INCH-POUND

MIL-DTL-81381C
26 August 2005
SUPERSEDING
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DETAIL SPECIFICATION

WIRE, ELECTRIC, POLYIMIDE-INSULATED, COPPER OR COPPER ALLOY

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

1. SCOPE

1.1 Scope. This specification covers polyimide-insulated single conductor electric wires made with tin-coated, silver-coated, or nickel-coated conductors of copper or copper alloy as specified in the applicable specification sheet. The polyimide insulation may be used alone or in combination with other insulation materials.

1.2 Classification. The wires are as described in the applicable defense specification sheet.

1.2.1 Part or Identifying Numbers. PINs under this specification are coded as in the following example:

M81381/1	-	22	-	9
Applicable specification sheet		Wire size		Insulation color designator

1.2.2 Temperature rating of finished wire. The maximum conductor temperature of the finished wire for continuous use is as specified in the applicable specification sheet (see 6.1.1).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 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 specified requirements documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

Comments, suggestions, or questions on this document should be addressed to: Defense Supply Center Columbus, ATTN: DSCC-VAI, P.O. Box 3990, Columbus, OH 43218-3990, or email to WireCable@dscc.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the solicitation or contract.

FEDERAL STANDARDS

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

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-5624 - Turbine Fuel, Aviation, Grades JP-4, JP-5 and JP5/JP - 8ST

MIL-PRF-87257 - Hydraulic Fluid, Fire resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

MIL-PRF-23699 - Lubrication Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code # O-156

MIL-PRF-27402 - Propellant, Hydrazine - uns-Dimethylhydrazine (50% N_2H_4 - 50% UDMH)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-104 - Limit for Electrical Insulation Color.

MIL-STD-681 - Identification Coding and Application of Hookup and Lead Wire.

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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

Handbook H4/H8 - Commercial and Government Entity (CAGE) Handbook.

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless the otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM B 33	-	Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B286	-	Standard Specification for Copper Conductors for use in Hookup Wire for Electronic Equipment
ASTM B 298	-	Standard Specification for Silver-Coated Soft or Annealed Copper Wire
ASTM B 355	-	Standard Specification for Nickel-Coated Soft or Annealed Copper Wire
ASTM D 149	-	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D 374	-	Standard Test Method for Thickness of Solid Electrical Insulation
ASTM D 882	-	Standard Test Method for Tensile Properties of Thin Plastic Sheeting

(Copies of these documents are available online at http://www.astm.org or from the ASTM International, P.O. Box C700, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

AMERICAN SOCIETY FOR QUALITY (ASQ)

ASQC A8402	-	Quality Management and Quality Assurance Vocabulary
ASQC Z1.4	-	Sampling Procedures and Tables for Inspection by Attributes

(Copies of these documents are available online at http://www.asq.org or from the American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53203.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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 the requirements of this specification and the specification sheet, the latter shall govern.

3.1.1 Specification sheet limitations. The requirements for the individual wires under this specification shall be as specified herein and in accordance with the applicable defense specification sheets. In the event of a conflict between this specification and the requirements of the applicable defense specification sheet, the requirements of the defense specification sheet shall govern, except that the required 0.001 inch (.03 mm) minimum thickness of modified aromatic polyimide resin insulation coating in specification sheets 7 through 20 shall be read as 0.0005 inch (.013 mm) minimum (see 3.6).

3.2 Classification of requirements. The applicable requirements are classified herein as follows:

Requirement	Paragraph
Qualification	3.3
Materials	3.4
Construction	3.5
Finished Wire	3.6

3.3 Qualification. The wire furnished under this specification shall be a product that is authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.3 and 6.3). The provisions of 4.5 for retention of qualification are included in this requirement.

3.4 Material.

3.4.1 Conductor material. All strands used in the manufacture of the conductors shall be soft annealed copper conforming to ASTM B 33, ASTM B 298, or ASTM B 355, as applicable, or shall be high strength copper alloy. Strands shall be free from lumps, kinks, splits, scraped or corroded surfaces and skin impurities. In addition, the strands shall conform to the following requirements as applicable.

3.4.1.1 Silver-coated copper strands. The strands shall have a coating thickness of not less than 40 micro-inches of silver when tested in accordance with ASTM B 298.

3.4.1.2 Nickel-coated copper strands. The strands shall have a coating thickness of not less than 50 micro-inches of nickel when tested in accordance with ASTM B 355. Adhesion of the nickel coating shall be such that, after subjection to the procedures of 4.6.2.1, the strands shall still pass the continuity of coating test in ASTM B 355. Nickel-coated copper strands should be required only when the intended uses of the products require the unique properties provided only by nickel.

3.4.1.3 High strength copper alloy. The strands shall be of the applicable AWG gage specified in table II and of such tensile properties that the conductor from the finished wire conforms to the requirements of 3.5.1.3.2 for elongation and tensile strength. The strands shall be silver-coated or nickel-coated in accordance with 3.4.1.1 or 3.4.1.2 as applicable.

3.4.1.4 Tinned copper strands. The tin coating shall be as specified in ASTM B 33.

3.4.2 Insulation material. All material used in any part of the insulation shall be certified virgin material (3.4.2.1) containing no additives except those required as pigmentation for colors or lubricants used in extrusion. Fillers shall be added only when required by the applicable defense specification sheet. When tested in accordance with 4.6.3 , all fluorocarbon/polyimide composite films (tapes) used in the insulation shall conform to the requirements of table I. Other tapes or insulation coating materials shall be as specified in the applicable specification sheet.

3.4.2.1 Virgin material. For purposes of this specification, virgin material shall be 100% new material which has been through only the processes essential to its manufacture and its application to the wire and has been through these essential processes one time only. Any material which has previously been processed in any other manner is considered non-virgin material. This requirement shall apply to the manufacture of all ingredients and components used.

3.5 Construction. Construction of the wire shall be as specified herein and in the applicable defense specification sheet.

3.5.1 Conductor.

3.5.1.1 Stranding.

3.5.1.1.1 Concentric lay stranding. The conductors of wire sizes 30 through 10 shall be concentric-lay conductors constructed as specified in table II. Concentric lay shall be interpreted to be a central strand surrounded by one or more layers of helically wound strands. It is optional for the direction of lay of the successive layers to be alternately reversed (true concentric lay) or to be in the same direction (unidirectional lay). The strands shall be assembled in a geometric arrangement of concentric layers, so as to produce a smooth and uniform conductor, circular in cross-section and free of any crossovers, high stands, or other irregularities. The direction of lay of the individual strands in the outer layer of the concentrically stranded conductors of finished wire shall be left hand. The length of lay of the outer layer shall not be less than 8 nor more than 16 times the maximum conductor diameter as specified in the applicable defense specification sheet.

3.5.1.1.2 Rope lay stranding. The conductors of wire sizes 8 through 0000 shall be rope-lay as specified in table II and in a and b below.

a. Rope-lay stranded conductors shall be laid up concentrically with a central member surrounded by one or more layers of helically wound members. It is optional for the direction of lay of successive layers to be alternately reversed (true concentric lay), or to be in the same direction (unidirectional lay). The length of lay of the outer layer of rope-lay stranded members forming the conductor shall not be less than 10 or more than 14 times the outside diameter of the completed conductor. The direction of lay of the outside layer shall be either left or right hand.

b. Members of rope-lay stranded conductors: The length of lay of the wires composing the stranded members shall be not greater than 16 times the outside diameter of the member. Stranding of the individual members may be either concentric or bunch.

3.5.1.2 Splices. Splices in individual strands or members shall be butt brazed. There shall not be more than one strand-splice in any two lay lengths of a stranded concentric-lay conductor or in any two lay lengths of any member in a rope lay conductor, except that not more than one splice of an entire member shall be permitted in any two lay lengths of a rope lay conductor. Splices in members of a rope lay construction shall be so finished that the conductor diameter is not increased at the point of brazing. In no case shall the whole conductor be spliced at one point.

3.5.1.3 Elongation and tensile strength of conductor.

3.5.1.3.1 Soft or annealed copper. The individual strands removed from finished wires with soft or annealed copper conductors, wire sizes 20 and larger, or the whole soft or annealed copper conductor removed from finished wire, sizes 22 and smaller, shall have the following minimum elongation when tested in accordance with 4.6.4.7.1:

Sizes 24 and smaller - 6% (minimum)
Sizes 22 and larger - 10% (minimum)

There shall be no tensile strength requirements for soft or annealed copper conductors.

TABLE I. Requirements of fluorocarbon/polyimide insulation films (tapes).

	Polyimide-Fluorocarbon Tapes						
Characteristics	.1/1/.1	0/1/.5	.5/1/.5	0/1/1	0/2/.5	0/2/1	.5/2/.5
Tensile Strength (Minimum Average, lbs./sq/in.)	18,000	12,000	11,000	11,000	15,000	10,000	10,000
Elongation (Minimum Average, Percent)	35	40	40	40	40	40	40
Dielectric Strength (Minimum Average, volts/mil)	4,000	3,500	3,000	3,000	2,500	2,500	2,500
Thickness							
Minimum, inches/(mm)	0.00110/(.028)	0.00125(.032)	0.0017(.043)	0.0017(.043)	0.00238(.0605)	0.0026(.066)	0.0026(.066)
Maximum, inches/(mm)	0.00126(.032)	0.00175(.0444)	0.0023(.058)	0.0023(.058)	0.00263(.0668)	0.0034(.086)	0.0034(.086)

Tape Code	Products
.1/1/.1	0.1 mil FEP-fluorocarbon resin/1-mil polyimide film/0.1-mil FEP-fluorocarbon resin
0/1/.5	1-mil polyimide film/0.5-mil FEP-fluorocarbon film
.5/1/.5	0.5-mil FEP-fluorocarbon resin/1-mil polyimide film/0.5-mil FEP-fluorocarbon resin
0/1/1	1-mil polyimide film/1-mil FEP-fluorocarbon resin
0/2/.5	2-mil polyimide film/0.5-mil FEP-fluorocarbon resin
0/2/1	2-mil polyimide film/1-mil FEP-fluorocarbon resin
.5/2/.5	0.5-mil FEP-fluorocarbon resin/2-mil polyimide film/0.5-mil FEP-fluorocarbon resin

NOTE: First number in tape code is FEP-fluorocarbon resin nominal thickness in mils; second number is polyimide film nominal thickness in mils; and third number is FEP-fluorocarbon resin nominal thickness in mils.

FEP = Fluorinated Ethylene Propylene

3.5.1.3.2 High strength copper alloy. The whole conductor removed from finished wires with high strength copper alloy conductors shall exhibit elongation of 6%, minimum, and a tensile breaking strength conforming with table II, when tested in accordance with 4.6.4.7.2.

3.5.1.4 Conductor diameter. The diameter of the conductor shall be as specified in table II. Applicability of the "general purpose" or of the "small diameter" table II requirements for maximum conductor diameter shall be as indicated in the specification sheet.

TABLE II. Details of conductors. 2/

Size Desig-nation	Nominal Conductor Area (Cir. Mils) 1/	Stranding (No. of Strands x AWG Gage of Strands)	Allowable No. of Missing Strands (Max)	Nominal Dia of Individual Strands (inch) 1/	Diameter of Stranded Conductor							Maximum Resistance of Finished Wire (Ohms/1,000 Ft. at 20°C)				Breaking Strength Alloy Conductor (lbs) (min)
					Min. (inch)	Max (inch)										
						General Purpose		Small Dia(Cu)		Small Dia (Alloy)		Soft or Annealed Copper		High Str Cu Alloy		
						Silver Coated	Nickel Coated	Silver Coated	Nickel Coated	Silver Coated	Nickel Coated	Silver Coated	Nickel Coated	Silver Coated	Nickel Coated	
30	112	7 x 38	0	0.0040	0.011	0.012	0.013	0.012	0.013	0.012	0.013	100.7	110.7	117.4	129.6	5.17
28	175	7 x 36	0	0.0050	0.014	0.015	0.016	0.015	0.016	0.015	0.016	63.8	67.9	74.4	79.0	8.16
26	304	19 x 38	0	0.0040	0.018	0.020	0.021	0.019	0.020	0.020	0.020	38.4	42.2	44.8	49.4	14.2
24	475	19 x 36	0	0.0050	0.023	0.025	0.026	0.024	0.024	0.024	0.025	24.3	25.9	28.4	30.1	22.4
22	754	19 x 34	0	0.0063	0.029	0.032	0.033	0.030	0.031	0.031	0.031	15.1	16.0	17.5	18.6	35.8
20	1,216	19 x 32	0	0.0080	0.037	0.040	0.041	0.038	0.039	0.039	0.040	9.19	9.77	10.7	11.4	58.1
18	1,900	19 x 30	0	0.0100	0.046	0.050	0.051	0.048	0.049	-	-	5.79	6.10			
16	2,426	19 x 29	0	0.0113	0.052	0.057	0.058	0.054	0.055	-	-	4.52	4.76			
14	3,831	19 x 27	0	0.0142	0.065	0.072	0.073	0.068	0.069	-	-	2.88	3.00			
12	5,874	37 x 28	0	0.0126	0.084	0.089	0.090	0.087	0.089	-	-	1.90	1.98			
10	9,354	37 x 26	0	0.0159	0.106	0.112	0.114	0.110	0.112	-	-	1.19	1.24			
8	16,983	133 x 29	0	0.0113	0.158	0.169	0.173	0.166	0.169	-	-	0.658	0.694			
6	26,818	133 x 27	0	0.0142	0.198	0.213	0.217	0.208	0.212	-	-	0.418	0.436			
4	42,615	133 x 25	0	0.0179	0.250	0.268	0.274	0.263	0.268	-	-	0.264	0.275			
2	66,500	665 x 30	2	0.0100	0.320	0.340	0.340	-	-	-	-	0.170	0.177			
1	81,700	817 x 30	2	0.0100	0.360	0.380	0.380	-	-	-	-	0.139	0.144			
0	104,500	1,045 x 30	3	0.0100	0.405	0.425	0.425	-	-	-	-	0.108	0.113			
00	133,000	1,330 x 30	3	0.0100	0.450	0.475	0.475	-	-	-	-	0.085	0.089			
000	166,500	1,665 x 30	4	0.0100	0.515	0.540	0.540	-	-	-	-	0.068	0.071			
0000	210,900	2,109 x 30	5	0.0100	0.580	0.605	0.605	-	-	-	-	0.054	0.056			

1/ Nominal values are for information only. Nominal values are not requirements.
2/ For diameters and maximum resistance values of tin coated conductors, see the applicable specification sheets.

3.5.2 Insulation. The insulation shall be constructed as specified in the applicable specification sheet. The minimum percent overlap in applying each layer of insulation tape shall be as indicated on the specification sheet. If more than one layer of tape is used in the insulation, each layer after the first shall be applied as a cross or reverse wrap to the immediately preceding layer of tape. Splices shall be permitted on the insulation tapes provided the performance characteristics of the finished wire, as defined in this specification, are not affected. However, no splice in one layer of insulation tape shall be so positioned on the wire as to overlap any part of a splice in another layer of insulation tape; also, the measured maximum diameter of the finished wire at a splice in the insulation tape shall not exceed the measure diameter of the nominal thickness of the tape in which the splice occurs. Splices of the outer insulation tape shall not be longer than one inch and not more than one splice of the outer insulation tape shall occur in any 150 feet of the finished wire. The laminated insulation shall be heated to obtain fusion between layers of tape. All insulation will be readily removable by mechanical wire stripping devices.

3.5.2.1 Insulation coating or jacket. When specified in the applicable specification sheet, a coating or a tape jacket of the composition prescribed in the specification sheet shall be applied over the polyimide or fluorocarbon/polyimide insulation. Such coating or jacket shall be continuous and free of checks, cracks, splits, blisters, or other defects when examined with normal vision without magnification.

3.6 Finished wire. The finished wire shall conform to the requirements of table III and those of the applicable specification sheet. However, in specification sheets 7 through 20, the specified 0.002 inch (.05 mm) minimum thickness of modified aromatic polyimide resin insulation coating shall be read as 0.0005 inch (.013 mm) minimum (see 3.1). The requirements of 3.6.1 through 3.6.7 also apply.

3.6.1 Minimum insulation wall thickness. The requirement for minimum insulation wall thickness shall apply to the total insulation wall of the finished wire and also to any individual part of the total insulation (e.g., primary insulation, insulation coating, or jacket) for which the specification sheet prescribes a minimum thickness value.

3.6.2 Impulse dielectric test. One hundred percent of the finished wire shall pass the impulse dielectric test of 4.6.4.1, which test shall be made during the final winding of the wire on shipment spools or reels.

3.6.3 Color. The color of the finished wire shall be as specified in the procurement contract or order in accordance with this paragraph and the applicable specification sheet. Preferred colors, if any, are as indicated in the individual specification sheets. Except as otherwise provided in this paragraph or in the specification sheet, all colors shall be in accordance with MIL-STD-104, class 1, or shall be “opaque dark yellow” (color designator “N”) as defined in 3.6.3.1. When specified in the procurement contract or order, the MIL-STD-104, class 1, limits for the colors red, orange, brown, green and blue shall be extended in accordance with 3.6.3.1 or wire with unpigmented polyimide resin insulation coating (color designator “C”) shall be acceptable. When the wire is to be used in an end item for the Government, such extension of the color limits or use of unpigmented insulation coating shall be permissible only when so specified in the Government contract for the end item. Color coding by stripes, bands, or braided tracers, if used, shall be in accordance with MIL-STD-681.

3.6.3.1 Special color limits. The color limits for opaque dark yellow (3.6.3) and those for red, orange, brown, green, and blue when extended as provided in 3.6.3 beyond the limits of MIL-STD-104, class 1, shall be as follows (Munsell notation).

Color	Light limit	Dark limit
Opaque dark yellow	2.5Y 8/8	2.5Y 5/8
Red	2.5R 5/12	7.5R 2/6
Orange	2.5YR 6.5/14	1.25YR 3/12
Brown	2.5YR 4.5/6	2.5YR 2/2
Green	2.5G 6/12	5.0G 2/6
Blue	2.5PB 5.2/10	2.5B 2/4

For unpigmented polyimide resin insulation coating (3.6.3), no color limits shall be applicable.

3.6.3.2 Durability of color. All solid color insulation coatings (3.5.2.1) and color stripes or bands shall be capable of withstanding the durability test of 4.6.4.3 for the number of cycles and with the weight specified in the applicable specification sheet. This test shall not be required if the color coating, striping, or banding is under a clear jacket and shall not be required of braided tracers.

3.6.4 Identification of product. Unless otherwise specified in the applicable specification sheet, the finished wire shall be identified by a printed marking applied to the outer surface or visible through the outer surface. The printed identification shall consist of the following, at intervals of 9 to 60 inches (229 to 1534 mm), as measured from the beginning of one complete marking to the beginning of the succeeding complete marking.

Specification sheet PIN
Manufacturer's code designation in accordance with Handbook H4/H8

The printing shall be green in color in accordance with MIL-STD-104, class 1, except that when the wire is solid green or any other color against which green is difficult to distinguish, the printing shall be white. Identification printing shall be applied with the vertical axes of the printed characters lengthwise of the wire when the nominal diameter of the finished wire is 0.050 inch (1.27 mm) or smaller. The vertical axes of the printed characters may be either crosswise or lengthwise of the wire when the nominal diameter of the wire exceeds 0.050 inch (1.27 mm). All printed characters shall be complete and legible.

3.6.4.1 Durability of identification. Identification printing, when applied to the outer surface of the finished wire, shall be capable of withstanding the durability test specified in 4.6.4.3 for the number of cycles and with the weight specified in the applicable specification sheet. This test shall not be required when the identification marking is under a clear jacket.

3.6.5 Blocking. Adjacent turns or layers of the wire shall not stick to one another when tested as specified in 4.6.4.4 at the temperature specified in the applicable specification sheet.

3.6.6 Workmanship. All details of workmanship shall be in accordance with high grade aircraft wire manufacturing practice. The insulation shall be free of cracks, splits, irregularities, and imbedded foreign material.

3.6.7 Continuous lengths. Unless otherwise specified in the contract or order, the individual continuous lengths of wire in each inspection lot shall be of such footage that the inspection lot shall conform to table IV when examined in accordance with 4.6.4.22. Unless otherwise specified in the contract or order, the footage of the individual continuous lengths in each spool or reel shall be marked on the spool or reel in the sequence in which the lengths will be unwound by the user.

TABLE III. Properties of finished wire.

Examination or test	Requirement	Method
Conductor stranding	Table II and 3.5.1.1	4.6.1
Conductor diameter	Table II and 3.5.1.4	4.6.1
Finished wire diameter	Specification sheet	4.6.1
Construction of insulation	Specification sheet; also 3.5.2 and 3.5.2.1	4.6.1
Minimum insulation wall thickness	Specification sheet and 3.6.1	4.6.4.8
Removability of insulation	3.5.2	4.6.1
Impulse dielectric test	3.6.2	4.6.4.1
Insulation resistance	Specification sheet	4.6.4.2
Color	3.6.3	4.6.1
Durability of color coating, striping, or banding	3.6.3.2	4.6.4.3
Identification of product	3.6.4	4.6.1
Durability of identification	3.6.4.1	4.6.4.3
Blocking	3.6.5	4.6.4.4
Workmanship	3.6.6	4.6.1
Finished wire weight	Specification sheet	4.6.4.5
Conductor resistance	Table II	4.6.4.6
Conductor elongation and tensile strength	3.5.1.3	4.6.4.7
Shrinkage	Specification sheet	4.6.4.9

TABLE III. Properties of finished wire – Continued.

Examination or test	Requirement	Method
Lamination sealing	Specification sheet	4.6.4.10
Abrasion resistance, initial	Specification sheet	4.6.4.11
Low temperature (cold bend)	No cracking; no dielectric breakdown	4.6.4.12
Thermal shock resistance	Specification sheet	4.6.4.13
Wrap test	No cracking; no dielectric breakdown	4.6.4.14
Polyimide cure test (sizes 10 and smaller, polyimide coated constructions)	No cracking	4.6.4.15
Flammability	Specification sheet	4.6.4.16
Life cycle	No cracking in bend test No dielectric breakdown No pitting of conductor	4.6.4.17.2 4.6.4.17.3 4.6.4.17.1
Immersion tests	Diameter increase, 5 percent max; no cracking on bending; no dielectric breakdown	4.6.4.18
Humidity resistance	Specification sheet	4.6.4.19
Surface resistance	Specification sheet	4.6.4.20
Propellant resistance (except polyimide coated constructions)	No dielectric breakdown	4.6.4.21
Continuous lengths	Table IV and 3.6.7	4.6.4.22

TABLE IV. Minimum continuous wire lengths.

Wire size (Range)	Required minimum percent of total inspection lot footage in continuous lengths greater than		
	100 feet	50 feet	25 feet
30 - 20	50%	80%	100%
18 - 10	30%	80%	100%
8 - 0000	-	50%	100%

3.7 Recycled, recovered or environmental preferable materials. Recycled, recovered or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

4. VERIFICATION

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

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

c. Process control inspection (see 4.4).

d. Periodic qualification re-evaluation (see 4.5.1).

4.2 Qualification inspection. Qualification inspection shall consist of all the examinations and tests of this specification except the examination for continuous lengths and the examination of preparation for delivery.

4.2.1 Sampling for qualification inspection. A finished wire sample of the required length shall be submitted for each range of wire sizes for which qualification is desired. The sample may be any size wire within the specified size range. Ten linear feet of the coated conductor strand and fifty linear feet of each tape used in the manufacture of the finished wire sample shall be submitted with the finished wire sample.

Wire size range	Required length of sample (feet)
30 through 26	150
24 through 16	150
14 through 10	150
8 through 6	100
4 through 0000	100

4.2.1.1 Optional qualification samples. In cases where two or more specifications sheets cover wires identical in materials and construction except for conductor (i.e., the specified conductor may be silver coated copper, nickel coated copper, silver coated alloy, or nickel coated alloy in the different specification sheets), the finished wire sample, tape sample, and conductor strand sample in accordance with 4.2.1 may be submitted for any one of the specification sheets in each range of wire sizes for which qualification is desired. In addition, 10-foot samples of conductor strand only, applicable to the same wire size range or ranges as the finished wire sample, may be submitted for any of the other specification sheets which differ only in conductor. Approval of the finished wire qualification sample shall also qualify the same wire size range or ranges in each of the other specification sheets for which conductor strand samples have been submitted and approved.

4.2.2 Forwarding of qualification samples. Samples and the manufacturer's certified test reports shall be forwarded to the testing laboratory designated in the letter of authorization from the activity responsible for qualification (see 6.3), plainly identified by securely attached, durable tags marked with the following information:

Sample for qualification test
WIRE, ELECTRIC, POLYIMIDE-INSULATED, COPPER OR COPPER ALLOY
Specification sheet PIN
Manufacturer's name and CAGE code (Handbook H4/H8)
Manufacturer's part number
Comprehensive description and prime manufacturer's name and formulation number of the base materials from which the product is made. (This information will not be divulged by the Government)
Place and date of manufacture of sample
Submitted by (name) (date) for qualification tests in accordance with the requirements of MIL-DTL-81381 under authorization (reference authorizing letter).

4.3 Conformance inspection. Conformance inspection shall consist of the examinations and tests listed in table V and described under "Test methods" (4.6). Conformance inspection shall be performed on every lot of wire procured under this specification.

TABLE V. Conformance inspection.

Examination or test	Requirement	Method
Group I characteristics		
Conductor stranding	Table II and 3.5.1.1	4.6.1
Conductor diameter	Table II and 3.5.1.4	4.6.1
Finished wire diameter	Specification sheet	4.6.1
Construction of insulation	Specification sheet; also 3.5.2 and 3.5.2.1	4.6.1
Removability of insulation	3.5.2	4.6.1
Insulation resistance	Specification sheet	4.6.4.2
Color, initial	3.6.3	4.6.1
Durability of color coating, striping, or banding	3.6.3.2	4.6.4.3
Identification of product	3.6.4	4.6.1

TABLE V. Conformance inspection- Continued.

Examination or test	Requirement	Method
Durability of identification	3.6.4.1	4.6.4.3
Workmanship	3.6.6	4.6.1
Finished wire weight	Specification sheet	4.6.4.5
Conductor resistance	Table II	4.6.4.6
Conductor elongation and tensile strength	3.5.1.3	4.6.4.7
Group II characteristics		
Minimum insulation wall thickness	Specification sheet and 3.6.1	4.6.4.8
Shrinkage	Specification sheet	4.6.4.9
Lamination sealing	Specification sheet	4.6.4.10
Abrasion resistance, initial	Specification sheet	4.6.4.11
Low temperature (cold bend)	No cracking; no dielectric breakdown	4.6.4.12
Thermal shock resistance	Specification sheet	4.6.4.13
Wrap test	No cracking; no dielectric breakdown	4.6.4.14
Polyimide cure test (sized 10 and smaller, polyimide coated constructions)	No cracking	4.6.4.15
Group III characteristics		
Impulse dielectric test	3.6.2	4.6.4.1
Group IV characteristics		
Continuous lengths	Table IV and 3.6.7	4.6.4.22

4.3.1 Sampling for conformance inspection. ASQC A8402 shall apply for definitions of inspection terms used herein. For purposes of this specification, the following shall apply:

4.3.1.1 Lot. The inspection lot shall include all wire of one PIN subjected to inspection at one time.

4.3.1.2 Unit of product. The unit of product for determining lot size for sampling shall be one continuous length of wire as offered for inspection.

4.3.1.3 Sample unit (groups I and II tests). The sample unit for groups I and II tests, except for the group I insulation resistance test (4.3.1.3.1), shall consist of a single piece of finished wire chosen at random from the inspection lot and of sufficient length to permit all applicable examinations and tests. Unless otherwise specified, the length of the sample unit for group I tests of table V, other than insulation resistance, shall be 20 feet and the length of the sample unit for group II tests shall be 25 feet. Not more than one sample unit for each group of tests shall be taken from a single unit of product.

4.3.1.3.1 Sample unit for insulation resistance test (group I). The sample unit for the group I insulation resistance test shall be a specimen at least 26 feet in length selected at random from finished wire which has passed the group III dielectric test. It is optional whether the specimen is tested on the reel or removed from the reel for the test, provided the length of the specimen can be determined.

4.3.1.4 Sampling and acceptance for the group I test. For group I characteristics, including the insulation resistance test, a sample of 2 units shall be randomly selected. If one or more defects are found the lot shall be re-screened and defects removed. After screening and removal of defects, a new sample shall be randomly selected. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

4.3.1.5 Sampling and acceptance for the group II test. For group II characteristics, a sample of 8 units shall be randomly selected. If one or more defects are found the lot shall be re-screened and defects removed. After screening and removal of defects, a new sample shall be randomly selected. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

4.3.1.6 Sampling and acceptance for the group III (impulse dielectric) test. The sample for the group III impulse dielectric test shall be 100% of the finished wire and every length of the wire shall be subjected fully to the test. Insulation breakdowns resulting from the test and ends on portions not subjected to the test shall be marked or cut out of the finished wire (4.6.4.1).

4.3.1.7 Sampling and acceptance for the group IV (continuous lengths examination) test. The sample for the group IV continuous lengths examination test shall be as required for the applicable procedure of 4.6.4.22.

4.3.2 Nonconforming inspection lots. Disposition of inspection lots found unacceptable under initial quality conformance inspection shall be in accordance with ASQC Z1.4.

4.4 Process control inspection. This inspection comprises tests and examinations of such a nature that they cannot be performed on the finished wire as submitted for inspection and therefore must be conducted at the most appropriate stage of the manufacturing operations. The process control tests shall consist of the tests listed in table VI. Process control inspection shall be performed on every lot of wire procured under this specification.

TABLE VI. Process control inspection.

Examination or test	Requirement	Method
Conductor material 1/	3.4.1	4.6.2
Insulation material	3.4.2	4.6.3
Conductor splices	3.5.1.2	4.6.1

1/ Except adhesion of nickel coating. See table VII.

4.4.1 Sampling for process control inspection.

4.4.1.1 Conductor material. From each week's production of individual coated strands or from every 1000 pounds of such strands, whichever is less, three ten-foot lengths of strand shall be selected in such a manner as to be representative of the material to be used in the finished wire.

4.4.1.2 Insulation material. Three samples representative of each incoming lot of insulating material shall be selected for test before application to the wire.

4.4.1.3 Splices. The manufacturer's method of splicing individual strands and entire members shall be observed at the discretion of the Government representative.

4.4.2 Rejection and retest in process control inspection. When a process control sample selected from a production run fails to meet the specified tests, no items still on hand or later produced shall be accepted until the extent and cause of the failure have been determined. After investigation, the contractor shall advise the Government of the action taken and, after corrections have been made, shall repeat all the process control tests. Rejection after corrective action will require that the contractor advise the procuring activity of the details surrounding the retest and cause for rejection.

4.4.2.1 Effect of process control failure on quality conformance testing. Quality conformance testing may be continued during the investigation of the failure of a process control sample, but final acceptance of the material shall not be made until it is determined that the lot meets all the process control requirements and quality conformance requirements of the specification.

4.5 Retention of qualification. Periodic qualification reevaluations shall be made at two-year intervals after the date of the letter of notification of the product's acceptability for qualification. Materials from current production shall be evaluated against the requirements of table VII in addition to the quality conformance requirements and process control requirements of table V and table VI.

TABLE VII. Tests applicable only to qualification inspection and qualification re-evaluation.

Examination or test	Requirement	Method
Adhesion of nickel coating	3.4.1.2	4.6.2.1
Blocking	3.6.5	4.6.4.4
Flammability	Specification sheet	4.6.4.16
Life cycle	Table III	4.6.4.17
Immersion tests	Table III	4.6.4.18
Humidity resistance	Specification sheet	4.6.4.19
Surface resistance	Specification sheet	4.6.4.20
Propellant resistance (except polyimide coated constructions)	Table III	4.6.4.21

4.5.1 Re-evaluation procedure. It shall be the responsibility of the qualified supplier to furnish to the Government, at two-year intervals, the data necessary to establish the continued conformity of the product to all qualification requirements. These data should preferably be complete test results of a sample representative of current production tested against all requirements of the specification. At the discretion of the qualifying activity, test records from current production may be accepted for the re-evaluation to the extent they are available and samples from current production need be subjected to only the tests for which no production test records are available. The qualifying activity shall be notified of the test results. If a failure occurs, no wire represented by the sample nor any other wire manufactured with the same materials and processes, which has not already been submitted for quality conformance inspection, shall be offered for acceptance until the cause for failure has been determined and concurred in by the qualifying activity as not affecting the ability of the wire to pass qualification inspection requirements. In the event the date for re-evaluation has passed and no current production materials or data are available for re-evaluation, the supplier shall still be eligible for contract award, but final acceptance of material from such a supplier is contingent upon his material meeting all the qualifying requirements of the specification.

4.6 Test methods.

4.6.1 Examination of product. All samples shall be examined carefully to determine conformance to this specification and to the applicable specification sheets with regard to requirements not covered by specific test methods.

4.6.2 Conductor material. Conductor strands, prior to use in the conductor, shall be tested for conformity to ASTM B 33, ASTM B 298, or ASTM B 355, as applicable. Thickness of silver or nickel coating shall also be determined by the methods of ASTM B 298 and ASTM B 355.

4.6.2.1 Adhesion of nickel coating. Two 6-inch specimens shall be cut from the sample of nickel-coated strand. One specimen shall be wrapped over its own diameter for eight close turns. The second specimen shall remain in its straight form. Both specimens shall then be subjected to ten continuous cycles of temperature change. Each cycle of temperature change shall consist of 4 hours at 250±3 °C (482±5.4 °F) followed by 4 hours at room temperature. Upon completion of the thermal cycling, the straight specimen shall be wrapped over its won diameter for eight close turns in a manner identical to that of the first specimen. Both wrapped specimens shall then be tested for continuity of coating in accordance with the procedure given in ASTM B 355.

4.6.3 Insulation material. Samples of insulation material selected in accordance with 4.4.1.2 shall be subjected to the following tests:

4.6.3.1 Tensile strength and elongation of polyimide and fluorocarbon/polyimide. The samples of polyimide and fluorocarbon/polyimide tapes shall be subjected to the tensile strength tests and elongation tests of ASTM D 882 method A or B, except that there shall be no limitation as to width of the tape.

4.6.3.2 Dielectric strength of polyimide and fluorocarbon/polyimide tapes. Samples of the tape shall be subjected to the short-time test of ASTM D 149. For tapes having a width of .3125 inch (7.938 mm) or greater, stainless steel electrodes .25 inch (6.35 mm) in diameter with edges rounded to a .0313 inch (.794 mm) radius shall be used. For tape narrower than .3125 inch (7.938 mm), stainless steel electrodes .0937 inch (2.381 mm) in diameter with edges rounded to a .0156 inch (.397 mm) radius shall be used. The radius must be accurate, and should be checked on an optical comparator. Voltage shall be increased at approximately 500 volts per second. Tapes shall be tested with oil as the medium. The oil shall be as specified in MIL-PRF-23699.

4.6.3.3 Thickness of tapes. Samples of the polyimide or fluorocarbon/polyimide primary insulation tapes, and also of tapes used as jacketing material (3.5.2.1) when applicable, shall be subjected to the test procedure of ASTM 374, method C. The average shall be obtained from 10 randomly selected readings from a minimum area of 12 square inches.

4.6.4 Finished wire. Methods of test of the finished wire shall be as follows:

4.6.4.1 Impulse dielectric test.

4.6.4.1.1 Test equipment. The electrode head through which the wire is passed in the impulse dielectric test shall be of a suitable bead chain construction such that the electrode will give intimate metallic contact with practically all the wire insulation surface. The characteristics of the test impulse and of the equipment auxiliary to the electrode head shall be as follows:

a. Test impulse. The wave form of the voltage supplied to the electrode head shall consist of a negative pulse, the peak magnitude of which shall be as specified for the wire under test, followed by a damped oscillation. Unless otherwise specified in the applicable specification sheet, the peak impulse voltage for wire of this specification shall be 8.0 kV. The rise time of the negative impulse wave front from zero magnitude to 90% of the specified peak voltage shall be not more than 75 microseconds. The peak value of the first positive overshoot and each of the subsequent damped oscillations shall be smaller than the initial negative pulse. The time during which each pulse and accompanying damped oscillation (positive and negative) remains at an absolute potential of 80% or greater of the specified peak voltage shall be 20 to 100 microseconds. The pulse repetition rate shall be 200 to 250 pulses per second, inclusive. Except for the final peak voltage adjustment (4.6.4.1.3), conformity to these test impulse parameters shall be determined with no capacitive load impressed upon the electrode.

b. Capacitive tolerance. The tolerance of the equipment to change in capacitive load shall be such that the peak output voltage shall not be reduced by more than 12% in the event of an increase of capacitive load, between electrode and ground, from an initial load of 12.5 pF per inch to 25 pF per inch of electrode length.

c. Instrument voltmeter. Connected to the electrode head, there shall be a peak reading voltmeter indicating continually the potential of the electrode. The voltmeter shall show full deflection at a potential not exceeding 15 kilovolts and shall have a minimum accuracy of ± 4% at the specified test impulse potential.

d. Failure detection circuit. There shall be a failure detection circuit to give a visible or audible indication of insulation failure, automatically de-energize the electrode head, and stop progress of the wire through the electrode. The detecting circuit shall be sufficiently sensitive to indicate a fault at 75% of the specified test voltage when the electrode is arced to ground through a 20 kΩ resistor and shall be capable of detecting a fault which lasts for the duration of only one impulse.

4.6.4.1.2 Calibration of equipment. The instrument voltmeter shall be calibrated by comparison with an external standard voltmeter capable of detecting the peak potential at the electrode head with or without auxiliary circuitry. In performing the calibration, the standard voltmeter shall be connected to one of the electrode beads directly or through a calibrated attenuator circuit. The impulse generator shall be energized and the voltage control of the impulse generator shall be adjusted until the reading on the standard voltmeter is the specified potential, at which point the reading on the instrument voltmeter shall be observed and recorded. This calibration shall be repeated for each peak potential at which it is intended to operate the equipment. An alternative procedure is by means of a calibrated oscilloscope connected to the electrode through a suitable attenuator. The peak magnitude of the negative pulse can then be read directly from the waveform display. An oscilloscope connected to the electrode head at suitable test points shall also be used to verify conformance to the other waveform parameters specified in 4.6.4.1.1a.

4.6.4.1.3 Test procedure. The finished wire shall be threaded through the electrode head and the conductor shall be grounded at one or both ends. The electrode shall be energized to the specified peak potential and, after final adjustment of the voltage with wire in the electrode head, the wire shall be passed from the pay-off spool through the electrode and onto the take-up spool. The speed of passage of the wire through the electrode shall be such that the wire is subjected to not less than 3 nor more than 100 pulses at any given point. Any dielectric failures which occur shall be cut out or marked for later removal along with at least 2 inches of wire on each side of the failure. During all parts of the test, including string-up of new lengths, every effort shall be made to test the entire length, including ends of the wire, in accordance with this procedure. All ends or other portions of the wire not so tested shall be removed subsequent to the test. When specified in contract or order (6.2), dielectric failures, untested portions of wire, or portions which have been exposed to fewer or more than the specified number of pulses may be marked by stripping the insulation or by other suitable method of marking as specified in the contract in lieu of being cut out of the wire.

4.6.4.2 Insulation resistance. The uninsulated ends of a wire specimen at least 26 feet in length shall be connected to a positive DC terminal and the specimen shall be immersed to within 6 inches of its ends in a water bath, at 25± °C (77±9 °F), containing 0.5% to 1.0% of an anionic wetting agent. The specimen shall remain immersed for not less than 4 hours, after which a potential of not less than 250V nor more than 500V shall be applied between the conductor and the water bath which serves as the second electrode. The insulation resistance shall be determined after one minute of electrification at this potential, and shall be expressed as megohms-1000 feet by the following calculation:

$$\text{Megohms - 1000 feet} = \frac{\text{Total specimen resistance (megohms) x immersed length (feet)}}{1000}$$

4.6.4.3 Durability of color markings. The durability of solid color insulation coatings or of product identification or color markings applied to the wire for coding shall be evaluated at 20 to 25 °C (68 to 77 °F) as follows:

4.6.4.3.1 Durability testing apparatus. The markings durability tester shall be designed to hold a short specimen of finished wire firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. The instrument shall be capable of rubbing a small cylindrical mandrel, which shall be a sewing needle 0.025±.002 inch (.635±.05 mm) in diameter, repeatedly over the upper surface of the wire, in such position that the longitudinal axes of the mandrel and the specimen are at right angles to each other with cylindrical surfaces in contact. A weight affixed to a jig above the mandrel shall control the thrust normal to the surface of the insulation. A motor driven, reciprocating cam mechanism, and counter shall parallel to the axis of the specimen. The length of the stroke shall be .375 inch (9.53 mm) and the frequency of the stroke shall be 120 strokes (60 stroking cycles) per minute.

4.6.4.3.2 Durability testing procedure. In performing the test, a specimen of wire shall be mounted in the specimen clamp and the weight specified in the applicable specification sheet shall be applied through the abrading mandrel to the marked surface. The counter shall be set at zero and the drive motor started. The specimen shall be subjected to the number of strokes of the mandrel specified in the specification sheet and shall then be examined. If a continuous line of solid color insulation coating or of the stripe, band, or printed marking, as applicable, has been erased or obliterated by the mandrel, the specimen shall be considered as having failed. Three specimens shall be tested from each sample unit and failure of any specimen shall constitute failure of the sample unit.

4.6.4.4 Blocking. One end of a piece of finished wire, of sufficient length to perform the test, shall be affixed to a metal spool of the barrel diameter specified for the applicable wire size in table VIII. The wire shall then be wound helically on the spool for at least three turns, with the succeeding turns in close contact with one another. The tension for winding shall be equal to the test load specified for the cold bend test of the same size wire in the applicable specification sheet. The winding shall be continued until there are at least three closely-wound layers of such helical turns on the spool. The free end of the wire shall then be affixed to the spool so as to prevent unwinding or loosening of the turns or layers and the spool and wire shall be placed for 24 hours in an air oven at the temperature specified on the applicable specification sheet. At the end of the 24-hour period, the spool and wire shall be removed from the oven and allowed to cool to room temperature. After cooling, the wire shall be unwound manually, meanwhile being examined for evidence of adhesion (blocking) of adjacent turns or layers.

4.6.4.5 Wire weight. The weight of each lot of finished wire shall be determined by procedure I (4.6.4.5.1). Lots failing to meet the wire weight requirement of the applicable specimen sheet when tested in accordance with procedure I shall be subjected to procedure II (4.6.4.5.2). All reels or spools failing to meet the requirements of the applicable specification sheet, shall be rejected. The sampling plans of 4.3.1 are not applicable in procedure II.

4.6.4.5.1 Procedure I. The length and weight of a specimen at least 10 feet long shall be accurately measured and the resultant measurements converted to pounds per 1000 feet.

4.6.4.5.2 Procedure II. The net weight of the finished wire on each reel or spool shall be obtained by subtracting the tare weight of the reel or spool from the gross weight of the reel or spool and the wire thereon. The net weight of the wire on each reel or spool shall be divided by the exactly determined length of wire on that reel or spool and the resultant figure converted to pounds per 1000 feet. When wood or other moisture absorbent materials are used for reel or spool construction, weight determinations shall be made under substantially the same conditions of relative humidity.

4.6.4.6 Conductor resistance. The DC resistance of the conductor shall be measured in accordance with method 6021 of FED-STD-228 except that the wire shall be tested dry without immersion.

4.6.4.7 Conductor elongation and tensile strength.

4.6.4.7.1 Soft or annealed copper. Elongation tests of soft or annealed copper conductors shall be performed in accordance with method 3211 of FED-STD-228, except that the elongation at break of the individual strand or of the first strand of the whole conductor, as applicable, shall be determined by means of a recording chart on the testing machine rather than by measuring the specimen after the break. For wire sizes 20 and larger, the tests shall be performed upon individual strands taken from the conductor of the finished wire. For sizes 22 and smaller, the tests shall be performed upon the whole conductor removed form the finished wire and the elongation shall be measured when the first strand of the conductor breaks. For wire sizes 20 and larger, only the values obtained with individual strands shall be considered and, for wire sizes 22 and smaller, only the values obtained with the whole conductor shall be considered, in determining the conformance of soft or annealed copper conductors to elongation requirements of this specification.

4.6.4.7.2 High strength copper alloy. Elongation and tensile strength tests of high strength alloy conductors shall be performed in accordance with method 3211 of FED-STD-228, except that the tensile strength shall be reported as the tensile breaking strength of the conductor rather than in pounds per square inch and the elongation at break of the first strand of the whole conductor shall be determined by means of a recording chart on the testing machine rather than by measuring the conductor specimen after the first strand breaks. The tests shall be performed upon the whole conductor removed from the finished wire. Conductor elongation shall be measured when the first strand of the conductor breaks, and the total tensile force indicated by the testing machine at break of that strand shall be regarded as the breaking strength of the conductor. Only the values thus obtained with the whole conductor shall be considered in determining the conformity of high strength alloy conductor to the elongation and tensile strength requirements of this specification.

4.6.4.8 Minimum insulation wall thickness. The thickness of the entire insulation wall of the finished wire and, when applicable, the thickness of the primary insulation and of the insulation coating or jacket shall be measured at their thinnest points on a cross-section of the wire. Thickness measurements of the entire insulation wall or of the primary insulation wall and braided or taped jackets shall be made at 10x magnification (10 diameters). Thickness measurements of insulation coatings shall be made at 100x magnification (100 diameters). For the primary insulation and for the entire insulation, a wall thickness measurement shall be the shortest distance between the outermost rim of the primary insulation or of the finished wire, as applicable, and the outer rim of the outermost strand of the conductor. For the coating or jacket, the measurement shall be the shortest distance between the inner and outer surfaces of the coating or jacket.

4.6.4.9 Shrinkage. A 12-inch (305 mm) specimen of the finished wire shall be cut so that the insulation and conductor are flush at both ends. (For purposes of this test, insulation is defined as all layers of non-conducting material covering the electrical conductor; e.g., primary insulation, all tapes and braids, and the jacket.) The specimen shall be maintained at the temperature specified in the applicable defense specifications sheet for 6 hours in an air oven. At the end of this period, the specimen shall be removed form the oven and allowed to return to room temperature. Shrinkage of the insulation shall then be measured as the greatest distance which any part of the insulation has receded from either end of the conductor; that is, the measurement obtained at the end showing the greater shrinkage shall be considered the shrinkage of the specimen.

4.6.4.10 Lamination sealing. A 12-inch (305 mm) specimen of finished wire shall be prepared and exposed to air oven temperature as specified in 4.6.4.9, except that the oven temperature shall be as specified for test of lamination sealing in the applicable defense specification sheet and that the period of oven exposure shall be 48 hours. After cooling, the specimen shall be examined visually for de-lamination of the insulation. Any separation of layers, either along the insulation or at the ends, shall constitute failure.

4.6.4.11 Abrasion. The abrasion resistance test shall be conducted on a testing machine conforming to Appendix A, except that the machine shall be modified or supplemented by a device to determine the lengthwise tension of the wire specimen when it is being clamped into the machine. The insulation of the wire sample shall be free of surface contaminants such as oil or moisture and, for referee tests, atmospheric conditions shall be standard as defined in FED-STD-228. In making the test, an inch of the insulation shall be removed from one end of a 30-inch (762 mm) specimen of the finished wire and this end shall be connected to the detection circuit of the tester. The specimen shall be clamped into the tester, using the lengthwise tensile load, the weight support bracket and the vertical weight specified in the applicable specifications sheet. The specimen shall then be abraded. At the start of each measurement the center of a conducting stripe shall be at the point of contact with the wire. The reading of each measurement shall be the length of abrasion tape in inches to come in contact with the wire insulation to the point where the machine stops. After each reading, the specimen shall be moved forward 2 inches (51 mm) and rotated clockwise 90 degrees. Eight readings shall be obtained for each specimen. An average shall be obtained by calculating the arithmetic mean of all the readings which are individually less than the arithmetic mean of all the eight readings per specimen. This average shall define the abrasion resistance of the specimen under test.

4.6.4.12 Low temperature (cold bend). One end of a wire specimen 36 inches (914 mm) in length shall be secured to a rotatable mandrel in a cold chamber and the other end to the load weight specified in the applicable specification sheet. The diameter of the mandrel shall be as specified in the specification sheet. Provision shall be made for rotating the mandrel by means of a handle or control located outside the chamber. The specimen of wire and the mandrel shall be conditioned at -65±2 °C (-85±3.6 °F) for 4 hours. At the end of this period and while both mandrel and specimen are still at this low temperature, the specimen shall be wrapped helically, for its entire length or for 20 turns whichever is the lesser number of turns, around the mandrel without opening the chamber. The bending shall be accomplished at a uniform rate of 2±1 RPM. At the completion of this test the specimen shall be removed from the cold box and from the mandrel without straightening. The specimen shall be examined for cracks in the insulation. The insulation shall then be removed for a distance of 1 inch (25.4 mm) from each end of the specimen and the specimen shall be subjected to the wet dielectric test specified in 4.6.4.17.3 with the bent portion submerged.

4.6.4.13 Thermal shock resistance.

4.6.4.13.1 Preparation of specimen. A specimen of wire, five feet long, shall be prepared by carefully removing 1 inch (25.4 mm) of insulation from each end of the wire. (For purposes of this test, insulation is defined as all layers of non-conducting material covering the electrical conductor, e.g., primary insulation, all tapes and braids, and the jacket.) A razor blade or equivalent, held perpendicular to the axis of the wire, shall be used to cut the insulation for the removal operation. The length of exposed conductor at each end of the specimen shall be measured to the nearest 0.01 inch (.254 mm). The specimen shall be formed into a loose coil not less than 1 foot in diameter and shall be laid on a wire screen for handling throughout the test.

4.6.4.13.2 Test procedure. The specimen shall be placed for 30 minutes in a preheated air circulating oven at the temperature specified in the applicable specification sheet. The specimen shall then be removed from the oven and, within two minutes, placed in a chamber which has been pre-cooled to -55±2 °C (-67±3.6 °F). It shall be exposed to this temperature for 30 minutes, after which it shall be removed and allowed a minimum of 30 minutes to return to room temperature, 20 to 25 °C (68 to 77 °F). At the conclusion of this cycle, the distance from the end of each layer of insulation to the end of the conductor shall be measured to the nearest 0.01 inch (.254 mm). This thermal shock cycle and the measurements shall be repeated for an additional three cycles (a total of four cycles). Any measurement varying from the original measurement by more than the amount specified in the applicable specification sheet shall constitute failure. Any flaring of any layer shall also constitute failure.

4.6.4.14 Wrap test. A specimen of finished wire, with a length of 12 inches (305 mm) plus the additional length required for winding on the mandrel, shall be wound tightly for two close turns around a mandrel of the diameter specified in the applicable specification sheet. The winding may be accomplished manually and shall be in the middle portion of the specimen so that 6 inches of each end shall remain straight. The specimen shall then be removed from the mandrel, examined for cracks visually without aid of magnification, and subjected to the wet dielectric test of 4.6.4.17.3.

4.6.4.15 Polyimide cure test. Two hundred milliliters of distilled water together with a few boiling chips or beads shall be placed in a 1 liter Erlenmeyer flask and the flask shall be closed by a rubber stopper fitted with a water cooled reflux condenser. The flask shall be heated by hot plate or heating mantle until the water is boiling and condensate is returning from the reflux condenser. One end of an approximately 12 inch (305 mm) length of the wire to be tested shall be inserted into the flask by passing it between the rubber stopper and the side of the flask or through a snugly fitting hole in the stopper, so that 5 inches (127 mm) of the wire length extends into the vapor phase inside the flask. The portion of the wire inside the flask shall be essentially straight and shall not be in contact with the glass sides of the flask or condenser, the layer of liquid water in the bottom of the flask, or the liquid condensate returning from the condenser. Heating of the flask shall be resumed, with stopper and reflux condenser again in place. The portion of wire inside the flask shall be exposed to the vapor phase above the boiling water for exactly one hour and shall then be removed from the flask. A 4 inch (102 mm) specimen shall be cut from the vapor-exposed portion of the wire, avoiding the one inch which was nearest the rubber stopper during vapor exposure. The 4 inch (102 mm) specimen shall be allowed to cool at room temperature for a minimum of fifteen minutes, after which it shall be wrapped in a tight spiral for six turns or the full length of the specimen, whichever is lesser, around a mandrel which for wire sizes 18 and smaller shall be the specified maximum diameter of the wire and for wire sizes 16 and larger shall be three times the specified maximum diameter of the wire. The specimen shall then be inspected visually for cracks without the aid of magnification.

4.6.4.16 Flammability.

4.6.4.16.1 Apparatus. The test shall be performed within a test chamber approximately one foot square by two feet in height, open at top and front to provide adequate ventilation for combustion but to prevent drafts. The specimen holder shall be so designed that the lower end of a 24-inch (610 mm) wire specimen is held by a clamp, while the upper end of the specimen passes over a pulley and can be suitably weighted to hold the specimen taut at an angle of 60 degrees with the horizontal, in a plane parallel to and approximately 6 inches (152 mm) from the back of the chamber. The test flame shall originate from a Bunsen type gas burner with a .25 inch (6.35 mm) inlet, a needle valve in the base for gas adjustment, a bore of .375 inch (9.53 mm) nominal, and a barrel length of approximately 4 inches (102 mm) above the air inlets. The burner shall be adjusted to furnish a 3 inch conical flame with an inner cone approximately 1 inch in length and a flame temperature not less than 954 °C (1749 °F) at its hottest point, as measured with an accurate thermocouple pyrometer. A sheet of facial tissue shall be suspended taut and horizontal 9.5 inches (247 mm) below the point of application of the flame to the wire specimen and at least .500 inch (12.7 mm) from the chamber floor, so that any material dripping from the wire specimen shall fall upon the tissue.

4.6.4.16.2 Procedure. A 24-inch (38.1 mm) specimen of wire shall be marked at a distance of 8 inches (203 mm) from its lower end to indicate the point for flame application and shall be placed in the specified 60 degree position in the test chamber. The lower end of the specimen shall be clamped in position in the specimen holder and the upper end shall be passed over the pulley of the holder and weighted with the weight specified for life cycle test of the same wire in the applicable specification sheet. With the burner held perpendicular to the specimen and at an angle of 30 degrees from the vertical plane of the specimen, the hottest portion of the flame shall be applied to the lower side of the wire at the test mark. The period of test flame application shall be 30 seconds for all sizes of wire and the test flame shall be withdrawn immediately at the end of that period. The distance of flame travel upward along the specimen from the test mark and the time of burning after removal of the test flame shall be recorded; also the presence or absence of flame in the facial tissue due to incendiary drip from the specimen. Charred holes or charred spots in the tissue shall be ignored in the absence of actual flame. Breaking of the wire specimens in sizes 24 and smaller shall not be considered as failure provided the requirements for flame travel limits, duration of flame, and absence of incendiary dripping are met.

4.6.4.17 Life cycle.

4.6.4.17.1 Air oven. One inch of the insulation shall be removed from each end of a 24-inch (38.1 mm) sample of the finished wire. The central portion of the specimen shall then be bent over a horizontally placed mandrel of the diameter specified in the applicable specification sheet. Each end of the conductor shall be loaded with the weight specified in the specification sheet, so that the portion of the insulation between the conductor and mandrel is under compression and the conductor is under tension. This specimen so prepared on the mandrel shall be placed in an air-circulating oven and maintained for the period of time and at the temperature specified in the specification sheet. After completion of the air oven exposure, the specimen shall be cooled to between 20 and 25 °C (68 to 77 °F), within a period of 1 hour. When cooled, the wire shall be freed from tension, removed from the mandrel, and straightened. The specimen shall then be subjected to the bend test (4.6.4.17.2), followed by dielectric test (4.6.4.17.3). After the dielectric test, the insulation shall be removed from the specimen and the conductor shall be examined for pitting.

4.6.4.17.2 Bend test. In a temperature maintained between 20 and 25 °C (68 to 77 °F), one end of the specimen shall be secured to the mandrel and the other end to the load weight specified in the applicable specification sheet. The mandrel shall be rotated until the full length of the specimen is wrapped around the mandrel and is under the specified tension with adjoining coils in contact. The mandrel shall then be rotated in reverse direction until the full length of the wire which was outside during the first wrapping is now next to the mandrel. This procedure shall be repeated until two bends in each direction have been made in the wire. The outer surface of the wire shall then be observed with 10x magnification for cracking of the insulation. Checks in a dispersion coating do not constitute failure.

4.6.4.17.3 Wet dielectric test. The uninsulated ends of the specimen shall be attached to an electric lead. The specimen shall be immersed in a 5%, by weight, solution of sodium chloride in water at 20 and 25 °C (68 to 77 °F), except that the uninsulated ends and 1-1/2 inches (38.1 mm) of insulated wire at each end of the specimen shall protrude above the surface of the solution. After immersion for 5 hours, the voltage specified in the applicable specification sheet at a frequency of 60Hz (cycles per second) shall be applied between the conductor and an electrode in contact with the liquid. This voltage shall be gradually increased at a uniform rate from zero to the specified voltage in ½ minute, maintained at that voltage for a period of 5 minutes, and gradually reduced to zero in ½ minute.

4.6.4.18 Immersion tests. Specimens of wire of sufficient length to perform the subsequent tests shall be gaged accurately to determine their initial diameter and shall then be immersed to within 6 inches of their ends in each of the following fluids (using a separate specimen for each fluid) for the lengths of time and at the temperatures specified.

(a) Lubricating oil, aircraft turbine engine, synthetic base, MIL-PRF-23699, for 7 hours at 175±2 °C (347±3.6 °F).

(b) Hydraulic Fluid, Fire resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile, MIL-PRF-87257, for 20 hours at 48 to 50 °C (118.4 to 122 °F).

(c) Isopropyl alcohol, for 20 hours at 20 to 25 °C (68 to 77 °F).

(d) Turbine fuel, aviation, Grade JP-4, MIL-DTL-5624, for 20 hours at 20 to 25 °C (68 to 77 °F).

During immersion, the radius of bend of the wire shall be not less than fourteen times the maximum specified diameter of the wire under test. Upon removal from the liquids, the specimen shall remain for 1 hour in free air at room temperature. The diameter shall be gaged accurately and compared to the initial diameter. The insulation shall be removed for a distance of one inch from each end of a 24-inch (610 mm) length of the specimen and this length shall be subjected to the bend test of 4.6.4.17.2 and the dielectric test of 4.6.4.17.3.

4.6.4.19 Humidity resistance. A 52-foot specimen of wire shall be subjected to the following:

4.6.4.19.1 Apparatus. The apparatus shall consist of a test chamber capable of maintaining an internal temperature of 70±2 °C (158±3.6 °F) and an internal relative humidity of 95±5%. The test chamber shall be capable of being so sealed as to retain the total moisture content in the test space. The heat loss from the chamber shall be sufficient to reduce the internal temperature from the above specified operating temperature to not more than 38 °C (100.4 °F) within a period of 16 hours from the time of removal of the source of heat. Distilled or de-mineralized water shall be used to obtain the required humidity.

4.6.4.19.2 Procedure. The specimen shall be placed in the test chamber and the temperature and relative humidity raised over a 2-hour period to the values specified in 4.6.4.19.1 and maintained at such for a period of 6 hours. At the end of the 6-hour period the heat shall be shut off. During the following 16-hour period, the temperature shall drop to 38 °C (100.4 °F) or lower. At the end of the 16-hour period, heat shall be again supplied for a 2-hour period to stabilize at 70±2 °C (158±3.6 °F). This cycle (2 hours heating, 6 hours at high temperature, 16 hours cooling) shall be repeated a sufficient number of times to extend the total time of the test to 360 hours (fifteen cycles). At the end of the fifteenth cycle, the 50-foot center section of the specimen shall be immersed in a 5%, by weight, solution of sodium chloride in water at room temperature. The insulation resistance of the specimen shall be measured with the outer surface of the specimen grounded, through an electrode in the electrolyte, and with a potential of 250 to 500 volts DC applied to the conductor of the specimen. The measurement shall be made after 1 minute of electrification at this potential. The insulation resistance shall be converted to megohms-1000 feet by the calculation shown in 4.6.4.2.

4.6.4.20 Surface resistance. The surface resistance of the finished wire shall be measured in accordance with method 6041 of FED-STD-228. All specimens, after having been provided with the required electrodes by prior to testing, shall be cleaned by the procedure described in the test method. In positioning the specimens in the test chamber, the specimens shall be so placed that their ends are a minimum of one inch from any wall of the chamber.

4.6.4.21 Propellant resistance. A specimen of finished wire, 24 inches (610 mm) in length, shall be immersed to within 1-1/2 inches (38.1 mm) of each end in hydrazine-uns-dimethylhydrazine propellant (50% N_2H_4 - 50% UDMH) of MIL-PRF-27402 for 30 minutes at a temperature of 20 to 25 °C (68 to 77 °F). During immersion, the radius of bend of the wire shall be not less than fourteen times the maximum specified diameter of the wire under test. Upon removal from the liquid, the specimen shall be allowed to remain for 1 hour in free air at room temperature. The insulation shall then be removed for a distance of one inch from each end of the specimen and the specimen shall be subjected to the dielectric test of 4.6.4.17.3.

4.6.4.22 Continuous lengths. Unless otherwise specified in the ordering data (6.2), the inspection requirements for continuous wire lengths shall be satisfied by the supplier's certificate of conformity and the presence of the required piece length markings on the spools or reels (3.6.7). However, the Government reserves the right to examine such certified lots if deemed necessary to assure that the lengths actually conform to requirement. When the ordering data specifies examination of the wire lengths, the Government representative shall examine the wire at his own discretion to determine conformity in this characteristic. In measuring continuous wire lengths where marking or stripping of insulation has been used in lieu of cutting the wire to identify dielectric test failures or areas not properly tested (4.6.4.1.3), such marking or stripping shall be considered equivalent to severance of the wire at the two ends of each marked or stripped area.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. 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.

TABLE VIII. Barrel diameters of spools and reels.

Wire size (Range)	Minimum diameter of barrel (as times minimum diameter of finished wire)
30-14	50X
12-10	40X
8-0	30X
00-0000	20X

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Intended use. The electric wires covered by this specification are intended for use in any application where their performance characteristics are required. The wires are suitable for installation on aerospace electrical systems within the limitations of applicable performance requirements.

6.1.1 Limitations. Polyimide has characteristics making it a desirable insulation material, but also is known to exhibit problems such as hydrolysis, characterized by breakdown and cracking of the insulation material, wet arc tracking and dry arc tracking. It is important that wiring using polyimide insulation be installed and maintained properly. Manufacturer's recommendations should be followed, and polyimide insulated wire should not be used under certain conditions where it may be prone to developing problems such as in environments that expose the wire to caustic fluids or gases, where repeated flexing of the wire is required or where repeated exposure to water is expected, especially in the presence of ultraviolet light, etc.

6.1.1.1 Temperature rating. Temperature ratings as specified in specification sheets pertaining to this specification, represent the maximum permissible operating temperature of the conductor. The maximum ambient temperature should be the rated maximum conductor temperature of the wire diminished by the operating rise in temperature of the conductor.

6.1.2 Size designation. The conductor sizes and the corresponding wire size designations of this specification are in accordance with established usage for stranded copper conductors for hookup wire in the electronic and aircraft industries (see ASTM B 286). It should be noted that these sizes and size designations are not identical with American Wire Gage (AWG) sizes for solid wire and strands. The diameters and cross-sectional areas of the stranded conductors of this specification are, in most sizes, only roughly approximate to those of AWG solid conductors of the same numerical size designation.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.

b. Applicable specification sheet number, title, and date (1.2).

c. Applicable specification sheet PIN (1.2.1).

d. Color required (3.6.3, 3.6.3.1).

e. Quantity of wire required.

f. Levels of packaging and packing required.

g. Exceptions, if any, to the optional provisions of this specification including:

1. Applicable minimum length requirements, if other than specified in 3.6.7 and table IV.

2. Marking of dielectric test failures or irregularities by stripping of insulation or by other method specified in the contract in lieu of cutting of the wire, if applicable (4.6.4.1.3).

3. Special preparation for delivery requirements, if applicable (section 5).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the applicable Qualified Products List (QPL) No. 81381 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. Information pertaining to qualification of products may be obtained from Defense Supply Center Columbus, DSCC-VQ, 3990 East Broad Street, Columbus, OH., 43218-3990.

6.3.1 Conformity to qualified sample. It is understood that wire supplied under contract should be identical in every respect to the qualification sample tested and found satisfactory, except for changes previously approved by the Government. Any unapproved changes from the qualification sample should constitute cause for rejection.

6.4 Patent notice. The Government does not have a royalty free license under Patent No. 3,352,714 but does have a letter of non-assertion of patent infringement for the benefit of manufacturers in making insulated electrical conductors for sale to the Government or for use in equipment to be delivered to the Government, from the patent owner under claims 10, 24, 25, 26, 28 and 29 of the patent, and a statement that the remaining claims of the patent will not be used to exclude practice of the aforesaid claims. Except as stated, no license is given by the patent owner either expressly or by implication under any other claims of this patent or the claims of any other patent.

6.5 Subject term (key word) listing.

Conductor
Fluorinated Ethylene Propylene (FEP)
Fluorocarbon
Jacket
Stranding
Tensile strength

6.6 Supersession data. This specification supersedes MIL-DTL-81381B dated 8 September 1998.

6.7 Changes from previous issue. The margins of this specification are marked with a vertical line to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.8 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. Table IX lists the Environmental Protection Agency (EPA) top seventeen hazardous materials targeted for major usage reduction. Use of these materials should be minimized or eliminated unless needed to requirements specified herein (see section 3).

TABLE IX. EPA top seventeen hazardous materials.

Benzene	Dichloromethane	Tetrachloroethylene
Cadmium and Compounds	Lead and Compounds	Toulene
Carbon Tetrachloride	Mercury and Compounds	1,1,1 Trichoroethane
Chloroform	Methyl Ethyl Ketone	Trichloroethylene
Chromium and Compounds	Methyl Isobutyl Ketone	Xylene
Cyanide and Compounds	Nickel and Compounds	

ABRASION TESTER FOR ELECTRICAL CABLE

A.1 SCOPE

A.1.1 Scope. This appendix is a mandatory part of the specification. The information contained herein is intended for (compliance or guidance only). This appendix establishes the requirements for electrical abrasion testers. The abrasion tester is intended to provide a means of comparing the abrasion resistance of various types of electrical cable insulation.

A.2 APPLICABLE DOCUMENTS

(This section is not applicable to this appendix)

A.3 REQUIREMENTS

A.3.1 Design. The abrasion tester should be designed to provide a means of comparing the abrasion resistance of various types of cable insulation.

A.3.2 Construction. The tester shall consist of an assembly including an electric motor, pulley system, measuring device, detecting circuit, and a weight system. Component parts of the abrasion tester shall be located as shown on figure A-1.

A.3.2.1 Motor. The drive motor shall have sufficient torque to maintain constant speed within 5% over the entire loading range of the machine.

A.3.2.2 Pulley system. The pulley system shall include the following parts: drive-wheel, tension wheel, two reels, tape-aligning guide, and tape-positioning guide.

A.3.2.2.1 Drive wheel. The drive wheel shall be rubber faced and suitable for driving the tape at the specified rate of speed.

A.3.2.2.2 Tension wheel. The tension wheel shall be rubber faced and shall transmit sufficient pressure to the drive wheel through the tape to eliminate slippage.

A.3.2.2.3 Reels. Reels shall be provided to hold the abrasive tape. The capacity of each reel shall be sufficient to hold 50 yards of tape. Reels shall be secured to their spindles by a locking device in such a manner that they can be removed readily yet shall not become unlocked during operation. The machine shall be constructed to prevent excessive unwinding of the loaded reel and to wind the tape on the empty reel.

A.3.2.2.4 Tape aligning guide. The tape aligning guide shall be constructed in accordance with detail A on figure A-2.

A.3.2.2.5 Tape positioning guide. The tape positioning guide shall be constructed in accordance with detail B on figure A-2. This guide shall be mounted as shown on figure A-1.

A.3.2.3 Tape measuring device. The tape-measuring device shall provide a means to determine the length of abrasive tape that has contacted the cable under test.

A.3.2.4 Detecting circuit. The detecting circuit shall stop the machine when the insulation of the cable under test fails. A schematic diagram of a typical circuit is shown on figure A-3 The direct-current resistance of the detection circuit may vary from 3000 Ω to 6000 Ω. A relay shall be provided that can be actuated with the resistance in series.

A.3.2.5 Weight system. A weight system shall be provided to apply various loads to the cable at the point where it is being abraded.

A.3.2.5.1 Weight support brackets. Weight support rod and weights shall conform to the requirements of details C, E, and F on figure A-2 The combined weight of any weight support bracket and weight support rod shall be 0.12 pound.

A.3.2.5.2 Pivoted support arm. The pivoted support arm shall conform to dimensions shown in detail D on figure A-2. The pivot shall be as friction free as possible and shall be located so that the arm is horizontal when the bracket is in test position (see figure A-1). This support arm shall have a range of motion at right angles to the travel of the tape sufficient to bring the weight support bracket over any position of the tape.

A.3.2.6 Abrasive tape. Each roll of tape shall consist of a continuous strip 1 inch (25.4 mm) wide and 50 yards long. The abradant on the tape shall be aluminum oxide, grit 400, and the detection cross stripes of conductive silver paint on the tape shall be .25 inch (6.35 mm) wide, spaced 3 inches (76.2 mm) apart, center to center.

A.3.2.6.1 Preparation of tape for detection circuit. Detection strips shall be applied to the abrasive tape by coating sections with an aquadag or equivalent solution applied in strips .375 inch (9.52 mm) wide across the abrasive surface of the tape at right angles to its edge. The strips shall be placed 6 $\pm$ 1/4 inches (152±6.35 mm) center to center, and such that any 11 consecutive strips shall measure 60$\pm$1 inches (1520±25.4 mm), center to center. The .375 inch (9.52 mm) strips painted on the abrasive tape shall serve as an electrical conductor in the detection circuit and provide an indication as to when the insulation on the cable is worn through. The solution shall consist of 1 ounce of aquadag or equivalent conducting colloid to 1-1/2 ounces of water. The resulting solution should have a consistency of heavy motor oil. The applied coating shall have an average thickness of 0.0007 inch (.018 mm) and an average direct-current resistance of 15,000 Ω measured across a .75 inch (19 mm) length when the solution is air-dried. Care should be taken not to apply the aquadag or equivalent solution too thickly at one application, nor to dry it at temperatures above 27 °C (80.6 °F) since the coating has a tendency to crack excessively under these conditions, producing a high resistance path. If the dried coating is not cracked and its direct current resistance is too high, another coating may be applied.

A.3.2.7 Cable clamps. Cable clamps shall be provided to hold the test cable firmly in a horizontal position as shown on figure A-1. By means of these clamps it shall be possible to position the cable over any portion of the tape at right angles to the motion of the tape.

A.3.3 Performance.

A.3.3.1 Speed. The tester shall apply the abradant to the surface being tested at the rate of 60$\pm$3 inches (1520±76.2 mm) per minute.

A.3.3.2 Slippage. The tape shall travel at a uniform rate of speed. There shall be no slippage.

A.3.3.3 Accuracy of tape-measuring device. The measuring device shall record within an accuracy of 1% the length of tape that has come in contact with the test cable up to the point of indication of insulation failure.

A.3.4 Workmanship. The abrasion tester shall be fabricated and processed in accordance with the best commercial practice for laboratory instruments.

A.4. VERIFICATION

A.4.1 Inspection tests. The abrasion tester shall be subjected to the tests specified in the following paragraphs.

A.4.1.1 Large cable test. A test length of size 0 AWG cable shall be secured in the cable clamps. With the tape measuring device set at zero, the support bracket "C " and 4.25 pound weight positioned on the cable, the machine shall be started. When the abradant breaks through the insulation, energizing the detector circuit, the machine shall stop. An auxiliary detector circuit shall be used to determine when conductor contact occurs on the Aquadag strip and to determine satisfactory performance of the detector circuit.

A.4.1.1.1 The travel distance of the abrasive tape when measured from start and stop lines on the abradant shall equal the peripheral travel of the tape drive wheel and the reading of the tape-measuring device $\pm$ 1%. There shall not be more than 1% variation in these values when determined from one continuous 300 inch (7620 mm) cycle of operation and 5 intermittent 60 inch (1520 mm) cycles when using a nonabradant material if necessary. The peripheral speed of the tape driving wheel shall be 60$\pm$3 inches (1520±76.2 mm) per minute. Machine performance shall not vary when tests are performed on intermediate and small size cable.

A.4.1.2 Intermediate cable test. Repeat the above test using size 8 AWG test cable, 3-pound weight, and weight support bracket "B."

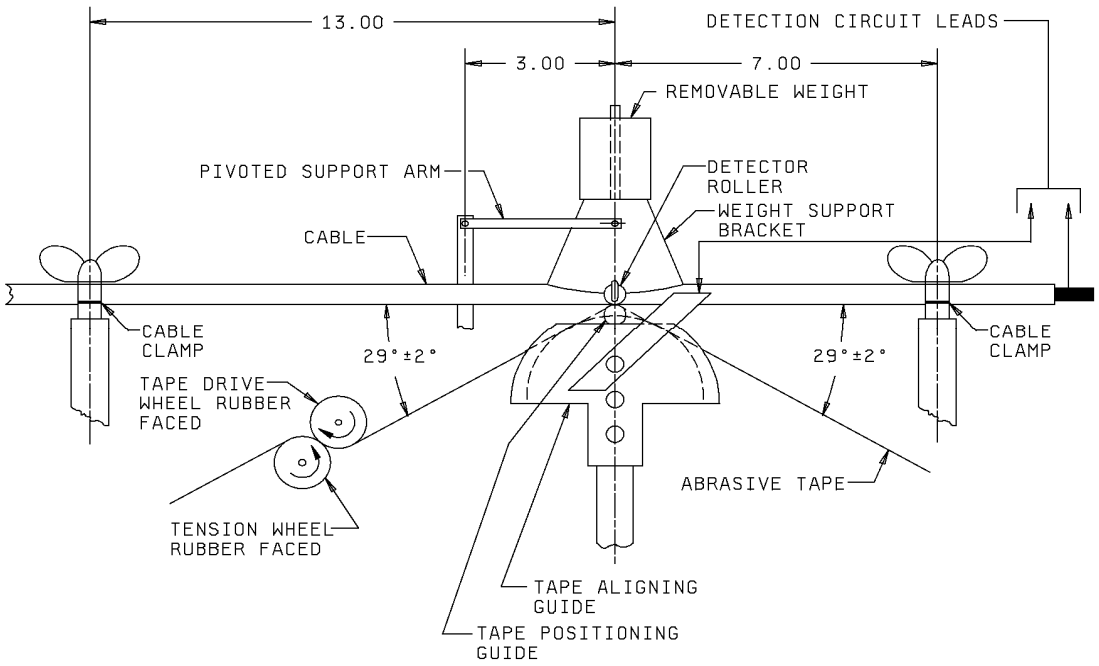
A.4.1.3 Small cable test. Same as large cable test except that size 16 AWG test cable, 1-pound weight, and weight support bracket "A" shall be used instead of those specified above.

A.4.1.4 Each tester shall be carefully examined for conformance with requirements of this appendix not covered by tests.

A.4.2 Rejection and retest. Failure to meet any of the requirements of this specification shall be cause for rejection. Abrasion testers which have been rejected may be reworked or replaced to correct the defects, and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the inspector.

A.5. NOTES

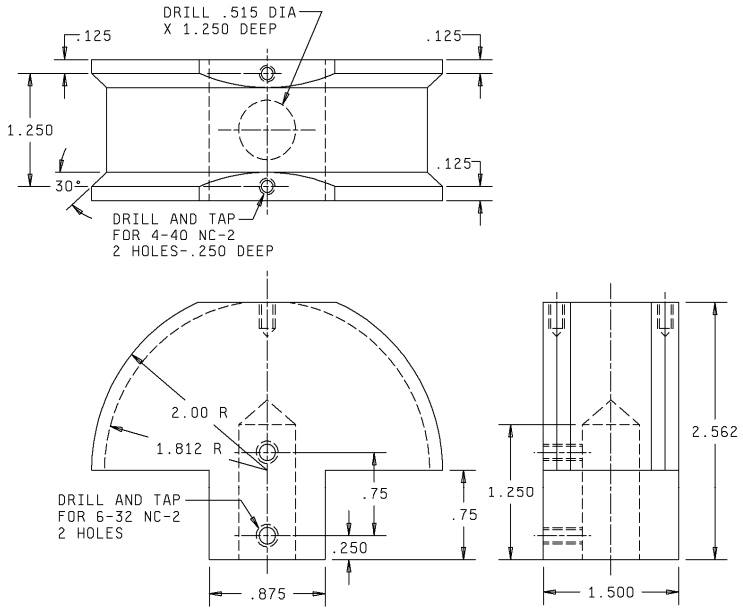
A.5.1 Intended use. The abrasion tester is intended to provide a means of comparing the abrasion resistance of various types of electrical cable insulation.



Inches	mm
3.0	76.2
7.0	178
13.00	330

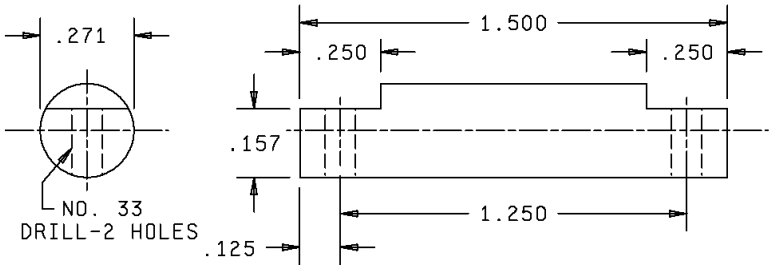
FIGURE A-1. Assembly sketch of abrasion tester

NOTES:
1. Dimensions are in inches.
2. Inch-pound equivalents are given for information only.



Inches	mm
.125	3.17
.157	3.99
.250	6.35
.271	6.88
.515	13.1
.75	19.0
.875	22.2
1.250	31.8
1.50	38.1
1.812	46.0
2.0	50.8
2.562	65.1

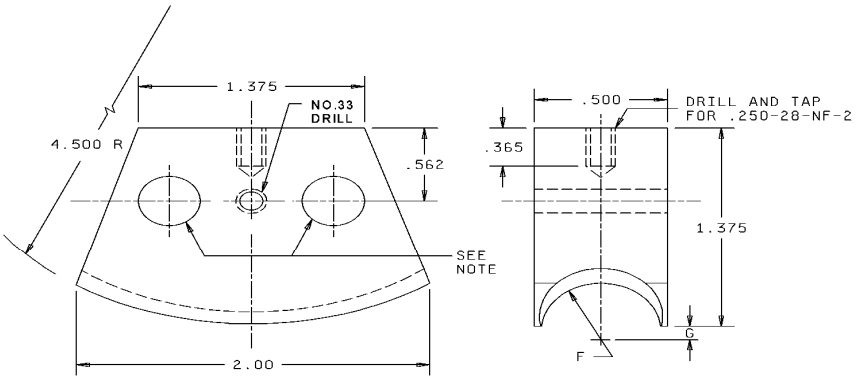
DETAIL A
Tape Aligning Guide, one required
Material - Dural



DETAIL B
Tape Position Guide, one required
Material - Tungsten Steel

NOTES:
1. Dimensions are in inches.
2. Inch-pound equivalents are given for information only.

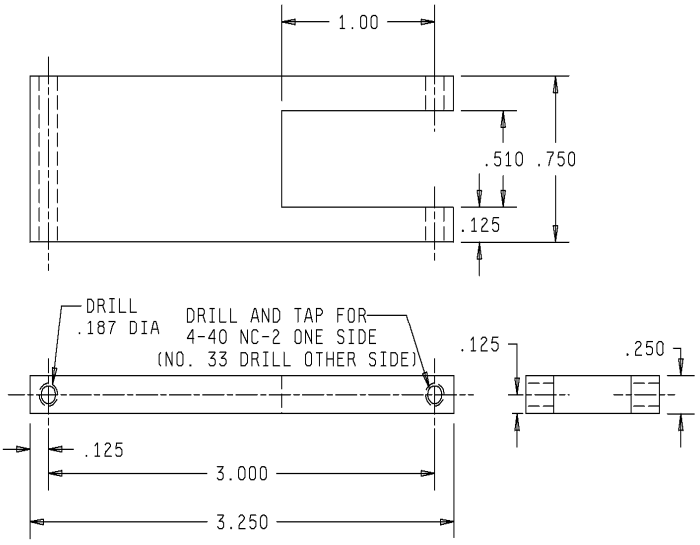
FIGURE A-2. Detail drawing of parts for abrasion tester.



DETAIL C
Weight Support Bracket, one each required
Material - Dural

Bracket	F inch/(mm)	G inch/(mm)
A	.0312/(.792)	.0156/(.396)
B	.0625/(1.59)	.0312/(.792)
C	.1875/(4.76)	.0625/(1.59)

NOTE: Weight of bracket and weight support rod to be 0.12 lbs. Drill holes to suit to obtain required weight.

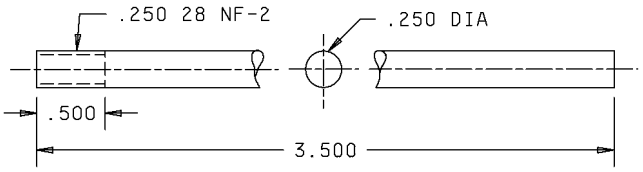


Inches	mm
.125	3.17
.187	4.75
.250	6.35
.365	9.27
.50	12.7
.510	13.0
.562	14.3
.75	19.0
1.00	25.4
1.250	31.8
1.375	34.9
1.50	38.1
2.0	50.8
3.0	76.2
3.25	82.5
4.5	114

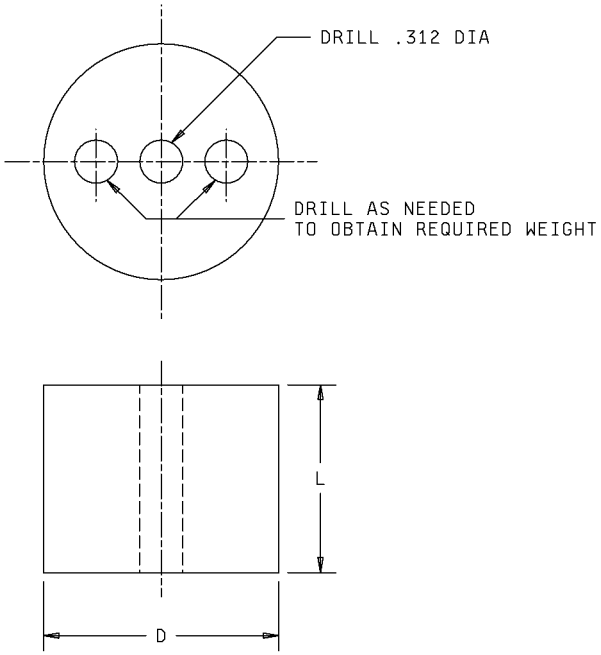
DETAIL D
Pivoted Support Rod, one required
Material - Dural

NOTES:
1. Dimensions are in inches.
2. Inch-pound equivalents are given for information only.

FIGURE A-2. Detail drawing of parts for abrasion tester - Continued.



DETAIL E
Weight Support Rod, one required
Material - Dural



Inches	mm
.250	6.35
.312	7.92
.50	12.7
1.50	38.1
1.75	44.4
2.0	50.8
2.25	57.1
2.50	63.5
2.56	65.1
2.81	71.4
3.50	88.9

DETAIL F
Removable Weight, one each required
Material - Brass

WEIGHT	D	L
1.0 LBS	1.750	1.50
3.0 LBS	2.250	2.562
4.25 LBS	2.500	2.812

NOTES:
1. Dimensions are in inches.
2. Inch-pound equivalents are given for information only.

FIGURE A-2. Detail drawing of parts for abrasion tester - Continued.

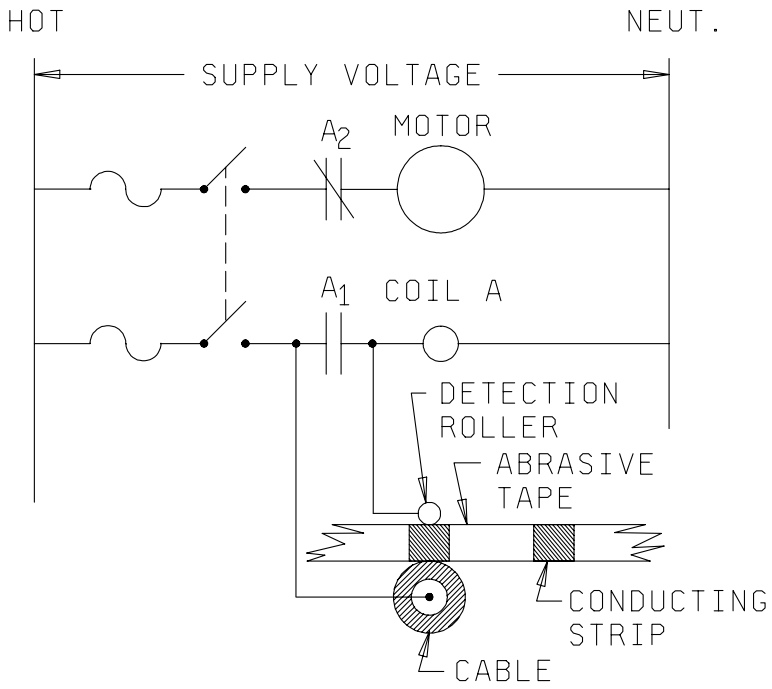


FIGURE A-3. Schematic wiring diagram of abrasion tester.

CONCLUDING MATERIAL

Custodians:
Army - CR
Navy - AS
Air Force - 11
DLA - CC
NASA - NA

Review activities:
Army - AT, AV
Navy - EC, MC, OS, SH
Air Force - 03

Preparing activity:
DLA-CC

(Project 6145-2396-000)

NOTE: The activities listed above were interested in this document as of the date of the document. Since organizations and responsibilities can change, you should verify the currency of this information above using the ASSIST Online database at http://assist.daps.dla.mil.