REVISIONS				
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PREPARED BY T. J. PERRY/UNISYS CORP.	DATE 5/01/90	TITLE Wire And Cable, Electrical, Insulated, For Space Flight Use, General Specification For
APPROVED G. F. KIERNAN/UNISYS CORP.	5/18/90	
APPROVED S. A. NAUS /GSFC	6-14-90	
APPROVED D. G. CLEVELAND/GSFC	6/14/90	
		#S-311-P-13

OFFICE OF FLIGHT ASSURANCE
PARTS BRANCH

NASA
National Aeronautics and Space Administration

GSFC
Goddard Space Flight Center
Greenbelt, Maryland
20771

CONTENTS

TABLES

1. SCOPE

1.1 PURPOSE - This specification covers the general provisions for radiation crosslinked, polyalkene insulated, single conductor wire. It also covers additional types of finished wires, and single or multiconductor cables which may be shielded and jacketed. The radiation crosslinked polyalkene insulation can be used alone or in combination with radiation crosslinked polyvinylidene fluoride. The wire or cable is intended for use in Goddard Space Flight Center (GSFC) space flight and critical ground-support equipment (GSE) applications.

1.2 QUALITY ASSURANCE PROGRAM - The requirements of NHB 5300.4(1C) are applicable (3.1).

1.3 GSFC DETAIL SPECIFICATION - Specific wire or cable provisions are described in the applicable GSFC detail specification. The type designations for the wire or cable shall be as specified in the applicable detail specification.

2. APPLICABLE DOCUMENTS - The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 SPECIFICATIONS

2.1.1 Federal

O-E-760..Ethyl Alcohol (Ethanol); Denatured Alcohol; Proprietary Solvents and Special Industrial Solvents
P-D-410..Dishwashing Compound, Hand (Synthetic Detergent, Solid and Liquid Form)
TT-I-735..Isopropyl Alcohol
UU-T-450..Tissue, Facial

2.1.2 Military

MIL-H-5606...Hydraulic Fluid, Petroleum Base: Aircraft, Missile and Ordnance
MIL-L-7808...Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-148
MIL-L-23699..Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-T-5624...Turbine Fuel, Aviation, Grades JP-4 and JP-5/JP-8 ST
MIL-W-81044..Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy

2.2 STANDARDS

2.2.1 Federal

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

2.2.2 Military

MIL-STD-104..Limits for Electrical Insulation Color
MIL-STD-105..Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-681..Identification Coding and Application of Hookup and Lead Wire

2.3 PUBLICATIONS

2.3.1 National Aeronautics and Space Administration

NHB 5300.4(1C)..Inspection Systems Provisions for Aeronautical and Space System Materials, Parts, Components and Services

2.3.2 Defense Logistics Services Center

The H4/H8 Commercial and Government Entity (CAGE) Publication:

Section A..Name to Code
Section B..Code to Name

2.4 OTHER PUBLICATIONS

2.4.1 American Society for Testing and Materials

B3....Standard Specification for Soft or Annealed Copper Wire
B33...Standard Specifications for Tinned Soft or Annealed Copper Wire for Electrical Purposes
B298..Standard Specification for Silver-Coated Soft or Annealed Copper Wire
B624..Specification for High-Strength, High-Conductivity Copper-Alloy Wire For Electronic Application
E104..Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions
E595..Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

2.5 COPIES OF DOCUMENTS - Copies of federal and military documents should be obtained from the Naval Publications and Forms Center, Attn: NPODS, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. Applications for copies of NASA docu-

ments should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Copies of ASTM Publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

2.6 ORDER OF PRECEDENCE - For purpose of interpretation, in case of conflicts, the following order of document precedence shall apply:

(a) Purchase Order or Contract - The purchase order or contract shall have precedence over any referenced document.

(b) Detail Specification - The detail specification shall have precedence over the general specification.

(c) General Specification - This specification shall have precedence over all documents listed in 2.1, 2.2, 2.3 and 2.4.

3. REQUIREMENTS - Individual wire or cable requirements shall be as specified in accordance with the applicable detail specification (1.3).

3.1 QUALIFICATION - Wire or cable furnished under this specification shall be that which has been granted qualification approval by GSFC. Qualification approval shall be based on the following (6.4):

3.1.1 Design and Source Approval - Before qualification under this specification, the manufacturer's facilities shall be subject to survey, at the option of GSFC, by the Office of Flight Assurance, GSFC. Compliance with Publication NHB 5300.4(1C) is required. In addition, the history and detailed engineering of the wire design will be reviewed, as will the documented manufacturing and quality control procedures. Only those sources approved in the design and source approval phase shall be eligible for qualification under this specification. Source approval and design approval do not constitute part qualification or an equivalent thereof (1.2).

3.1.2 Part Qualification - Wire or cable granted qualification approval shall be that which has passed the qualification inspection requirements of this specification (4.5).

3.2 LOSS OF QUALIFICATION AND APPLYING FOR REQUALIFICATION

3.2.1 Loss of Qualification - Qualification shall be withdrawn following any change in the design, processing, materials, or quality control procedures which, in

the opinion of the GSFC Parts Branch, significantly departs from those used on the qualified wire. In addition, qualification may be withdrawn as a result of discrepancies noted by GSFC, the procuring activity, or for failures experienced in equipment which are attributable to the manufacturer's wire or cable.

3.2.2 Applying for Requalification - The manufacturer may apply for requalification of this wire after demonstrating that satisfactory measures were taken to correct the conditions leading to loss of qualification, and after compliance with all standard qualification prerequisites, as defined by the GSFC Parts Branch, has been reestablished.

3.3 IDENTIFICATION

3.3.1 Wire or Cable Identification - The wire or cable identification consists of the type designation (1.3) and the date/lot identification (3.3.2).

3.3.2 Date/Lot Identification - The manufacturer shall be responsible for the assignment of a date and lot identification code which reflects the year and week of production and the numerical order of lots produced during the week of production. GSFC shall be provided with the key to the date/lot identification code. Once established, the manufacturer shall not change the date/lot identification code without notification to and approval by GSFC.

3.4 MATERIALS - Materials shall be as specified herein and in the applicable detail specifications. Materials not specifically designated herein shall be of quality and form best suited for the purpose intended.

3.4.1 Finished Wire or Cable Materials - Acceptance or approval of any constituent material shall not be construed as a guaranty for acceptance of the finished product.

3.4.2 Conductor Materials - All strands used in the manufacture of the conductors shall be soft annealed copper conforming to ASTM B3, or of high strength copper alloy conforming to ASTM B624. Strands shall be free from lumps, kinks, splits, abraded or corroded surfaces, or any other type of surface impurity. When applicable, the strands shall be coated uniformly with commercially pure tin in accordance with ASTM B33 or silver in accordance with ASTM B298 (4.9.2).

3.4.3 Shield Materials - Shield strands shall be in accordance with the requirements for conductor materials as specified in 3.4.2. When specified, conforming

strands shall be flattened and rectangular in cross section.

3.4.4 Insulating Materials - All insulating materials used shall be certified virgin material (3.4.4.1) containing no additives except those required to meet the performance requirements of this specification. No additives shall be used that prevent insulating material from meeting the vacuum effects requirement of 3.7.25.

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

3.5 CONSTRUCTION

3.5.1 Finished Wire or Cable Construction - Construction of the finished wire or cable shall be in accordance with the requirements specified herein and in the applicable detail specification.

3.5.2 Conductor

3.5.2.1 Stranding (Wire Sizes 30 Through 10) - When tested as specified in 4.9.1, stranding shall conform as follows. Wire sizes 30 through 10 shall be constructed with concentric lay conductors as specified in the applicable detail specification. Concentric lay shall be interpreted to be a central core surrounded by one or more layers of helically wound strands. It is optional for the direction of lay for the successive layers to be alternately reversed (true concentric lay) or to be in the same direction (unidirectional lay). When unidirectional lay is used, 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 high strands or other surface 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 be not less than eight nor more than 16 times the maximum conductor diameter as specified in the applicable detail specification.

3.5.2.2 Stranding (Wire Sizes 8 Through 00) - When tested as specified in 4.9.1, stranding shall conform as follows. Wire sizes 8 through 00 shall be rope lay as specified in the applicable detail specification and in (a) and (b) below.

(a) Rope lay stranded conductors shall be laid up concentrically with a central core surrounded by one or more layers of helically wound members. It is optional for the direction of lay for 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 be not less than 10 nor 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 comprising 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.

3.5.2.3 Splices - Splices in individual strands or members shall be butt-brazed. There shall be not 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.

3.5.2.4 Diameter - When tested as specified in 4.9.1, the conductor diameter shall not exceed the limit specified in the applicable detail specification.

3.5.3 Cable - Construction of the finished cable shall be in accordance with the applicable detail specification, with a length of lay 8 to 16 times the diameter of the cable core, using fillers and binders as required.

3.5.4 Insulation - The insulation shall be constructed as specified in the applicable detail specification.

3.5.4.1 Primary Insulation - The primary insulation and physical properties shall be as specified in the applicable detail specification.

3.5.4.2 Jacket - The jacket shall be concentric and tight-fitting. The physical properties shall be as specified in the applicable detail specification.

3.5.4.3 Removability of Insulation - When tested as specified in 4.9.1, all insulation shall be readily removable by conventional stripping devices.

3.5.5 Shield Construction - The shield shall be a closely woven braid of the type designated in the applicable detail specification.

3.5.6 Shield Coverage - When tested as specified in 4.9.28, the braid shall provide coverage not less than that specified in the applicable detail specification.

3.5.7 Concentricity - When tested as specified in 4.9.10, the concentricity of the primary insulation, the cable jacket (if applicable), and of the entire insulation shall be 70% minimum.

3.5.8 Workmanship - The wire or cable shall be constructed and finished in a thoroughly workmanlike manner when examined in accordance with 4.9.1. The surface of the wire or cable shall be free of lumps, kinks, abrasion or any other types of anomalies.

3.6 IDENTIFICATION MARKING - Product shall be examined for correct markings.

3.6.1 Color - Color shall be examined per 4.9.1 and be in accordance with MIL-STD-104, Class 1. White or white under a clear jacket is preferred. Color specified other than white shall be selected in accordance with and shall meet the requirements of MIL-STD-681.

3.7 PERFORMANCE

3.7.1 Examination of Product - When tested as specified in 4.9.1, wire and cable shall meet the following requirements:

(a) Dimensions (b) Materials (c) Construction	Applicable portions of this and the applicable detail specification

3.7.2 Temperature Rating - The maximum conductor temperature of the finished wire and cable for continuous use in any combination of conductor and insulation shall be as specified in the applicable detail specification.

3.7.3 Color Striping Durability - When tested as specified in 4.9.23, the durability of color stripings applied to the outer surface of the finished wire or cable shall meet the requirements specified in the applicable detail specification.

3.7.4 Identification Durability - When tested as specified in 4.9.23, the durability of identification markings applied to the outer surface of the finished wire or cable shall meet the requirements specified in the applicable detail specification.

3.7.5 Blocking - When tested as specified in 4.9.13, adjacent layers of wire, when wound on a spool or reel, shall not stick to one another.

3.7.6 Thermal Shock Resistance - When tested as specified in 4.9.24, finished wire shall meet the requirements of the thermal shock test.

3.7.7 Insulation Tensile Strength and Elongation - When tested as specified in 4.9.3, the primary insulation and cable jacket shall meet the requirements specified in the applicable detail specification.

3.7.8 Insulation Flaws (Spark Test) - The manufacturer shall subject 100% of the wire, after the application of the primary insulation and prior to the application of any other material, to the insulation flaws test in accordance with 4.9.4.

3.7.9 Impulse Dielectric Test - The manufacturer shall subject 100% of the finished wire or cable to the impulse dielectric test per 4.9.5 and the applicable detail specification. This test shall be performed during the final winding of the wire or cable on

shipment spools or reels. The impulse dielectric test may be used as an alternative for the insulation flaws (spark test).

3.7.10 Insulation Resistance - When tested as specified in 4.9.6, finished wire shall meet the limit specified in the applicable detail specification.

3.7.11 Weight - When tested as specified in 4.9.7, the weight of finished wire or cable shall meet the requirement in the applicable detail specification.

3.7.12 Conductor Resistance - When tested as specified in 4.9.8, the conductor resistance shall meet the limit specified in the applicable detail specification.

3.7.13 Conductor Elongation and Tensile Strength - Conductors shall meet the following requirements.

3.7.13.1 Soft or Annealed Copper - When tested as specified in 4.9.9.1, the conductor shall have the following minimum elongation:

Sizes 24 and smaller - 6 percent (min.)
Sizes 22 and larger - 10 percent (min.)

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

3.7.13.2 High Strength Copper Alloy - When tested as specified in 4.9.9.2, the conductor shall exhibit a minimum elongation of 6 percent. Conductors smaller than 19 AWG shall also meet the following tensile breaking strength requirements:

Size (AWG)	Tensile Breaking Strength (lbs., min.)
30	5.17
28	8.16
26	14.2
24	22.4
22	35.8
20	58.1

3.7.14 Shrinkage - When tested as specified in 4.9.11, wire shall meet the limit specified in the applicable detail specification.

3.7.15 Wicking - When tested as specified in 4.9.12, wire shall meet the limit specified in the applicable detail specification.

3.7.16 Low Temperature (Cold Bend) - When tested as specified in 4.9.14, wire or cable shall show no evidence of cracking or dielectric breakdown.

3.7.17 Wrap Test - When tested as specified in 4.9.15, wire shall show no evidence of cracking or dielectric breakdown.

3.7.18 Flammability - When tested as specified in 4.9.16, wire or cable shall meet the requirements specified in the applicable detail specification.

3.7.19 Life Cycle - When wire or cable is tested as specified in 4.9.17, there shall be no evidence of cracking in the bend test, dielectric breakdown, or pitting.

3.7.20 Accelerated Aging - When wire or cable is tested as specified in 4.9.18, there shall be no evidence of cracking in the bend test, dielectric breakdown, or pitting, and the identification marking shall remain legible.

3.7.21 Immersion Tests - When wire or cable is tested as specified in 4.9.19, the diameter increase shall be limited to 5% maximum. There shall be no evidence of cracking in the bend test or dielectric breakdown.

3.7.22 Humidity Resistance - When wire is tested as specified in 4.9.20, insulation resistance shall meet the limit specified in the applicable detail specification.

3.7.23 Surface Resistance - When wire is tested as specified in 4.9.21, surface resistance shall meet the limit specified in the applicable detail specification.

3.7.24 Smoke - When tested as specified in 4.9.22, the wire shall not exhibit any visible smoke.

3.7.25 Vacuum Effects (Material Outgassing) - When tested as specified in 4.9.25, material outgassing of the wire or cable shall not exceed the limits specified in the applicable detail specification.

3.7.26 Radiation Resistance - When wire or cable is tested as specified in 4.9.26, there shall be no evidence of dielectric breakdown.

3.7.27 Jacket Wet Dielectric Strength - When the cable jacket is tested as specified in 4.9.27, there shall be no evidence of dielectric breakdown.

3.7.28 Dielectric Strength - When the cable is tested as specified in 4.9.29, there shall be no evidence of dielectric breakdown.

4. QUALITY ASSURANCE PROVISIONS

4.1 RESPONSIBILITY FOR INSPECTION - Unless otherwise specified, the manufacturer is responsible for the performance of all qualification and acceptance inspection requirements as specified herein and in the detail specifications. GSFC reserves the right to reinspect wire and cable for any requirements deemed necessary and to designate representatives for in-plant surveillance and acceptance functions in connection with procurement of wire and cable to this and the detail specifications.

4.2 CLASSIFICATION OF INSPECTIONS - The inspection of wire and cable shall be classified as follows:

(a) Qualification inspection (4.5)
(b) Quality conformance inspection (4.6)
(c) Periodic inspection (4.6.6)

4.3 INSPECTION CONDITIONS - Unless otherwise specified, all tests, measurements, inspections, and examinations required by this and the applicable detail specification shall be conducted under any combination of conditions within the following ranges. Any specified condition shall not affect the other two ambient ranges.

(a)	Temperature:	+20° to +30°C (+68° to +86°F)
(b)	Relative humidity:	30 to 80 percent
(c)	Barometric pressure:	61 to 79 cm of mercury (24 to 31 inches of mercury)

4.4 PREPARATION OF SAMPLES - The samples shall be taken from a production run and shall be produced with the same labor, equipment and procedures normally used in production.

4.4.1 Sampling for Qualification Inspection

4.4.1.1 Finished Wire - A finished wire sample consisting of 150 feet for size 12 or smaller and 100 linear feet for size 10 or larger shall be submitted for each type designation for which qualification is desired, except

that certain sizes will qualify additional sizes as follows:

Sample Size	Will Qualify
28	30 through 26
20	24 through 16
12	14 through 10
8	8 through 6
2	4 through 00

In addition to the finished wire sample, 10 linear feet of each size of coated conductor strand used in the manufacture of the wire shall be submitted.

4.4.1.2 Cable - Cable shall be comprised of wire qualified to this specification. For each type of cable, the qualification sample shall consist of 100 linear feet of each type designation for which qualification is desired, except that one-conductor cables may be qualified by shielded and jacketed cables of one or more conductors, multiconductor cables may be qualified by shielded and jacketed cables of three or more conductors, and certain sizes will qualify additional sizes as follows:

Sample Size (Overall Diameter, Inches)	Will Qualify (Overall Diameter, Inches)
.045 - .060	smaller than .075
.085 - .105	.076 - .130
.135 - .160	.131 - .230
.260 - .295	larger than .231

4.5 QUALIFICATION INSPECTION - Qualification inspection shall consist of all examinations and tests in this specification. Specimens shall be taken from the sample (4.4.1) in lengths prescribed in the applicable test methods.

4.5.1 Qualification Objective - Qualification inspections and tests determine if the construction, materials, and processes employed in the manufacture of the wire and cable allow the wire and cable to comply with the requirements of this and the applicable detail specification.

4.5.2 Qualification Rejection - There shall be no failures in any examination or test of the wire and cable submitted for qualification inspection. After any failure, the activity responsible for qualification shall be notified by the manufacturer of all details

related to the corrective changes made in the wire or cable before initiating any further tests deemed necessary to assure compliance with the wire or cable requirements of this and the applicable detail specification.

4.5.3 Qualification of Additional Wire or Cable - Qualification may be granted, on the basis of similarity, to wire or cable which differs only in minor details from that submitted for qualification testing. Qualification is contingent on the degree of similarity and successful evaluation of any test data submitted to validate the difference (4.4.1).

4.5.4 Disposition of Qualification Sample Units - Samples and the manufacturer's certified qualification test reports shall be forwarded to the activity responsible for qualification for review and approval (6.1). Wire or cable subjected to qualification inspection shall not be delivered on a contract or order.

4.6 QUALITY CONFORMANCE INSPECTION - Quality conformance inspection shall consist of the examinations and tests listed in Table I for wire, or Table II for cable. Quality conformance inspection shall be performed on every lot of wire or cable procured to this specification.

4.6.1 Quality Conformance Objective - Quality conformance inspections and tests are intended to assure compliance of production wire and cable with the requirements of this and the applicable detail specification.

4.6.2 Sampling for Quality Conformance Inspection - For purposes of this specification, the following definitions shall apply.

4.6.2.1 Lot - The inspection lot shall consist of all wire or cable of one part number and identified by the same date/lot identification code (3.3.2) that is subjected to inspection at one time.

4.6.2.2 Unit of Product - The unit of product for determining lot size for sampling shall be one continuous length of wire or cable as offered for inspection.

4.6.2.3 Sample Unit (Groups I and II) - The sample unit for either Group I or Group II tests shall consist of a single piece of finished wire or cable, chosen at random from the inspection lot, and of sufficient length to permit all applicable examinations and

TABLE I

Quality Conformance Inspection for Finished Wire

Inspection	Requirements	Test Method
	Paragraph	
Group I Characteristics		
Color	3.6.1	4.9.1
Color Striping Durability	3.7.3	4.9.23
Conductor Diameter	3.5.2.4	4.9.1
Conductor Elongation and Tensile Strength	3.7.13	4.9.9
Conductor Resistance	3.7.12	4.9.8
Conductor Stranding	3.5.2.1 3.5.2.2	4.9.1
Dimensions	3.7.1	4.9.1
Identification Durability	3.7.4	4.9.23
Identification Marking	3.6	4.9.1
Insulation Resistance	3.7.10	4.9.6
Insulation Tensile Strength and Elongation	3.7.7	4.9.3
Removability of Insulation	3.5.4.3	4.9.1
Weight	3.7.11	4.9.7
Workmanship	3.5.8	4.9.1
Group II Characteristics		
Accelerated Aging	3.7.20	4.9.18
Concentricity	3.5.7	4.9.10
Flammability	3.7.18	4.9.16
Low Temperature (Cold Bend)	3.7.16	4.9.14
Shrinkage	3.7.14	4.9.11
Thermal Shock Resistance	3.7.6	4.9.24
Wicking	3.7.15	4.9.12
Wrap Test	3.7.17	4.9.15
Group III Characteristics		
Impulse Dielectric Test	3.7.9	4.9.5

tests. Not more than one sample unit for each group of tests shall be taken from a single unit of product, unless the inspection lot consists of only one unit of product.

TABLE II

Quality Conformance Inspection for Finished Cable

Inspection	Requirements Paragraph	Test Method Paragraph
Group I Characteristics		
Color	3.6.1	4.9.1
Dimensions	3.7.1	4.9.1
Jacket Tensile Strength and Elongation	3.7.7	4.9.3
Shield Coverage	3.5.6	4.9.28
Weight	3.7.11	4.9.7
Workmanship	3.5.8	4.9.1
Group II Characteristics		
Accelerated Aging	3.7.20	4.9.18
Concentricity	3.5.7	4.9.10
Flammability	3.7.18	4.9.16
Low Temperature (Cold Bend)	3.7.16	4.9.14
Group III Characteristics		
Impulse Dielectric Test	3.7.9	4.9.5
Dielectric Strength	3.7.28	4.9.29

4.6.2.4 Sample Sizes (Groups I and II) - Sample sizes shall be selected in accordance with MIL-STD-105 except for workmanship, which is a Group I characteristic. Workmanship shall be examined on each unit of product within the inspection lot. For the remaining Group I characteristics, the inspection level shall be S-2, and the AQL shall be 6.5 percent except no defectives are permitted. For Group II characteristics, the inspection level shall be S-3, and the AQL shall be 1.5 percent except no defectives are permitted.

4.6.2.5 Sample Unit and Size (Group III) - The sample unit and sample size for the Group III impulse dielectric test shall be 100% as the entire length of finished wire or cable must be subjected fully to this test.

4.6.3 Acceptance for Groups I and II - There shall be no failures in any examination or test of the wire or

cable submitted. If any failure results, the manufacturer shall take any corrective action necessary to assure compliance with this and the applicable detail specification. The inspections need not be held up, after such failure, while the manufacturer is investigating the cause of the failure and instituting corrective action. However, final acceptance of wire or cable related to the failure shall not be made until it is determined that the items meet all requirements of this and the applicable detail specification.

4.6.4 Acceptance for Group III - Insulation breakdowns resulting from the impulse dielectric test, or ends and any other portions not subjected to the test, shall be either stripped, clearly marked, or cut out of the finished product.

4.6.5 Lot Rejection Criteria - If for any reason, during the 100 percent Group III inspection or any other inspections, more than 10 percent of either the wire or cable is discarded due to test failures, the procuring activity shall be notified. The inspection lot shall be rejected and will not be subject to reinspection unless approval is granted by the procuring activity.

4.6.6 Periodic Inspection - If a qualified source has been inactive, or for other reasons has not supplied GSFC with wire or cable within the previous 12-month period, periodic inspection of the source may be required. The inspection criteria will be determined at the time a periodic inspection is deemed necessary, and shall consist of tests of sufficient magnitude and duration to ensure that the wire and cable continues to comply with the requirements of this and the applicable detail specification.

4.7 FAILURE ANALYSIS - A failure analysis shall be performed on each lot of wire or cable having failed during either qualification or acceptance inspection. The failure analysis shall be designed to isolate the cause(s) of failure and yield adequate conclusions to initiate a plan for corrective action to eliminate the cause and prevent recurrence of the type of failure mode(s) reported (4.8.3).

4.8 DOCUMENTATION AND DATA SUBMITTAL

4.8.1 Required Records - Wire and cable manufactured under this specification shall be supported by suitable records showing compliance with specified requirements. The manufacturer's quality assurance or quality control personnel must certify the test and inspection results, and this fact should be indicated

on a wire and cable record by means of inspection stamps, signatures, or other approved methods. Records shall be linked to a specific wire and cable lot by type designation and date/lot identification code.

4.8.2 Quality Conformance Certification - Quality conformance inspection (4.6) documentation shall clearly show that tests were conducted in accordance with specified requirements. The manufacturer shall certify that each lot of wire or cable meets all applicable specification requirements. A copy of this certification shall accompany each wire or cable shipment, identifying the wire or cable so certified. The manufacturer shall prepare the required documentation and retain the original. Two copies shall be forwarded to the procuring activity, and one copy shall be forwarded to the address listed in 6.1 (if procurement originated at GSFC).

4.8.3 Failure Analysis Report - Two copies of the Failure Analysis Report (4.7) shall be submitted, one copy to GSFC at the address listed in 6.1, and one copy to the procuring activity. The report shall include, as a minimum, the following information:

(a) Date/lot identification code
(b) Lot size
(c) Wire or cable type designation
(d) Test and/or examination at which defect was first noted
(e) Failure mode
(f) Cause of failure
(g) Corrective action taken or to be taken
(h) Effect of failure on other wire or cable in the inspection lot
(i) Purchase orders or contracts affected

4.8.4 Document Cross-Reference - All documentation, whether retained or submitted by the manufacturer, shall be cross-referenced to the applicable contract or purchase order.

4.8.5 Record Retention - All records pertinent to a specific lot of wire or cable shall be retained by the manufacturer for a minimum of four years.

4.9 TEST METHODS

4.9.1 Examination of Product - All samples of wire and cable shall be examined carefully to determine conformance to this specification and the applicable detail specification with regard to requirements not covered by specific test methods.

4.9.2 Conductor Material - Conductor strands, prior to use in the conductor, shall have been tested in accordance with ASTM B3, B33, B298, or B624, whichever is applicable.

4.9.3 Insulation Tensile Strength and Elongation - The primary insulation and jacket shall meet the following requirements.

4.9.3.1 Primary Insulation - Specimens of the finished wire shall have the primary insulation carefully removed from the conductor and tested for tensile strength and elongation in accordance with FED-STD-228, Methods 3021 and 3031 respectively, utilizing one-inch bench marks and one-inch jaw separation.

4.9.3.2 Jacket - Specimens of cable shall have the jacket carefully removed and tested for tensile strength and elongation in accordance with FED-STD-228, Methods 3021 and 3031 respectively, utilizing one-inch bench marks and one-inch jaw separation.

4.9.4 Insulation Flaws (Spark Test) - The wire shall be passed through a suitable chain-electrode spark test device without breakdown, using the voltage specified in the applicable detail specification. The electrode shall be of a suitable bead chain or fine mesh construction that will give intimate metallic contact with practically all the insulation or jacket surface. Electrode length and speed of wire movement shall be such that the primary insulation is subjected to the test voltage for a minimum of 0.2 second.

4.9.5 Impulse Dielectric Test - The test procedure delineated in Military Specification MIL-W-81044 shall apply. At the option of the wire manufacturer, the chain bead electrode type tester may be used to perform this test.

4.9.6 Insulation Resistance - The uninsulated ends of a wire specimen at least 26 feet in length shall be connected to a negative DC terminal, and the specimen shall be immersed to within six inches of its ends in a water bath, at room temperature, containing 0.5 percent of a synthetic detergent wetting agent per Federal Specification P-D-410. The specimen shall remain immersed for not less than four hours, after which a potential of not less than 250 volts nor more than 500 volts shall be applied between the conductor and the water bath which serves as the second elec-

trode. The insulation resistance of the specimen shall be determined after one minute of electrification at this potential and shall be calculated as megohms for 1000 feet as follows:

$$\frac{\text{specimen resistance (megohms) X immersed length (ft.)}}{1000}$$

4.9.7 Weight - The weight of finished wire or cable shall be determined by Procedure I (4.9.7.1). Product failing to meet the weight requirements of the applicable detail specification, when tested in accordance with Procedure I, shall be subjected to Procedure II (4.9.7.2). All reels or spools of product failing to meet the requirements of the applicable detail specification, when tested in accordance with Procedure II, shall be rejected.

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

4.9.7.2 Procedure II - The net weight of the finished wire or cable 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 containing the finished product. The net weight of wire or cable on each reel or spool shall be divided by the accurately determined length of finished wire or cable on that reel or spool with the resultant transposed 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.

4.9.8 Conductor Resistance - The DC resistance of the conductor shall be measured in accordance with Method 6021.1 of FED-STD-228.

4.9.9 Conductor Elongation and Tensile Strength

4.9.9.1 Soft or Annealed Copper - Elongation tests of soft or annealed copper conductor shall be performed in accordance with Method 3211 of FED-STD-228. For sizes 20 AWG and larger, tests shall be performed on individual strands taken from the conductor of the finished wire. For sizes 22 and smaller, tests shall be performed on the whole con-

ductor removed from the finished wire, and the elongation shall be measured when the first strand of the conductor breaks.

4.9.9.2 High Strength Copper Alloy - Elongation and tensile strength tests of whole, high strength copper alloy conductor removed from finished wire, shall be performed in accordance with Method 3212 of FED-STD-228, and the tensile strength shall be reported as the tensile breaking strength of the conductor rather than in pounds per square inch. The tensile strength and elongation shall be measured when the first strand of the whole conductor breaks, as indicated on the recording device of the tensile machine.

4.9.10 Concentricity - The concentricity of the primary insulation, of the cable jacket (if applicable), and of the entire insulation of the finished wire shall be determined in accordance with the procedures of 4.9.10.1 and 4.9.10.2 as applicable. All wall thickness measurements shall be determined under suitable magnification. For the primary insulation, and for the entire insulation, a wall thickness measurement shall be the radial distance between the outer rim of the insulation and the outermost rim of the outermost strand of the concentric lay conductor; or between the outer rim of the insulation and the outermost rim of the outermost strand of the stranded member of the rope lay conductor.

4.9.10.1 Wire Sizes 30 Through 10 - The concentricity of the primary insulation, of the entire insulation, and of the cable jacket shall be determined by first locating and recording the minimum wall thickness measured on a cross section of the insulation. The maximum wall thickness of this same cross section of the insulation material shall be measured and recorded. The ratio of the minimum wall thickness to the maximum wall thickness, times 100, shall define the percent concentricity.

4.9.10.2 Wire Sizes 8 Through 00 - The concentricity of the primary insulation, and of the entire insulation, shall be determined by first locating and recording the minimum wall thickness measured on a cross section of the insulation. From this point on the outer rim of the insulation at which the minimum wall thickness was measured, three more reference points, 90 degrees apart on

the outside rim of the insulation, shall be measured. At each of these three reference points, the nearest member of the rope lay conductor shall be selected, and the insulation wall thickness between that member and the outer rim of the insulation shall be measured. The average of the four readings shall be considered to be the average wall thickness. The ratio of the minimum wall thickness to the average wall thickness, times 100, shall define the percent concentricity. The concentricity of the jacket shall be determined by the method of 4.9.10.1.

4.9.11 Shrinkage - A 12-inch specimen of the finished wire shall be cut so that the insulation and conductor are flush at both ends. The specimen shall be placed in an air-circulating oven and maintained for a period of six hours at the temperature specified in the applicable detail specification. The velocity of air past the specimen shall be between 100 and 200 feet per minute. At the end of this period, the specimen shall be removed from the oven and allowed to return to room temperature. Shrinkage of the insulation shall be measured as the greatest distance which any layer of the insulation has receded from either end of the conductor; i.e., the measurement obtained at the end showing the greater shrinkage shall be considered the shrinkage of the specimen.

4.9.12 Wicking - A specimen of each finished wire size to be tested shall be cut 6 ± 1/16 inches with square ends. The specimen shall be vertically immersed for two inches of its length in the fluorescent dye solution, defined below, contained in an open test tube and conditioned for 24 hours at room temperature in a draft-free room. The fluorescent dye solution shall be prepared by dissolving 0.02 gram of rhodamine B dye in a mixture of two liters of distilled water, 30 cc's of ethyl alcohol (Federal Specification O-E-760), and three cc's of a synthetic detergent wetting agent (Federal Specification P-D-410). After this conditioning, the specimen shall be removed from the fluorescent dye solution, and excess solution on the surface shall be removed immediately from the two inches immersed by wiping gently with a clean, dry, lint-free cloth. The jacket shall be removed from the specimen, and the outside of the primary insulation and the inside of the jacket shall be examined for evidence of fluorescent dye using an ultraviolet source. The distance that the fluorescent dye has wicked above the

two-inch portion of immersed specimen shall be recorded as the distance of wicking.

4.9.13 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 III. 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 detail specification. 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 or shall continue to be weighted with the winding tension load so as to prevent unwinding or loosening of the turns or layers. The spool of wire shall be placed for 24 hours in an air oven at the temperature specified in the applicable detail specification. 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.

4.9.14 Low Temperature (Cold Bend) - One end of a previously untested specimen of suitable length shall be secured to a rotatable mandrel in a cold chamber and the other end to a load weight. Mandrel diameter and load weight shall be as specified in the applicable detail specification. Provision shall be made for rotating the mandrel by means of a handle or control located outside the chamber. The specimen of wire or cable and the mandrel shall be conditioned at -65 ± 2°C (-85 ± 4°F) for four hours. At the end of this period, and while both mandrel and specimen are still at this low temperature, the specimen shall be wrapped in its entire length around the mandrel for wire, 180° around the mandrel for cable, without opening the chamber. The bending shall be accomplished at a uniform rate of speed of 2 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 one inch from each end of the specimen. Finished wire shall be subjected to the wet dielectric test specified in 4.9.17.3 with the bent portion submerged. Cable shall be subjected to the wet dielectric strength test in accordance with 4.9.27.

4.9.15 Wrap Test - Specimens of finished wire, each having a length of 12 inches plus a length required for winding on the mandrel, shall be wound tightly around a mandrel whose diameter is specified in the applicable detail specification. A total of two close turns of a central portion of the specimen shall be made such that six inches of each end shall remain straight. Wrapping may be accomplished manually. The specimens then shall be removed and subjected to the wet dielectric test of 4.9.17.3.

4.9.16 Flammability - The test specimen shall be 24 inches in length and marked at a distance of eight inches from the lower end to indicate the central point for flame application. The specimen shall be placed at an angle of 60 degrees to the horizontal within a chamber approximately 2 feet by 1 foot by 1 foot, open at the top and one vertical side (front) to allow sufficient (but draft-free) flow of air for complete combustion. The specimen shall be parallel to and approximately six inches from the front of the chamber. The upper end of the specimen shall pass over a pulley and shall have an appropriate weight attached to it so that the specimen is held taut throughout the flammability test. A piece of sanitary tissue paper conforming to Federal Specification UU-T-450, not less than 8x8 inches exposed, shall be suspended taut and horizontally centered 9-1/2 inches directly below the test mark on the specimen and at least 1/2 inch away from the table top. A flame from a Bunsen burner shall be applied for 30 seconds at the test mark. The Bunsen burner shall be mounted underneath the test mark on the specimen, perpendicular to the specimen. Any burning particles or melted or dripping material from the wire specimen shall fall on the tissue paper. The Bunsen burner shall have a 1/4 inch inlet, a nominal bore of 3/8 inch, and a length of approximately four inches from top to primary inlets. The burner shall be adjusted to produce a 3-inch high flame with an inner cone approximately one-third of the flame height. The temperature of the hottest portion of the flame, as measured with an accurate thermocouple pyrometer, shall be not less than 954°C (1750°F). The burner shall be positioned so that the hottest portion of the flame is applied to the test mark of the specimen. The distance of flame travel upward along the specimen from the test mark and the time of burning after removal of the flame shall be recorded. Any burning particles or drippings which cause the tissue paper to burst into flame shall be recorded. Charred holes or charred spots in the tissue paper caused by

burning particles do not constitute failure. Breaking of the wire specimens in sizes 24 and smaller shall not be considered as failure.

4.9.17 Life Cycle

4.9.17.1 Air Oven - One inch of the insulation shall be removed from each end of a 24-inch sample of the finished wire or cable. The central portion of the specimen then shall be bent at least halfway around a cylindrical, smooth, polished stainless steel mandrel having a diameter as specified in the applicable detail specification. To prevent sticking of the specimen to the mandrel, the mandrel may be coated with polytetrafluoroethylene either in the form of enamel or wrapped tape, provided that the diameter of the mandrel does not exceed that specified in the applicable detail specification. Each end of the conductor(s) shall be loaded with the weight specified in the applicable detail specification such that the portion of the insulation between the conductor and mandrel is under compression while the conductor is under tension. This specimen, so prepared on the mandrel, shall be placed in an air-circulating oven and maintained for a period of 120 hours at the temperature specified in the applicable detail specification. The velocity of air past the specimen shall be between 100 and 200 feet per minute. After completion of the air oven test, the specimen shall be cooled to 23 ± 3°C (73 ± 5°F) within a period of one hour. When cooled, the specimen shall be freed from tension, removed from the mandrel, and straightened. The specimen then shall be subjected to the bend test of 4.9.17.2 followed by the wet dielectric test of 4.9.17.3 for finished wire, or 4.9.27 for cable.

4.9.17.2 Bend Test - In a temperature maintained at 23 ± 3°C (73 ± 5°F), one end of the specimen shall be secured to the mandrel and the other end to the load weight specified in the applicable detail specification. 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 turns in contact. The mandrel then shall be rotated

in reverse direction until the full length of the specimen, 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 formed in the same section of the specimen. The outer surface of the specimen then shall be observed for cracking of the insulation or cable jacket.

4.9.17.3 Wet Dielectric Test - The uninsulated ends of the specimen shall be fastened, in a metallic contact, to a metal bar. The specimen shall be so immersed in a five percent solution of sodium chloride in water at a temperature of 23 ± 3°C (73 ± 5°F) that the insulation protrudes 1-1/2 inches from the surface of the liquid. After immersion for five hours, the voltage specified in the applicable detail specification at 60 hertz 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 1/2 minute, maintained at that voltage for a period of five minutes, and gradually reduced to zero in 1/2 minute. The insulation shall be removed and the conductor examined for pitting. Darkening of the tin or silver coating caused by normal air oxidation shall not be cause for rejection.

4.9.18 Accelerated Aging - One inch of the insulation shall be removed from each end of a 24-inch specimen which includes a product identification marking. The central portion of this specimen then shall be bent at least halfway around a cylindrical, smooth, polished stainless steel mandrel having a diameter as specified in the applicable detail specification. To prevent sticking of the specimen to the mandrel, the mandrel may be coasted with polytetrafluoroethylene either in the form of enamel or wrapped tape, provided that the diameter of the mandrel does not exceed that specified in the applicable detail specification. Each end of the conductor(s) shall be loaded with the weight specified in the applicable detail specification such that the portion of the insulation between the conductor and mandrel is under compression while the conductor is under tension. This specimen, so prepared on the mandrel, shall be placed in an air-circulating oven and maintained for a period of six hours at the temperature

specified in the applicable detail specification. The velocity of air past the specimen shall be between 100 and 200 feet per minute. After completion of the accelerated aging test, the specimen shall be cooled to 23 ± 3°C (73 ± 5°F) within a period of one hour. When cooled, the specimen shall be freed from tension, removed from the mandrel, straightened, and examined for legibility of product identification. The specimen then shall be subjected to the bend test of 4.9.17.2 followed by the wet dielectric test of 4.9.17.3 for finished wire, or 4.9.27 for cable.

4.9.19 Immersion Tests - Separate specimens of wire or cable of sufficient lengths to perform the subsequent tests shall be immersed to within six inches of their ends in each of the following fluids for 20 hours at 49 ± 2°C (120 ± 4°F)

(a) Isopropyl alcohol, Federal Specification TT-I-735
(b) Hydraulic fluid, petroleum base: aircraft, missile and ordnance, Military Specification MIL-H-5606
(c) Fuel, grade JP-4, Military Specification MIL-T-5624
(d) Lubricating oil, aircraft turbine engine, synthetic base, Military Specification MIL-L-7808
(e) Lubrication oil, aircraft turbine engines, synthetic base, Military Specification MIL-L-23699

During immersion tests, the radius of bend of the specimen shall be not less than fourteen times the maximum diameter of the wire or cable specified in the applicable detail specification. Upon removal from the liquids, the specimen shall remain for one hour in free air at room temperature. The insulation shall be removed for a distance of one inch from each end of a 24-inch length of the specimen and this length subjected to the bend test of 4.9.17.2 followed by the wet dielectric test of 4.9.17.3 for finished wire, or 4.9.27 for cable.

4.9.20 Humidity Resistance - A 52-foot specimen of wire shall be subjected to the following test.

4.9.20.1 Apparatus - The apparatus shall consist of a test chamber capable of maintaining an internal temperature of 71 ± 2°C (160 ± 4°F) and an internal relative humidity of 95 ± 5 percent. 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°F) within a period of 16 hours from the time of removal of the source of heat. Distilled or demineralized water shall be used to obtain the required humidity.

4.9.20.2 Procedure - The specimen shall be placed in the test chamber and relative humidity raised to the values specified in 4.9.20.1 and maintained at such for a period of six 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°F) or lower. At the end of the 16-hour period, heat shall again be supplied for a 2-hour period to stabilize at 71 ± 2°C (160 ± 4°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 (15 cycles). Within two minutes after the end of the fifteenth cycle, the 50-foot center section of the specimen shall be immersed in a five percent solution of sodium chloride in water at room temperature. The insulation resistance shall be measured after one minute of electrification at a potential between 250 and 500 volts DC applied to the conductor. The outer surface of the specimen shall be grounded through an electrode in the electrolyte.

4.9.21 Surface Resistance

4.9.21.1 Specimens - The specimens shall consist of 6-inch lengths of finished wire, each provided near its center with two electrodes spaced 1.0 inch apart between their nearest edges, for electrical testing of the wire surface between the electrodes. Each electrode shall be constructed of several turns of fine (AWG 27 or smaller) tin-coated copper wire wrapped snugly around the circumference of the specimen, leaving a free end of the fine wire of sufficient length for soldering to electrical lead wires. The specimens and electrodes shall be cleaned in accordance with the procedure specified in FED-STD-228, Method 6041, and shall subsequently be handled

with maximum care to avoid even the slightest contamination, especially with regard to the electrodes and the insulation surface between the electrodes.

4.9.21.2 Test Chamber - Atmospheric conditions for this test shall be at a relative humidity of 95 ± 5 percent and a temperature of 23 ± 5°C (73 ± 9°F). A recommended conditioning and test chamber may be formed from a tightly-covered rectangular glass vessel containing a reservoir of saturated aqueous potassium nitrate or potassium sulfate solution to maintain the required relative humidity (see ASTM E104, Annex 1) and a humidity gage, observable from outside the chamber, to indicate the relative humidity actually obtained. A thick collar of paraffin wax, molded around the rim of the vessel, functions as a means for access of electrical lead wires into the vessel and also as a gasket between the vessel and the flat glass plate which serves as a cover. On the two long sides of the vessel, tin-coated copper lead wires (AWG 18, solid), permanently sealed into the wax collar, penetrate into the vessel at intervals of approximately an inch and at least an inch from any edge. As an alternate construction, the lead wires may be insulated with TFE (polytetrafluoroethylene) and brought through the sides of the chamber by using paraffin wax, silicone stopcock grease, or TFE bushings, provided at least two inches of TFE insulation extend beyond the seal inside the chamber. To improve the tightness of closure, the lower surface of the plate glass cover is lubricated with silicone stopcock grease where it rests upon the wax collar during use. The electrical resistance of the chamber measured across the lead wires with no specimens in place shall be not less than one million megohms.

4.9.21.3 Procedure - With the specimens and electrodes prepared as specified in 4.9.21.1, the electrodes shall be soldered to the lead wires in the test chamber, the cover of the chamber shall be put in place, and the test assemblies shall be conditioned for 96 hours at the relative humidity and temperature specified in 4.9.21.2. The

resistance between the electrodes shall then be measured using a DC potential of 200 to 500 volts while the specimens are still within the conditioning chamber and after one minute of electrification. The surface resistance shall be computed by multiplying the measured resistance value by the measured overall diameter of the specimen in inches. Following the initial resistance measurement, a 2500 volt rms, 60 Hz, potential shall be applied between electrodes for a period of one minute. There shall be no evidence of distress such as arcing, smoking, burning, flash-over, or dielectric failure. After a discharge interval of 15 to 20 minutes following the potential test, the surface resistance shall be remeasured and computed.

4.9.22 Smoke - This test shall be conducted in still air at an ambient temperature of 23 ± 3°C (73 ± 5°F). A specimen approximately 15 feet long of the wire shall be so suspended that at least the central 10-foot section is horizontal and unsupported. One end of the wire shall be suitably weighted in order that no sagging will occur throughout the test. An electric current shall be applied to the wire, and the voltage drop measured over the central 10-foot portion. From the current and voltage values, the resistance of the wire shall be calculated. The temperature of the wire conductor shall be determined from the change in resistance. The current shall be so adjusted that the conductor temperature stabilizes at the temperature specified in the applicable detail specification. This conductor temperature shall be thus maintained for 15 minutes during which time evidence of visible smoke shall be recorded. A flat-black background shall be used for this test.

4.9.23 Durability of Markings - The durability of product identification or color stripings applied to the wire or cable for coding shall be evaluated at 23 ± 3°C (73 ± 5°F) as follows.

4.9.23.1 Durability Testing Apparatus - The durability tester shall be designed to hold a short specimen of finished wire or cable firmly clamped in a horizontal position with the longitudinal surface of the specimen fully exposed. The instrument shall be capable of rubbing a small cylindrical steel mandrel (usually a needle), 0.025

inch in diameter, repeatedly over the wire or cable surface in such position that the longitudinal axis of mandrel and specimen are at right angles to each other and the area of tangency is very small. A specified weight affixed to a jig above the rubbing mandrel shall control the thrust exerted normal to the surface of the insulation. A motor driven, reciprocating cam mechanism and counter shall be used to provide an accurately measured number of abrading strokes in a direction parallel to the axis of the specimen. The length of the stroke shall be 3/8 inches and the frequency of the stroke shall be 120 strokes (60 stroking cycles) per minute.

4.9.23.2 Durability Testing Procedure - In performing the test, a specimen of wire or cable shall be mounted in the specimen clamp and a 500 gram total weight shall be applied through the rubbing needle to the surface. The counter shall be set at zero and the drive motor started. The specimen shall be observed throughout the progress of the test and, as soon as a continuous line of the stripe or printed marking is removed under the abrading mandrel, the number of abrading cycles shall be recorded. Three specimens from each sample unit chosen to be representative of the unit shall be tested and the results averaged.

4.9.24 Thermal Shock Resistance

4.9.24.1 Preparation of Specimen - A specimen of wire [illegible] five feet long, shall be prepared by carefully removing one inch of insulation from each end of the wire. (For purposes of this test, insulation is defined as all layers of non-conductive material covering the electrical conductor.). 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. The specimen shall be formed into a loose coil not less than one foot in diameter and shall be laid on a wire screen for handling throughout the test.

4.9.24.2 Test Procedure - The specimen shall be placed for 30 minutes in a preheated air-circulating oven at the temperature specified in the applicable detail specification. In the event no temperature is so specified, the oven shall be at the specified maximum conductor temperature of the wire. It shall then be removed from the oven and, within two minutes, place in a chamber which has been precooled to -55 ± 2°C (-67 ± 4°F). The specimen 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. 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 detail specification, or by more that 0.06 inch if no amount is specified, shall constitute failure. Any flaring of any layer shall also constitute failure.

4.9.25 Vacuum Effects (Material Outgassing) - Vacuum effects of wire or cable specimens shall be tested in accordance with ASTM E595 and shall meet the requirements specified in the applicable detail specification.

4.9.26 Radiation Resistance - An appropriate length of the finished wire or cable shall be subjected to the radiation dosage specified in the applicable detail specification at an average rate of between 5 and 10 megarads per minute. Immediately following exposure, the center portion of the specimen shall be wound for 10 turns around a mandrel whose diameter is specified in the applicable detail specification sheet. The ends of the specimen shall extend at least six inches beyond the wound portion. The specimen shall be removed from the mandrel without unwinding and shall be subjected to the wet dielectric strength test of 4.9.17.3 for finished wire, or 4.9.27 for cable.

4.9.27 Jacket Wet Dielectric Strength - The outer jacket shall be removed from both ends of a 24-inch specimen for a distance of 1-3/4 inches, without damage

to the insulation of basic wires. The insulation shall be removed from both ends of each basic wire for a distance of one inch, leaving 3/4 inch of insulation on each basic wire exposed beyond the cable jacket. The individual basic wires and shield shall be fanned out so that they will be separated from each other beyond the end of the cable jacket. The conductors of the basic wires and shield at each end of the cable shall be electrically connected together by means of a copper wire. The specimen shall be bent in the shape of a U with the diameter of the bend not less than the mandrel diameter specified in the applicable detail specification for that specimen. Each specimen shall be so immersed in a five percent salt solution at a temperature of 23 ± 3°C (73 ± 5°F) that the jacket of the cable specimen will protrude three inches from the surface of the liquid. After submersion for 1 hour, 1,000 volts rms at a commercial frequency shall be applied between the conductors connected with the shield to an electrode in contact with liquid. The potential shall be increased at a uniform rate from 0 to 1000 volts within 1/2 minute and maintained at 1000 volts for a period of 1 minute.

4.9.28 Shield Coverage - The shield coverage shall be determined in accordance with the following formula:

$$\text{Percent Coverage} = (2F-F^2)100;$$

$$F = NPd_1/\sin(\alpha) \qquad \tan(\alpha) = 2\pi(D + 2d_2)P/C$$

Where: N = number of strands per carrier

P = picks per inch

d_1 = diameter of strand (inches); width, if flat braid used

d_2 = diameter of strand (inches); thickness, if flat braid used

α = angle of shield with cable axis (degrees)

D = effective diameter of cable under shield (inches)

C = number of carriers

4.9.29 Dielectric Strength - The cable shall be subjected to a potential of 2,500 volts ac at commercial frequency, applied in turn between each conductor of the multiple-conductor cable and all other conduc-

tors electrically connected together, and to the shield, where applicable. Each voltage application shall be maintained for 15 seconds minimum.

5. PREPARATION FOR DELIVERY

5.1 PRESERVATION AND PACKAGING - Unless otherwise specified, the manufacturer shall be responsible for packaging wire and cable in a manner which prevents degradation, corrosion, deterioration, or physical damage, and for ensuring the packages have a safe delivery and remain in good condition. The manufacturer shall be responsible for any damage to or deterioration of wire or cable resulting from faulty or improper packing, preservation, or packaging, and shall replace such wire and/or cable with acceptable wire and/or cable without cost to GSFC or to the procuring activity.

5.1.1 Reels and Spools - Wire or cable shall be delivered wound on reels or spools marked as indicated on the purchase order. Each reel or spool shall have an appropriate diameter for the respective wire or cable size. For finished wire, in no case shall the barrel of the reel or spool have a diameter less than that specified in Table III or less than three inches, whichever is greater. Reels and spools shall be suitably finished to prevent corrosion under typical storage and handling conditions. The method of attachment of flanges to barrels on metal reels or spools shall be structurally equivalent to a full circumferential crimp.

TABLE III

Barrel Diameters of Spools and Reels

Wire Size (Range)	Minimum Diameter of Barrel (as Times Nominal Diameter of Finished Wire or Cable, Except See 5.1.1)
30-16	50X
14-10	40X
8-4	30X
2-0000	20X

5.2 PACKING - Containers enclosing the packaged wire or cable to be furnished under this specification shall be packed in an exterior container using cushioning on all sides to prevent movement. Required documentation (4.8.2) shall be enclosed in this outer container. As a minimum, wire or cable pack-

aged as specified shall be packed in containers of the type, size, and kind commonly used for the purpose, in a manner that will assure acceptance by common carrier and safe delivery at the destination. Shipping containers shall comply with the uniform freight classification rules or regulations of other carriers as applicable to the mode of transportation.

5.2.1 Packing Marking - Each container shall be permanently and legibly marked in accordance with the instructions contained in the purchase order.

6. NOTES

6.1 DATA ADDRESS - When supplemental data, reports, or information requests are to be transmitted to GSFC, the following address shall be used unless otherwise specified:

Parts Branch, Code 311
Goddard Space Flight Center
Greenbelt, MD 20771

6.2 DEFINITIONS - The following definitions shall apply to this specification:

(a) Finished wire - A single conductor, insulated as specified in the applicable detail specification.

(b) Cable - A single conductor with or without insulation or shielding or outer jacket (single conductor cable), or a combination of conductors insulated from one another with or without shielding or outer jacket (multiconductor cable).

6.3 ORDERING DATA - Procurement documents should specify the following:

(a) Title, number, and date of this and the applicable detail specification
(b) Wire and/or cable type designation (1.3)
(c) Quantity
(d) Reel or spool marking
(c) Packaging marking

6.4 QUALIFICATION PROVISIONS - With respect to products requiring qualification, awards will be made only for products which have been tested and approved by GSFC before the time set for opening of bids. The attention of the suppliers is called to this requirement; manufacturers should arrange to have qualification tests made on products which they propose to offer to GSFC to become eligible for awards of contracts or orders for products covered by this specification. The manufacturer shall bear the cost of qualification inspection

to this specification. Information pertaining to qualification of products may be obtained from the activity whose address is listed in 6.1.

6.5 NOTICE - When GSFC drawings, specifications, or other data are used for any purpose other than in connection with a definitely related GSFC procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; the fact that GSFC might have formulated, furnished, or in any way supplied the said drawing, specification, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:

Code 311
Goddard Space Flight Center
Greenbelt, MD 20771