Raychem Wire and Cable
501 Oakside Avenue, Redwood City, CA 94063-3800

CABLE, ELECTRIC, MARINE, LIGHTWEIGHT, ZEROHAL™ JACKETED

This amendment forms a part of Raychem Specification 345,
Issue 1, dated December 16, 1983.

PAGE 2

Para 2.1.1, under SPECIFICATIONS, Military, add the following:

"MIL-C-24640 Cable, Electrical, Lightweight, for Shipboard Use, General Specification for"

Para 2.1.1, under STANDARDS, Military, delete MIL-STD-129 and MIL-STD-686 and their titles.

PAGE 6

Para 3.6.3.1 Configuration, delete and substitute the following:

"3.6.3.1 Configuration

The required number of components as specified in the applicable specification sheet shall be cabled together with a left-hand lay. For cables having multiple layers, the outer layer shall be left-hand and the inner layer or layers may be either right-hand or left-hand lay. The lay length of the components in the outer layer shall be not less than eight nor more than sixteen times the outside diameter of the cable bundle."

Para 3.6.4.1 Identification Codes, delete and substitute:

"The circuit identification designation codes shall be in accordance with Table III of MIL-C-24640."

PAGE 7

Para 3.6.4.2 Identification Method, second sentence, delete and substitute:

"The legend shall be printed in contrasting color; i.e., white ink on black or dark background or black ink on white or light background."

PAGE 8

Para 3.6.12 Jacket Flaws, delete 2nd sentence and substitute the following:

"Jacket flaws testing shall be performed during the final winding of the cable on shipment spools or reels using a voltage of 3.0 kV (rms) at a frequency of 50 Hz, 60 Hz, or 3 kHz.

PAGE 30

Para 4.6.23.2 Voltage Withstand (Post-Environmental), delete and substitute the following:

"4.6.23.2 Voltage Withstand (Post-Environmental)

Voltage withstand (post-environmental) tests on the outer jacket shall be performed after the specified conditioning. The finished cable shall be immersed in a 5-percent, by weight, solution of sodium chloride in water at room temperature for at least one hour and, while the cable is still immersed, a voltage of 3.0 kV (rms) shall be applied between all the conductors and shields, tied together, and the water bath which shall be grounded."

PAGE 31

Para 5.1.4 Marking of Shipments, delete in its entirety.

Add the following paragraph:

"5.2 LABELING REQUIREMENTS

All spools and reels shall be identified with the following information:

Manufacturer's Part Number
Lot Number
Quantity in Feet *(or Meters)*
Name of Manufacturer"

Raychem

Raychem Corporation, 300 Constitution Drive, Menlo Park, California 94025

SPECIFICATION: 345
THIS ISSUE: ISSUE 1
DATE: December 16, 1983
REPLACES: None

CABLE, ELECTRIC, MARINE, LIGHTWEIGHT, ZEROHAL™ JACKETED

1. SCOPE

1.1 SCOPE

This specification covers the performance requirements for lightweight, fire-retardant Zerohal jacketed electrical cables for inboard or outboard use on ships or offshore platforms.

1.2 CLASSIFICATION

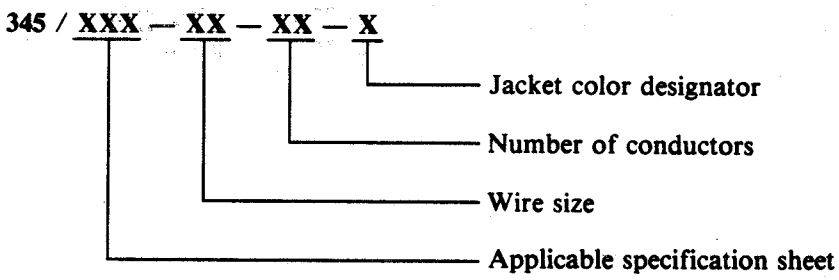
Products in accordance with this specification shall be of the following types, as specified in the applicable specification sheet.

1.2.1 Non-waterblocked

1.2.2 Waterblocked

1.3 CABLE DESIGNATION

Cable shall be identified by a combination of digits and letters in accordance with the following:



1.4 VOLTAGE RATING

The maximum voltage rating of the cable for continuous use shall be as specified in the applicable specification sheet.

2. APPLICABLE DOCUMENTS

2.1 GOVERNMENT-FURNISHED DOCUMENTS

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

Zerohal is a trademark of Raychem Corporation

2.1.1 Department of Defense

SPECIFICATIONS

Federal

TT-I-735	Isopropyl Alcohol

Military

MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-F-16884	Fuel Oil, Diesel, Marine
MIL-L-17331	Lubricating Oil, Steam Turbine and Gear, Moderate Service
MIL-H-17672	Hydraulic Fluid, Petroleum, Inhibited
MIL-L-24467	Lubricating Oil, Steam Turbine, Vapor-space Inhibited
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive

STANDARDS

Federal

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

Military

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-686	Cable and Cord, Electrical: Identification Marking and Color Coding of
MIL-STD-810	Environmental Test Methods

(Copies of Department of Defense documents may be obtained from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.)

2.2 RAYCHEM CORPORATION DOCUMENTS

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

SPECIFICATIONS

35	Wire and Cable, Electrical, Insulated, High Temperature
44	Wire and Cable, Electric, Radiation-Crosslinked, Polyalkene-Insulated Copper or Copper Alloy

SPECIFICATION CONTROL DRAWINGS (SCD)

35N0711	Wire, Electric, Radiation-Crosslinked, Extruded, Modified, Flame-Retarded Polyolefin-Insulated, Tin-Coated Copper
44A0111	Wire, Electric, Radiation-Crosslinked, Polyalkene-Insulated, Tin-Coated Copper, Lightweight, General Purpose, 600 Volt
44A0811	Wire, Electric, Radiation-Crosslinked, Polyalkene Insulated, Tin-Coated Copper, Medium Weight, Airframe, 600 Volt

2.3 OTHER PUBLICATIONS

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

2.3.1 American Society for Testing and Materials (ASTM)

D 470	Standard Methods of Testing Thermosetting Insulated and Jacketed Wire and Cable
D 2565	Standard Practice for Operating Xenon Arc-Type (Water-Cooled) Light-Exposure Apparatus With and Without Water for Exposure of Plastics
G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

2.3.2 Institute of Electrical and Electronics Engineers, Inc. (IEEE)

STD 383-1974	IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

(Copies of IEEE publications may be obtained from the Institute of Electrical and Electronics Engineers, Inc., 345 East 47 Street, New York, New York 10017.)

2.3.3 Ministry of Defence

2.3.3.1 Naval Engineering Standard (NES)

711	Determination of the Smoke Index of the Products of Combustion from Small Specimens of Materials
715	Determination of the Temperature Index of Small Specimens of Materials

(Copies of Naval Engineering Standards are sponsored by the Procurement Executive, Ministry of Defence, Ship Department, Section D123a, Block B, Foxhill, Bath, UK BA1 5AB.)

3. REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 Specification Sheets

The requirements for the component wire and finished cable furnished under this specification shall be as specified herein and in accordance with the applicable specification sheet. In the event of discrepancy between this specification and the requirements of the applicable specification sheet, the requirements of the specification sheet shall govern.

3.1.2 Components

Unless otherwise specified, component wire shall be 44A0111, 44A0811 or 35N0711 in accordance with the applicable specification sheet.

3.2 CLASSIFICATION OF REQUIREMENTS

The applicable requirements are classified herein as follows:

Requirement	Paragraph
Qualification	3.3
Materials	3.4
Construction	3.5
Detail requirements	3.6

3.3 QUALIFICATION

Finished cable furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein (see 4.3).

3.4 MATERIALS

Materials not specifically designated herein shall be of the quality and form best suited for the purpose intended. Unless otherwise specified, the materials shall meet the following requirements:

3.4.1 Component Wire

3.4.1.1 44A0111

44A0111 component wire shall meet all requirements of Raychem SCD 44A0111 prior to cabling.

3.4.1.2 44A0811

44A0811 component wire shall meet all requirements of Raychem SCD 44A0811 prior to cabling.

3.4.1.3 35N0711

35N0711 component wire shall meet all requirements of Raychem SCD 35N0711 prior to cabling.

3.4.2 Shield Material

All shield material shall conform to the requirements of Raychem Specification 44 and the applicable specification sheet.

3.4.3 Cable Jacket Material

All cable jackets shall be Zerohal material and shall meet all applicable requirements of Table I and the applicable specification sheet.

3.4.4 Fungus Resistance

All nonmetallic materials shall be fungus resistant and shall be certified that the observed growth rating is 1 or less when tested in accordance with ASTM G 21.

3.4.5 Waterblocking Compound

Waterblocking compound used in cable and shield interstices shall be compatible with all other cable materials. The compound shall be clean and nontacky to the touch. The compound shall be free-stripping from the cable components and shield by hand or with the aid of a brush, and shall not require the use of chemicals or other mechanical means of removal. The compound shall not interfere with any termination technique used with finished cable, shields or components.

3.5 CONSTRUCTION

Construction of the finished cable shall be as specified herein and in the applicable specification sheet.

3.5.1 Component Wire

Component wires shall be the type and size as specified on the applicable specification sheet.

3.5.2 Shield

The shield shall be constructed so as to meet the physical and surface transfer impedance requirements of the applicable specification sheet. The shield shall be free of irregularities, discontinuities or whole braid splices.

3.5.3 Wraps

Wrap tapes, where specified on the applicable specification sheet, shall be applied with an overlap of 25 percent, minimum, and shall meet the requirements of the applicable specification sheet.

3.5.4 Jacket

A Zerohal jacket shall be extruded concentrically over the cable core. The jacket shall meet the applicable requirements of Table I and the applicable specification sheet and shall be removable without damage to the underlying shield or components.

3.6 DETAIL REQUIREMENTS

Finished cable shall conform to the requirements of 3.6.1 to 3.6.20 and those of the applicable specification sheet.

3.6.1 Accelerated Aging

When the finished cable jacket is tested in accordance with 4.6.1, the tensile strength and elongation retention shall be 60 percent, minimum, of the original values.

3.6.2 Aging Stability

When the finished cable jacket is tested in accordance with 4.6.2, the tensile strength and elongation retention shall be 60 percent, minimum, of the original values.

3.6.3 Cabling

3.6.3.1 Configuration

The required number of component wires as specified in the applicable specification sheet shall be cabled together with a left-hand lay. For cables having multiple layers, the outer layer shall be left-hand and the inner layer or layers may be either right-hand or left-hand lay. The lay length of the individual component wires shall be not less than eight nor more than sixteen times the diameter of the applicable layer.

3.6.3.2 Cabling Sequence

In the case of cables having more than one layer of components, the component numbering sequence shall be from the innermost to the outermost; i.e., component number 1 shall be the center component (or one of the center components where two or more are used as a center) of the concentric layup.

3.6.3.3 Fillers and Binders

Fillers and binders shall be used as necessary to produce a firm round cable. Filler and binder material shall be moisture resistant and shall be compatible with all other cable components.

3.6.4 Color Codes and Methods

Individual component wires and individual wires of component groups shall be identified in accordance with 3.6.4.1, 3.6.4.2 and 3.6.4.3.

3.6.4.1 Identification Codes

The circuit identification designation codes shall be in accordance with Table IIB of MIL-STD-686.

3.6.4.2 Identification Method

The identification method shall be surface printing of both number and color designations. The legend shall be printed in contrasting color; i.e., white ink on black wire or black ink on white or red wire. The legend shall be repeated at intervals not exceeding 3.0 inches *(76 mm)* and alternate legends shall be inverted. For example: "10-ORANGE-BLACK ꓘƆ∀˥ᗺ-ƎפNⱯᴚO-0⇂". The vertical axes of the characters may be either perpendicular or parallel to the longitudinal axis of the wire. The character type shall be block or italic and shall have a height in accordance with the diameter over which it is applied as follows:

Diameter Range		Height of Character (Approx)	
Inch	*(mm)*	Inch	*(mm)*
0.045 to 0.070	*1.1 to 1.8*	0.025	*0.64*
0.070 to 0.095	*1.8 to 2.4*	0.031	*0.79*
0.095 to 0.115	*2.4 to 2.9*	0.047	*1.2*
0.115 to 0.200	*2.9 to 5.1*	0.063	*1.6*
0.190 to 0.250	*4.8 to 6.4*	0.078	*2.0*
0.235 to 0.375	*6.0 to 9.5*	0.094	*2.4*
0.330 and larger	*8.4 and larger*	0.125	*3.2*

Identification marking shall be capable of withstanding the durability test of 4.6.11 for 125 cycles with a weight of 500 grams.

3.6.4.3 Special Identification Requirements

The following special identification requirements shall also apply:

a. All component wires and wires of component groups shall be printed with the appropriate circuit identification code. Unless otherwise specified on the applicable specification sheet, individual wires of any component group shall have the same circuit identification number.

b. Each black wire in shielded and unshielded twisted pairs and triads shall be printed with the circuit identification number and color designation. All other wires in such constructions shall be printed only with the circuit identification number.

3.6.5 Conductor and Shield Continuity

One hundred percent of all finished cable shall be tested for continuity prior to shipment in accordance with 4.6.7. There shall be no indication of discontinuity in any of the component wires or shields, as applicable.

3.6.6 Drip Test

When tested in accordance with 4.6.10, there shall be no dripping.

3.6.7 Flammability

Samples of finished cable, when tested in accordance with 4.6.12, shall self-extinguish and shall not burn to the top of the tray.

3.6.8 Identification of Finished Cable

The outer surface of the cable jacket shall be printed in accordance with the applicable specification sheet. The legend shall be printed at 12-inch *(305-mm)*, nominal, intervals in a contrasting color; preferably white ink on black or dark jackets and black ink on white or light-colored jackets.

3.6.8.1 Durability of Identification

When required by the applicable specification sheet, identification printing on the outer surface of finished cable shall be capable of withstanding the durability test specified in 4.6.11 for 500 cycles with a weight of 150 grams.

3.6.9 Immersion

When the finished cable jacket is tested in accordance with 4.6.13, the tensile strength and elongation retention shall be 50 percent, minimum, of the original values.

3.6.10 Insulation Resistance

When finished cable is tested in accordance with 4.6.14, the insulation resistance shall be 5000 megohms, minimum, for 1000 feet *(1525 megohm-km)*.

3.6.11 Jacket Concentricity

When finished cable is tested in accordance with 4.6.15, the cable jacket concentricity shall be 70 percent, minimum.

3.6.12 Jacket Flaws

When the finished cable has an overall shield, 100 percent of the cable shall pass the jacket flaws test of 4.6.16. Jacket flaws testing shall be performed during the final winding on shipment spools or reels at 3.0 kV (rms), 50 or 60 Hz.

3.6.13 Jacket Tear Strength

When tested in accordance with 4.6.17, the minimum jacket tear strength shall be 35 pounds force per inch *(6.1 kN/m)* thickness.

3.6.14 Low Temperature-Cold Bend

When finished cable is tested in accordance with 4.6.18, there shall be no jacket cracking observed. Finished cables with overall shields shall then pass the voltage withstand (post-environmental) test without breakdown of the jacket.

3.6.15 Materials Tests

3.6.15.1 Abrasion Resistance

When Zerohal jacket material is tested in accordance with 4.6.19.1, the number of cycles to failure shall be 250, minimum.

3.6.15.2 Acid Gas Generation

When tested in accordance with 4.6.19.2, the amount of acid gas generated shall not exceed the following values.

Material	Acid Gas ppm/mg (maximum)
35N0711 insulation material	500
Zerohal jacket material	100

3.6.15.3 Halogen Content

The total halogen content of Zerohal jacket material shall be determined in accordance with 4.6.19.3 and shall be less than 0.2 percent by weight.

3.6.15.4 Oxygen Index Temperature

The temperature at which the oxygen index of the component insulation material and Zerohal jacket material is 20.8 percent shall be determined in accordance with NES 715 and shall be not less than 250 °C.

3.6.15.5 Salt Spray

When Zerohal jacket material is tested in accordance with 4.6.19.4, the wire shall show no evidence of cracking, blistering, pitting or peeling when examined using 5X magnification.

3.6.15.6 Smoke Index

When tested in accordance with NES 711 using 1-meter lengths of the 16 AWG test specimens as defined in 4.3.1.2.1 for 35N0711 insulation material and Zerohal jacket material, the maximum smoke indices shall be as follows:

Material	Maximum Smoke Index
35N0711 insulation material	90
Zerohal jacket material	20

3.6.15.7 Water Absorption

When Zerohal jacket material is tested in accordance with 4.6.19.5 using the 16 AWG test specimen defined in 4.3.1.2.1, the maximum water absorption shall be 25 milligrams per square inch *(3.9 mg/cm²)*.

3.6.15.8 Weathering

When Zerohal jacket material is tested in accordance with 4.6.19.6, the tensile strength and elongation retention shall be 75 percent, minimum, of the original values. In addition, the sample surface shall show no signs of cracking when examined using 5X magnification.

3.6.15.9 Voltage Withstand of Jacket Material

When tested in accordance with 4.6.19.7, there shall be no breakdown.

3.6.16 Shrinkage

When finished cable is tested in accordance with 4.6.20, the total shrinkage shall be 0.25 inch *(6.4 mm)*, maximum.

3.6.17 Surface Transfer Impedance

When tested in accordance with 4.6.21, the surface transfer impedance of the overall shield shall not exceed the requirements of the applicable specification sheet.

3.6.18 Tensile Strength and Elongation

When the finished cable jacket is tested in accordance with 4.6.22, the tensile strength shall be 1300 psi *(9.0 N/mm²)*, minimum, and the elongation shall be 160 percent, minimum.

3.6.19 Waterblocking (Waterblocked Constructions Only)

When finished cable is tested in accordance with 4.6.24, the maximum leakage shall be as specified below. Cable exceeding the specified maximum leakage shall be rejected.

Total Circular-Mil Area of Conductors in Cable			Maximum Water Leakage	
			cubic inch	*(ml)*
0	to	9,000	1	*16*
9,050	to	15,000	2	*33*
15,050	to	25,000	3	*49*
25,050	to	50,000	4	*66*
50,050	to	100,000	5	*82*
100,050	to	200,000	6	*98*
200,050	to	500,000	7	*115*
500,050	to	800,000	8	*131*
800,050	to	2,100,000	9	*147*

3.6.20 Workmanship

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

4. QUALITY ASSURANCE PROVISIONS

4.1 RESPONSIBILITY FOR INSPECTION

The supplier is responsible for the performance of all inspection tests specified herein. The supplier may utilize his own or any other inspection facility and services acceptable to the buyer. Inspection records of the examinations and tests shall be kept complete and available to the buyer as required.

4.2 CLASSIFICATION OF INSPECTIONS

The examinations and tests of materials and finished cable under this specification shall be divided into the following classifications:

Classification	Paragraph
Qualification inspection	4.3
Quality-conformance inspection	4.4
Periodic qualification re-evaluation	4.5

4.3 QUALIFICATION INSPECTION

Qualification inspection shall consist of all the tests of this specification as listed in Table I, as applicable to materials or finished cable.

4.3.1 Sampling for Qualification Inspection

4.3.1.1 Finished Cable Qualification Inspection

A finished cable sample, of sufficient length to permit the performance of all qualification tests, shall be tested for each group of cables for which qualification is desired. For purposes of selecting cable samples for qualification, a group of cables shall consist of all cable constructions with the same insulation system that are specified on any one specification sheet. 44A0111 and 44A0811 component wires shall be considered to have the same insulation system. The overall diameter of the cable sample selected for qualification shall be greater than 0.38 inch *(9.7 mm)* and less than 1.00 inch *(25 mm)*. Where a group of cables does not include any cable with an overall diameter in this range, the cable sample may be selected from any cable construction in the group.

4.3.1.2 Materials Qualification Inspection

The materials tests as defined in Table IV shall be performed on representative materials for which qualification is desired. The qualification sample shall qualify these materials for use in all constructions.

4.3.1.2.1 *Materials Qualification Samples*

Test samples for materials qualification shall be insulated 16 AWG wire, or insulation removed from such wire as follows. 35N0711 insulation material and Zerohal jacket material samples shall be prepared by extruding the material onto a 16 AWG (19/29 AWG) conductor. The total diameter of this insulated wire shall be 0.119 ± 0.002 inch *(3.0 ± .05 mm)*. Prepared samples shall be manufactured using process conditions as close as possible to those used to produce the finished product.

TABLE I

PROPERTIES OF FINISHED CABLE

Examination or Test	Requirement	Method
Accelerated Aging	3.6.1	4.6.1
Aging Stability	3.6.2	4.6.2
Attenuation	Specification Sheet	4.6.3
Cabling	Specification Sheet and 3.6.3	4.6.26
Capacitance	Specification Sheet	4.6.4
Capacitance Unbalance	Specification Sheet	4.6.5
Characteristic Impedance	Specification Sheet	4.6.6
Color Codes and Methods	3.6.4	4.6.26
Conductor and Shield Continuity	3.6.5	4.6.7
Construction and Materials	Specification Sheet, 3.4 and 3.5	4.6.26
Crosstalk	Specification Sheet	4.6.8
Drip Test	3.6.6	4.6.10
Durability of Marking	3.6.4.2 and 3.6.8.1	4.6.11
Finished Cable Diameter	Specification Sheet	4.6.9
Flammability	3.6.7	4.6.12
Fungus Resistance	3.4.4	3.4.4
Identification of Finished Cable	Specification Sheet and 3.6.8	4.6.26
Immersion	3.6.9	4.6.13
Insulation Resistance	3.6.10	4.6.14
Jacket Concentricity	3.6.11	4.6.15
Jacket Flaws	3.6.12	4.6.16
Jacket Tear Strength	3.6.13	4.6.17
Jacket Thickness	Specification Sheet	4.6.15
Low Temperature-Cold Bend	3.6.14	4.6.18
Materials Tests	3.6.15	4.6.19
Shrinkage	3.6.16	4.6.20
Surface Transfer Impedance	Specification Sheet and 3.6.17	4.6.21
Tensile Strength and Elongation	3.6.18	4.6.22
Voltage Withstand	Specification Sheet	4.6.23.1
Waterblocking	3.6.19	4.6.24
Weight	Specification Sheet	4.6.25
Workmanship	3.6.20	4.6.26
Wraps	3.5.3	4.6.26

4.3.2 Qualification Test Reports

When requested by the procuring activity, qualification test reports shall be supplied plainly identified with the following information:

Qualification test report for
CABLE, ELECTRIC, MARINE,
LIGHTWEIGHT, ZEROHAL™ JACKETED
Raychem Corporation
Part number of qualification sample
Part numbers qualified
Specification 345

4.4 QUALITY-CONFORMANCE INSPECTION

Quality-conformance inspection shall consist of the examinations and tests listed in Table II and described under "Test Methods" (4.6). Quality-conformance inspection shall be performed on every lot of finished cable manufactured under this specification.

4.4.1 Sampling for Quality-Conformance Inspection

MIL-STD-109 shall apply for definitions of inspection terms used herein. For purposes of this specification, the following shall apply.

4.4.1.1 Lot

The inspection lot shall include all finished cable of one part number subjected to inspection at one time.

4.4.1.2 Unit of Product

The unit of product for determining lot size for sampling shall be one continuous length of finished cable as offered for inspection.

4.4.1.3 Sample Unit (Groups I and II Tests)

The sample unit for Groups I and II tests, except for the Group I insulation resistance test, shall consist of a single piece of finished cable chosen at random from the inspection lot and of sufficient length to permit all applicable examinations and tests. Not more than one sample unit for each group of tests shall be taken from a single unit of product.

4.4.1.3.1 *Sample Unit for Insulation Resistance Test (Group I)*

The sample unit for the Group I insulation resistance test shall be a specimen at least 25 feet *(7.6 m)* in length selected at random from finished cable. 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.

4.4.1.4 Inspection Levels and Acceptable Quality Levels (AQL) (Groups I and II Tests)

For Group I tests, including the insulation resistance test, the inspection level shall be S-2 and the AQL shall be 6.5 percent defective units in accordance with MIL-STD-105. For Group II tests, the inspection level shall be S-3 and the AQL shall be 1.5 percent defective units.

TABLE II

QUALITY-CONFORMANCE INSPECTION

Examination or Test	Requirement	Method
Group I Characteristics		
Cabling	Specification Sheet and 3.6.3	4.6.26
Color Codes and Methods	3.6.4	4.6.26
Construction and Materials	Specification Sheet, 3.4 and 3.5	4.6.26
Durability of Marking	3.6.4.2 and 3.6.8.1	4.6.11
Finished Cable Diameter	Specification Sheet	4.6.9
Identification of Finished Cable	Specification Sheet and 3.6.8	4.6.26
Insulation Resistance	3.6.10	4.6.14
Jacket Tear Strength	3.6.13	4.6.17
Tensile Strength and Elongation	3.6.18	4.6.22
Waterblocking	3.6.19	4.6.24
Weight	Specification Sheet	4.6.25
Workmanship	3.6.20	4.6.26
Wraps	3.5.3	4.6.26
Group II Characteristics		
Accelerated Aging	3.6.1	4.6.1
Attenuation	Specification Sheet	4.6.3
Capacitance	Specification Sheet	4.6.4
Capacitance Unbalance	Specification Sheet	4.6.5
Characteristic Impedance	Specification Sheet	4.6.6
Crosstalk	Specification Sheet	4.6.8
Drip Test	3.6.6	4.6.10
Jacket Concentricity	3.6.11	4.6.15
Jacket Thickness	Specification Sheet	4.6.15
Low Temperature-Cold Bend	3.6.14	4.6.18
Shrinkage	3.6.16	4.6.20
Surface Transfer Impedance	Specification Sheet and 3.6.17	4.6.21
Group III Characteristics		
Conductor and Shield Continuity	3.6.5	4.6.7
Jacket Flaws	3.6.12	4.6.16
Voltage Withstand	Specification Sheet	4.6.23.1

4.4.1.5 Sampling and Acceptance for the Group III Tests

The sample for the Group III tests shall be 100 percent of the finished cable, and every length of the cable shall be fully tested. Portions showing breakdown and ends or portions not subjected to these tests shall be removed and the remaining lengths tested until no failure occurs.

4.4.2 Nonconforming Inspection Lots

Disposition of inspection lots found unacceptable under initial quality-conformance inspection shall be in accordance with MIL-STD-105.

4.5 PERIODIC QUALIFICATION RE-EVALUATION

Materials from current production shall be evaluated periodically against the requirements of Tables III and IV in addition to the quality-conformance requirements of Table II.

TABLE III

TESTS APPLICABLE ONLY TO QUALIFICATION INSPECTION AND QUALIFICATION RE-EVALUATION OF FINISHED CABLE

Examination or Test	Requirement	Method
Aging Stability	3.6.2	4.6.2
Flammability	3.6.7	4.6.12
Immersion	3.6.9	4.6.13

TABLE IV

TESTS APPLICABLE ONLY TO QUALIFICATION INSPECTION AND QUALIFICATION RE-EVALUATION OF INSULATING AND JACKET MATERIALS

Examination or Test	Requirement	Method
Component Insulation Material:		
Acid Gas Generation	3.6.15.2	4.6.19.2
Oxygen Index Temperature	3.6.15.4	NES 715
Smoke Index	3.6.15.6	NES 711
Zerohal Jacket Material:		
Abrasion Resistance	3.6.15.1	4.6.19.1
Acid Gas Generation	3.6.15.2	4.6.19.2
Halogen Content	3.6.15.3	4.6.19.3
Oxygen Index Temperature	3.6.15.4	NES 715
Salt Spray	3.6.15.5	4.6.19.4
Smoke Index	3.6.15.6	NES 711
Water Absorption	3.6.15.7	4.6.19.5
Weathering	3.6.15.8	4.6.19.6
Voltage Withstand of Jacket Material	3.6.15.9	4.6.19.7

4.6 TEST METHODS

4.6.1 Accelerated Aging

The finished cable jacket shall be conditioned in accordance with Method 4031 of FED-STD-228 at 175 ± 3 °C for four hours. Tensile strength and elongation shall be determined in accordance with 4.6.22.

4.6.2 Aging Stability

The finished cable jacket shall be conditioned in accordance with Method 4031 of FED-STD-228 at 130 ± 3 °C for 120 hours. Tensile strength and elongation shall be determined in accordance with 4.6.22.

4.6.3 Attenuation

4.6.3.1 Specimen

The specimen shall be of sufficient length to exhibit at least 3 dB of attenuation at any measurement frequency above 1 MHz. For measurement frequencies of 1 MHz or less, the specimen length shall be at least 300 feet *(91 m)*.

4.6.3.2 Configuration

The configuration of the equipment for determining attenuation is shown in Figures 1 and 2. A signal generator is connected to a matching pad, which is connected to the cable under test. The other end of the cable under test is connected to a matching pad, which is connected to a detector. The matching pads shall have a characteristic impedance of 50 ± 2 ohms on one end, and Z_0 ± 10 percent on the other end, where Z_0 is the characteristic impedance of the cable under test. For shielded twisted pairs, all measurements and connections shall be made wire to wire, with the shield left floating. Each end of the specimen cable may be looped through a ferrite core to suppress surface leakage. The initial permeability shall be 4700 nominal.

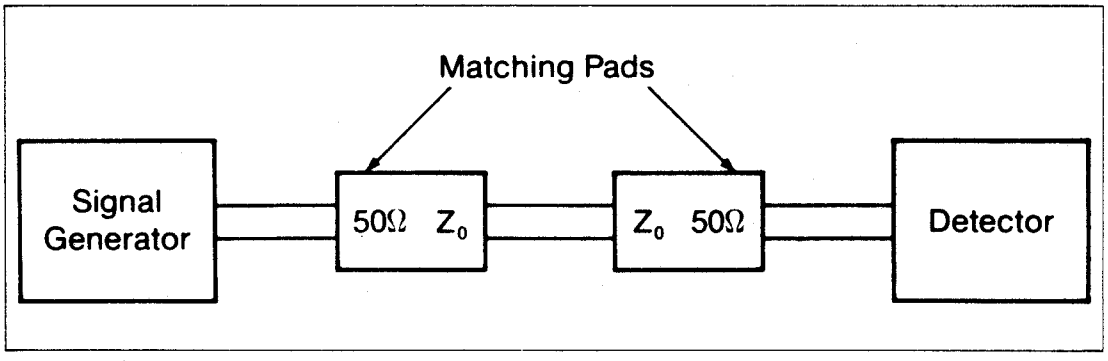


Figure 1. Configuration of Equipment for Calibration

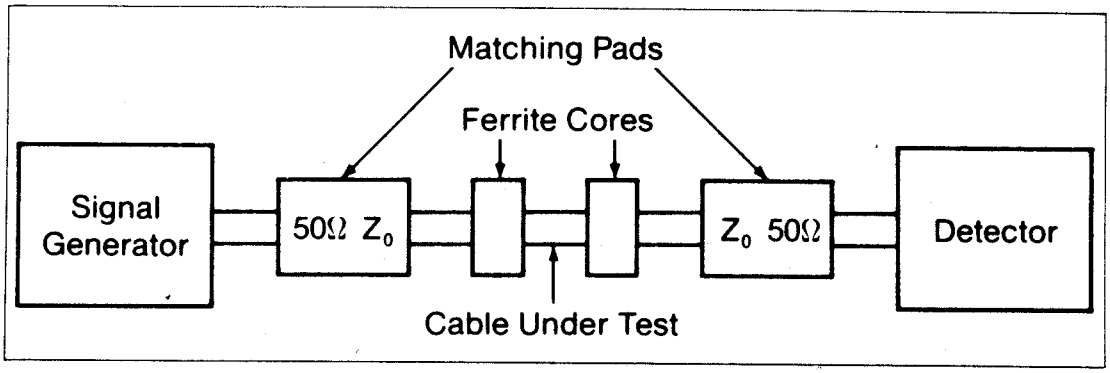


Figure 2. Configuration of Equipment for Measurement

4.6.3.3 Procedure

The measuring system shall be configured as shown in Figure 1, with the Z_0 ends of the matching pads connected together. At each test frequency, the detector reading shall be recorded and designated as V_0 for that frequency. The test frequencies shall cover at least two decades. Unless otherwise specified, the frequency range shall be 0.1 to 10 MHz. The matching pads shall be separated and the cable under test shall be inserted as shown in Figure 2. At each test frequency, the detector reading shall be recorded and designated as V_1 for that frequency. The raw attenuation value at any test frequency is given by,

$$\text{Attenuation} = \frac{2000}{L} \log_{10} \left[\frac{V_0}{V_1}\right] \text{ dB/100 feet } \textit{(or dB/100 m)} \qquad [1]$$

Where:

L = length of specimen in feet *(or meters)*
V_0, V_1 = detector readings at the test frequency

4.6.3.4 Determination of Compliance

A standard regression analysis shall be performed on the raw attenuation data given by equation [1]. The regression polynomial used shall be,

$$A(f) = a_1 \sqrt{f} + a_2 f \qquad [2]$$

Where:

f = frequency in MHz
a_1, a_2 = coefficients determined by regression analysis
A(f) = attenuation in dB/100 feet *(or dB/100 m)* at frequency (f)

The regression analysis is used to smooth out SWR effects. To determine compliance, the frequency or frequencies listed on the specification sheet shall be substituted into equation [2], along with the regression coefficients a_1 and a_2, and the attenuation A(f) calculated.

4.6.4 Capacitance

4.6.4.1 Specimen Preparation

For a specified measuring frequency of 1 MHz, the specimen shall consist of an approximate 10-foot *(3-m)* length of finished cable with all shields removed for a distance of 1.0 inch *(25 mm)* from each end and the insulation removed for a distance of 0.50 inch *(13 mm)* from each end of all conductors. The length of the specimen shall be the shielded length. For measuring frequencies other than 1 MHz, the sample shall be prepared as described, except that the specimen length shall be less than 1/40 wavelength, but not less than 5.0 feet *(1.5 m)*.

4.6.4.2 Configuration

Capacitance shall be measured with a capacitance bridge at 1 MHz unless otherwise specified.

4.6.4.3 Measurement Procedure

4.6.4.3.1 *Coaxial Cables and Components*

The capacitance shall be measured between the inner conductor and outer conductor (shield), with the outer conductor grounded.

4.6.4.3.2 *Shielded Pair Cables and Components*

The capacitance between the two inner conductors shall be measured by a two-terminal technique. With the outer conductor (shield) connected to the ground terminal of the capacitance bridge, the mutual capacitance (C_m) shall be determined as follows:

Designate:

C_a = Capacitance between no. 1 conductor and no. 2 conductor, with no. 2 conductor connected to the outer conductor.

C_b = Capacitance between no. 2 conductor and no. 1 conductor, with no. 1 conductor connected to the outer conductor.

C_c = Capacitance between no. 1 and no. 2 conductors (connected together) and the outer conductor.

The mutual capacitance (C_m) per unit length for each shielded pair shall be determined by the formula:

$$C_m = \frac{2\,(C_a + C_b) - C_c}{4\,(\text{Length of specimen})}$$

4.6.4.3.3 *Shielded Triad Cables and Components*

The capacitance shall be measured by the two-terminal technique. With the outer conductor (shield) connected to the ground terminal of the capacitance bridge, the capacitance (designated the mutual capacitance) shall be determined as follows:

Designate:

Ca = Capacitance between no. 1 conductor and all other conductors connected to the outer conductor.

Cb = Capacitance between no. 2 conductor and all other conductors connected to the outer conductor.

Cc = Capacitance between no. 3 conductor and all other conductors connected to the outer conductor.

Cd = Capacitance between all conductors connected together and the outer conductor.

The mutual capacitance (C_m) per unit length for each shielded triad shall be determined by the formula:

$$C_m = \frac{3\,(C_a + C_b + C_c) - C_d}{12\ (\text{Length of specimen})}$$

4.6.4.3.4 *Unshielded Pair Cables*

For unshielded pairs, the procedure shall be the same as for shielded pair cables except the overall shield, if any, and all conductors of the specimen except the pair under test, shall be connected together and treated as the outer conductor when making measurements. The mutual capacitance (C_m) for each pair shall be determined by the formula specified for shielded pairs.

4.6.4.3.5 *Unshielded Triad Cables*

For unshielded triads, the procedure shall be the same as for shielded triad cables except that the overall shield, if any, and all conductors of the specimen except the triad under test, shall be connected together and treated as the outer conductor when making measurements. The mutual capacitance (C_m) for each triad shall be determined by the formula specified for shielded triads.

4.6.5 Capacitance Unbalance

4.6.5.1 Capacitance Unbalance to Shield

4.6.5.1.1 *Capacitance Unbalance Pair-to-Shield*

The capacitance shall be determined in accordance with 4.6.4.3.2. The capacitance unbalance (C_u) in percent shall be determined from the following formula:

$$C_u = \frac{400\,|C_a - C_b|}{2\,(C_a + C_b) - C_c} \quad \%$$

4.6.5.1.2 *Capacitance Unbalance Triad-to-Shield*

The capacitance shall be determined in acccordance with 4.6.4.3.3. The capacitance unbalance (Cu) in percent shall be determined from the following formula:

$$Cu_1 = \frac{200|Ca - Cb|}{(Ca + Cb)} \quad \%$$

$$Cu_2 = \frac{200|Cb - Cc|}{(Cb + Cc)} \quad \%$$

$$Cu_3 = \frac{200|Ca - Cc|}{(Ca + Cc)} \quad \%$$

Where:

Cu_1 = The percent of capacitance unbalance of conductor no. 1 in relation to conductor no. 2.

Cu_2 = The percent of capacitance unbalance of conductor no. 2 in relation to conductor no. 3.

Cu_3 = The percent of capacitance unbalance of conductor no. 3 in relation to conductor no. 1.

4.6.5.2 Capacitance Unbalance Pair-to-Pair

Capacitance unbalance between the pairs of the finished cable shall be measured using a suitable meter or bridge specifically designed for use with telephone cable. The cable sample shall be connected to the measuring instrument in accordance with the instrument manufacturer's procedure. The measurement frequency shall be 1 kHz. The capacitance unbalance of all adjacent and alternate pairs shall be measured as well as the capacitance unbalance between the pairs in adjacent layers. A lesser number of measurements may be made if allowed by the applicable specification sheet. The measured value of the capacitance unbalance for the particular sample under test shall be converted to an unbalance per 1000 feet *(or km)* by use of the following formula:

$$Cu = C\sqrt{\frac{1000}{L}}$$

Where:

Cu = capacitance unbalance in pF/1000 feet *(or pF/km)*

C = measured capacitance unbalance of sample in picofarads (pF)

L = length of sample in feet *(or meters)*

4.6.6 Characteristic Impedance

4.6.6.1 Method A

This method shall only be used for cables whose nominal impedance is within 20 percent of Z_{ref}, where Z_{ref} is the impedance of the calibrated reference air line (CRAL). (For a 50-ohm CRAL, the measurable range of cables is 40-60 ohms.) This method cannot be used for determination of characteristic impedance at a single given frequency.

4.6.6.1.1 *Specimen Preparation*

For a coaxial cable, attach suitable connectors to both ends. For twisted pairs, the measurement shall be made wire to wire. Designate one wire as the inner conductor and the other wire as the outer conductor and attach suitable connectors to both ends.

4.6.6.1.2 *Apparatus*

The apparatus shall consist of a Time Domain Reflectometer (TDR) with a maximum rise time of 150 picoseconds and a minimum reflection coefficient sensitivity of .005. A calibrated reference air line (CRAL) of suitable impedance and suitable connectors shall be used.

4.6.6.1.3 *Procedure*

Attach CRAL to TDR output. Designate the resulting trace as Z_{ref} and adjust horizontal magnifier control until Z_{ref} extends through at least six horizontal divisions. The sample cable shall then be attached and the resulting Z_{ref} trace shall be designated as Z_C. With cable attached, the REFLECTION COEFFICIENT dial shall be adjusted so that Z_{ref} and Z_C are both on the graticule portion of the screen, but as far apart vertically as possible. Record the setting on the dial as A_{RC}. Determine the vertical spacing between Z_{ref} and Z_C in vertical divisions and designate as ρu. If Z_{ref} is higher than Z_C, then ρu is negative. If Z_{ref} is lower than Z_C, then ρu is positive.

Define ρ as:

$$\rho = \rho u \cdot A_{RC}$$

Characteristic impedance, Z_0, shall be determined from the following formula:

$$Z_0 = Z_{ref} \frac{1 + \rho}{1 - \rho}$$

4.6.6.2 Method B

This method is appropriate for determination of the characteristic impedance of cables at a given frequency which, unless otherwise specified shall be 1 MHz.

4.6.6.2.1 *Procedure*

Using a 1 MHz bridge, determine the capacitance (C) per paragraph 4.6.4. The end of the specimen used to determine the capacitance shall then be shorted and the inductance (L) of the specimen shall be determined using a 1 MHz bridge. Determination of the capacitance and inductance may also be made at other specified frequencies by use of a suitable bridge. The characteristic impedance at 1 MHz, or other specified frequency, shall be determined from the relation:

$$Z_0 = \sqrt{L/C}$$

Where:

Z_0 = the characteristic impedance in ohms
L = the inductance in henries
C = the capacitance in farads

For multipair cables, the capacitance (C) shall be the mutual capacitance (C_m).

4.6.7 Conductor and Shield Continuity

To establish continuity, 25 volts dc, maximum, shall be applied to both ends of each conductor and shield of the cable through an appropriate indicator, such as an ohmmeter, light or buzzer. The test voltage may be applied to the conductors and shields individually or in series.

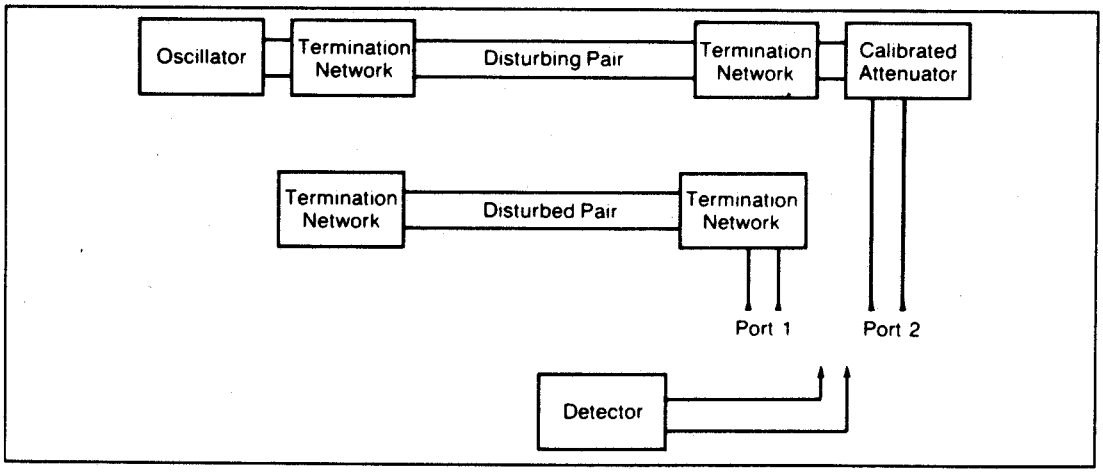
4.6.8 Crosstalk

The crosstalk loss shall be measured using the circuit shown below at the frequency given in the applicable specification sheet. The termination networks shall be the characteristic impedance of the pairs as determined in accordance with 4.6.6. The attenuator shall be adjusted until the detector indicates the same signal strength in Ports 1 and 2. The crosstalk loss is then taken to be the attenuation set on the attenuator. Alternate methods of equivalent accuracy may be used. The crosstalk loss (FEXT) in dB measured on the finished cable shall be converted to the crosstalk loss in dB for 1000 feet *(or km)* using the following formula:

$$\text{Crosstalk loss for 1000 feet } \textit{(or km)} = \text{FEXT} - 10 \log_{10} \left(\frac{1000}{L} \right) \text{ dB}$$

Where:

L = length of specimen in feet *(or meters)*



4.6.9 Dimensions

Measurements shall be made on a 12-inch *(305-mm)* minimum length of finished cable taken from the end of the sample unit. Four points for measurement shall be located 3 to 4 inches *(76 to 102 mm)* apart along the specimen length. Measurements shall be made at each point at two approximately perpendicular planes or as required to assure that the minimum and maximum reading is attained at each point. A total of eight measurements shall be performed on each specimen. The minimum, maximum and average value shall be recorded, as applicable. Measurements shall be made with a micrometer caliper or any other instrument of equal accuracy.

4.6.10 Drip Test

4.6.10.1 Specimen

A specimen shall consist of a 12-inch *(305-mm)* length of finished cable.

4.6.10.2 Procedure

The specimen shall be suspended vertically in an oven for a period of 6 hours at an oven temperature of 150 ± 3 °C.

4.6.11 Durability of Marking

4.6.11.1 Apparatus

The durability tester shall be designed to hold a short specimen 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 steel mandrel (usually a needle), 0.025 inch *(.64 mm)* in diameter, repeatedly over the upper surface of the specimen, 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 exerted normal to the surface of the insulation. A motor-driven, reciprocating cam mechanism and counter shall be used to deliver an accurate number of abrading strokes in a direction parallel to the axis of the specimen. The length of the stroke shall be 0.375 inch *(9.5 mm)* and the frequency shall be 60 stroking cycles (120 strokes) per minute.

4.6.11.2 Procedure

In performing the test, a specimen shall be mounted in the specimen clamp and the weight specified shall be applied through the abrading mandrel to the specimen surface. The counter shall be set at zero and the drive motor started. After the required number of cycles, the specimen shall be removed and examined. Failure shall consist of a continuous line of erasure or obliteration through all applicable markings contacted during the strokes.

4.6.12 Flammability

Samples of finished cable shall be tested in accordance with the vertical tray flame test of IEEE Std 383-1974, Section 2.5, using a ribbon gas burner.

4.6.13 Immersion

Specimens of the finished cable jacket prepared in accordance with 4.6.22 shall be immersed in the fluids shown in the table below for 24 hours at the temperatures specified. The specimens shall then be removed, blotted to remove excess fluid, then suspended in air at room temperature for not less than 3.5 nor more than 4.5 hours. The tensile strength and elongation of the specimens shall then be determined in accordance with 4.6.22.

Test Fluid	Test Temperature
Fuel Oil, MIL-F-16884	98 to 100 °C
Turbine Fuel, JP-4, MIL-T-5624	48 to 50 °C
Turbine Fuel, JP-5, MIL-T-5624	48 to 50 °C
Isopropyl Alcohol, TT-I-735	20 to 25 °C
Hydraulic Fluid, MIL-H-5606	48 to 50 °C
Hydraulic Fluid, MIL-H-17672	48 to 50 °C
Lubricating Oil, MIL-L-17331	98 to 100 °C
Lubricating Oil, MIL-L-24467	98 to 100 °C
Coolant, Monsanto Coolanol 25	20 to 25 °C

4.6.14 Insulation Resistance

Insulation resistance shall be measured on samples of finished cable at least 25 feet *(7.6 m)* in length. A dc potential between 200 and 500 volts shall be applied between each conductor or shield in the cable and all the other conductors and shields. The leakage current shall be measured and the applied potential shall be divided by this leakage current to give the insulation resistance of the conductor or shield insulation under test. A direct reading megohmmeter may also be used provided that the dc potential requirements are met. The leakage current shall be measured or the direct reading taken at any time after the application of the dc potential up to a maximum of 5 minutes.

4.6.15 Jacket Concentricity and Wall Thickness

The concentricity of the cable jacket shall be determined by first locating and recording the minimum wall thickness measured on a cross section of the jacket. The maximum wall thickness of this same cross section of jacket shall also be measured and recorded. The wall thickness shall be the radial distance between the inner and outer rim of the jacket as measured under suitable magnification. The ratio of the minimum wall thickness to the maximum wall thickness, multiplied by 100, shall define the percent concentricity.

4.6.16 Jacket Flaws

Finished cable shall be passed through a chain electrode spark test device using the required voltage and frequency. The shield shall be grounded at one or both ends. The electrode shall be of a suitable bead chain or fine mesh construction that will give intimate metallic contact with practically all of the jacket surface. Electrode length and speed of specimen movement shall be such that the jacket is subjected to the test voltage for a minimum of 0.2 second. Any portion showing breakdown shall be cut out including at least 2 inches *(51 mm)* of cable on each side of the failure.

4.6.17 Jacket Tear Strength

The tear strength of the cable jacket shall be determined in accordance with FED-STD-228, Method 3111.

4.6.18 Low Temperature-Cold Bend

A 5-foot *(1.5-m)* specimen of finished cable shall be straightened and placed in the cold chamber. If necessary, the specimen may be secured to keep it straight during the conditioning. The chamber shall be lowered to a temperature of −30 °C at a rate not to exceed 50 °C per minute. The specimen shall be conditioned at this temperature for four hours. At the end of this period, the specimen shall be removed from the chamber and immediately bent 180 degrees around a mandrel. The mandrel diameter shall be 12 times the nominal cable diameter, rounded up to the nearest half inch for mandrel diameters smaller than 4 inches *(102 mm)* and rounded up to the nearest inch for mandrel diameters greater than 4 inches *(102 mm)*. The time required for bending around 180 degrees of the mandrel shall be 0.5 minute at a uniform rate of speed. The specimen shall then be removed from the mandrel without straightening and visually examined without magnification for cracks and, if required, then subjected to the voltage withstand test specified in 4.6.23.2.

4.6.19 Materials Tests

4.6.19.1 Abrasion Resistance

4.6.19.1.1 *Specimen Preparation*

Test specimens of the Zerohal jacket material shall be prepared in accordance with 4.3.1.2.1.

4.6.19.1.2 *Apparatus*

The tester shall be designed to hold a short specimen of the sample wire firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. The tester shall be capable of rubbing the edge shown in Figure 3 repeatedly over the upper surface of the wire in such position that the longitudinal axes of the edge and the specimen are at right angles to each other with surfaces in contact. A weight added to a fixture above the rubbing edge shall control the force exerted normal to the surface of the insulation. A motor-driven, reciprocating cam mechanism shall be used to deliver an accurate number of abrading strokes in a direction parallel to the longitudinal axis of the specimen. The number of cycles shall be measured by a counter. The length of the stroke shall be 2 inches *(51 mm)* and the frequency of the stroke shall be 30 cycles (60 strokes) per minute. An electrical-detection circuit shall stop the counter and machine when the edge contacts the conductor of the sample wire.

4.6.19.1.3 *Procedure*

One inch *(25 mm)* of insulation shall be removed from one end of a 36-inch *(914-mm)* specimen of sample wire and the exposed conductor shall be attached to the detection circuit. The specimen shall be clamped in the tester and a weight of 1.5 pounds *(680 g)* shall be carefully applied to the surface of the insulation through the edge. Five tests shall be performed on each specimen with the specimen being moved forward 8 inches *(203 mm)* and rotated clockwise 90 degrees between each test. The test shall be discontinued when the edge abrades through the insulation and contacts the conductor. The abrasion resistance shall be the average of the five test result values.

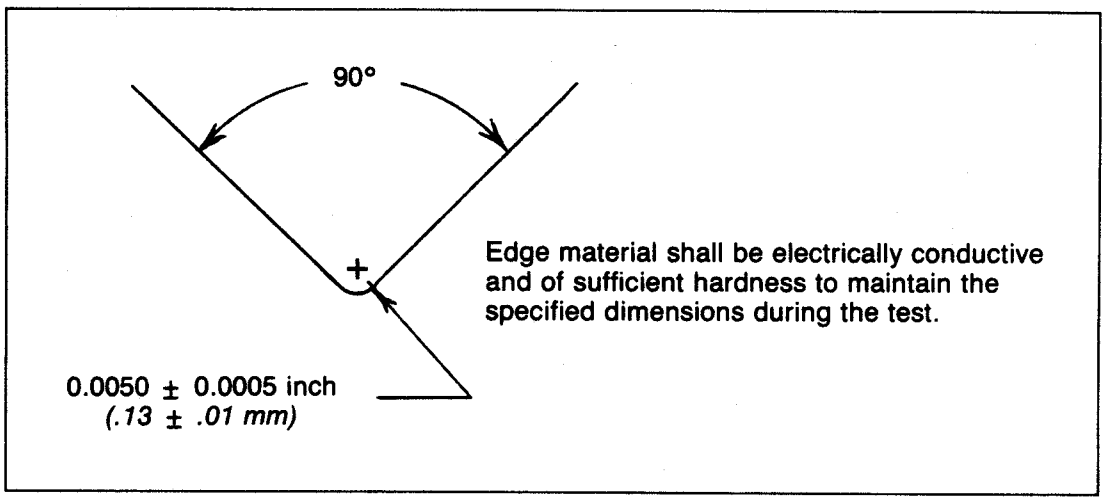


Figure 3. Abrasion Edge

4.6.19.2 Acid Gas Generation

4.6.19.2.1 *Apparatus*

The apparatus shall be as shown in Figure 4. The fused-quartz tube and the porcelain boat shall be flame and chemically cleaned to be free of deposits and organic material. The Meker burner shall be supplied with methane at a pressure of approximately 6 inches *(152 mm)* of water and the adjustment orifices shall be completely open.

4.6.19.2.2 *Procedure*

The burner shall be located as shown in Figure 4 and the fused-quartz tube shall be heated for at least 5 minutes to a dull-red temperature. The porcelain boat containing 1.0 ± 0.1 milligram of insulation or jacket material shall be located in the end of the fused-quartz tube farthest from the flame. The ends of an MSA† Part No. 91636 detector tube shall be broken off and the tube shall be connected to the MSA universal air-sampling pump as shown in Figure 4, with the arrow on the tube pointing toward the sample pump. The other end of the detector tube shall then be inserted in the rubber stopper, which then shall be inserted in the fused-quartz tube. The sampling pump then shall be set at the index mark specified in the instructions supplied with the lot of detector tubes being used. The porcelain boat containing the specimen then shall be quickly pushed and centered over the Meker burner, at which point a timer shall be started. The open end of the fused-quartz tube then shall be immediately stoppered with the metering orifice. When the specimen ignites, the sample pump shall be pulled one full stroke. After 1 minute, the detector tube shall be read using the calibration supplied with the lot of detector tubes being used. Five tests shall be performed. The acid gas generation (ppm/mg) shall be the detector tube reading (ppm) and shall be the average of the last four tests.

4.6.19.3 Halogen Content

The halogen content of the Zerohal jacket material shall be determined by x-ray fluorescence or method of equivalent accuracy.

4.6.19.4 Salt Spray

Specimens prepared in accordance with 4.3.1.2.1 shall be tested in accordance with Method 509.1 of MIL-STD-810. The exposure period shall be 500 hours.

†Mine Safety Appliances Company

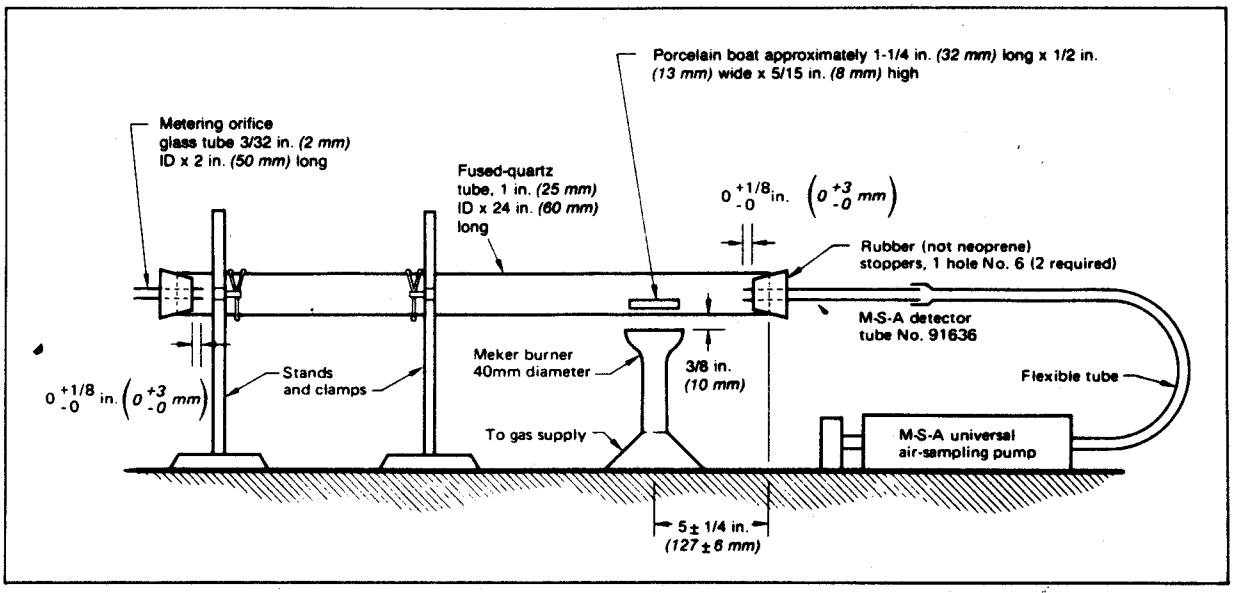


Figure 4. Acid Gas Generation Test Apparatus

4.6.19.5 Water Absorption

Water absorption shall be determined in accordance with the gravimetric method of ASTM D 470 with a water temperature of 70 ± 1 °C.

4.6.19.6 Weathering

Specimens prepared in accordance with 4.3.1.2.1 shall be tested in accordance with ASTM D 2565 using the following conditions:

Xenon Arc Lamp
6500 Watt
Borosilicate Glass Filters
Irradiance: 1.75 (watts/square meter)/nanometer

Exposure:	Arc Lamp On:	18 hours
		Black panel temperature 50 ± 2 °C
		Relative humidity 50 ± 2 percent
		(Every 2 hours, water is sprayed onto specimen for 18 minutes)
	Arc Lamp Off:	6 hours
		Temperature 25 ± 2 °C
		Relative humidity 90-95 percent
Total Exposure Time:		1000 hours

4.6.19.7 Voltage Withstand of Jacket Material

A 25-foot *(7.6-m)* sample, prepared in accordance with 4.3.1.2.1, shall be conditioned by immersion in water at 70 ± 1 °C for 168 hours. After conditioning, the sample shall be allowed to cool to room temperature while still immersed and then shall be subjected to the voltage withstand (post-environmental) test of 4.6.23.2.

4.6.20 Shrinkage

A 12-inch *(305-mm)* specimen of cable shall be cut so that all components are flush at both ends. The specimen shall then be aged at 150 ± 3 °C for 6 hours in an air-circulating oven. 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 or jacket shall then be measured as the total distance which any layer of the insulation or jacket has receded from both ends of the conductor.

4.6.21 Surface Transfer Impedance

The surface transfer impedance of the overall shield of finished cable shall be tested in accordance with MIL-C-85485 and as described in 4.6.21.1, 4.6.21.2 and 4.6.21.3.

4.6.21.1 Specimen Preparation

The individual shields of shielded components, when present, shall be connected to the conductors, and the connected conductors and shields shall be "the conductor" as defined in MIL-C-85485, except on end "B" where only one conductor shall be "the conductor" with all other conductors and individual shields of shielded components floating.

4.6.21.2 Determination of Compliance

The values of Z_t as determined from measurements made in accordance with the above shall not exceed the maximum specified values of Z_t as shown on the applicable specification sheet in any of the following ways:

a. A single maximum value of Z_t may be specified at a discrete frequency or over a range of frequencies.

b. The maximum value of Z_t over a range of frequencies may be specified by a plot of the maximum value of Z_t versus frequency.

c. The maximum value of Z_t over a range of frequencies may be specified as shown in Figure 5.

4.6.21.3 Determination of EMP Response

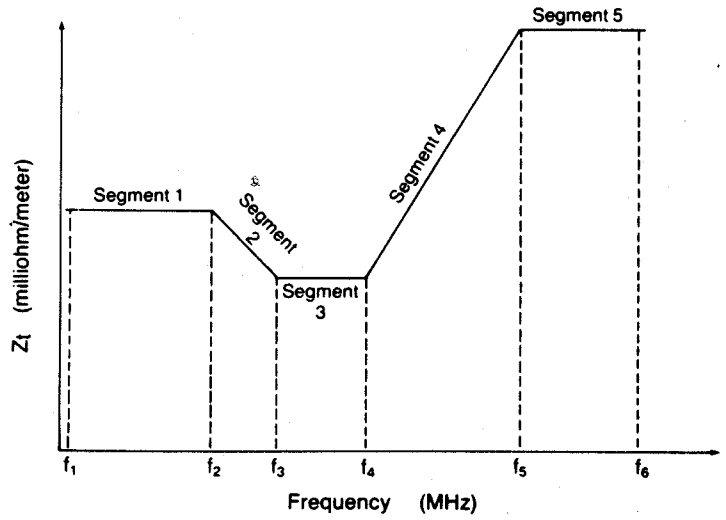
The surface transfer impedance determined as described above shall be known over the frequency range of 1 Hz to 400 MHz. Z_t shall be assumed constant in the frequency range of 1 Hz to 0.1 MHz. The EMP response in dB shall be defined as:

$$\text{EMP response} = -185 - 10 \log \int_{1}^{4 \times 10^8} \frac{[Z_t(f)]^2 \, df}{(\alpha^2 + f^2)(\beta^2 + f^2)} \quad \text{(dB)}$$

Where:

$Z_t(f)$ = surface transfer impedance at frequency f (Ω/m)
α = 2.39×10^5
β = 4.12×10^7
f = frequency (Hz)

The integral expression may be approximated by a summation, provided that at least 100 points per decade of frequency are used.



Note: Surface transfer impedance (Z_t) and Frequency (f) are both plotted with log scales.

The maximum specified values of Z_t shall be determined from the surface transfer impedance calculation parameters A_Z and B_Z as follows:

Segment 1: $Z_t = A_{Z^1}(f)^{Bz^1}$
Segment 2: $Z_t = A_{Z^2}(f)^{Bz^2}$
Segment 3: $Z_t = A_{Z^3}(f)^{Bz^3}$
Segment 4: $Z_t = A_{Z^4}(f)^{Bz^4}$
Segment 5: $Z_t = A_{Z^5}(f)^{Bz^5}$
etc.

Figure 5. Surface Transfer Impedance Plot

4.6.22 Tensile Strength and Elongation

Specimens of the finished cable jacket shall be tested in accordance with Methods 3021 and 3031 of FED-STD-228 with one-inch *(25-mm)* bench marks, one-inch *(25-mm)* jaw separation and a jaw separation speed of 10 inches *(254 mm)* per minute, unless otherwise specified on the applicable specification sheet. The thickness of the specimen shall be measured using a suitable micrometer.

4.6.23 Voltage Withstand

Voltage withstand tests shall be made using an ac source with a frequency of 50 or 60 Hz. The voltage specified shall be applied for one minute.

4.6.23.1 Voltage Withstand (Dielectric)

Voltage withstand (dielectric) tests shall be performed upon finished cable as described in 4.6.23.1.1, 4.6.23.1.2 or 4.6.23.1.3 as appropriate, with the voltage specified on the applicable specification sheet.

4.6.23.1.1 *Wire-to-Wire*

Wire-to-wire tests shall be conducted by applying the specified voltage to each conductor in turn with all the other conductors grounded. Any shields present shall be left unconnected from any conductors and from each other except as described in 4.6.23.1.2.

4.6.23.1.2 *Wire-to-Shield*

Wire-to-shield tests shall be conducted by applying the specified voltage to each conductor in turn with all shields grounded. When the specified voltages for wire-to-wire tests and wire-to-shield tests are identical, the tests may be combined and the common specified voltage shall be applied to each conductor in turn with all other conductors and shields connected together and grounded.

4.6.23.1.3 *Shield-to-Shield*

Shield-to-shield tests shall be conducted by applying the specified voltage to each shield in turn with all other shields grounded.

4.6.23.2 Voltage Withstand (Post-Environmental)

Voltage withstand (post-environmental) tests on the outer jacket shall be performed after the specified conditioning. The finished cable shall be immersed in water at room temperature for at least one hour and, while the cable is still immersed, a voltage of 3.0 kV (rms) shall be applied between all the conductors and shields, tied together, and the water bath which shall be grounded.

4.6.24 Waterblocking

4.6.24.1 Specimen

A specimen shall consist of a 5-foot *(1.5-m)* length of finished cable.

4.6.24.2 Procedure

One end of the specimen shall be placed in a terminal fitting which will allow water pressure to be applied directly to the exposed cross-sectional area of the end of the cable. The ends of the conductors exposed to the water shall be capped. Exposure of the sides of the cable to the water shall be kept to a minimum, and the fitting shall not exert radial compression against the cable. The specimen shall be subjected to a water pressure of 25 psi *(.17 N/mm²)* for a period of 6 hours.

4.6.25 Weight

The weight of each lot of finished cable shall be determined by Procedure I (4.6.25.1). Lots failing to meet the weight requirement of the applicable specification sheet when tested in accordance with Procedure I shall be subjected to Procedure II (4.6.25.2). All reels or spools failing to meet the requirements of the applicable specification sheet when tested to Procedure II shall be rejected.

4.6.25.1 Procedure I

The length and weight of a specimen at least 10 feet *(3.0 m)* long shall be accurately measured and the resultant measurements converted to pounds per 1000 feet *(kg/km)*.

4.6.25.2 Procedure II

The net weight of the finished 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 cable. The net weight of cable on each reel or spool shall be divided by the accurately determined length of finished cable on that reel or spool and the resultant figure converted to pounds per 1000 feet *(kg/km)*. When wood or other moisture absorbent materials are used for reel or spool construction, weight determinations shall be made under substantially uniform conditions of relative humidity.

4.6.26 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.

5. PREPARATION FOR DELIVERY

5.1 PACKAGING AND PACKING

5.1.1 Cable shall be delivered wound on reels or spools in accordance with 5.1.2. Cable shall be wound on the reel or spool in such a manner that all ends are accessible.

5.1.2 Reels and Spools

Reels and spools shall be of a non-returnable type. Each reel or spool shall have an appropriate diameter for the respective cable size. In no case shall the barrel of the reel or spool have a diameter less than 12 times the nominal diameter of the finished cable. Reels and spools shall be suitably finished to prevent corrosion under typical storage and handling conditions.

5.1.3 Containers

Unless otherwise specified (see 6.1), cable shall be delivered in standard commercial containers so constructed as to ensure acceptance by common or other carrier for safe transportation to the point of delivery.

5.1.4 Marking of Shipments

Interior packages and exterior shipping containers shall be marked in accordance with MIL-STD-129. The identification shall be composed of the following information listed in the order shown:

Lot number
Part number
Length _____ feet
Raychem Corporation

6. NOTES

6.1 ORDERING DATA

Procurement documents shall specify the following:

a. Title and number of this specification
b. Applicable specification sheet part number
c. Quantity
d. Special preparation for delivery requirements, if applicable

6.2 METRIC UNITS

Metric units, where shown in parentheses, are for information only.