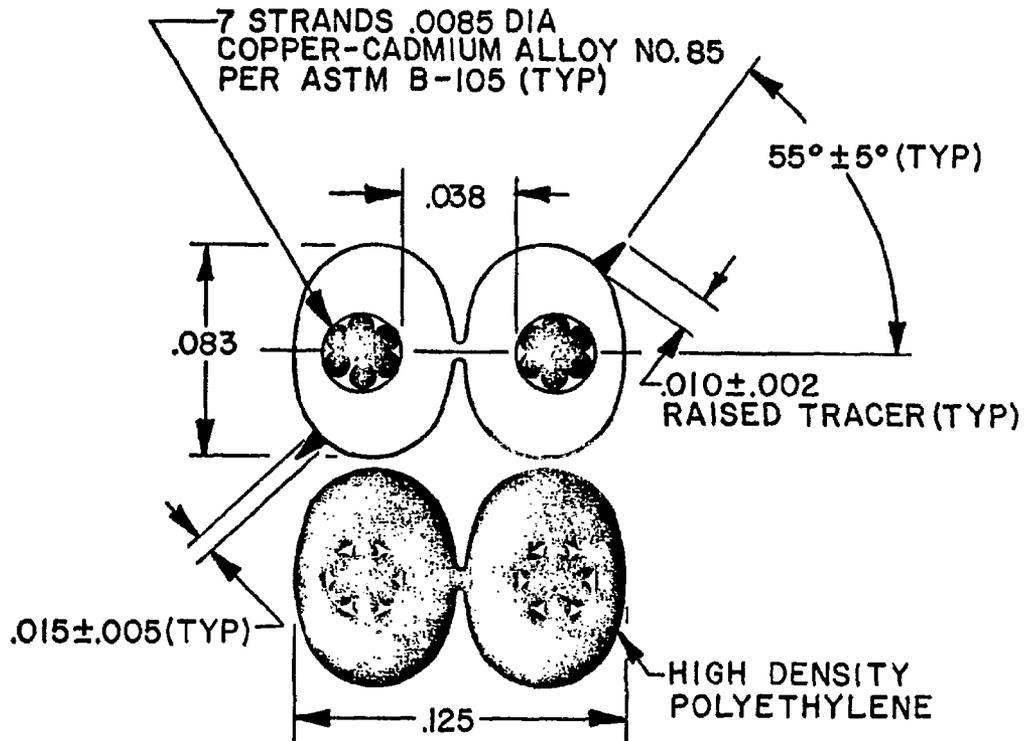
3.3.2 Insulation.- Each pair shall be insulated with a tight, well centered compound as specified in 3.2.2, with a minimum wall thickness at any point of .014 inches when measured as specified by Method 1018 of FED-STD-228. The insulation shall strip cleanly and readily with the use of pliers.

3.3.2.1 Configuration.- Each conductor pair shall consist of two conductors in parallel mutually insulated in an approximate figure eight cross section. The pair colored olive shall have two "V" shaped tracer ridges. They shall be located and dimensioned as shown on figure 1.

3.3.2.2 Separation.- Separation of the conductors of each pair if accomplished by snipping the insulation at the end of the pair midway between the conductors and tearing them apart. The tensile force necessary to separate the two wires after snipping shall be not less than one pound and not more than three pounds.

3.3.2.3 Overall diameter.- The overall diameter of each pair shall be as follows:

Major axis	0.125 ± .007 inches
Minor axis	0.083 ± .005 inches
Conductor separation	0.038 ± .005 inches (between inside surfaces of the conductors)



WF-16()/U

4-WIRE FIELD WIRE

WT PER MILE - 62 LBS

NOTE: This pictorial presentation is for reference purposes only and does not necessarily represent the actual configuration of the finished cable. However, all dimensions and requirements of this specification apply.

Figure 1

3.3.3 Finished cable.- Two finished single pairs (one of each color) shall be twisted closely together, with a right hand lay which shall not exceed six inches when averaged over a 10 foot length, to form a twisted two pair assembly. Uniform tension shall be maintained on both pairs during the twisting operation to prevent looping or bunching of the pairs and to assure that each pair supports half the tensile load.

3.4 Physical requirements.-

3.4.1 Tubing (heat shock).- The insulated pair shall show no visible strains or cracking of the insulation when tested as specified in 4.6.1.

3.4.2 Thermal stress cracking.- The insulated pair shall show no visible strains or cracking of the insulation when tested as specified in 4.6.2.

3.4.3 Cold bend.- The insulated pair shall not crack either before or after aging when tested as specified in 4.6.3 and 4.6.3.1.

3.4.4 Elongation.- Insulation elongation shall be not less than 400% when tested as specified in 4.6.4.

3.4.4.1 Elongation after aging.- Insulation elongation after aging, when tested as specified in 4.6.4.1, shall have not less than 80% of elongation as measured in 4.6.4.

3.4.5 Cutting.- The average cutting load shall be not less than 70 pounds and the cutting load for any one specimen shall be not less than 60 pounds. (See 4.6.5).

3.4.6 Breaking load.- The breaking load shall be not less than 77 pounds for each insulated pair. (See 4.6.6).

3.5 Electrical requirements.-

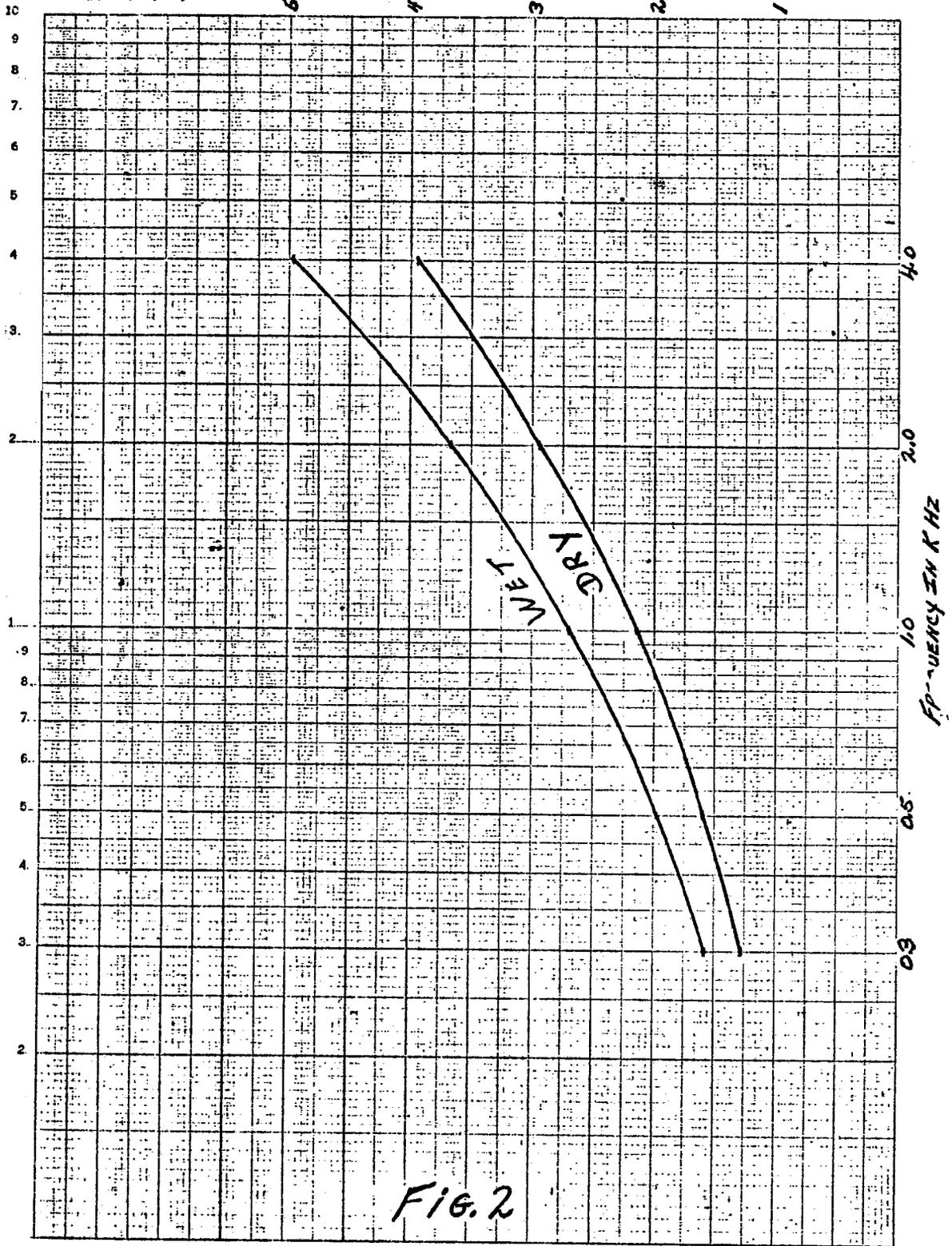
3.5.1 Dielectric strength, separated conductors.- The individually insulated conductors shall withstand a potential of 1,000 volts root-mean-square for one minute when tested as specified in 4.7.1.

3.5.2 Attenuation.- The attenuation of each pair shall be no greater than shown on figure 2 when measured both wet and dry and as specified in 4.7.6.

3.5.3 DC resistance.- The direct current (dc) resistance of each pair, at or corrected to 20°C, shall not exceed 282.5 ohms per loop-mile. (See 4.7.2).

MIL-C-55425C(EL)

ATTENUATION IN "DB" PER MILE



GENILOGARITHMIC 359-63
KELMPELL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 140 DIVISIONS

FIG. 2

3.5.4 Dielectric strength, cable.- The cable shall withstand a potential of 1,000 volts root-mean-square for one minute when tested as specified in 4.7.3.

3.5.5 Insulation resistance.- Insulation resistance of the cable at or corrected to 15.6°C, shall be not less than 5,000 megohms - per single conductor mile. (See 4.7.4).

3.5.6 Mutual capacitance.- The mutual capacitance shall not exceed 0.11 microfarads per pair mile when tested in accordance with 4.7.5.

3.6 Insulation repairs and splices.- No insulation repairs or splices shall be allowed.

3.7 Workmanship.- The cable shall be manufactured in such a manner as to be of uniform quality and free from defects that will affect life, serviceability, or appearance and shall be in accordance with the applicable portions of paragraphs 3.2 and 3.3. (See 4.8).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, 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 supplies and services conform to prescribed requirements.

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

(a) First article inspection. (See 4.3). Does not include preparation for delivery.

(b) Inspections covered by subsidiary documents. (See 4.4).

(c) Quality conformance inspections.

(1) Quality conformance inspection of equipment before preparation for delivery. (See 4.5).

(2) Quality conformance inspection of preparation for delivery. (See 4.9).

4.3 First article.- Unless otherwise specified in the contract, the first article inspection shall be performed by the contractor.

4.3.1 First article units.- The contractor shall furnish five (5) one mile lengths of finished cable WD-16() each mile wound on Reel DR-5 as a sample for approval, if required by the invitation for bids or contracts.

4.3.2 First article inspection.- The first article inspection shall consist of the inspections specified in subsidiary documents covering the items in 4.4 and the inspections specified in Tables I, II and III.

4.4 Inspection covered by subsidiary documents.- The following shall be inspected under the applicable subsidiary documents as part of the inspection required by this specification, and the inspection requirement specified in the contract.

<u>Item</u>	<u>Where required</u>
Strands	3.2.1
Insulating compound	3.2.2
Marker threads	3.2.3

4.5 Quality conformance inspection of equipment before preparation for delivery.- The contractor shall perform the inspections specified in 4.4 and 4.5.1 through 4.5.3. This does not relieve the contractor of his responsibility for performing any additional inspection which is necessary to control the quality of the product and to assure compliance with all specification requirements.

4.5.1 Group A inspection.- Each unit on contract shall be inspected for conformance to the inspections specified in Table I. Discrete lots shall be formed from units that pass this inspection. Factors of lot composition not defined herein, or in the contract, shall be in accordance with MIL-STD-105. Each lot shall be subject to sampling inspection, utilizing the procedures of MIL-STD-105, using the general inspection levels, the AQLs indicated in Table I.

4.5.1.1 Order of inspection within Group A.- Group A inspection shall be performed in an order satisfactory to the Government.

Table I.- Group A inspection

Inspection	Req Para	Insp Para	AQL (percent defective)
<u>Visual and dimensional</u>			
Conductors	3.3.1	4.8)	1.0 for the group
Stranding	3.3.1.1	4.8)	
Insulation	3.3.2	4.8)	
Configuration	3.3.2.1	4.8)	
Separation	3.3.2.2	4.8)	
Overall diameter	3.3.2.3	4.8)	
Finished cable	3.3.3	4.8)	
Code markers	3.2.3	4.8)	
Workmanship	3.7	4.8)	
<u>Performance</u>			
DC resistance	3.5.3	4.7.2)	1.0 for the group
Dielectric strength, cable	3.5.4	4.7.3)	
Insulation resistance	3.5.5	4.7.4)	
Mutual capacitance	3.5.6	4.7.5)	

4.5.2 Group B inspection.- Group B inspection shall normally be performed in inspection lots that have passed Group A inspection and on samples selected from units that have been subjected to and met the Group A inspection. This inspection shall conform to Table II and to the special inspection levels of Table I of MIL-STD-105.

4.5.2.1 Group B sampling plans.- The Group B AQLs shall be 4.0 percent defective for the group and the inspection levels shall be S-4.

4.5.2.2 Order of inspection within Group B.- Group B inspection shall be in an order satisfactory to the Government.

Table II.- Group B inspection

Inspection	Req Para	Insp Para
Physical properties		
Tubing	3.4.1	4.6.1
Thermal stress cracking	3.4.2	4.6.2
Cold bend, before aging	3.4.3	4.6.3
Cold bend, after aging	3.4.3	4.6.3.1
Elongation	3.4.4	4.6.4
Elongation, after aging	3.4.4.1	4.6.4.1
Cutting	3.4.5	4.6.5
Breaking load	3.4.6	4.6.6
Dielectric strength, separated conductors	3.5.1	4.7.1
Attenuation	3.5.2	4.7.6

4.5.3 Group C inspection.- Group C inspection shall be performed on units that have passed Group A and Group B inspection. The inspection shall consist of the inspections specified in Table III.

4.5.3.1 Group C sampling procedure.- One sample unit shall be selected from each 500 miles of finished cable and two specimens shall be cut from each sample unit to perform the group C inspection.

Table III - Group C inspection

Inspection	Req Para	Insp Para
Cold bend after aging	3.4.3	4.6.3.1
Elongation after aging	3.4.4.1	4.6.4.1

4.5.3.2 Group C failures.- Actions required relative to Group C failures shall be as specified in the contract.

4.6 Physical tests.

4.6.1 Tubing (heat shock).- The specimen (insulated pair) shall be looped back and wound tightly on itself for five close turns. The ends shall be securely taped, and the specimen shall be placed in an air oven maintained at a temperature of $121^{\circ} \pm 1^{\circ}\text{C}$ for 24 hours, plus 5, minus 0 minutes. The specimen shall then be removed from the oven and the insulation examined for strains and cracks under a magnification of at least three diameters (focal distance of 8 centimeters) and meet the requirements of 3.4.1.

4.6.2 Thermal stress cracking.- The test of 4.6.1 shall be performed except that the specimen shall be placed in an air oven for 14 days at $100^{\circ} \pm 1^{\circ}\text{C}$. The specimen shall then meet the requirements of 3.4.2.

4.6.3 Cold bend.- The specimen of insulated pair and a mandrel of $0.125 \pm .003$ inch diameter shall be placed in a cold chamber maintained at a temperature of $-55^{\circ} \pm 1^{\circ}\text{C}$ for a period of 24 hours. At the end of this time, while still in the cold chamber, the specimen shall be wound around the mandrel for five close turns at a rate of approximately one turn per second. During this processing, no object having a temperature higher than $-55^{\circ} \pm 1^{\circ}\text{C}$ shall come within twelve inches of the point of the specimen being wound. After the test, the specimen shall be examined under a magnification glass with at least three diameters magnification for visible evidence of cracking of the insulation and meet the requirements of 3.4.3.

4.6.3.1 Cold bend after aging.- A specimen of insulated pair shall be placed in an oxygen bomb containing an atmosphere of oxygen at 300 ± 10 pounds per square inch at a temperature of $70^{\circ} \pm 1^{\circ}\text{C}$, and held there for a period of 96 hours, plus 2, minus 0 hours. At the end of this period, the specimen shall be tested as specified in 4.6.3, except the temperature shall be $-40^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The specimen shall then meet the requirements of 3.4.3.

4.6.4 Elongation.- A specimen of a full cross-section of conductor pair insulation shall be tested in accordance with ASTM D-470 at a speed of not less than two inches per minute and meet the requirements of 3.4.4.

4.6.4.1 Elongation after aging.- A specimen of a full cross-section of conductor pair insulation shall be placed in an air oven conforming to the requirements of paragraph 4 of ASTM D-573 and maintained at a temperature of $100^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for a period of seven days. After a cooling period of at least 24 hours at room temperature, the specimen shall be tested as specified in 4.6.4. The specimen shall then meet the requirements of 3.4.4.1.

4.6.5 Cutting.- A specimen of insulated pair shall be cut in half and the insulation stripped from one end of each piece. One piece shall be formed in a loop, the ends of which shall be tightly clamped in one of the grips of a tensile tester. The second piece shall be passed through the loop and its ends shall be tightly clamped in the other grip of the tensile tester. The two bared conductors of a pair shall be connected together. These bared ends shall be connected in series with an electrical alarm circuit and a load shall be applied to the looped conductors by separation of the tensile tester grips at a rate of two inches per minute until they cut through the insulation, thus making electrical contact as indicated by the alarm circuit. If metal grips are used, one of them must be insulated from the rest of the machine to avoid false indications. The specimen shall then meet the requirements of 3.4.5.

4.6.6 Breaking load.- The breaking load of an insulated pair shall be determined using the apparatus and method described in method 3212 of FED-STD-228 and shall meet the requirements of 3.4.6.

4.7 Electrical tests.-

4.7.1 Dielectric strength, separated conductors.- A five foot length of an insulated pair shall be separated by tearing apart along the mid-rip. Three feet in the center of the piece of each insulated conductor shall be immersed in water for one hour and a potential of 1,000 volts root-mean-square shall be applied between the conductors and the water, and meet the requirements of 3.5.1.

4.7.2 DC resistance.- The dc resistance of the conductors shall be determined as specified in method 6021 of FED-STD-228 and meet the requirements of 3.5.3.

4.7.3 Dielectric strength, cable.- The dielectric strength of the twisted pairs shall meet the requirements of 3.5.4 and shall be determined as specified in method 6111 of FED-STD-228 with the following exceptions:

(a) The immersion shall be four hours.

(b) All the conductors connected together shall be one terminal and the other terminal shall be the water.

4.7.4 Insulation resistance.- The insulation resistance of the cable shall meet the requirements of 3.5.5, and shall be determined as specified in method 6031 of FED-STD-228 with the following exceptions:

(a) The test voltage shall be not less than 100 volts dc.

(b) The polarity of the test conductor shall be maintained negative with respect to the other conductors and the water.

(c) Each conductor shall be connected to one terminal in turn and the other terminal shall be the other three conductors fastened together plus water ground.

(d) If the measurement is made at a temperature other than 15.6°C, the manufacturer shall correct the measured value of insulation resistance to the resistance at 15.6°C. However, if the insulation resistance is equal to or greater than that required by 3.5.5 when the measurement is made at a temperature greater than 15.6°C, no correction factor need be employed. The manufacturer shall demonstrate that the correction factor is accurate for his compound.

(e) The insulation resistance test may be terminated in less than one minute if the galvanometer or meter has ceased fluctuating and the reading indicates that a steady insulation resistance value has been obtained. However, readings obtained on 5% of the lengths after one minute electrification shall be recorded to establish a continuous check of quality.

4.7.5 Mutual capacitance.- Following the test of 4.7.4 and while the cable is still immersed, measure the mutual capacitance between the conductors of each pair at a frequency of 1,000 cycles per second to determine compliance with the requirements of 3.5.6.

4.7.6 Attenuation.- The attenuation of each pair shall be measured on a fifty (50) foot length of cable and computed to db per mile. The wet readings shall be taken on cable that has been in water at least 96 hours. Measurements shall be taken at frequencies of 300 cycles, 1 kilocycle and 4 kilocycles to establish compliance with 3.5.2. If individual readings do not comply, several samples shall be measured and an average taken. The attenuation shall be calculated from direct measurements of the parameters R, L, C, and G and using the standard formula for the attenuation of a two wire transmission line which is as follows:

$$A = 8.69 \sqrt{\frac{1}{2} (\sqrt{(R^2 + W^2 L^2)(G^2 + W^2 C^2)} + RG - W^2 LC)} \text{ db/mile}$$

Where attenuation is in decibels per mile, 8.69 is a factor to convert nepers to decibels.

- R = Resistance in ohms per loop mile of each conductor pair.
- L = Inductance in henries per loop mile of each conductor pair.
- C = Capacitance in farads per mile.
- G = Conductance in mhos per mile.
- $W = 2\pi f$ and f = frequency in hertz.

4.8 Visual and dimensional examination.- The telephone cable shall be examined to verify that the characteristics listed in table I are in accordance with the applicable requirements of 3.2.

4.9 Quality conformance inspection of preparation for delivery.- Preparation for delivery shall be inspected in accordance with MIL-P-116 to determine conformance to the requirements of section 5.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.- Preservation and packaging shall be level A or C as specified. (See 6.3(b)).

5.1.1 Level A.- Cable, Telephone, WF-16()/U shall be furnished in one continuous length as specified (See 6.2.1), and shall be packaged in accordance with method III of MIL-P-116 as follows: Each length of cable shall be fully and evenly wound on a reel conforming to MIL-R-3241, Type DR-5, Both ends of cable shall be brought out and secured in a position that will permit a continuity check (DC resistance, see 3.5.3). Each reel with cable shall be over-wrapped with one thickness of fiberboard conforming to PPP-F-320, Type CF, class-weather resistant, variety SW, grade V3C, of sufficient width to extend the full distance between the reel flanges and of sufficient length to overlap the ends by at least six inches. The overwrap shall be secured with two bands of flat steel strapping conforming to QQ-S-781, type 1, class B, 1/2 inch wide by 0.020 inch thick.

5.1.2 Level C.- Unless otherwise specified, Cable, Telephone, WF-16()/U shall be furnished on Reel DR-5 in one continuous length as specified. (See 6.2.1). The finished cable shall be afforded adequate protection against physical damage from the supply source to the first receiving activity for immediate use.

5.2 Packing.- Packing shall be level A, B, or C as specified. (See 6.3(b)).

5.2.1 Level A or B.- No packing required.

5.2.2 Level C.- No packing required.

5.3 Marking.- In addition to any special marking required by the contract, reels of cable shall be marked in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use.- Cable, Telephone WF-16()/U is intended for use in loop circuits with automatic electronic switching.

6.2 Definitions.-

6.2.1 Unit of product.- The unit of product shall be one continuous length of cable WF-16() one (1) mile $+ 2\%$ long wound on Reel DR-5(). Both ends of the cable on each reel shall be readily accessible.
- 0%

6.2.2 Specimen.- A specimen shall consist of a length of single insulated pair taken from each sample unit. Specimen from a lot shall include approximate equal quantities of each color.

6.2.3 Inspection lot.- An inspection lot shall consist of all units of product, produced under essentially the same conditions, and submitted for inspection at the same time.

6.3 Ordering data.- Procurement documents should specify the following:

- (a) Title, number, and date of this specification and any amendment thereto.
- (b) Levels of preservation, packaging and marking. (See section 5).
- (c) Preproduction pack(s) as follows:
 - Makeup of pack(s).
 - Number of each kind of pack to be submitted.
 - Inspection to be performed therein.
- (d) Marking and shipping of samples.
- (e) Place of final inspection.

6.4 Group C inspection.- Approval to ship may be withheld, at the discretion of the Government, pending the decision from the contracting officer on the adequacy of corrective action. (See 4.5.3.2).

6.5 Nomenclature.- The parentheses in the nomenclature will be deleted or replaced by a letter identifying the particular design; for example: WF-16W/U. The contractor should apply for nomenclature in accordance with the applicable clause in the contract. (See 1.1).

6.6 Verification inspection.- Verification by the Government will be limited to the amount deemed necessary to determine compliance with the contract and will be limited in severity to the definitive quality assurance provisions established in this specification and the contract. The amount of verification inspection by the Government will be adjusted to make maximum utilization of the contractor's quality control system and the quality history of the product.

CUSTODIAN

ARMY EL

Preparing Activity

ARMY EL

Project No. 6145-A03B