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**11 Laurier St. / 11, rue Laurier**  
**Place du Portage, Phase III**  
**Core 0B2 / Noyau 0B2**  
**Gatineau, Québec K1A 0S5**  
**Bid Fax: (819) 997-9776**

**SOLICITATION AMENDMENT**  
**MODIFICATION DE L'INVITATION**

The referenced document is hereby revised; unless otherwise indicated, all other terms and conditions of the Solicitation remain the same.

Ce document est par la présente révisé; sauf indication contraire, les modalités de l'invitation demeurent les mêmes.

**Comments - Commentaires**

**Vendor/Firm Name and Address**  
**Raison sociale et adresse du**  
**fournisseur/de l'entrepreneur**

**Issuing Office - Bureau de distribution**  
Electrical & Electronics Products Division  
11 Laurier St./11, rue Laurier  
7B3, Place du Portage, Phase III  
Gatineau, Québec K1A 0S5

<b>Title - Sujet</b> CABLE ASSEMBLY, FIBER OPTIC	
<b>Solicitation No. - N° de l'invitation</b> W8486-152144/A	<b>Amendment No. - N° modif.</b> 001
<b>Client Reference No. - N° de référence du client</b> W8486-152144	<b>Date</b> 2015-02-20
<b>GETS Reference No. - N° de référence de SEAG</b> PW-\$\$HN-463-66712	
<b>File No. - N° de dossier</b> hn463.W8486-152144	<b>CCC No./N° CCC - FMS No./N° VME</b>
<b>Solicitation Closes - L'invitation prend fin</b> <b>at - à 02:00 PM</b> <b>on - le 2015-03-18</b>	<b>Time Zone</b> <b>Fuseau horaire</b> Eastern Standard Time EST
<b>F.O.B. - F.A.B.</b> <b>Plant-Usine:</b> <input type="checkbox"/> <b>Destination:</b> <input checked="" type="checkbox"/> <b>Other-Autre:</b> <input type="checkbox"/>	
<b>Address Enquiries to: - Adresser toutes questions à:</b> DeRito, Johanne	<b>Buyer Id - Id de l'acheteur</b> hn463
<b>Telephone No. - N° de téléphone</b> (819) 956-8278 ( )	<b>FAX No. - N° de FAX</b> ( ) -
<b>Destination - of Goods, Services, and Construction:</b> <b>Destination - des biens, services et construction:</b>	

**Instructions: See Herein**

**Instructions: Voir aux présentes**

<b>Delivery Required - Livraison exigée</b>	<b>Delivery Offered - Livraison proposée</b>
<b>Vendor/Firm Name and Address</b> <b>Raison sociale et adresse du fournisseur/de l'entrepreneur</b>	
<b>Telephone No. - N° de téléphone</b> <b>Facsimile No. - N° de télécopieur</b>	
<b>Name and title of person authorized to sign on behalf of Vendor/Firm</b> <b>(type or print)</b> <b>Nom et titre de la personne autorisée à signer au nom du fournisseur/</b> <b>de l'entrepreneur (taper ou écrire en caractères d'imprimerie)</b>	
<b>Signature</b>	<b>Date</b>

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Cet amendement est porté à répondre aux questions suivantes:

- 1) Pour prolonger la date de clôture des soumissions.
  - 2) Pour supprimer l'article «Pas de substitution»
  - 3) Pour inclure la clause «équivalents»
  - 4) Pour inclure la clause 'échantillons MDN »
  - 5) Pour fournir des dessins techniques
- 

- 1) L'appel d'offres a été prolongée jusqu'à 14h00 HNE le 18 Mars 2015.
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- 2) A Partie 2 - Instructions du soumissionnaire; section 1.1 Clauses du guide des CCUA:

DELETE: 1,1 Clauses du guide des CCUA

Section de référence Date de SACC

B4024T Aucun produit de remplacement 2006-08-15

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- 3) À la partie 3 - INSTRUCTIONS POUR LA PRÉPARATION; ci-dessous Section I:  
Soumission technique

INSERT: 1,1 produits équivalents

1. Les produits qui sont équivalentes forme, l'ajustage, la fonction et de qualité au produit (s) dans la demande de soumissions sera envisagée si le soumissionnaire désigne le nom de la marque et le modèle et / ou numéro de pièce et COEEP du produit de substitution;
2. Les produits offerts comme équivalent forme, l'ajustage, la fonction et la qualité ne seront pas prises en considération si:  
(A) l'offre ne parvient pas à fournir toutes les informations demandées pour permettre au pouvoir adjudicateur d'évaluer pleinement l'équivalence de chaque produit de substitution; ou  
(B) le produit de remplacement ne atteindre ou dépasser les critères obligatoires de rendement spécifiés dans la demande de soumissions pour cet article.
3. Dans le cadre de son évaluation des soumissions, le Canada peut, mais ne aura aucune obligation, demander aux soumissionnaires offrant un produit de substitution de fournir des informations techniques démontrant l'équivalence (par exemple tirage, les spécifications, les rapports techniques et / ou rapports d'essai), ou démontrer que le produit de remplacement est

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équivalent à l'élément spécifié dans la demande de soumissions, à la seule coût des soumissionnaires, dans les dix (10) jours ouvrables suivant la demande. Si le soumissionnaire ne fournit pas les informations demandées dans les délais prescrits, le Canada peut déclarer l'offre non recevable.

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4) À la partie 3 - INSTRUCTIONS POUR LA PRÉPARATION; ci-dessous Section I:  
Soumission technique; 1,1 produits équivalents:

INSERT: 1,2 produits équivalents - Échantillons (MDN)

Si le soumissionnaire propose un produit équivalent, le Canada se réserve le droit de demander un échantillon du Soumissionnaire afin de déterminer son équivalence en forme, l'ajustement, la fonction, la qualité et la performance de l'élément spécifié dans la demande de soumissions. Le soumissionnaire doit, sur demande de l'autorité contractante, fournir un échantillon à l'autorité technique, les frais de transport payés d'avance, et sans frais pour le Canada, dans les quinze (15) jours calendaires à compter de la date de la demande. L'échantillon soumis par le soumissionnaire restera la propriété du Canada et ne sera pas considéré comme faisant partie des livrables dans tout contrat subséquent. Si l'échantillon ne répond pas aux exigences de la demande de soumissions ou le soumissionnaire ne se conforme pas à la demande de l'autorité contractante, l'offre sera déclarée non recevable.

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5) Se il vous plaît trouver ci-joint, copie de l'OM 3 câble Spec. paquet technique.  
(Voir PDF joint)

TOUS LES TERMES ET CONDITIONS demeurent inchangées

### OM 3 CABLE SPECIFICATION

Insertion loss for EB VDN cables is primarily caused by the expanded beam lens air gap. Initial insertion loss for each dual ended EB cables primary fibre path shall be measured and recorded at least from Ax to Bx, in accordance with MIL-DTL-83526C, subsections 3.10.1 and 4.8.1, using Method B2 as described in Fibre optic Test Procedures (FOTP)-171A. For 100m/110m multimode cable assemblies the insertion loss shall be less than 1.8db at 850nm with 50µm OM3 core fibre. The 300m multimode cable assembly insertion loss shall be less than 2.4db at 850nm with 50µm OM3 core fibre. For 500m multimode cable assemblies, the insertion loss shall be less than 3.0db at 850nm with 50µm OM3 core fibre. Insertion loss for single ended expanded beam cables with other connectivity styles on the remote end shall be measured and recorded at least from B to Bx, in accordance with MIL-DTL-83526C, subsections 3.10.1 and 4.8.1, using Method C2 as described in FOTP-171A or an equivalent method. Example reference FOTP-171A Methods B2 and C2 setups are shown in Appendix B.

For each delivered cable, the insertion loss test results shall be provided

The cable assembly shall be in accordance with all the environmental requirements of MIL-DTL-83526C. The Impact, Compressive Loading, Cyclic, Twist specifications of the fibre optic cable shall be in accordance with the series of TIA/EIA-455 FOTP documents. Distribution type cable shall be qualified by inspection by similarity to MIL-PRF-85045/ environmental specifications shall be qualified by inspection to meet or exceed OCC B-004VALT5KM environmental performance requirements. Alternate vendor cables shall be implemented only when approved by the technical design authority.

#### **Connector specification Minimum specification for EB connector**

Minimum specification for EB connector

M83526/20-01/Hermetic Equivalent Plug Assembly, Colour Black Camo  
FED-STD-595/37030

Hermaphroditic Protective Cap, in accordance with MIL-DTL-83526, colour  
Black Camo

**Insertion Loss** ≤2.0 dB multimode, ≤2.5 dB single mode

**Return Loss** ≥-31.0 dB mated, ≥-34.0 dB unmated

**Mating Durability** 2000 cycles

**Operating Temperature** -46°C to 71°C

**Transit Temperature** -54°C to 71°C

**Storage Temperature** -57°C to 85°C

METRIC

MIL-PRF-85045F  
August 12 1999  
SUPERSEDING  
MIL-C-85045E  
21 May 1992

PERFORMANCE SPECIFICATION  
CABLES, FIBER OPTICS, (METRIC), GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers the general requirements and characteristics for cables utilizing optical fibers for signal transmission.

1.2 Classification. Cables covered by this specification consist of one or more single fiber, optical transmission elements with properties as specified (see 3.1) and are of the following categories:

1.2.1 Fiber optic cable configuration type. The fiber optic cable configuration type is designated by a single number as indicated in table I.

TABLE I. Fiber optic cable configuration type.

Cable configuration type	Designation
Buffered fiber <u>1/</u>	1
OFCC <u>2/</u>	2
Cable bundle <u>3/</u>	3
Ribbon <u>4/</u>	4
Tube <u>5/</u>	5

1/ The cable is constructed using buffered fibers (see 6.5.2) with no individual protective jackets or strength members.

2/ The cable is constructed using OFCCs (see 6.5.8) that are not grouped into bundles having bundle jackets or binders (see 6.5.4 and 6.5.1).

3/ The cable is constructed using buffered fibers or OFCCs that are grouped into cable bundles (see 6.5.3) with bundle jackets or binders.

4/ The cable is constructed using fiber ribbons (see 6.5.9).

5/ The cable is constructed using hollow tubes or ducts.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command (SEA 05G), DoD Standardization Program and Documents Division, Department of the Navy, 2531 Jefferson Davis Highway Arlington, VA 22206-5160, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1.2.2 Class. The class designation is defined by the mode volume of the optical fiber.

MM - Multimode  
SM - Single-mode

1.2.3 Application. The application designation is defined by the intended application of the optical cable.

A. Airborne  
B. Shipboard  
C. Ground benign  
D. Space  
E. Ground tactical

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in section 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

TT-P-645 - Primer, Paint, Zinc-Molybdate, Alkyd Type.

DEPARTMENT OF DEFENSE

MIL-S-901 - Shock tests, H.I. (High Impact), Shipboard Machinery, Equipment, and Systems, Requirements for.

MIL-PRF-49291 - Fiber, Optical (Metric) General Specification for.

(See supplement 1 for list of associated specifications).

STANDARDS

FEDERAL

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

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

NAVAL ENGINEERING STANDARDS

NES-713 - Determination of the Toxicity Index of the Products of Combustion from Small Specimens of Material.

(Copies of Naval Engineering Standards are available from the preparing activity, Naval Sea Systems Command, Code 03J2, Arlington, VA 22206-5160.)

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NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION (NASA)

- NHB 8060.1 - Flammability, Odor, and Offgassing and Compatibility Requirements and Test Procedures For Materials in Environments That Support Combustion.

(Application for copies should be addressed to Office of Safety and Mission Quality, (Code QR), NASA Headquarters, Washington, DC 20546.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM-E-84 - Standard Test Method for Surface Burning Characteristics of Building Materials. (DoD adopted)
- ASTM-D-470 - Crosslinked Insulations and Jackets for Wire and Cable, Methods of Testing. Materials from Outgassing in a Vacuum Environment. (DoD adopted)
- ASTM-D-512 - Standard Test Method for Chloride Ion in Water. (DoD adopted)
- ASTM-E-595 - Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment. (DoD adopted)
- ASTM-E-800 - Standard Guide for Measurement of Gases Present or Generated During Fires. (DoD adopted)
- ASTM-D-1141 - Standard Specification for Substitute Ocean Water. (DoD adopted)
- ASTM-D-1179 - Standard Test Method for Fluoride Ion in Water. (DoD adopted)
- ASTM-D-1246 - Standard Test Method for Bromine Ion in Water. (DoD adopted)
- ASTM-D-2565 - Standard Practice for Operating Xenon Arc-Type (Water Cooled) Light-Exposure Apparatus With and Without Water for Exposure of Plastics. (DoD adopted)
- ASTM-D-3761 - Standard Test Method for Total Fluorine in Coal by the Oxygen Bomb Combustion/Ion Selective Electrode Method. (DoD adopted)
- ASTM-D-3868 - Standard Test Method for Fluoride Ions in Brackish Water, Seawater, and Brines.
- ASTM-D-3869 - Standard Test Method for Iodide and Bromide Ions in Brackish Water, Seawater, and Brines.
- ASTM-D-4327 - Standard Test Method for Anions in Water by Chemically Suppressed Ion Chromatography.

(Application for copies of ASTM Publications should be addressed to the American Society for Testing and Materials, 100 Bar Harbor Drive, Conshohocken, Pennsylvania, 19428-2959)

ELECTRONIC INDUSTRIES ASSOCIATION/TELECOMMUNICATIONS INDUSTRY ASSOCIATION (EIA/TIA)

- EIA/TIA-455 - Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components. (DoD adopted)
- EIA/TIA-455-3 - Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components. (DoD adopted)
- TIA/EIA-455-4 - Fiber Optic Component Temperature Life Test. (DoD adopted)
- TIA/EIA-455-5 - Humidity Test Procedure for Fiber Optic Components. (DoD adopted)
- EIA/TIA-455-12 - Fluid Immersion Test for Fiber Optic Components.
- TIA/EIA-455-13 - Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies. (DoD adopted)

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TIA/EIA-455-20	-	Measurement of Change in Optical Transmittance. (DoD adopted)
TIA/EIA-455-25	-	Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies. (DoD adopted)
TIA/EIA-455-32	-	Fiber Optic Circuit Discontinuities. (DoD adopted)
EIA-455-33	-	Fiber Optic Cable Tensile Loading and Bending Test. (DoD adopted)
EIA/TIA-455-37	-	Low or High Temperature Bend Test for Fiber Optic Cable. (DoD adopted)
EIA/TIA-455-39	-	Fiber Optic Cable Water Wicking Test. (DoD adopted)
TIA/EIA-455-41	-	Compressive Loading Resistance of Fiber Optic Cables. (DoD adopted)
EIA/TIA-455-42	-	Optical Crosstalk in Fiber Optic Components. (DoD adopted)
EIA/TIA-455-46	-	Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers. (DoD adopted)
EIA-455-50	-	Light Launch Conditions for Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements. (DoD adopted)
TIA/EIA-455-56	-	Test Method for Evaluating Fungus Resistance of Optical Fiber and Cable. (DoD adopted)
TIA/EIA-455-71	-	Procedure to Measure Temperature-Shock Effects on Fiber Optic Components.
EIA/TIA-455-78	-	Spectral-Attenuation Cut Back Measurement for Single-Mode Optical Fibers. (DoD adopted)
EIA/TIA-455-81	-	Compound Flow (Drip) Test for Filled Fiber Optic Cable. (DoD adopted)
EIA/TIA-455-84	-	Jacket Self-Adhesion (Blocking) Test for Fiber Optic Cable. (DoD adopted)
EIA/TIA-455-87	-	Fiber Optic Cable Knot Test. (DoD adopted)
EIA-455-88	-	Fiber Optic Cable Bend Test. (DoD adopted)
TIA/EIA-455-91	-	Fiber Optic Cable Twist-Bend Test. (DoD adopted)
TIA/EIA-455-98	-	Fiber Optic Cable External Freezing Test.
TIA/EIA-455-104	-	Fiber Optic Cable Cyclic Flexing Test. (DoD adopted)
EIA/TIA-455-190	-	Low Air Pressure (High Altitude) Testing of Fiber Optic Components.
TIA/EIA-598	-	Optical Fiber Cable Color Coding. (DoD adopted)

(Application for copies should be addressed to the Electronic Industries Association/Telecommunications Industry Association, 2500 Wilson Boulevard, Suite 300, Arlington, Virginia 22201-3834).

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

IEEE-STD-299	-	Standard for Measuring the Effectiveness of Electromagnetic Shielding Enclosures. (DoD adopted)
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(Copies of IEEE documents are available from the IEEE, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC-794-1-E10	-	Optical fibre cables - Part 1: Generic specification.
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(Copies of IEC documents are available from the U. S. National Committee of the IEC, 11 West 42nd Street, 13th Floor, New York, NY 10036.)

UNDERWRITERS LABORATORY (UL)

UL-910	-	Standard for Safety Test for Flame Propagation and Smoke Density Values for Electrical and Optical Fiber Cables Used in Spaces Transporting Environmental Air. (DoD adopted)
UL-1685	-	Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

(Application for copies should be addressed to: Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062).

(Non-Government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

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

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### 3. REQUIREMENTS

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

3.2 Qualification. The optical fiber cables furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.5 and 6.3). The provisions of 4.5.5 for retention of qualification are included in this requirement.

3.3 Materials. The cable shall be constructed of material as specified (see 3.1). Materials selected for cable usage shall be of a type and quality to assure compliance with the requirements of this specification, and shall be physically and chemically compatible for their intended use and throughout their intended lifetime. All combinations of materials used shall be nonnutrient to fungus and of a virgin nature. When specified (see 3.1), materials and combinations of materials used in cable construction shall meet the requirements for toxic or explosive fumes produced by flame. Materials and combinations of materials used in cable construction shall have no adverse effect on the health of personnel or equipment when used for its intended purpose.

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

3.3.2 Filler. The fillers shall be evenly distributed, easily removable, and shall provide compactness and cross-sectional circularity to the finished cable.

3.3.2.1 Waterblocking material. Waterblocking material used in cable interstices shall be compatible with all other cable materials. Unless otherwise specified, the material shall be clean, nontacky, and nonirritating to the touch when not exposed to moisture. The material shall be free-stripping from the cable and components by hand and shall not require the use of chemicals or other mechanical means of removal. The material shall not interfere with any termination technique used with finished cable or components.

3.3.3 Strength members. Unless otherwise specified, strength members shall be all dielectric (see 3.1).

3.3.4 Jackets. Materials used for jackets (inner and outer) shall be as specified (see 3.1).

3.3.5 Cable nuclear vulnerability. When specified (see 3.1), materials shall meet the nuclear vulnerability requirements specified in appendices to the individual specification sheets.

3.3.6 Materials for space applications. When specified, materials used in space flight applications shall meet the following additional material requirements.

3.3.6.1 Thermal vacuum outgassing. When specified and when tested in accordance with 4.8.5.1, all non-metallic materials shall not exhibit greater than 1.0 percent total mass loss and shall not produce greater than 0.1 percent collected volatile condensable materials.

3.3.6.2 Material flammability. When specified and when tested in accordance with 4.8.5.2, non-metallic materials shall be considered non-flammable or self-extinguishing if, less than 6 inches of the minimum use thickness sample is consumed and the time of burning does not exceed 10 minutes. There shall be no sparking, sputtering, or dripping of flaming particles from the test sample.

3.3.6.3 Material toxicity (offgassing). When specified and tested in accordance with 4.8.5.3, all non-metallic materials shall not exceed a total hazard index of 0.5.

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**3.4 Design and construction.** The design, construction, and physical dimensions of the complete cable and cable elements shall be as specified (see 3.1). The cable shall consist of one or more optical transmission elements individually surrounded by protective layers to provide performance and dimensional characteristics as specified (see 3.1). Unless otherwise specified (see 3.1), the cable shall be of a circular cross-section and concentric geometry. The surface of the jacket shall be dry and free from any coating, film, or treatment which would interfere with the bonding to the jacket of encapsulating or molding materials used in splicing and terminating. Unless otherwise specified (see 3.1), finished cable and optical fiber cable components (OFCC) short term (dynamic) minimum bend diameter (see 6.5.10) shall be as listed in table II. The cable and the cable components shall be designed to comply with the specified properties while subject to specific operating and storage temperature ranges as specified (see 3.1). The long term (static) minimum bend diameter (see 6.5.7) shall be as specified (see 3.1).

TABLE II. Minimum short term bend diameter.

Application	Bend diameter to cable diameter (or OFCC diameter)
Ground tactical (T)	5X
Shipboard (B)	8X
Ground benign (G)	24X

**3.4.1 Optical fibers.** Optical fibers shall be in accordance with MIL-PRF-49291 and the applicable specification sheets (see 3.1). The optical fiber shall be coated with a material to preserve the high, pristine tensile strength of the glass fiber. The fiber and coatings shall maintain their physical characteristics at temperatures not greater than 85°C. Coating and buffer material shall be readily removable by mechanical means.

**3.4.1.1 Number of fibers.** The number of optical fibers in the cable shall be as specified (see 3.1).

**3.4.2 Cable configuration.** The detailed cable configuration shall be as specified (see 3.1) and shall be either a buffered fiber, an OFCC, a cable bundle, a ribbon cable, or a tube cable (see 1.2.1).

**3.4.2.1 Buffered fibers.** Unless otherwise specified (see 3.1), the outer diameter of the buffered fiber shall be 900  $\mu\text{m}$ . The buffer design shall be tight buffer, and the concentricity of the buffer shall be greater than or equal to 0.65 for 900  $\mu\text{m}$  buffered fibers.

**3.4.2.1.1 Buffered fiber color coding.** Unless otherwise specified (see 3.1), individual fiber buffers shall be color-coded for identification in accordance with EIA/TIA-598. The fiber buffer within an OFCC shall be color coded the same as the OFCC jacket color code.

**3.4.2.2 Optical fiber cable component (OFCC).** The OFCC dimensions and concentricity requirements shall be as specified (see 3.1).

**3.4.2.2.1 OFCC jacket color coding.** Unless otherwise specified (see 3.1), individual OFCC jackets shall be color coded for identification in accordance with EIA/TIA-598. For cable designs with more than 12 OFCCs within a bundle, the OFCCs may be marked for identification in lieu of color coding.

**3.4.2.2.2 OFCC kink.** When tested in accordance with 4.7.3.5, visual inspection shall reveal no kinking, cracking, splitting, tearing, or collapsing of the OFCC jacket for free form loop diameters not less than the minimum short term bend diameter of the OFCC.

**3.4.2.3 Cable bundle jacket.** The cable bundle jacket dimensions and concentricity requirements shall be as specified in the specification sheet (see 3.1).

**3.4.2.3.1 Cable bundle jacket color coding.** Unless otherwise specified (see 3.1), individual cable bundle jackets shall be color coded for identification in accordance with EIA/TIA-598.

**3.4.2.4 Optical fiber ribbon (Type 4 only).** The dimensional requirements and the number of fibers per ribbon for the optical fiber ribbons shall be as specified (see 3.1). A ribbon shall consist of a linear array of nominally contiguous fibers which are held between the adhesive faces of two pressure sensitive tapes or are bonded together with a matrix material. The ribbons shall have no crossovers, defective fibers or splices.

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3.4.2.4.1 Ribbon fiber color coding. Unless otherwise specified (see 3.1), each fiber in a ribbon shall be color coded for identification in accordance with EIA/TIA-598.

3.4.2.4.2 Ribbon color coding. Ribbon color coding shall be as specified (see 3.1).

3.4.2.5 Binders. The dimensional requirements and the number of fibers, buffered fibers, or OFCC's for each binder shall be as specified (see 3.1).

3.4.2.5.1 Binder color coding. Unless otherwise specified (see 3.1), each binder shall be color coded for identification in accordance with EIA/TIA-598.

3.4.2.6 Cable tubes. The dimensional requirements for cable tubes shall be as specified (see 3.1).

3.4.2.6.1 Cable tube color coding. Cable tube color coding shall be as specified (see 3.1).

3.4.3 Cable jacket. The cable jacket shall provide environmental and physical protection to the enclosed cable elements. The cable jacket shall be applied concentrically to the cable core to maintain circularity in the completed cable. Jacket dimensions and dimensional tolerances shall be as specified (see 3.1). The concentricity of the jacket shall be equal to, or greater than 0.65. This requirement applies to primary layers, coatings, or underlying jackets. The jackets shall be easily removable without damage to other cable component members as specified in 3.6.18. The jackets shall be dry and free from any coating, film, or treatment that would tend to interfere with the bonding of it to encapsulating or molding materials used in splicing and terminating. All jackets shall be free of pinholes, blowouts, and bumps (see 4.7.2).

3.4.3.1 Cable and cable core component jacket colors. Unless otherwise specified (see 3.1 and 6.2), the color of the overall cable jacket shall be black. The individual OFCC jackets and cable bundle jackets shall be separately color-coded as specified in 3.4.2.2.1 and 3.4.2.3.1, respectively. The ribbon fibers and ribbons shall be color-coded as specified in 3.4.2.4.1 and 3.4.2.4.2, respectively.

3.4.4 Fillers. Fillers may be used to provide firmness, roundness, and water tightness of finished cables. Fillers shall be made of electrically nonconducting material meeting the applicable requirements of 3.5, 3.6 and 3.7. Filler material shall be of a consistency so as to not induce attenuation during the cabling process and shall have physical properties so as to prevent changes in optical parameters when the cable is subjected to the physical and environmental tests specified (see 3.1). The fillers shall be removable in accordance with 3.6.18.

3.4.5 Strength and central members. The strength members shall consist of peripheral layers of nonelectrically conducting materials as specified (see 3.1). If a central member is specified (see 3.1), the central member shall be electrically nonconductive.

3.4.6 Cabling. Optical cables shall be cabled as specified (see 3.1). The length of lay shall be that required to meet the minimum specified bend radius, flexing, and twist-bending requirements. Strength members, fillers, and central members may contain splices. Splices in the strength members, fillers, and central members shall be dimensionally indistinguishable within the manufacturer's tolerances from the unspliced components. The splice strength shall be not less than the strength of the unspliced material.

3.4.6.1 Cable physical dimensions. When tested in accordance with 4.7.3.1 and 4.7.3.2, the physical dimensions of the finished cable shall be as specified (see 3.1).

3.4.6.2 Concentricity. When tested in accordance with 4.7.3.3, the concentricity of the finished cable, OFCC, buffered fiber(s), and cable bundle(s), shall be as specified (see 3.1). The concentricity shall be greater than or equal to 0.65, and shall apply to jackets and underlying jackets.

3.4.6.3 Cable mass per unit length. When tested in accordance with 4.7.3.4, the mass per unit length of a fully assembled cable shall not exceed the value specified (see 3.1).

3.4.6.4 Cable continuous lengths. Lengths shall be as specified (see 6.2). Fully assembled cable shall be continuous and shall not be repaired or spliced.

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3.5 Optical performance requirements.

3.5.1 Attenuation rate. The attenuation rate of the fiber prior to cabling or application of other stresses shall be tested in accordance with 4.7.4.1. Unless otherwise specified (see 3.1), the change in attenuation rate of the optical fiber in the finished cable shall not exceed the values shown in Table III from the precabled coated fiber value. The attenuation rate at the wavelengths of operation of the finished cable shall be as specified (see 3.1).

Table III. Maximum change in attenuation rate.

Application	Fiber type	Change in attenuation rate (dB/km)
Tactical (T)	Multimode	$\leq 0.5$ dB/km
	Single mode	$\leq 0.3$ dB/km
Shipboard (B)	Multimode	$\leq 1.0$ dB/km
	Single mode	$\leq 0.5$ dB/km

3.5.2 Change in optical transmittance. The change in optical transmittance of the cabled fibers due to exposure to mechanical (environmental and physical) tests shall not exceed the values specified in table IV when tested in accordance with 4.7.4.2. The end resultant attenuation due to cumulative environmental and mechanical testing shall not exceed that specified (see 3.1).

TABLE IV. Maximum change in optical transmittance.

Fiber type	Change in optical transmittance	
	Mechanical (dB)	Environmental (dB/km) <sup>1/</sup>
Multimode (MM)	0.5	0.5
Single mode (SM)	0.2	0.3

<sup>1/</sup> The change in optical transmittance requirement for freezing water immersion, gas flame, and shock are for the specified test length and shall not be normalized for one kilometer.

3.5.3 Crosstalk. When specified (see 3.1), the cable shall be tested in accordance with 4.7.4.3. The far end crosstalk between any two fibers shall be not greater than minus 60 dB below the active fiber optical output level.

3.6 Mechanical performance requirements.

3.6.1 Tensile loading and elongation. After testing a specimen of finished cable or OFCC in accordance with 4.7.5.1, there shall be no evidence of cracking, splitting, or breaking of the cable components or elongation greater than 2 percent. Unless otherwise specified, the change in optical transmittance of each fiber shall not exceed 2.0 dB during the test and the values specified in 3.5.2 after testing.

3.6.1.1 Operating tensile load. When specified (see 3.1), cable shall be tested in accordance with 4.7.5.1.1. There shall be no evidence of cracking, splitting, or breaking of the cable components. The change in optical transmittance shall not exceed the values specified in 3.5.2 during or after the test.

3.6.2 Dynamic bend. When tested in accordance with 4.7.5.2, the finished cable or OFCC shall reveal no jacket softening, surface damage (cracking, splitting, or other defect to permit jacket penetration), or identification marking impairment. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after the test.

3.6.3 Low temperature flexibility (cold bend). When tested in accordance with 4.7.5.3, a post-test visual examination of the cable jacket shall reveal no cracking, splitting, or other failure permitting jacket penetration. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 after the test.

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3.6.4 Cyclic flexing. When tested in accordance with 4.7.5.4, a post-test visual examination of the cable shall reveal no splitting, cracking, or crazing of the specimen jacket. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after the test.

3.6.5 Crush. When tested in accordance with 4.7.5.5, a post-test visual examination of the cable jacket shall reveal no cracking, splitting, or other defects to permit jacket penetration. Cable exterior deformation shall not be considered as damage or cable failure. The change in optical transmittance shall not exceed the values specified in 3.5.2 during and after the test and the optical crosstalk shall meet the requirements of 3.5.3 during and after the test.

3.6.6 Cable twist-bending. When tested in accordance with 4.7.5.6, finished cable specimens shall exhibit no evidence of degradation of jacket materials. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after testing. A post-test visual examination shall reveal no jacket softening, surface damage (cracking, splitting, or other defect to permit jacket penetration), or any identification marking impairment which affects legibility.

3.6.7 Radial compression (for application B only). When specified and when tested in accordance with 4.7.5.7, the finished cable shall reveal no cracking, splitting, or other defects to permit jacket penetration. The change in optical transmittance of each fiber shall not exceed 0.1 dB during and after the test.

3.6.8 Impact. When tested in accordance with 4.7.5.8, the cable shall meet the following requirements: A visual examination of the cable jacket shall reveal no cracking, splitting, or other defect to permit jacket penetration. The jacket may crack or split on any low temperature impact after the second low temperature impact. The change in optical transmittance shall not exceed the values specified in 3.5.2 after the test.

3.6.9 Corner bend. Unless otherwise specified (see 3.1), cables shall be tested in accordance with 4.7.5.9. A post-test visual examination shall reveal no cracking, splitting, or tearing of the cable. The change in optical transmittance shall not exceed the values specified in 3.5.2 during and after the test.

3.6.10 Knot. When specified (see 3.1), the cable shall be tested in accordance with 4.7.5.10. A post-test visual inspection shall reveal no cracking, splitting, or tearing of the cable. The change in optical transmittance shall not exceed the values specified in 3.5.2 during and after the test.

3.6.11 Pressure cycling (for application B only). When specified (see 3.1), during the test specified in 4.7.5.11, the change in optical transmittance for each fiber shall not exceed the values specified in 3.5.2.

3.6.12 Hosing (for application B only). When specified and when tested in accordance with 4.7.5.12, the requirements of 3.6.12.1 and 3.6.12.2 apply only to water-blocked cables.

3.6.12.1 Low pressure. When tested in accordance with 4.7.5.12.1, water leakage through the cable specimen shall be only axial and shall not exceed 35 milliliter (ml).

3.6.12.2 Hydrostatic. When tested in accordance with 4.7.5.12.2, the cable specimen shall permit no more than 1000 ml times the squared cable outer diameter (in centimeters) flow of axial water and no more than 20.0 mm slippage of cable internal parts (strength members, OFCCs, fillers etc.). Splitting or cracking of the cable between the gland nuts (inside of the stuffing tube) is allowed.

3.6.13 Dripping. When specified (see 3.1), the cable shall be tested in accordance with 4.7.5.13. A post-test visual inspection of the lower vertical cable end shall reveal no evidence of globule formation nor shall any dripping be observed on the drip collector.

3.6.14 Cable jacket tear strength. When tested in accordance with 4.7.5.14, the cable jacket tear strength shall be not less than 60 newtons per centimeter (N/cm) of jacket thickness.

3.6.15 Cable jacket material tensile strength and elongation. When tested in accordance with 4.7.5.15, the tensile strength of the cable and cable component jacket materials shall be not less than 900 N/cm<sup>2</sup>. The percent elongation shall be not less than 125 percent.

3.6.16 Cable abrasion resistance. When tested in accordance with 4.7.5.16, the cable shall withstand 250 cycles of scraping abrasion and 150 cycles of cable-to-cable abrasion. Unless otherwise specified, exposure of any layers below the cable jacket shall be considered failure.

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3.6.17 Cable shrinkage. When tested in accordance with 4.7.5.17, the total shrinkage of the length of finished cable (and buffered fiber, OFCC, cable bundle jacket and ribbon, as specified (see 3.1)) shall be not greater than 6.35 mm for thermoset jacket cables and 20 mm for thermoplastic jacket cables.

3.6.18 Cable element removability. When tested in accordance with 4.7.5.18, finished cable jacket, OFCC jacket, cable bundle jacket, optical fiber buffer, and ribbon tape shall be easily and cleanly removable by mechanical means without damage to the cable or optical fibers or both. No surface scratches or defects to the optical fiber shall be visible under 10X magnification after the fiber buffer material has been removed. The cable waterblock or filler materials, if applicable, shall be flexible and easily removable from any part to which it is in contact through the use of fingers only. The presence of occasional particles or slivers of filler residue will be acceptable, provided that these can be removed by light brushing with the fingers or with a dry cloth. Filler material which leaves residue that is removable only by vigorous wiping or through the use of solvents shall not be acceptable.

3.6.19 Durability of identification marking. Identification marking, including stripping or banding when specified (see 3.1), when applied to the outer surface of the finished cable, shall be capable of withstanding the durability test specified in 4.7.5.19 for 500 cycles. This test shall not be required when the identification marking is under a clear jacket.

3.6.20 Ribbon delamination (Type 4 only). When tested in accordance with 4.7.5.20, the ribbon shall not delaminate.

3.7 Environmental performance requirements. The finished cable shall perform according to all the requirements herein and as specified (see 3.1), during the specified operating environments and after the specified storage environment. The operating temperature range and storage temperature range shall be as shown in table V and as specified (see 3.1).

TABLE V. Temperature ranges.

Application	Operating range (°C)	Storage range (°C)
Ground tactical (T)	-46 to +71	-54 to +85
Shipboard (B)	-28 to +65	-40 to +70 <sup>1/</sup>
Ground benign (G)	-40 to +75	-40 to +75
Aircraft (A)	-46 to +125	-54 to +125
Space (S)	-60 to +85	-60 to +85

<sup>1/</sup> The shipboard nonoperational temperature range is the same as the shipboard storage temperature range.

3.7.1 Temperature cycling. When tested in accordance with 4.7.6.1, a post-test visual examination shall reveal no jacket softening, surface damage, or identification marking impairment. Post-test cable outer diameter shall remain within plus or minus 10 percent of the pretest cable outer diameter. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 at the low and high temperatures during and after the test.

3.7.2 Thermal shock. When tested in accordance with 4.7.6.2, a post-test visual examination shall reveal no jacket softening, surface damage (cracking, splitting or other defects to permit jacket penetration), or identification marking impairment. Post-test cable outer diameter shall remain within 10 percent of the pretest cable outer diameter. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 after the test.

3.7.3 Temperature humidity cycling. When tested in accordance with 4.7.6.3, a post-test visual examination shall reveal no jacket softening, surface damage, or identification marking impairment. Post-test cable outer diameter shall remain within plus or minus 10 percent of the pretest cable outer diameter. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after the test.

3.7.4 Storage temperature. When specified (see 3.1), the cable shall withstand the test specified in 4.7.6.4. The exterior surface of the test specimens shall show no cracks or defects. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 after the test.

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3.7.5 Barometric pressure (reduced). When specified (see 3.1), the cable shall withstand the test specified in 4.7.6.5. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after the test.

3.7.6 Life aging. When tested in accordance with 4.7.6.6, a post-test visual examination shall reveal no jacket softening, surface damage, or identification marking impairment. Post-test cable outer diameter shall remain within plus or minus 10 percent of the pretest cable outer diameter. The jacket tensile strength and elongation shall be not less than 75 percent of the initial value. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 after the test.

3.7.7 Freezing water immersion (ice crush). When specified (see 3.1), the cable shall withstand the test specified in 4.7.6.7. The change in optical transmittance of each fiber shall not exceed the values specified in 3.5.2 during and after the test.

3.7.8 Weathering. When specified and tested in accordance with 4.7.6.8, after the 1200 hours exposure, the cable jacket shall show no evidence of softening, gumminess or surface damage (cracking, splitting, or other defects to permit jacket penetration). The jacket tensile strength and elongation shall be not less than 75 percent of the initial value (see 4.7.5.15).

3.7.9 Fluid immersion. When tested in accordance with 4.7.6.9, the tensile strength and elongation retention properties of the cable jacket material shall be not less than 50 percent of the initial values. The finished cable shall reveal no cracks, splits, gumminess, or voids in the cable jacket. The outer diameter of the finished cable shall not deviate greater than 50 percent. The cable jacket shall not be preconditioned before this test other than normal jacket processing.

3.7.10 Wicking. When specified for water tight cables (see 3.1) and when tested in accordance with 4.7.6.10, a post-test examination of the immersed end of the cable specimen shall reveal a water penetration of less than 5 millimeters (mm) from the cable end and a change in mass of less than 1 percent.

3.7.11 Jacket self-adhesion or blocking. When tested in accordance with 4.7.6.11, a post-test visual inspection shall reveal no areas of localized adhesion between contacting cable surfaces, the metal storage spool, or areas that are of a more severe nature than a "mild" condition.

3.7.12 Flammability. When tested in accordance with 4.7.6.12, the requirements of 3.7.12.1, 3.7.12.2, or 3.7.12.3 apply only when specified (see 3.1).

3.7.12.1 Flammability (60° angle). When tested in accordance with 4.7.6.12.1, cables shall self-extinguish within 30 seconds. The distance of flame travel shall not exceed 10 cm, and there shall be no ignition of the tissue paper.

3.7.12.2 Flame extinguishing. When tested in accordance with 4.7.6.12.2, cables shall be self-extinguishing and shall not burn to the top of the tray.

3.7.12.3 Smoke generation and flame propagation. When tested in accordance with 4.7.6.12.3, the cables shall meet the requirements of UL-910 for smoke generation and flame propagation.

3.7.13 Shock. When specified and tested in accordance with 4.7.6.13, the finished cable shall reveal no physical damage. Unless otherwise specified (see 3.1), discontinuities shall not have a magnitude greater than the values specified in 3.5.2 for change in optical transmittance and a duration greater than 50 $\mu$ s.

3.7.14 Water absorption. When tested in accordance with 4.7.6.14, the maximum water absorption of the finished cable or a sample of the external cable jacket material shall not be greater than 4.0 mg per square centimeter (mg/cm<sup>2</sup>) of exposed cable surface area.

3.7.15 Paint susceptibility. When specified and tested in accordance with 4.7.6.15, the cable jacket shall show no signs of jacket weakening, cracking, or other damage.

3.7.16 Electromagnetic effects. When specified and tested in accordance with 4.7.6.16, the propagated radio frequency (RF) attenuation of the cable shall be not less than 100 dB attenuation for frequencies not greater than 1 GHz and 60 dB attenuation at 10 GHz.

3.8 Chemical properties.

3.8.1 Acid gas generation. When tested in accordance with 4.8.1, the acid gas generation, expressed as acid equivalent, shall be not greater than 2.0 percent of the weight of the sample.

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3.8.2 Halogen content. When tested in accordance with 4.8.2, the total halogen content of the cable shall be as specified (see 3.1).

3.8.3 Toxicity index. When tested in accordance with 4.8.3, the toxicity index shall not exceed 5.0.

3.8.4 Fungus resistance. When tested in accordance with 4.8.4, polymeric cable materials shall show sparse or very restricted microbial growth and reproduction with minor or inhibited substrate utilization. There shall be little or no chemical, physical, or structural change detectable.

3.9 Identification marking. Except as otherwise specified in the procurement contract or in the specification sheet, the finished cable shall be identified by a marking applied to the outer surface of the cable or visible through the outer surface. When cable is to be used in an end item for the Government, omission of the identification marking of product shall be permissible only when so stated in the specification sheet for the cable or the Government contract for the end item. The identification marking shall consist of the following, at intervals of 0.25 to 1.5 meters, as measured from the beginning of one complete marking to the beginning of the succeeding complete marking:

- a. PIN (see 6.6).
- b. Manufacturer's code designation.
- c. The words "Fiber Optic Cable".
- d. Date code (4 digit - week, year).
- e. When specified (see 6.2), meter markings shall be included.

The identification marking shall be permanent and legible. Identification marking shall be applied with the vertical axis of the printed characters lengthwise of the cable when the nominal diameter of the finished cable is 1.25 mm or smaller. The vertical axis of the printed characters may be either crosswise or lengthwise of the cable when the nominal diameter of the cable exceeds 1.25 mm.

3.9.1 JAN and J marking. The United States Government has adopted and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of military specifications. Accordingly, items procured to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the PIN except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets or detail specifications, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN" and Registration Number 1,586,261 for the certification mark "J".

3.10 Workmanship. All details of workmanship shall be in accordance with high grade fiber optic cable manufacturing practice. Cables shall be dimensionally uniform. The minimal level of visual examination to be performed shall be as specified in a through e and is not intended to restrict other pertinent workmanship examinations deemed necessary by the manufacturer (see 4.7.2).

- a. Outer jacket shall be free of cuts, burnt areas, abrasions, holes, roughened areas, bulges, thin spots, and discontinuities.
- b. Inner layers shall be free of cuts, holes, bulges, thin spots, and discontinuities.
- c. Strength members shall be uniformly laid with no discontinuities.
- d. Fillers and water sealant shall be uniformly distributed throughout the cable body.
- e. OFCC's shall not kink at diameters above the minimum short term bend diameter.

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#### 4. VERIFICATION

4.1 Verification program. Requirements for the verification program shall be as required by the qualifying activity (see 6.3.2).

4.2 Test equipment and inspection facilities. Requirements for test equipment and inspection facilities shall be as required by the qualifying activity (see 6.3.3).

4.3 Classification of inspections. The inspections specified herein are classified as follows:

- a. Qualification inspection (see 4.5).
- b. Conformance inspection (see 4.6).

4.4 Inspection conditions. Unless otherwise specified (see 3.1), all inspections shall be performed in accordance with the standard test conditions specified in EIA/TIA-455 or as specified herein. When a cable construction utilizes spliced fibers, test samples shall be selected to include the fiber splices.

4.5 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government, (see 3.2 and 6.3) on sample units produced with equipment and procedures normally used in production. Group qualification (extent of qualification) shall be as specified in 4.5.2.

4.5.1 Sample units. Unless otherwise specified (see 3.1), the sample units shall be as specified in table VI. The qualification sample shall consist of two sample units, one a minimum of 1 km in length and one a minimum of 0.5 km in length. The 1 km sample unit shall be cut to form two sample units, each a minimum of 0.5 km in length.

4.5.2 Extent of qualification. In instances where two or more specification sheets cover cables identical in materials and construction except for attenuation, or in instances where cable constructions include varying numbers of fibers, the cable configuration incorporating the lowest attenuation range and the largest number of fibers shall be submitted and shall meet all the requirements of this specification and the specification sheet (see 3.1). Qualification may be extended to include those cables with higher attenuation and fewer number of fibers provided the samples submitted in accordance with 4.5.1 meet all the requirements of the specification sheet.

4.5.2.1 Qualification by similarity for a modified cable jacket compound. Manufacturers who produce cables using one particular overall cable jacket compound and are qualified under the applicable specification sheets for cables and pass the size, attenuation rate, electromagnetic effects, low temperature flexibility (cold bend), cyclic flexing, impact, cable life, fungus, weathering, cross-link verification (if applicable), fluid immersion, paint susceptibility, jacket self adhesion or blocking, hosing, dripping, cable jacket tear strength, cable jacket tensile strength and elongation, cable abrasion resistance, cable shrinkage, durability of identification, smoke generation and flame propagation, flame extinguishing, water absorption, acid gas generation, halogen content, and toxicity index for cables with a modified overall cable jacket compound are qualified under the same specification sheets for cables with a modified overall cable jacket compound. Qualification by similarity testing shall be performed on the eight fiber cable for each modified overall cable jacket compound.

4.5.3 Inspection routine. The samples shall be subjected to the qualification inspection specified in table VI in the order shown. In cases where certain requirements and tests are applicable only when specified (see 3.1), these tests shall be conducted in the order shown when specified in the appropriate specification sheet (see 3.1). Tests which are specified as not applicable to a specific cable construction shall not be conducted. All sample units shall be subjected to the applicable inspections of groups I and II. Specimens shall be cut from each sample unit in lengths at least as long as specified in table VI. Test specimens from each sample unit shall be subjected to the applicable tests of group III through group V, inclusive, of table VI; however, each test specimen shall be subjected to only one group of tests in addition to groups I and II. Test specimens for group VI shall be cut from undamaged test specimens from groups III, IV, or V. Optical tests shall be performed on the sample when required in section 3 as specified by the individual test in section 4.

4.5.3.1 Qualification of modified designs. Qualification inspection of items which contain design changes from previously qualified items may be limited to a subset of the qualification inspections identified in 4.5.3. Qualification inspection reductions will be determined by the qualification activity based on the extensiveness of the design changes and the anticipated effects of those changes on the item performance.

4.5.4 Failures. One or more failures shall constitute qualification inspection failure.

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TABLE VI. Qualification inspection.

Inspection	Requirement paragraph	Test paragraph	Specimen length
<u>Group I</u>			
Visual and mechanical inspection	3.4, 3.9, 3.10	4.7.2	3 units 0.5 km each <u>3/</u>
Attenuation rate	3.5.1	4.7.4.1	3 units 0.5 km each <u>4/</u>
<u>Group II</u>			
Crosstalk	3.5.3	4.7.4.3	3 units 0.5 km each <u>4/</u>
Electromagnetic effects	3.7.16	4.7.6.16	1 unit 6 m <u>5/</u>
<u>Group III</u>			
Temperature cycling	3.7.1	4.7.6.1	2 units 0.5 km each <u>4/</u> (1 on reel, 1 off reel)
Temperature humidity cycling	3.7.3	4.7.6.3	2 units 0.5 km each <u>6/</u>
Storage temperature	3.7.4	4.7.6.4	2 units 0.5 km each <u>6/</u>
Low temperature flexibility (cold bend)	3.6.3	4.7.5.3	2 units 8 m each <u>7/</u>
Cyclic flexing	3.6.4	4.7.5.4	6 units 5 m each <u>8/</u> (2 units for each temperature)
Crush	3.6.5	4.7.5.5	2 units 5 m each <u>7/</u>
Cable twist-bending	3.6.6	4.7.5.6	6 units 5 m each <u>8/</u> (2 units for each temperature)
Impact	3.6.8	4.7.5.8	2 units 5 m each <u>7/</u>
Barometric pressure (reduced)	3.7.5	4.7.6.5	1 unit .46 km <u>9/</u>
Life aging	3.7.6	4.7.6.6	2 units 300 m each <u>7/</u>
Tensile loading and elongation	3.6.1	4.7.5.1	2 units 150 m each <u>10/</u>
Operating tensile loading	3.6.1.1	4.7.5.1.1	2 units 150 m each <u>11/</u>
Freezing water immersion (ice crush)	3.7.7	4.7.6.7	2 units 30 m each <u>7/</u>
Fungus resistance	3.8.4	4.8.4	2 units 0.5 m each <u>7/</u>
Knot	3.6.10	4.7.5.10	6 units 5 m each <u>8/</u>
Cable element removability	3.6.18	4.7.5.18	2 units 0.5 m each <u>7/</u>
Flammability (60 degree angle)	3.7.12.1	4.7.6.12.1	2 units 6 m each <u>7/</u>
<u>Group IV</u>			
Thermal shock	3.7.2	4.7.6.2	1 unit 0.49 km <u>4/</u> (on reel)
Weathering	3.7.8	4.7.6.8	1 unit 2 m <u>12/</u> and 3 material samples <u>13/</u>
Fluid immersion	3.7.9	4.7.6.9	1 unit 2 m <u>12/</u> and 3 material samples <u>13/</u> for each specified fluid
Paint susceptibility	3.7.15	4.7.6.15	2 units 2 m <u>14/</u>
Jacket self-adhesion or blocking	3.7.11	4.7.6.11	1 unit 30 m <u>12/</u>
Shock	3.7.13	4.7.6.13	1 unit 30 m <u>12/</u>
Dynamic bend	3.6.2	4.7.5.2	1 unit 150 m <u>15/</u>
Hosing: Low pressure	3.6.12.1	4.7.5.12.1	1 unit 1.5 m <u>12/</u>
Hydrostatic	3.6.12.2	4.7.5.12.2	1 unit 2 m <u>12/</u>
Radial compression	3.6.7	4.7.5.7	1 unit 10 m <u>12/</u>
Pressure cycling	3.6.11	4.7.5.11	1 unit 30 m <u>12/</u>
Corner bend	3.6.9	4.7.5.9	2 units 5 m <u>14/</u>
OFCC kink	3.4.2.2.2	4.7.3.5	2 units 1 m <u>12/</u>

See footnotes at end of table.

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TABLE VI. Qualification inspection - Continued.

Inspection	Requirement paragraph	Test paragraph	Specimen length
<u>Group V</u>			
Dripping	3.6.13	4.7.5.13	1 unit 30 cm <u>12/</u>
Cable jacket tear strength	3.6.14	4.7.5.14	3 units 1 m each <u>14/</u>
Cable jacket material tensile strength and elongation	3.6.15	4.7.5.15	5 units <u>16/</u>
Cable abrasion resistance	3.6.16	4.7.5.16	4 units 2 m each <u>17/</u>
Cable shrinkage	3.6.17	4.7.5.17	3 units 0.5 m each <u>14/</u>
Durability of identification	3.6.19	4.7.5.19	3 units 2 m each <u>14/</u>
Ribbon delamination	3.6.20	4.7.5.20	3 units 2 m each <u>14/</u>
Smoke generation and flame propagation	3.7.12.3	4.7.6.12.3	220 m <u>18/</u>
Flame extinguishing	3.7.12.2	4.7.6.12.2	1 unit 50 m <u>12/</u>
Wicking	3.7.10	4.7.6.10	2 units 2 m <u>14/</u>
Water absorption	3.7.14	4.7.6.14	2 units <u>19/</u>
<u>Group VI</u>			
Acid gas generation	3.8.1	4.8.1	1 unit 1 m <u>20/</u>
Halogen content	3.8.2	4.8.2	1 unit 1 m <u>20/</u>
Toxicity index	3.8.3	4.8.3	1 unit 1 m <u>20/</u>
Thermal vacuum outgassing	3.3.6.1	4.8.5.1	1 unit 1 m <u>20/</u>
Material flammability	3.3.6.2	4.8.5.2	1 unit 1 m <u>20/</u>
Material toxicity (offgassing)	3.3.6.3	4.8.5.3	1 unit 1 m <u>20/</u>

1/ Tolerance on 0.5 km length is plus or minus 10 percent provided results are normalized to 1 km.

2/ Tolerance on shorter lengths is plus or minus 10 percent.

3/ The visual and mechanical inspection shall only be conducted on a 2 m section of each sample.

4/ The same samples as used in the visual and mechanical inspection shall be used.

5/ A specimen cut from one of the visual and mechanical inspection test samples shall be used.

6/ The same samples as used in the temperature cycling test shall be used.

7/ A specimen cut from each sample used in the temperature cycling test shall be used.

8/ Three specimens cut from each sample used in the temperature cycling test shall be used.

9/ One of the samples used in the temperature cycling test shall be used.

10/ A specimen cut from each sample used in the life test shall be used.

11/ The same sample as used in the tensile loading and elongation test shall be used.

12/ A specimen cut from the sample used in the thermal shock test shall be used.

13/ Three jacket material samples as specified in 4.7.5.15 shall be used in this test.

14/ Specimens cut from the sample used in the thermal shock test shall be used.

15/ A specimen cut from the sample used in the thermal shock test or one of the samples used in the tensile loading and elongation test shall be used.

16/ Jacket material samples as specified in 4.7.5.15 shall be used in this test.

17/ Specimens cut from the sample used in the thermal shock test shall be used. Two specimens shall be used for scraping abrasion testing and two specimens shall be used in the cable to cable abrasion testing.

18/ A specimen consisting of several pieces, each cut from samples used in previous tests, shall be used.

19/ Jacket material samples as specified in 4.7.5.15 shall be used.

20/ A specimen cut from one of the samples used in the temperature cycling or thermal shock tests shall be used.

21/ Hybrid cables, consisting of alternating single mode and multimode fibers, can be used for qualification purposes. If a failure occurs for any fiber in a hybrid cable then all of the fibers in the cable are considered to have failed (both single mode and multimode).

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4.5.5 Retention of qualification. To retain qualification, the manufacturer shall verify in coordination with the qualifying activity the capability of manufacturing products which meet the performance requirements of this specification. Refer to the qualifying activity for the guidelines necessary to retain qualification to this particular specification. The manufacturer shall immediately notify the qualifying activity at any time that the inspection data indicates failure of the qualified product to meet the performance requirements of this specification.

4.6 Conformance inspection. Conformance inspection shall consist of the inspections and tests specified for group A inspection (table VII), group B inspection (table VIII), and group C inspection (table IX). Requirements for alternate forms of conformance inspection shall be as identified in the qualification instructions (see 6.3.4).

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspections.

4.6.1.1 Unit of product. A unit of product shall be 1 km of cable of the same part number. If a production run is less than a unit of product, then the quantity produced shall be one unit of product.

4.6.1.2 Production unit. The production unit shall consist of the number of units of product produced on the same production line or lines, and offered for inspection at one time. All of the units of product in the production unit submitted shall have been produced during the same production period with the same materials and processes.

4.6.1.3 Sample unit. A sample unit shall be a unit of product selected at random from the production unit without regard to quality.

4.6.1.4 Specimen. A specimen shall be an individual length of cable cut from the sample unit.

4.6.2 Group A inspection. Group A inspection shall consist of the inspections and tests specified in table VII. In cases where certain requirements and tests are applicable only when specified (see 3.1), these tests shall be conducted in the order shown when specified (see 3.1). Tests which are specified in the basic specification or specific slash sheet as not applicable to a specific cable construction shall not be conducted.

TABLE VII. Group A Inspection.

Inspection	Requirement paragraph	Test paragraph
Visual and mechanical	3.4, 3.9, 3.10	4.7.2
Attenuation rate	3.5.1	4.7.4.1

4.6.2.1 Sampling plan. Group A inspection shall be performed on 100 percent of delivered product.

4.6.2.2 Failures. One or more failures shall constitute group A inspection failure of the sample unit.

4.6.2.3 Disposition of sample units. Sample units that have failed any of the group A inspection tests shall not be shipped or submitted for group B testing.

4.6.3 Group B inspection. Group B inspection shall consist of the inspections specified in table VIII. In cases where certain requirements and tests are applicable only when specified (see 3.1), these tests shall be conducted in the order shown when specified (see 3.1). Tests which are specified in the basic specification or specific slash sheet as not applicable to a specific cable construction shall not be conducted. Group B inspection shall be made on sample units that have passed the group A inspection.

TABLE VIII. Group B Inspection.

Inspection	Requirement paragraph	Test paragraph
Low temperature flexibility (cold bend)	3.6.3	4.7.5.3
Dynamic bend	3.6.2	4.7.5.2

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4.6.3.1 Sampling plan. Two 170 m specimens shall be selected from those sample units covered by a single specification sheet within 24 months after the date of notification of qualification and during every 24 month period thereafter, except when the total production in a 24 month period is less than 2 units of product (2 km) or a total of 60 months have elapsed since the inspection was performed, in which case only one specimen shall be tested.

4.6.3.2 Failures. If one or more specimens fail to pass group B inspection, the production unit from which the specimens were selected shall be rejected.

4.6.3.3 Rejected production units. Requirements regarding the rework of rejected production units shall be as identified in the qualification instructions (see 6.3.10).

4.6.3.4 Disposition of sample units. Sample units from which a specimen has failed any of the group B inspection tests shall not be shipped, even though the production unit submitted is accepted.

4.6.4 Periodic inspection. Periodic inspection shall consist of group C. Except where the results of these inspections show noncompliance with the applicable requirements (see 4.6.4.1.4), delivery of products which have passed group A and group B inspections shall not be delayed pending the results of periodic inspection.

4.6.4.1 Group C inspection. Group C inspection shall consist of inspections specified in table IX. In cases where certain requirements and tests are applicable only when specified (see 3.1), these tests shall be conducted in the order shown when specified (see 3.1). Tests which are specified in the basic specification or specific slash sheet as not applicable to a specific cable construction shall not be conducted. Group C inspection shall be made on sample units selected from production units which have passed the group A and group B inspections.

4.6.4.1.1 Sampling plan. Two 500 m specimens shall be selected from those sample units covered by a single specification sheet within 60 months after the date of notification of qualification and during every 60 month period thereafter, except when the total production in a 60 month period is less than two units of product (2 km) inspection need not be made until production is at least 2 units of product.

4.6.4.1.2 Failures. One or more specimen or sample unit failures shall constitute group C inspection failure.

4.6.4.1.3 Disposition of sample units. Specimens that have been tested to group C inspection shall not be shipped.

4.6.4.1.4 Noncompliance. Requirements regarding failure of group C inspection shall be as identified in the qualification instructions (see 6.3.11).

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Table IX. Group C inspection.

Inspection	Requirement paragraph	Test paragraph
<u>Group I</u>		
Temperature cycling	3.7.1	4.7.6.1
Temperature humidity cycling	3.7.3	4.7.6.3
Cable twist-bending	3.6.6	4.7.5.6
Impact (low temperature)	3.6.8	4.7.5.8
Life aging	3.7.6	4.7.6.6
Tensile loading and elongation	3.6.1	4.7.5.1
Operating tensile load	3.6.1.1	4.7.5.1.1
<u>Group II</u>		
Knot	3.6.10	4.7.5.10
Cable element removability	3.6.18	4.7.5.18
Flammability (60 degree angle)	3.7.12.1	4.7.6.12.1
Fluid immersion	3.7.9	4.7.6.9
Hosing: Low pressure	3.6.12.1	4.7.5.12.1
Hydrostatic	3.6.12.2	4.7.5.12.2
Pressure cycling	3.6.11	4.7.5.11
Cable jacket tear strength	3.6.14	4.7.5.14
Cable abrasion resistance	3.6.16	4.7.5.16
Cable shrinkage	3.6.17	4.7.5.17
Ribbon delamination	3.6.20	4.7.5.20
Wicking	3.7.10	4.7.6.10
<u>Group III</u>		
Acid gas generation	3.8.1	4.8.1
Thermal vacuum outgassing	3.3.6.1	4.8.5.1
Material flammability	3.3.6.2	4.8.5.2
Material toxicity (offgassing)	3.3.6.3	4.8.5.3

4.7 Methods of inspection.

4.7.1 Equivalent test methods. The use of equivalent test methods is allowed provided that the preparing activity and the qualifying activity have approved the use of that equivalent test method by that manufacturer (see 6.3.4).

4.7.2 Visual and mechanical examination (see 3.4, 3.6, 3.7, 3.8, and 3.9 and 3.10). Visual and mechanical examinations shall be performed in accordance with TIA/EIA-455-13 to verify that the design, construction, physical characteristics, dimensions, marking, and workmanship are in accordance with the applicable requirements. Visual examination shall be accomplished utilizing 10X magnification. Visual inspection for the color of the cable and the color of the fiber may be accomplished without magnification. Visual inspection of the cable may be limited to the cable ends and the exposed surface of the cable. Unspooling of the cable to inspect the unexposed portions is not required.

4.7.3 Fiber and cable construction inspections.

4.7.3.1 Cable and cable core component dimensions (see 3.4.6.1). Buffered fiber, OFCC, cable bundle, ribbon, and the finished cable dimensions shall be measured in accordance with FED-STD-228, method 1018.

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4.7.3.2 Finished cable diameter (see 3.4.6.1). The diameter of finished cable shall be computed from the circumference measurement determined in accordance with FED-STD-228, method 1441.

4.7.3.3 Concentricity (see 3.4.6.2). The concentricity of the buffer, OFCC jacket, cable bundle jacket, and finished cable jacket shall be determined by locating and recording the minimum and maximum wall thickness of the same cross section. The ratio of the minimum wall thickness to the maximum wall thickness is defined as concentricity.

4.7.3.4 Cable mass per unit length (see 3.4.6.3). The mass of 1 km of fiber optic cable shall be determined in accordance with FED-STD-228, method 8311.

4.7.3.5 OFCC kink (see 3.4.2.2.2). The OFCC shall be tested in a free form loop using method IEC 794-I-E10. Three specimens shall be tested from each fiber on each end of the cable. The free standing loop diameter shall be measured in a direction parallel to that in which the forces are applied. The test on each specimen shall be terminated when either a kink is formed or when one half the minimum bend diameter is reached. The free form loop diameter in which the first noticeable detrimental effect occurs is to be recorded along with the effect.

4.7.4 Optical properties inspections. Unless otherwise specified (see 3.1), the optical requirements specified herein shall be met at the center wavelength of 1.300  $\mu\text{m}$  with a plus or minus 0.020  $\mu\text{m}$  tolerance.

4.7.4.1 Attenuation rate (see 3.5.1). The multimode fiber attenuation rate shall be measured in accordance with EIA/TIA-455-46. For multimode fibers, the source shall be noncoherent. Light launch conditions used during the attenuation rate measurements shall be made in accordance with EIA-455-50 and table X. The attenuation rate of each individual single mode fiber shall be measured in accordance with EIA/TIA-455-78.

TABLE X. Light Launch conditions for attenuation rate tests.

Fiber type	Launch conditions
SM	30-mm diameter mandrel
MM	70/70 restricted or equivalent

4.7.4.2 Change in optical transmittance (see 3.5.2). This test shall evaluate the change in optical transmittance of the fibers due to exposure of the cable to one or more inspection (environment and physical) tests.

4.7.4.2.1 Method. The change in optical transmittance of each fiber shall be measured in accordance with TIA/EIA-455-20, utilizing a monitor fiber to evaluate the change in transmittance due to exposure of the cable to environmental and physical tests. Any optical power detection method may be utilized if the method has the sensitivity to measure the differential optical power levels as specified in the individual mechanical test requirements of section 3, and if the method provides repeatable readings (less than 3 percent variation). A pretest optical power measurement shall be made and the specimen shall then undergo inspection testing. All optical power measurements, subsequent to the pretest measurement, shall be referenced to the pretest value and the change in dB calculated.

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4.7.4.2.2 Guidelines. These types of measurements require highly stable optical devices (source and detector) and repeatability of loss at the device-to-fiber interface. Use of the same reference fiber for calibrating the light source power output just prior to making all the measurements on the cable specimen, will enhance the measurement accuracy.

4.7.4.3 Crosstalk (see 3.5.3). Fully assembled cable specimens shall be tested for crosstalk in accordance with EIA/TIA-455-42. When applicable, the crosstalk shall be determined between a minimum of three randomly selected fibers in a multi-fiber cable, using each selected fiber sequentially as the actively transmitting element, and measuring the far-end power output of all other fibers in the cable specimen. The center wavelength shall be  $1.300\ \mu\text{m} \pm 0.020\ \mu\text{m}$ , and the light launch conditions shall be as specified (see 4.7.4.1).

4.7.5 Mechanical properties inspections (see 3.6). Unless otherwise specified (see 3.1), for mechanical tests, the specimen length shall be as given in individual inspections. The change in optical transmittance shall be measured in accordance with 4.7.4.2. The change in optical transmittance shall be measured for all fibers in the cable or a total of 12 fibers, whichever is less. In large count fiber cables, at least one fiber per ribbon, cable bundle, or binder shall be monitored. Visual examination, where required, shall be conducted in accordance with 4.7.2.

4.7.5.1 Tensile loading and elongation (see 3.6.1). The tensile loading on both the OFCC and the finished cable shall be measured in accordance with EIA-455-33. The OFCC may be tested using the same mandrel size as is used to test the finished cable. A minimum preload of 45 newtons shall be placed on the cable. The load shall be increased to 2500 newtons times the cable outer diameter in centimeters in 4 equal increments. Attenuation measurements on all fibers shall be determined in unstressed and stressed conditions. At the completion of this test, the cable jacket shall be visually examined in accordance with 4.7.2.

4.7.5.1.1 Operating tensile load (see 3.6.1.1). The operating tensile load of the finished cable shall be tested in accordance with EIA-455-33. A minimum preload of 45 newtons shall be placed on the cable. The load shall be increased to 500 newtons times the cable outer diameter in centimeters and held for 72 hours. Attenuation measurements on all fibers shall be determined in unstressed and stressed conditions. At the completion of this test, the cable jacket shall be visually examined in accordance with 4.7.2.

4.7.5.2 Dynamic bend (see 3.6.2). The finished cable and OFCC shall be pulled  $90^\circ$  over a sheave whose outside diameter is equal to the minimum bend diameter of the cable, rounded to the next higher centimeter. A  $90^\circ$  bend shall be placed in the cable by the sheave. The cable shall be pulled at a rate of 9 meters per minute (m/min), with a minimum tensile load of 875 newtons for each centimeter of cable outer diameter. The cable core components shall be pulled and loaded as specified (see 3.1). Specimen length shall be 150 meters. Apparatus shall be used to permit pulling the entire specimen length over the sheave. Tensile load shall not be applied by friction devices in direct contact with the cable. Friction applied to the supply reel or spool is an acceptable technique. The change in optical transmittance shall be measured during and after the test. At the completion of the test, the cable jacket shall be visually examined in accordance with 4.7.2.

4.7.5.3 Low temperature flexibility (cold bend) (see 3.6.3). The low temperature flexibility characteristic shall be tested in accordance with procedure II of EIA/TIA-455-37. The following special test conditions shall apply:

- a. The mandrel diameter shall be equal to the minimum bend diameter of the cable rounded up to the nearest centimeter.
- b. The conditioning temperature shall be the low operating temperature plus or minus  $2^\circ\text{C}$ .
- c. Tensioning masses as specified in EIA/TIA-455-37 shall be used.
- d. Test level 6 shall apply (3 mandrel turns).
- e. Visually examine the specimen under ten-power magnification.
- f. Optical loss measurements at the low conditioning temperature prior to and after bending are not required. Post test loss or transmittance measurements are required after the sample has been returned to room temperature and the bends removed. The post test loss or transmittance values shall be compared to the loss or transmittance values obtained prior to the low temperature conditioning.

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4.7.5.4 Cyclic flexing (see 3.6.4). A length of finished cable shall be tested at 30 cycles per minute over a sheave whose outer diameter is equal to the cable minimum bend diameter rounded up to the nearest centimeter. The cyclic flexing test shall be performed in accordance with TIA/EIA-455-104. The test sample shall be conditioned at the test temperature before conducting each test for a duration not less than two hours. The change in optical transmittance shall be measured during and after the test. After completion of the test, the specimen shall be visually examined in accordance with 4.7.2. The test shall be conducted at the temperatures and for the number of cycles shown in table XI for the application specified.

TABLE XI. Cyclic flexing test limits.

Application	Number of cycles	Temperature
Ground tactical (T)	2000	Minimum operating temperature
	2000	$25 \pm 2^{\circ}\text{C}$
	2000	Maximum operating temperature
Shipboard (B)	500	$25 \pm 2^{\circ}\text{C}$
	100	Minimum operating temperature

4.7.5.5 Crush (see 3.6.5). Compressive loading testing shall be accomplished in accordance with TIA/EIA-455-41 for the finished cable. Unless otherwise specified (see 3.1), the following special test conditions shall apply:

- The compressive load exposure shall be not less than 2000 N/cm of cable outer diameter (in cm), held for 3 minutes, and released.
- The compressive loading rate shall be not less than 2000 N/min.
- The change in optical transmittance shall be measured while the specimen is under load and after load removal. Visual inspection of the specimen shall be made under 10X magnification after load removal.
- A break in any fiber caused by this test shall be a failure of the cable.
- Optical crosstalk shall be monitored in accordance with 4.7.4.3.

4.7.5.6 Cable twist-bending (see 3.6.6). A length of cable shall be tested over a sheave whose outside diameter is equal to the minimum bend diameter of the cable, rounded to the next higher centimeter for the number of cycles and at the temperatures listed in table XII for the specified application. Twist bending shall be accomplished in accordance with TIA/EIA-455-91. Unless otherwise specified (see 3.1), the test load shall be 100 newtons. The test sample shall be conditioned at the test temperatures before conducting each test for a duration not less than two hours. The change in optical transmittance shall be measured during and after the test. After the tests, the specimen shall be visually examined in accordance with 4.7.2.

Table XII. Cable twist bending test limits.

Application	Number of cycles	Temperature
Ground tactical (T)	2000	Minimum operating temperature
	2000	$25 \pm 2^{\circ}\text{C}$
	2000	Maximum operating temperature
Shipboard (B)	500	$25 \pm 2^{\circ}\text{C}$
	100	Minimum operating temperature

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4.7.5.7 Radial compression (see 3.6.7). The intent of this test is to determine the response of the finished cable to the radial compressive forces that are applied to the cable when it is installed in multi cable penetrators (MCP). A cable specimen shall be fitted into three multi cable penetrators of appropriate size. A radial force shall be applied to the cable within the multi cable penetrators by installing the cable in accordance with the approved assembly drawing for the appropriate multi cable penetrator. The insert block inner diameter shall be not greater than 1 mm larger than the cable outside diameter. Multi cable penetrators that are an integral part of an interconnection box (see MIL-I-24728) may be used for this test. The minimum torque applied to the nuts on the MCP wedgepack shall be 5.6 Nm. Cable exterior deformation shall not be considered as danger or cable failure. The change in optical transmittance shall be measured during and after the test.

4.7.5.8 Impact (see 3.6.8). A length of cable specimen shall be tested in accordance with TIA/EIA-455-25. The specimen shall be conditioned at the test temperature for a duration not less than two hours before conducting each test. The change in optical transmittance shall be monitored after testing. During the low temperature test, after the second cycle, the test shall be temporarily halted and the cable jacket shall be visually examined in accordance with 4.7.2. At the completion of each test, the cable jacket shall be visually examined in accordance with 4.7.2. The test shall be conducted at the conditions listed in table XIII for the application specified.

TABLE XIII. Application test conditions.

Application	Number of cycles	Temperature
Ground tactical (T)	50	Minimum operating temperature
	100	25 ± 2°C
	50	Maximum operating temperature
Shipboard (B)	50	25 ± 2°C
	20	Minimum nonoperating temperature

4.7.5.9 Corner bend (see 3.6.9). A length of finished cable shall be tested in accordance with EIA-455-88 except that the radius of the corner shall be 5 times the cable outer radius, rounded to the next highest centimeter (for cable only) and 1.3 cm for cable core components. A test force of 1000 N/cm of cable outer diameter or 500 N, whichever is less, shall be applied for one minute. The change in optical transmittance shall be measured after one minute of loading (while loaded) and after unloading.

4.7.5.10 Knot (see 3.6.10). A length of finished cable shall be tested in accordance with EIA/TIA-455-87, method A, except the test force shall be 1000 N/cm of cable outer diameter or 500 N, whichever is less.

4.7.5.11 Pressure cycling (see 3.6.11). The specimen shall be installed in a water pressure chamber with both ends brought out approximately 1 m through bulkhead stuffing tubes (MIL-S-24235 stuffing tubes are recommended). The protruding ends of the specimen shall be prepared for attenuation testing. The specimen within the chamber shall be subjected to 24 pressure cycles. During each cycle, the gauge pressure of the chamber shall be raised to 7.0 MPa (1,000 lbf/in<sup>2</sup>) and reduced to zero. For each cycle, the high pressure shall be held for 30 minutes and the zero pressure shall be held for 30 minutes. The change in optical transmittance shall be measured continuously throughout the test on a minimum of three randomly selected fibers per specimen, when applicable.

4.7.5.12 Hosing (see 3.6.12). Hosing shall be as specified in 4.7.5.12.1 and 4.7.5.12.2.

4.7.5.12.1 Low pressure (see 3.6.12.1). A fully assembled cable specimen shall be tested in accordance with the procedure specified herein. 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. 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. Unless otherwise approved by the qualifying activity, the sealer used for the packing and in the terminal fitting shall be a metal alloy having a maximum melting point of 88°C. The specimen shall be subjected to a sea water pressure of 172 kilopascal (kPa) (25 pounds per square inch (lbf/in<sup>2</sup>)) for a period of 6 hours at 23°C. A 3 percent solution of salt (NaCl) water or sea water in accordance with ASTM-D-1141 shall be used. Water leakage through the specimen shall be measured and shall not exceed the maximum leakage specified in 3.6.12.1.

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4.7.5.12.2 Hydrostatic (see 3.6.12.2). A fully assembled cable specimen shall be tested in accordance with the procedure specified herein. One end of the specimen shall be fitted into the appropriate size of stuffing tube (refer to MIL-STD-2042 for guidance in choosing the appropriate size stuffing tube). The specimen end shall protrude from the stuffing tube a minimum of 0.5 m and a maximum of 0.75 m. The stuffing tube shall be torqued to 41 Nm and preconditioned at ambient temperature for 24 hours. The stuffing tube shall then be retorqued to 41 Nm and the cable internal components trimmed flush with the cable jacket end. Water pressure shall be applied to the stuffing tube end of the specimen. A 3 percent solution of salt (NaCl) water or sea water in accordance with ASTM-D-1141 shall be used. The water pressure shall be gradually applied up to the specified value (see 3.1) over a 3 to 10 minute time period and then held for 6 hours. Water leakage through the specimen and slippage of the cable internal parts shall not exceed the values specified in 3.6.12.2.

4.7.5.13 Dripping (see 3.6.13). A fully assembled cable specimen shall be tested in accordance with EIA/TIA-455-81. The specimen shall be suspended vertically in an oven for a period of 6 hours at an oven temperature of  $150 \pm 3^\circ\text{C}$ . The extent of fluid flow or dripping from the open cable end shall be reported. Visual inspection of the specimen shall be made using ten-power magnification.

4.7.5.14 Cable jacket tear strength (see 3.6.14). The tear strength of the finished cable shall be determined in accordance with FED-STD-228, method 3111.

4.7.5.15 Cable jacket material tensile strength and elongation (see 3.6.15). Unless otherwise specified (see 3.1), extruded flat specimens of the jacket material shall be tested in accordance with FED-STD-228, method 3021 and 3031, with 2.5 cm bend marks, 2.5 cm jaw separation, and a rate of travel of 25 cm/minute. The thickness of the specimen shall be measured using a micrometer.

4.7.5.16 Cable abrasion resistance (see 3.6.16).

4.7.5.16.1 Cable scraping resistance.

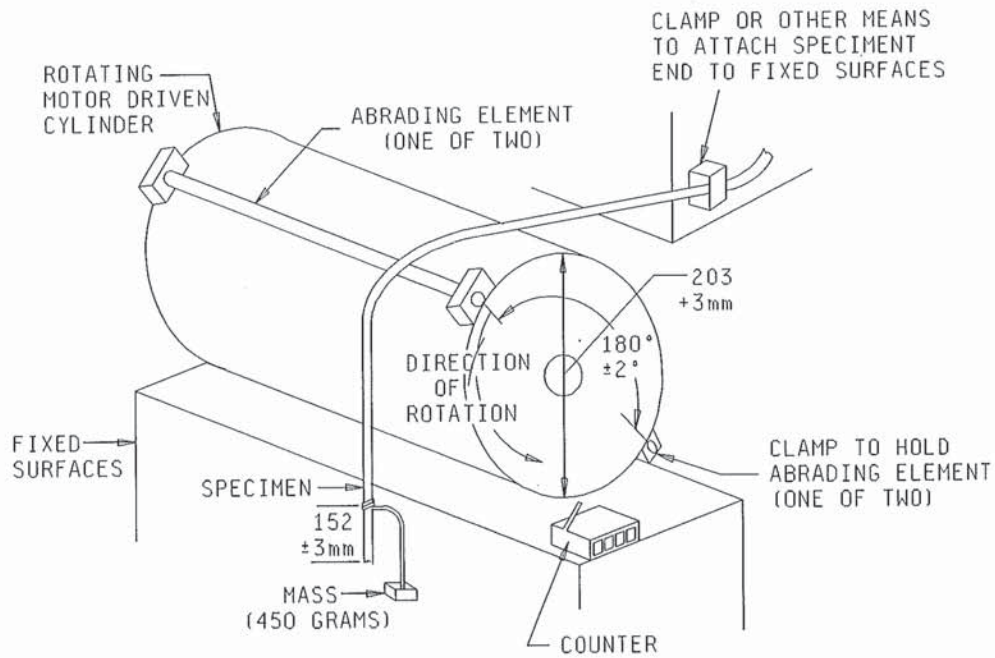
4.7.5.16.1.1 Test apparatus. The tester shall hold the test specimen firmly clamped in a horizontal position with the outer longitudinal surface of the specimen fully exposed. The tester shall rub an edge (a drum with an abrading edge, or equivalent, as shown in figure 1 shall be used) repeatedly over the outer surface of the specimen in such a position that the longitudinal axis of the edge and the specimen are at right angles to each other with the edge and outer surface of the specimen in contact. The clamped end of the cable shall be positioned such that the abrading element abrades the cable for the length specified. The abrading elements shall consist of high speed tool bits which have been ground on two adjacent longitudinal sides to produce a single, sharp 90 degree longitudinal edge, free of visible nicks. A weight affixed to the cable sample as shown in figure 1 shall control the force exerted normal to the surface of the jacket material. 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 5 cm and the frequency of the stroke shall be 30 cycles (60 strokes) per minute.

4.7.5.16.1.2 Test procedure. The specimen shall be clamped in the tester and a mass of 0.45 kg shall be carefully applied by the edge to the surface of the jacket. Two tests shall be performed on each specimen being moved forward 20 cm and rotated clockwise 90 degrees along the longitudinal axis between each test. Each test shall be discontinued when the specified number of cycles is attained for each of the two tests performed on each specimen.

4.7.5.16.2 Cable-to-cable abrasion.

4.7.5.16.2.1 Test apparatus. Cable-to-cable abrasion test apparatus and specimen relationship are shown on figures 2 and 3 respectively. The test apparatus shall consist of an electromagnetic transducer (driver) rigidly mounted on a heavy steel frame with the axial motion of the driver in a horizontal plane. The transducer shall drive a rocker arm via a spring steel bar. Mounted on this arm shall be a curved specimen holder upon which is mounted one of the cable (lower). The curvature of the upper surface of the specimen holder shall be an arc whose center is located at the pivot point of the rocker arm. The second (upper) specimen shall be mounted on the underside of a beam which is fastened to the frame through a thin, flexible nickel titanium alloy strip which shall serve as a hinge and allow the beam to be displaced only in a vertical direction. The beam and the driven specimen holder shall be positioned such that two cable specimens form an included angle of 60 degrees. The lower specimen holder shall be driven, by the transducer, at a rate of 1 Hertz and a peak-to-peak amplitude of 0.4 cm, along the bisector of the included angle. This symmetrical driving arrangement shall produce wear patterns of equal area on both specimens.

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Notes:

1. The length from the top center of the rotating cylinder to the end of the cable specimen to which the weight is attached shall be a minimum of 762 mm (30 inches).
2. The bottom edge of the clamped specimen shall be level with the top surface of the rotating cylinder.

FIGURE 1. Scraping abrasion test apparatus.

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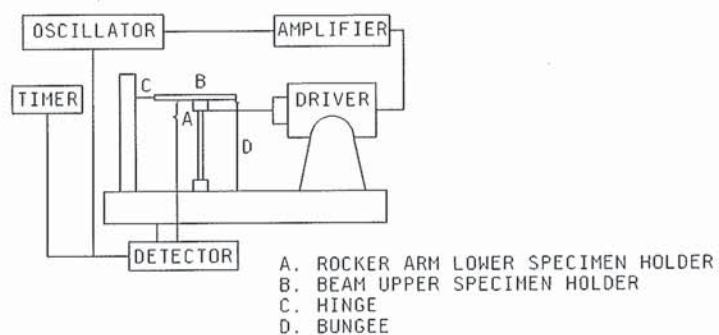


FIGURE 2. Abrasion resistance test apparatus.

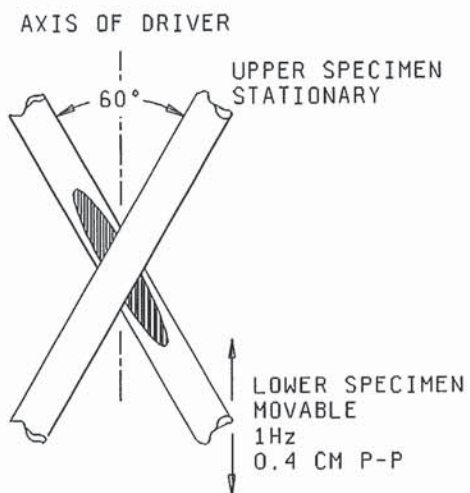


FIGURE 3. Abrasion resistance specimen relationships.

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4.7.5.16.2.2 Test procedure. Test specimens shall be mounted as described above. The applied force between the two cable specimens shall be produced by one or more rubber bungees between the beam and the frame. The actual force shall be measured with a force gauge directly in line with the intersection of the two specimens. The force measurement shall be taken when a force just sufficient to separate the two specimens is achieved. The force shall be measured before and after the test, and the results shall be averaged. The average force determined in this manner shall be  $10.0 \pm 1.0$  newtons. The end point of the test shall be when the specified number of cycles is attained for the specimen under test.

4.7.5.17 Cable shrinkage (3.6.17). A 30 cm specimen of cable shall be cut so that all components are flush at both ends. The specimen shall be aged at  $150^{\circ}\text{C} \pm 3^{\circ}\text{C}$  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. The length of the specimen shall again be measured and the shrinkage shall be calculated as the difference between the two measurements.

4.7.5.18 Cable element removability (see 3.6.18). This test is applicable to the materials used to fill the voids within or between cable bundles, between the cable core components, or between and around fiber ribbons. It is also applicable to filler material used to fill the voids between the cable core components inner and outer jackets.

4.7.5.18.1 Specimens. A specimen shall consist of a length of completed cable approximately 1.0 meter long.

4.7.5.18.2 Procedure. All cable parts external to the cable core, such as cable jacket and strength member, shall be removed from one end of the specimen so as to expose the cable fibers and filler material for a distance of approximately 0.9 meter. Using fingers only (no hand tool), the filler shall be separated from the buffered fibers, cable core components, cable bundles, or fiber ribbon(s) for their fully exposed length. For cable bundles, approximately 40 cm of jacket shall be removed exposing the buffered fibers and cable core components, or both. The residual filler material on the buffered fiber or cable core component outer jackets, or both, shall be removed using fingers only. For core component, approximately 20 cm of the outer jacket shall be removed exposing the core component's core. The core component strength member shall be pushed back and removed exposing the inner jacket. The residual filler material on the core component inner jacket shall be removed using fingers only. For ribbons, approximately 20 cm of the tapes or matrix materials shall be removed from the ribbons and fibers shall be separated. Any residual material left on the fibers from the tapes shall be removed with a dry cotton cloth.

4.7.5.19 Durability of identification marking (see 3.6.19). The durability of product identification or markings applied to the cable for coding shall be evaluated at  $20^{\circ}\text{C}$  to  $25^{\circ}\text{C}$ .

4.7.5.19.1 Durability testing apparatus. The marking durability tester shall be designed to hold a short specimen of finished cable firmly clamped in a horizontal position with the upper longitudinal surface of the specimen fully exposed. This instrument shall be capable of rubbing a small cylindrical steel mandrel,  $0.60 \text{ mm} \pm 0.05 \text{ mm}$  in diameter, repeatedly over the upper surface of the cable, in such position that the longitudinal axes of the mandrel and the specimen are at right angles to each other with their cylindrical surfaces in contact. A mass affixed to a jig above the mandrel shall control the force exerted normal to the outer surface of the jacket. 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 10 mm and the frequency shall be 120 strokes (60 stroking cycles) per minute.

4.7.5.19.2 Durability testing procedure. In performing the test, a specimen of cable shall be mounted in the specimen clamp and the mass of 150 grams shall be applied through the abrading mandrel to the marked surface. The counter is then set at zero and the drive motor started. The test shall continue for 500 cycles. The specimen shall be removed and visually examined in accordance with 4.7.2. Failure is defined as an erasure or obliteration to the point of illegibility of any marking contacted during the test exposure.

4.7.5.20 Ribbon delamination (see 3.6.20). A 30 cm sample of fiber ribbon shall be exposed to a temperature of  $88^{\circ}\text{C} \pm 2^{\circ}\text{C}$  and relative humidity of 95 percent for 72 hours in a forced air oven.

4.7.6 Environmental tests (see 3.7). For environmental tests, the specimen lengths are given in the individual inspections. Change in optical transmittance measurements shall be made in accordance with 4.7.4.2. Measurements of the change in optical transmittance for environmental properties shall be made for all fibers in the cable or a total of 12 fibers, whichever is less. In large count fiber cables, at least two fibers per ribbon, cable bundle, or binder shall be tested. Visual examination of the specimen after exposure, where required, shall be conducted in accordance with 4.7.2.

4.7.6.1 Temperature cycling (see 3.7.1). The cable shall be tested in accordance with EIA/TIA-455-3 using the test condition schedule and soak times in accordance with table XIV. Change in optical transmittance shall be measured during and after the test.

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TABLE XIV. Temperature cycling steps.

Step	Temperature (°C)	Duration (hours)
1. Maintain	Room ambient	8 (min)
2. Ramp to	Low operating temp +0, -3	2
3. Maintain	Low operating temp +0, -3	8 (min)
4. Ramp to	25 ± 2	2
5. Maintain	25 ± 2	6 (min)
6. Ramp to	High operating temp +3, -0	1
7. Maintain	High operating temp +3, -0	6 (min)
8. Ramp to	25 ± 2	1
9. Maintain	25 ± 2	6 (min)
10. Repeat steps 2 through 9 four additional times for a total of five cycles		

4.7.6.2 Thermal shock (see 3.7.2). Cables shall be tested in accordance with TIA/EIA-455-71 using test condition A-0. The temperature extremes shall be the specified storage temperature extremes (see 3.1). Soak times less than those specified in TIA/EIA-455-71 may be used if approved by the qualifying activity. The change in optical transmittance shall be measured after the test. Pretest and post-test measurements of the cable outer diameter shall be made and reported. Visual inspection of the test specimens shall be accomplished using ten-power magnification.

4.7.6.3 Temperature humidity cycling (see 3.7.3). Cables shall be tested in accordance with TIA-EIA-455-5 method B. The subcycle shall be included in the test. The change in optical transmittance shall be measured during and after the test. Pretest and post-test measurements of the cable outer diameter shall be made and reported. Visual inspection of the test specimens shall be accomplished using ten-power magnification.

4.7.6.4 Storage temperature (see 3.7.4). The specimen shall be subjected to 240 hours minimum of exposure to the low storage temperature extreme plus or minus 2°C. Following the low temperature exposure, the specimen shall be exposed to room ambient temperature for a period of 24 hours, plus or minus 1 hour. The specimen shall then be exposed for 240 hours minimum to the high storage temperature extreme plus or minus 2°C. Following the high temperature test, the specimen shall be exposed to room ambient temperature for a period of 24 hours, plus or minus 1 hour. The change in optical transmittance shall be measured after the test. After the test, the specimen shall be visually examined using the ten-power magnification.

4.7.6.5 Barometric pressure (reduced) (see 3.7.5). The cable shall be subjected to the test of EIA/TIA-455-190, test condition K, with mounting the same as that in normal service. Altitude exposure shall be 1 hour, minimum. The change in optical transmittance shall be measured following the test.

4.7.6.6 Life aging (see 3.7.6). Flat extruded jacket material shall be tested in accordance with TIA/EIA-455-4 at the temperature and duration listed in table XV for that particular material. Fully assembled cable samples shall be tested in accordance with TIA/EIA-455-4 for 240 hours at 110°C or for 450 hours at 100°C. The change in optical transmittance shall be measured after the test. The special test conditions specified in a through c shall apply.

- a. Pretest and post-test measurements of the cable outer diameter shall be made and reported.
- b. Visual inspection of the jacket shall be made using ten-power magnification.
- c. The tensile strength and elongation of the aged extruded flat jacket material shall be determined in accordance with 4.7.5.15 after the test.

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TABLE XV. Cable life test conditions.

Jacket material	Aging conditions
Thermoplastic	240 hours @ 110°C
Thermoset	4 hours @ 175°C

4.7.6.7 Freezing water immersion (ice crush) (see 3.7.7). The specimen shall be tested in accordance with TIA/EIA-455-98, method A, procedure 1. The change in optical transmittance shall be monitored during and after the test.

4.7.6.8 Weathering (see 3.7.8). Flat extruded jacket material and the finished cable shall be tested in accordance with ASTM-D-2565, using conditions specified in table XVI. After completion of the test exposure, the finished cable shall be visually examined and the flat extruded jacket material shall be tested for jacket material tensile strength and elongation in accordance with 4.7.5.15.

TABLE XVI. Conditions for weathering tests.

Conditions	
Xenon arc lamp	6000 Watts
Borosilicate glass filters irradiance	0.35 Watts per square meter at 340 nm
Procedure	
Exposure - arc lamp on	18 hours Black panel temp $63 \pm 2^\circ\text{C}$ Relative humidity $50 \pm 2$ percent (Water is sprayed onto the specimen for 18 minutes every 2 hours)
arc lamp off	6 hours Temperature $25 \pm 2^\circ\text{C}$ Relative humidity 90 to 95 percent
Total exposure	1200 hours

4.7.6.9 Fluid immersion (see 3.7.9).

4.7.6.9.1 Cable jacket material. Specimens of flat extruded cable outer jacket material shall be tested in accordance with EIA/TIA-455-12. The size of each specimen shall be in accordance with 4.7.5.15. After each 24 hour immersion, the specimen shall be removed, blotted to remove excess fluid, and suspended in the air at room temperature for not less than 3 hours, 30 minutes and not more than 4 hours, 30 minutes. The tensile strength and elongation of each specimen shall then be determined in accordance with 4.7.5.15.

4.7.6.9.2 Finished cable. One specimen of finished cable shall be tested in accordance with EIA/TIA-455-12. The two meter specimen may be cut into five pieces, and each piece immersed such that its two ends are exposed to the atmosphere. After each 24 hour immersion, the specimen shall be removed, blotted to remove excess fluid, and suspended in air at room temperature for not less than 3 hours, 30 minutes and not more than 4 hours, 30 minutes. After the test, the cable shall be tested for diameter change. The cable diameter shall be determined by measuring the cable circumference and dividing the resultant value by 3.14.

4.7.6.10 Wicking (see 3.7.10). Wicking characteristics shall be tested in accordance with EIA/TIA-455-39. The visual examination shall be made using ten-power magnification.

4.7.6.11 Jacket self-adhesion or blocking (see 3.7.11). Blocking characteristics shall be tested in accordance with EIA/TIA-455-84 to qualify the cable jacket self-adhesion property. The cable specimen shall be conditioned at the high storage temperature plus or minus  $2^\circ\text{C}$  for a period of 48 hours prior to testing for blocking. After the test exposure, the specimen shall be visually examined using ten-power magnification.

4.7.6.12 Flammability (see 3.7.12). Cables shall be tested in accordance with 4.7.6.12.1, 4.7.6.12.2, and 4.7.6.12.3 as specified.

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4.7.6.12.1 Flammability (60° angle) (see 3.7.12.1). Cables shall be tested as follows. The specimen shall be placed at an angle of 60 degrees with the horizontal and marked 200 mm from the lower end. The specimen shall be held taut in this position throughout the test using cable clamps or other suitable holding fixtures. A tissue shall be suspended horizontally 250 mm below the test specimen with the tissue center directly below the test mark on the specimen. A bunsen burner shall be adjusted to produce a 75 mm flame with the inner cone approximately 25 mm in height. The temperature of the hottest portion of the flame, as measured with a pyrometer, shall be not less than 950°C. The bunsen burner shall be positioned beneath the specimen (the burner shall be perpendicular to the specimen) so that the hottest portion of the flame is applied to the specimen at the test mark and the flame applied for 30 seconds. The time required for the specimen to self-extinguish, the maximum distance of flame travel from the mark, and any ignition of the tissue paper shall be recorded.

4.7.6.12.2 Flame extinguishing (see 3.7.12.2). Cables shall be subjected to the UL Flame Exposure test of UL-1685. Specimen length and quantity shall be as specified in UL-1685. The information specified in a through c shall be reported:

- a. Flame temperature.
- b. Period of time between burner shut off and cessation of flame on the specimen.
- c. Overall distance of specimen jacket damage above the burner.

4.7.6.12.3 Smoke generation and flame propagation (see 3.7.12.3). Cable shall be tested for smoke generation and flame propagation in accordance with the Steiner Tunnel Test as described in UL-910.

4.7.6.13 Shock (see 3.7.13). A 30-meter minimum length of cable shall be used for this test. The specimen shall be subjected to grade A, type A, class I shocks as specified by MIL-S-901. Not less than 1 meter of the test specimen shall be mounted to simulate shipboard installation in a cable tray (refer to MIL-STD-2003, section 4 for guidance). After completion of the test, the cable shall be visually examined in accordance with 4.7.2. Signal discontinuity shall be monitored during the test, in accordance with TIA/EIA-455-32, with equipment having a time resolution sufficient to resolve discontinuities of duration not less than 50  $\mu$ s.

4.7.6.14 Water absorption (see 3.7.14). Water absorption shall be determined using the gravimetric method of ASTM-D-470 with a water temperature of  $71 \pm 1^\circ\text{C}$  for a continuous 3 day period. The exposed surface area of the finished cable or cable jacket specimen shall be not less than 5 square cm and not greater than 10 square cm.

4.7.6.15 Paint susceptibility (see 3.7.15). A two meter sample of finished cable shall be wrapped around a mandrel having an outer diameter equal to the minimum bend diameter of the cable. This cable mandrel assembly shall be painted using paint in accordance with TT-P-645 and allowed to dry for 120 hours. After drying the cable sample shall be removed from the mandrel and visually examined.

4.7.6.16 Electromagnetic effects (see 3.7.16). Cables shall be tested for conformance to 3.7.16 as specified herein. The cable shall be tested to determine the propagation characteristics (toward attenuation or conduction) of the cable through the waveguide. The enclosure shielding effectiveness for the enclosure to be used in the test shall be verified in accordance with the procedures specified in IEEE-STD-299 at the discrete frequencies specified in Table XVII with the waveguide in position. The dynamic range of the test setup shall be measured as specified in IEEE-STD-299 at each discrete frequency specified in Table XVII. The measured level of radio frequency (RF) propagation through the cable and waveguide installed in the shielded enclosure shall be determined in accordance with the procedures specified in IEEE-STD-299 at each discrete frequency specified in Table XVII.

TABLE XVII. Electromagnetic effects test frequencies.

Field propagation	Test frequency		
	1	2	3
Planewave	100 MHz	400 MHz	1 GHz
Microwave	10 GHz	---	---

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4.7.6.16.1 Cable positioning and setup. The cable specimen used shall be a minimum of 6 meters long. A minimum of 0.3 meters of cable shall be protruding from the waveguide on the receiver side of the enclosure (inside the shielded enclosure). The remaining cable length shall be extended normal to the enclosure wall on the transmitter side of the enclosure. The cable shall be suspended, dielectrically, at least 1 meter above the floor of the enclosure on both sides of the enclosure wall.

4.7.6.16.2 Waveguide type and configuration. The waveguide type used for this test shall be a waveguide at cut-off (WACO). The waveguide shall be installed in the setup panel or shielded enclosure wall and shall have an inside diameter to total length ratio of 1 to 72. For test purposes, a straight waveguide shall be used to simulate a worst case condition. The waveguide shall protrude inside the shielded enclosure from the wall.

4.7.6.16.3 Antenna orientation and setup. Antenna types and placement distances shall conform to Tables XVIII and XIX, respectively. Matched antennas shall be used for each measurement. The specified placement distances are for both antenna to cable and for antenna to setup panel or wall of the shielded enclosure. The transmitting antenna shall be oriented in both the parallel and perpendicular directions for each frequency listed in Table XVII. Energy from the transmitting antenna shall be maximized by positioning the antenna parallel along the cable length and perpendicular along the cable circumference. The sensitivity of the receiving antenna shall be maximized by measuring both end view and side (length) view with a constant rotation between the horizontal and vertical antenna positions. For planewave measurement in the perpendicular direction, the transmit antenna shall be 1 meter above the cable.

TABLE XVIII. Antenna types.

Field propagation	Antenna type
Planewave	Log periodic or dipole
Microwave	Horn

TABLE XIX. Antenna placement distances.

Location	Placement <sup>1/</sup>
Receiving antenna to cable	5 cm
Transmitting antenna to cable	1 m
Transmitting antenna to shielded enclosure	2 m

<sup>1/</sup> Extended dipole antenna distance measurements shall be made from the center of the antenna elements.

4.8. Chemical tests.

4.8.1 Acid gas generation (see 3.8.1). The total emission of any soluble acids (pH less than 3) shall be determined as follows. The required apparatus is shown on figure 4. A weighted sample of the finished cable, approximately 2.5 cm long, shall be placed in a silica boat which is put into the center of a silica tube, 26 to 60 cm long with 3.7 to 15.3 cm of internal diameter. The silica tube shall be placed in the tube furnace. An air supply, derived from a blower or compressed air cylinder, at the rate of 1 liter per minute, plus or minus 5 percent, shall be passed through the silica tube and then through four absorber flasks each containing 150 ml of deionized water. The furnace heating shall be commenced and the temperature of the tube and sample shall be raised to 800°C plus or minus 10°C over a period of approximately 40 minutes and then held at temperature for an additional 40 minutes. During the heating period, acid gases produced will be carried into the absorber flasks by the air flow. On completion of heating cycle, the fluids in the absorber flasks shall be titrated against 0.1 normal sodium hydroxide solution using Congo Red as an indicator. The total titer indicates the total soluble acids; 1.0 ml of 0.1 normal sodium hydroxide solution is equivalent to 3.65 mg of acid expressed as acid equivalent relative to hydrochloric acid.

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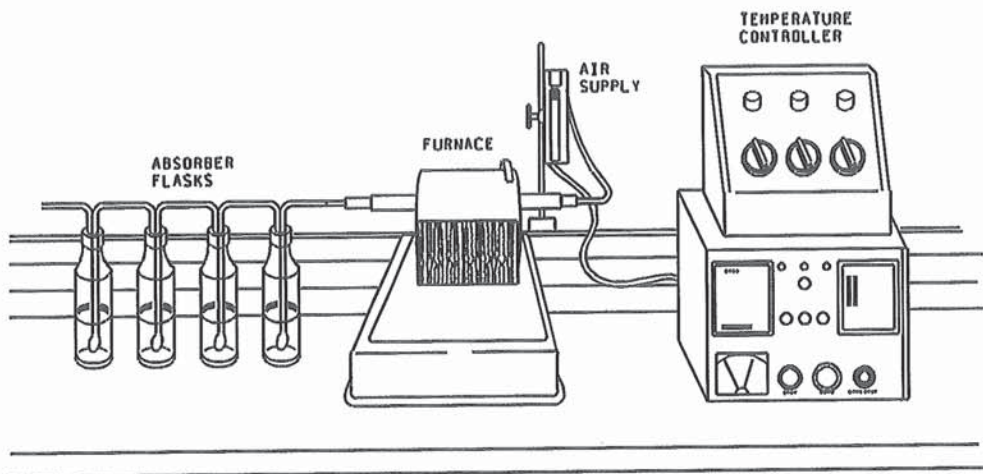


FIGURE 4. Acid gas generation test apparatus.

4.8.2 Halogen content (see 3.8.2). Cable specimens shall be tested to determine the fluorine, chlorine, bromine, and iodine content using any of the methods identified in 4.8.2.1 through 4.8.2.3.

4.8.2.1 X-ray fluorescence. An X-ray fluorescence instrument shall be used to determine the amount of all four halogens in an approximately 1 gram sample. The sample shall not be combusted prior to making the measurement. The X-ray fluorescence instrument used shall have sufficient measurement detection limits for each of the four halogens.

4.8.2.2 Ion chromatograph. Approximately 1 gram of finished cable shall be analyzed to determine the amount of all four halogens. Sample pretreatment shall be performed in accordance with ASTM-E-800. Halogen content shall be determined in accordance with ASTM-D-4327.

4.8.2.3 Ion selective electrode. Approximately 1 gram samples shall be used in these tests. Sample pretreatment shall be performed in accordance with ASTM-E-800. Fluoride content shall be determined in accordance with ASTM-D-1179, ASTM-D-3868, or ASTM-D-3761. Chloride content shall be determined in accordance with ASTM-D-512. Bromide content shall be determined in accordance with ASTM-D-1246. Iodide content shall be determined in accordance with method C of ASTM-D-3869.

4.8.3 Toxicity index (see 3.8.3). The toxicity index of the finished cable shall be tested in accordance with NES-713. An 8 cm length of cable shall be prepared in the following manner. Coat the ends of the exposed cable core material with a high temperature ceramic cement and allow 72 hours to cure. This capping procedure should eliminate dripping of the core material during testing. Support the cement caps with a rigid clamping device to hold the caps in place during testing. Position the cable sample above the flame source at a 45 degree angle and apply the flame so that it is centered on the cable sample. The combustion gases shall be chemically analyzed using calorimetric gas reaction tubes.

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4.8.4 Fungus resistance (see 3.8.4). Cables composed of materials not listed as fungus inert in guideline 4 of MIL-HDBK-454 shall be tested in accordance with TIA/EIA-455-56.

4.8.5 Materials test for space applications.

4.8.5.1 Thermal vacuum outgassing (see 3.3.6.1). Non-metallic materials shall be tested in accordance with ASTM-E-595.

4.8.5.2 Material flammability (see 3.3.6.2). Material samples shall be tested in accordance with NASA Handbook NHB 8060.1, test 1.

4.8.5.3 Material toxicity (offgassing) (see 3.3.6.3). Material samples shall be tested in accordance with NASA Handbook NHB 8060.1, test 7.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of material is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Points' packaging activity within the Military Department or Defense Agency, or within the military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.1 Intended use. The fiber optic cables covered by this specification are intended for use in military applications where their performance characteristics are required. These cables are military unique due to the fact that these cables must operate satisfactorily in demanding system environments as listed below. For example, shipboard application conditions include numerous unique requirements for cables such as fluid, shock, stringent toxicity and flammability requirements.

- a. Fixed plant. Used in systems in fixed locations including indoor, outdoor aerial, direct burial, duct, and undersea applications.
- b. Tactical. Concerned with use in non-vehicular and mobile militarized systems.
- c. Space. Which involves use in vehicles and/or systems deployed in outer space.
- d. Avionics. Involving use in aircraft or missile systems.
- e. Shipboard. Involving use in systems deployed in a mobile marine environment (on board or in tow).
- f. Ground vehicle. Involving use in land vehicular systems.
- g. Other specialized military applications.

6.1.1 Temperature rating. Temperature ratings as specified in specification sheets pertaining to this specification represent the maximum permissible operating temperature range of the cable.

6.1.2 Materials compatibility. The jacketing systems of the fiber optic cables covered by this specification may be degraded by certain fluids or compounds. If such degradation occurs, the fluids or compounds and the conditions necessary for failure shall be added to the specification sheet as a precautionary note.

6.1.2.1 Compatibility note. The insulation systems of polyvinylidene fluoride jacketed cables of this specification may be degraded by contact with hydraulic fluids of the phosphated ester type at high temperature. Cables of this specification with polyvinylidene fluoride jackets are not recommended for applications where they will be in contact with hydraulic fluids of phosphate ester types at temperatures above 50°C.

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6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification.
- b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1 and MIL-PRF-85045F).
- c. Title, number, and date of the applicable specification sheet.
- d. Complete cable part number.
- e. Jacket and fiber color required (see 3.4.2 and 3.4.3).
- f. Special marking requirements.
- g. Level of packaging and packing required (see 5.1).
- h. Minimum acceptable continuous cable length (see 3.1).
- i. Total quantity of cable required.
- j. Meter marking requirements (see 3.1 and 3.9).
- k. Equivalent test methods, if other than as specified (see 4.7.1).
- l. Length of cable per reel.
- m. Data required.
- n. White outer jacket color (if not black).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the applicable Qualified Products List QPL-85045, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government, tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Commander, Naval Sea Systems Command, (SEA 03R42), 2531 Jefferson Davis Highway, Arlington, VA 22242-5160; however, information pertaining to qualification of products may be obtained from the agent for the qualifying activity: Defense Supply Center Columbus, (ATTN: DSCC-VQ), 3990 East Broad Street, Columbus, OH 43216-5000 (see 3.2 and 4.5).

6.3.1 Provisions governing qualification SD-6. Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Standardization Documents Order Desk, Bldg 4D, 700 Robbins Ave Philadelphia, PA 19111-5094.

6.3.2 Verification program. A verification program must be established and maintained in accordance with MIL-STD-790 or equivalent standard. Evidence of such compliance will be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification. The verification system procedures, planning, and all other documentation and data that comprise the verification system must be available to the Government for review. The Government may perform any necessary inspections, verifications, and evaluations to ascertain conformance to the requirements and the adequacy of the implementing procedures (see 4.1).

6.3.3 Test equipment and inspection facilities. Provision for test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspections must be the responsibility of the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment must be in accordance with NCSL Z540-1 or equivalent standard (see 4.2).

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6.3.4 Alternative forms of conformance inspection and equivalent test methods. Requests for alternate forms of conformance inspection (see 4.6) must be submitted to the qualifying activity and to the preparing activity. Alternate forms of conformance inspection may be used upon written approval by the qualifying activity and by the preparing activity. The use of equivalent test methods is allowed (see 4.7.1). The manufacturer must have conducted both test methods and have submitted complete test data to the preparing activity and to the qualifying activity verifying the equivalency of each alternate test method proposed.

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

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

- a. Sample for qualification test.
- b. "MIL-PRF-85045F".
- c. Specification sheet part number.
- d. Manufacturer's name and CAGE code number.
- e. Manufacturer's part number.
- f. Comprehensive description and prime manufacturer's name and formulation number of the base materials from which the product is made. (This information will not be divulged by the Government.)
- g. Place and date of manufacture of sample.
- h. Submitted by (name) (date) for qualification tests in accordance with the requirements of MIL-PRF-85045 under authorization (reference authorizing letter).

6.3.7 Optical transmittance instrumentation stability. Optical transmittance instrumentation should be subjected to the following stability tests before qualification testing is performed. The first test should consist of measuring the transmitted power through each channel once every minute for a four hour period. The second test should consist of measuring the transmitted power through each channel once every 30 minutes for a 96 hour period. The data for each channel should be analyzed to determine average transmittance, minimum and maximum transmittance, the standard deviation of the transmittance, and the minimum and maximum percent deviation of the transmittance.

6.3.8 Government witnessing of qualification tests. The qualification activity may require that a government witness be present during the following tests: tensile loading and elongation, cyclic flexing, low temperature flexibility (cold bend), impact, cable twist-bending, hosing (low pressure and hydrostatic), cable jacket material tensile strength and elongation, thermal shock, fluid immersion, water absorption, flammability, cable abrasion resistance, and cross-link verification.

6.3.9 Electromagnetic effects test documentation. Electromagnetic effects test documentation should include a detailed test plan and test report. The test plan should detail the specific test setups and procedures, the test facility, and the test profiles that will be used. The test report should detail the exact procedures followed, the equipment used for each test phase, calibration dates of all test equipment, test results in graphical and tabular format, photographs/sketches of the test setups, the test data sheets, and an indication of pass/fail. The test data sheets should include test sample identification, ambient temperature and humidity values, dates and times of the test initiation and completion, names and initials of the test personnel, and data tables. The data tables should include the frequency at which each measurement was conducted, the field propagation/orientation, enclosure shielding effectiveness, reference level of the transmitter, dynamic range of the measurement, measured level for the test, the propagated RF attenuation, the required RF attenuation, and an indication of pass/fail. The reference level should include the source output, receiver sensitivity, and antenna gain.

6.3.10 Rejected production units. If a production unit is rejected, the supplier may screen out the defective units of product (if possible), and resubmit for reinspection.

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6.3.11 Noncompliance. If a specimen fails to pass group C inspection, the manufacturer should notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted. Acceptance and shipment of the product should be discontinued until corrective action, acceptable to the qualifying activity, has been taken. After the corrective action has been taken, group C inspection should be repeated on additional sample units (all tests and examinations, or the test which the original sample failed, at the option of the qualifying activity). Group A and group B inspections may be reinstituted; however, final acceptance and shipment should be withheld until the group C inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure should be furnished to the cognizant inspection activity and the qualifying activity.

6.4 Personnel safety. Care should be taken when handling the very fine (small diameter) optical fibers to prevent skin puncture or contact of fiber with the eye area. Also, direct viewing of the optical terminal face of a terminated cable, while it is propagating optical energy, is not recommended unless the radiation is in the visible portion of the optical spectrum, of sufficiently low power, and needed to perform test examinations not obtainable by other methods.

6.5 Definitions. The following definitions of terms in this document are generally accepted by the optical fiber cable manufacturing industries. EIA-440 may be used as an additional reference for definitions of terms related to fiber optics.

6.5.1 Binder. A binder is a string or tape which ties together a number of fibers, buffered fibers, or OFCC's.

6.5.2 Buffered fiber. A buffered fiber is a coated optical fiber augmented with an additional coating or buffer jacket to protect the fiber and render it more visible and manageable.

6.5.3 Cable bundle. A cable bundle is a number of fibers, buffered fibers, ribbons, or OFCC's, grouped together in the cable core within a common protective layer.

6.5.4 Cable bundle jacket. A cable bundle jacket is the material which forms a protective layer around a bundle of fibers, buffered fibers, ribbons or OFCC's.

6.5.5 Cable core. Cable core is the part of the cable interior to the outermost jacket.

6.5.6 Cable core component. Cable core component is a part of the cable core, such as a buffered fiber, OFCC, cable bundle, ribbon and perhaps other parts.

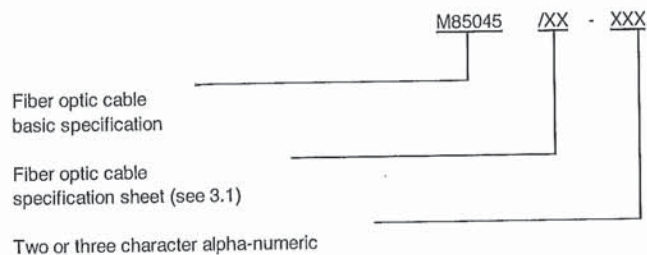
6.5.7 Long term minimum bend diameter. Long term minimum bend diameter is the minimum diameter at which a cable may be bent for extended periods of time with no degradation in optical performance.

6.5.8 OFCC. An OFCC is a buffered fiber augmented with a concentric layer of strength members and an overall jacket.

6.5.9 Ribbon. A ribbon is optical fibers arrayed side by side and maintained in this lateral position by various means.

6.5.10 Short term minimum bend diameter. Short term minimum bend diameter is the minimum diameter at which the cable may be bent for short periods of time (such as during cable installation) with no permanent degradation in optical performance.

6.6 Part or Identifying Number (PIN). The PIN shall be constructed in accordance with the following:



Example: M85045/02-001

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6.7 Subject term (key word listing).

Aperture, numerical  
Armor sheathing  
Attenuation  
Bandwidth  
Binder  
Bundle  
Core  
Crosstalk  
Diameter, cable  
Dielectric construction  
Flammability  
Jacket  
OFCC  
Ribbon

6.8 Changes from previous issue. Asterisks (or vertical lines) are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:

Army - CR  
Navy - SH  
Air Force - 11

Review activities:

Army - AR, AV, MI,  
Navy - EC, OS  
Air Force - 02, 13, 19, 80, 99  
NASA - NA

Preparing activity:  
Navy - SH

Agent:  
DLA - CC

(Project 6015-0034)

## STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

### INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

### I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER  
MIL-PRF-85045F

2. DOCUMENT DATE (YYMMDD)

### 3. DOCUMENT TITLE

CABLES, FIBER OPTICS, (METRIC) GENERAL SPECIFICATION FOR

### 4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

### 5. REASON FOR RECOMMENDATION

### 6. SUBMITTER

a. NAME (Last, First, Middle initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)

7. DATE SUBMITTED  
(YYMMDD)

(1) Commercial

(2) DSN  
(If applicable)

### 8. PREPARING ACTIVITY

a. NAME  
Claude Cassidy

b. TELEPHONE (Include Area Code)  
(1) Commercial (2) DSN  
(703) 602-7468 X-279 332-7468 X-279

c. ADDRESS (Include Zip Code)  
Naval Sea Systems Command 03R42  
2531 Jefferson Davis Highway  
Arlington, VA 22242-5160

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:  
Defense Standardization Program Office (DLSC-LM)  
8725 John J. Kingman Road, Suite 2533  
Fort Belvoir, Virginia 22060-6221  
Telephone (703) 767-6888 DSN 427-6888

INCH-POUND

MIL-DTL-83526D  
23 September 2014  
SUPERSEDING  
MIL-DTL-83526C  
20 September 2006

## DETAIL SPECIFICATION

### CONNECTORS, FIBER OPTIC, CIRCULAR, ENVIRONMENTAL RESISTANT, HERMAPHRODITIC, GENERAL SPECIFICATION FOR

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

#### 1. SCOPE

1.1 Scope. This specification covers the characteristics, performance and testing criteria for a circular, environmental resistant, hermaphroditic interface, fiber-optic connector. The connectors covered have a consistent and predictable optical performance and are sufficiently rugged to withstand military field application.

1.2 Classification. Hermaphroditic connector designs are included in this specification. Hardware associated with the connector is also specified including backshells, protective covers and storage receptacles.

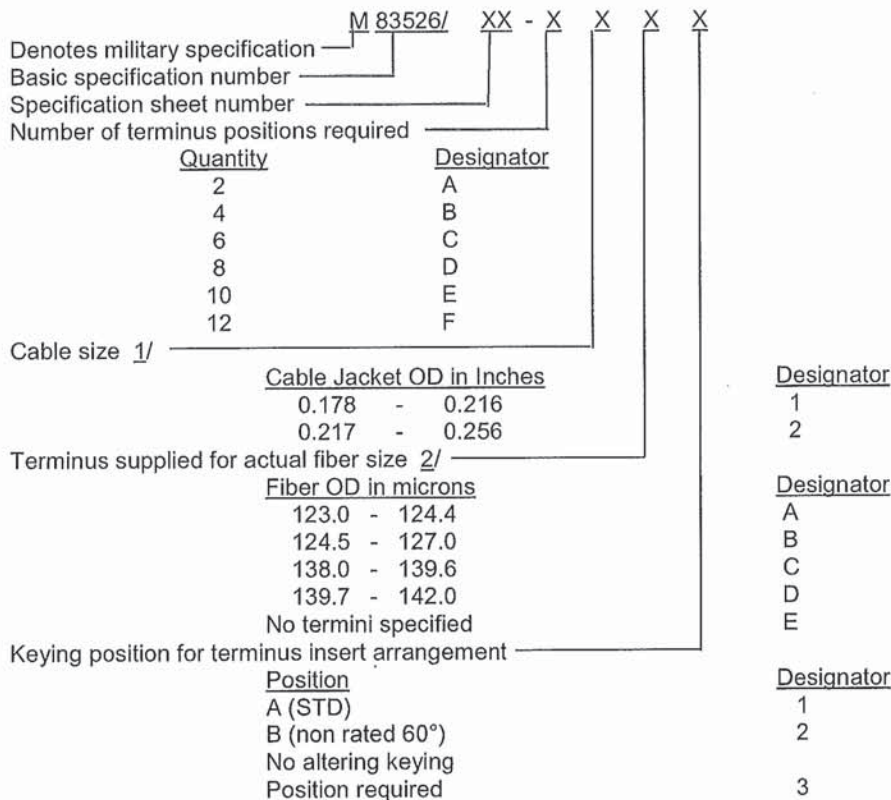
Comments, suggestions, or questions on this document should be addressed to: DLA Land and Maritime, Columbus, Attn: DLA Land and Maritime-VAT, P. O. Box 3990, Columbus, OH 43218-3990 or emailed to [FiberOpticGroup@dla.mil](mailto:FiberOpticGroup@dla.mil). Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil/>.

AMSC N/A

FSC 6060

# MIL-DTL-83526D

1.3 Part or Identifying Number (PIN). The PIN is in the following format, consisting of the letter "M" followed by the basic specification number, sequentially assigned dash number and additional designators from applicable specification sheets (see 3.1 and 6.2).



1/ Select cable size and type in accordance with MIL-PRF-85045.

2/ Select fiber size and tolerance in accordance with MIL-PRF-49291.

## 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4 of this specification, whether or not they are listed.

### 2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

MIL-DTL-83526D

FEDERAL STANDARDS

FED-STD-H28 - Screw Threads Standards for Federal Services.

DEPARTMENT OF DEFENSE SPECIFICATIONS

<u>MIL-DTL-5624-</u>	Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8T
<u>MIL-PRF-16884-</u>	Fuel, Naval Distillate
<u>MIL-PRF-17331-</u>	Lubricating Oil, Steam Turbine Gear, Moderate Service
<u>MIL-PRF-23699-</u>	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156
<u>MIL-PRF-29504-</u>	Termini, Fiber Optic Connector, Removable, General Specification For
<u>MIL-PRF-49291-</u>	Fiber, Optical, (Metric), General Specification For
<u>MIL-PRF-85045-</u>	Cables, Fiber-Optics, (Metric), General Specification For
<u>MIL-PRF-87252-</u>	Coolant Fluid, Hydrolytically Stable, Dielectric

(See supplement 1 for list of associated specifications).

DEPARTMENT OF DEFENSE STANDARDS

<u>MIL-STD-790-</u>	Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications
<u>MIL-STD-889-</u>	Dissimilar Metals
<u>MIL-STD-1285-</u>	Marking of Electrical and Electronic Parts

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

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

ASME INTERNATIONAL

<u>ASME Y14.5M-</u>	Dimensioning and Tolerancing.
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(Copies of this document are available online from <https://www.asme.org> or from ASME International, Two Park Avenue, New York, New York 10016-5990.)

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

<u>EIA-364-81-</u>	Combustion Characteristics Test Procedure for Electrical Connector Housings, Connector Assemblies and Sockets
<u>EIA455.98-</u>	Fiber Optic Cable External Freezing Test

(Copies of these documents are available online at <http://www.eciaonline.org> or from the Electronic Component Industry Association, 1111 Alderman Drive, Suite 400, Alpharetta, GA 30005-4175.)

MIL-DTL-83526D

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

<u>TIA455.12-</u>	Fluid Immersion Test Procedure for Electrical Connectors and Sockets
<u>TIA455.6-</u>	Connectors, Electrical, Cable Pull-Out Test Procedures for
<u>TIA-455-13-</u>	Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
<u>TIA-455-14-</u>	Fiber Optic Shock Tests
<u>TIA-455-15-</u>	Altitude/Immersion of Fiber Optic Components
<u>TIA455.20-</u>	Measurement Methods and Test Procedures-Monitoring of Changes in Optical Transmittance (IEC-60793-1-46 Optical Fibers Part 1-46)
<u>TIA455.21-</u>	Fiber Optic, Interconnecting Devices, Mating Durability of
<u>TIA-455-22-</u>	FOTP-22-B Ambient Light Susceptibility of Fiber Optic Components
<u>TIA455.26-</u>	Fiber Optic Cable Interconnecting Devices, Crush Resistance of
<u>TIA-455-36-</u>	Twist Test for Fiber Optic Connecting Devices
<u>TIA-455-56-</u>	Test Method for Evaluating Fungus Resistance of Optical Fiber and Cable
<u>TIA-455-107-</u>	FOTP-107 Determination Of Component Reflectance Or Link/System Return Loss Using A Loss Test Set
<u>TIA 455-189-</u>	Ozone Exposure Test Procedure for Electrical Connectors
<u>TIA455-</u>	Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
<u>TIA/EIA-455-1-</u>	Cable Flexing for Fiber Optic Interconnection Devices
<u>TIA455.2-</u>	Optic Devices, Fiber, Impact Test Measurements for
<u>TIA455.4-</u>	Fiber Optic Component Temperature Life
<u>TIA455.5-</u>	Humidity Test Procedure for Fiber Optic Components and Cable
<u>TIA-455-11-</u>	Vibration Test Procedure for Fiber Optic Components
<u>TIA-455-16-</u>	Salt Spray Test Procedure for Fiber Optic Components
<u>TIA-455-32-</u>	Fiber Optic Circuit Discontinuities
<u>TIA455.34-</u>	Interconnection Device Insertion Loss Test
<u>TIA455.35-</u>	Fiber Optic Component Dust (Fine Sand) Test
<u>TIA-455-71-</u>	Procedure to Measure Temperature-Shock Effects on Fiber Optic Components
<u>TIA/EIA-604-</u>	Fiber Optic Connector Intermateability Standards (FOCIS)

(Copies are available from <http://www.global.ihs.com> or to Global Engineering Documents, 1990 M Street NW, Suite 400, Washington, DC 20036.)

## INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE-299-

## Measuring the Effectiveness of Electromagnetic Shielding Enclosures

(Copies of this document may be purchased from <http://www.ieee.org> or the Institute of Electrical and Electronic Engineers 445 Hoes Lane Piscataway, New Jersey, United States, 08855-1331.)

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

## 3. REQUIREMENTS

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

3.2 Qualification. Fiber optic connectors and accessories furnished under this specification shall be products, which are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.5 and 6.3).

3.2.1 QPL system. The manufacturer shall establish and maintain a QPL system for parts covered by this specification. Requirements for this system are specified in MIL-STD-790.

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

3.3.1 Materials. The connectors, caps, covers, storage receptacles or other protective accessory hardware shall be constructed of material as specified herein and in the applicable specification sheet (see 3.1). In all cases, materials selected for use shall meet all qualification requirements as specified, and be of a type and quality to assure physical, chemical, and optical compatibility with the requirements of this specification. All materials used shall be nontoxic (see 3.3.4.2), nonnutrient to fungus (see 3.3.4.6) and manufactured to good workmanship quality (see 3.13). Materials chosen shall be the lightest practicable material suitable for the intended use. Materials shall not interfere with or degrade the terminus cleaning operation.

3.3.1.1 General. Materials may be dielectric or conductive as applicable. Materials shall in no manner interfere with or degrade the fiber-optical termination process, terminus cleaning operation, or optical junction transmission. Materials which are not specified shall be of the lightest practical weight and suitable for the intended purpose.

3.3.2 Metals. Unless otherwise specified (see 3.1), all metals shall be corrosion resistant types (300 series CRES recommended), or shall be suitably plated or otherwise finished to prevent corrosion during service life under any of the environmental conditions specified by the document. All metals shall be nonmagnetic.

3.3.2.1 Dissimilar metals. Dissimilar metals shall not be used in intimate contact with each other unless suitably finished to prevent electrolytic corrosion. The criteria for the selection and protection of dissimilar metal combination shall be in accordance with MIL-STD-889.

3.3.3 Steel parts and finishes. Unless otherwise specified (see 3.1), all exposed corrosion-resistant steel parts of the connector assembly shall have a passivated finish which permits the attainment of a surface finish condition compatible with external coatings or platings of the type and color specified (see 3.1).

3.3.3.1 Stainless steel components. Stainless steel components shall be passivated and nonreflective.

3.3.4 Nonmetallic materials. All nonmetallic materials used in the construction of connectors specified by this document shall not be affected by the use of cleaning materials nor shall any substance used in the construction of the connectors be degraded when operating at the environmental conditions herein specified.

3.3.4.1 Mercury and radioactive material. Mercury and radioactive materials shall not be used in the construction of the connectors, caps, covers, storage receptacles, or other protective accessory hardware specified by this document.

3.3.4.2 Toxic and hazardous products and formulations. Materials used in the connector, backshell, or accessories shall not give off toxic or explosive fumes when exposed to flame. The material shall have no adverse effect on the health of personnel when used for its intended purpose. Questions pertinent to this effect shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency.

3.3.4.3 Solvents, adhesives and cleaning agents. No incompatibility shall exist between the materials employed in the fiber to terminus securing or polishing processes, such that degradation of these materials shall result from in-service use or when tested in accordance with requirements of the temperature life test of 4.9.20.

3.3.4.4 Epoxies. Epoxies are not precluded from use in the construction of the connectors controlled by this specification. However, only those epoxy types, which have been tested and found to be fungus-inert, shall be specifically defined in the detail specification sheet for the connector type. The detail sheet shall also specify the process to be followed in mixing and curing the epoxy. Epoxies may not be used in the optical path of the connector. The service life of epoxy material shall be consistent with the intended useful lifetime of the connector. The termination and retermination of the connector shall not be affected by the use of epoxy material.

3.3.4.5 Sealing compounds. Sealing compounds which may flow at the maximum upper storage temperature specified herein, or crack at the minimum lower storage temperature specified herein shall not be used.

3.3.4.6 Fungus resistance. All materials used in connectors designed to this specification shall be non-nutrient to fungus. When tested in accordance with 4.11, connector materials shall show sparse or very restricted microbial growth and reproduction with minor or inhibited substrate utilization. There shall be little or no chemical, physical or structural change detectable.

3.4 Design and construction. Connectors, backshells and protective accessories shall be of the design, construction, and physical dimensions specified (see 3.1).

3.4.1 Threads. Threads shall be in accordance with FED-STD-H28.

3.4.1.1 Thread lubricants. Suitable lubricants are allowed on ramps and threads of metal connectors. Lubricants shall not be affected by cleaning solvents, which are required to maintain the optical performance of the connectors.

3.4.2 Sealing. When specified, the connector design shall include environmental sealing capabilities at the interface and rear of the connector. The seals, dynamic, static or both, shall preclude the entrance of moisture, dust, sand, and dirt that might degrade the performance required under specified environmental conditions.

3.4.2.1 Optical junction sealing. Optical junctions shall be sealed against moisture and contaminants as specified herein.

3.4.2.2 Cable sealing. Connectors shall seal the terminating cables to meet the environmental requirements specified herein.

3.4.2.3 Adhesives and sealing compounds. When specified, the connector manufacturer shall specify necessary adhesives for terminating the optical fiber or for sealing the connector. These compounds shall not be used unless otherwise specified (see 3.1).

3.4.3 Intermateability and interoperability (see Appendix A). When specified (see 3.1) connector parts shall be intermateable and interoperable as specified in 3.4.3.1 and 3.4.3.2 respectively.

3.4.3.1 Intermateability. All connectors having the same termini, insert arrangement and shell size shall be intermateable with their counterpart connectors (see Appendix A).

3.4.3.2 Interoperability. All connectors of the same PIN shall be interoperable. Upon qualification of the first manufacturer, all subsequent manufacturers shall provide proof of interoperability with each qualified manufacturer as specified in Appendix A. The connectors shall meet the requirements of insertion loss (see 3.10.1), terminus insertion and removal forces (see 3.11.9), and terminus retention force (see 3.11.8) for each specified interoperability condition (see Appendix A).

3.4.4 Nontoxic and nonhazardous. The connectors shall not release toxic or explosive fumes exceeding the limits specified when exposed to flame or chemical agents commonly used in the environment in which the connectors are intended for use.

3.4.5 Cleaning. The design of the connector shall permit cleaning of the optical face of the terminus without requiring major disassembly of the connector or removal of the terminus from the connector. The connector shall not be softened, embrittled, etched, or otherwise affected by the optical cleaning agent. Attention shall be given to the criteria for inspection and test of the connector to determine if the cleaning procedure has been successful.

3.4.6 Scoop proof. The optical mating faces must be suitably protected to prevent degradation of the specified light transfer characteristics as a result of repeated mechanical matings and unmatings. Neither the shell assemblies nor the connector dust cover shall make contact with the optical faces during the mating or unmating of the connector.

3.4.7 Mating characteristics. The connectors specified herein shall satisfy the following operational and human factor requirement.

3.4.7.1 Blind mating. The connector designs shall allow mating and unmating in "blind" conditions where the operator cannot fully observe the connector during the mating process.

### 3.5 Connectors.

3.5.1 Shell. The connector shell or backshells shall retain the connector insert.

3.5.2 Engagement of connectors. Unless otherwise specified (see 3.1), the connector shall be capable of being mated and unmated without the use of special tools.

3.5.3 Coupling mechanism. Coupling rings of the connectors shall be knurled or fluted to facilitate hand tightening, and designed so that the mating halves optical termini shall approach or recede from each other as the coupling mechanism is respectively tightened by clockwise rotation or loosened in the counter-clockwise direction as viewed from rear of plug connector. No strap wrenches or other tools shall be required to torque the connectors to accomplish mate up. The coupling mechanism shall be captive on the plug to mate with the receptacle shell. Coupling ring and coupling screw threads shall be in accordance with FED-STD-H28, and as specified (see 3.1). If the coupling threads must be lubricated to meet the requirements contained herein, the lubricant shall be applied only during manufacture. The lubricant selected shall not be reapplied nor migrate into the optical junctions region during use.

3.5.4 Polarization. Polarization of the mating halves shall be provided and designed to prevent physical contact of the mating optical termini or of the termini with the insert surface of the counterpart connector until properly aligned for engagement. Backshell splines, keys, and keyways shall be polarized and mated prior to coupling (see 3.1).

3.5.5 Termini. Termini shall be sufficiently specified to insure interchangeability and intermateability. Removable, environment resisting fiber optic termini shall be used with these connectors for interconnecting fiber optic cables. The termini are not supplied with connectors acquired to this specification. Termini, for use with the connectors specified herein, shall be in accordance with MIL-PRF-29504 (see 3.1).

3.5.6 Inserts. The connector design shall preclude fiber damage due to potential cable winding (see 3.8.1).

3.5.6.1 Number of termini, arrangement and spacing. The insert pattern, that is, the number of termini, their arrangement and spacing shall be as specified (see 3.1). Every terminus position shall accept either optical or dummy termini. Termini spacing shall permit adequate terminus marking identification and easy terminus insertion and removal.

3.5.6.2 Terminus insertion and removal methods. Optical terminus insertion shall be accomplished by inserting the terminus through the inserts of the connector mating halves and by locking it in place. The individual termini shall be positively retained in the connector when installed with the terminus insertion tool and shall be capable of being removed without damage to the terminus or connector insert when using the terminus removal tool. Requirements for these tools shall be as specified (see 3.1).

3.6 Backshell accessories. Backshells shall conform to the requirements as specified (see 3.1). The backshell shall provide cable strain relief. The backshell shall be free of any sharp edges or other configurations that could cause damage to optical fibers extending through them.

3.7 Protective covers and storage receptacles. Connectors shall be provided with a protective cover or storage receptacle. These protective devices shall maintain the connector free of moisture, prevent entry of air or dust into the connector and comply with the applicable requirements as specified herein and in the specification sheet. When not in place, the protective device shall be protected against the environment so that dirt, dust, or moisture are not carried to the connector mating surfaces by the protective cover.

3.8 Cable strength member terminations. The termination of the cable strength member shall be such that applying the tensile force specified herein to the cable will not damage the optical fibers or degrade optic performance within specified limits.

3.8.1 Cable strain relief. As specified, the cable strain relief shall grip the cable as it exits the connector to prevent degradation of optical performance by:

- a. Cable flexing or twisting at or near the termination.
- b. Cable pull out by tensile forces.

3.8.2 Cable service loop. Connectors shall be of a design so as to provide room for a service loop in the optical fibers of sufficient length to allow an individual connector terminus to be repaired at least one time before it is necessary to reterminate the entire connector.

3.9 Tools. Tools used to terminate connectors onto cables shall be as specified (see 3.1). The connector manufacturer shall provide the tools when specified in the acquisition documents (see 6.2).

3.10 Optical performance requirements. The optical performance requirements of 3.10.1 through 3.10.6 shall be used to monitor the effects of the inspection requirements specified in 3.11 as required by 4.7.1.2, 4.7.1.3, and 4.7.1.4.

3.10.1 Insertion loss. When measured in accordance with 4.8.1, the maximum per channel insertion loss under all conditions shall be 1.5 dB for 100  $\mu\text{m}$  core fibers, 1.8 dB for 62.5  $\mu\text{m}$  core fibers and 2.0 dB for 50  $\mu\text{m}$  core fibers.

3.10.2 Discontinuities. When measured in accordance with 4.8.2, no discontinuity shall occur. A discontinuity is considered to be a reduction of strength of 0.5 dB or more for a duration of 50 microseconds ( $\mu\text{s}$ ) or more.

3.10.3 Analog modulation. When tested in accordance with 4.8.3, the peak-to-peak analog modulation, band pass limited to between 4 hertz (Hz) and 40 kilohertz (kHz), shall be not more than one percent of the steady state signal level.

3.10.4 Crosstalk. The signal power level of passive channel(s) shall be below the signal on the active channel by at least the amount shown in table I when tested in accordance with 4.8.4.

TABLE I. Crosstalk reduction values for a given number of channels.

Independent signal channels	Reduction
2	50 dB
3	53 dB
4 or 5	56 dB
6 or 9	58 dB
10 or more	60 dB

3.10.5 Change in optical transmittance. When tested in accordance with 4.8.5, the optical transmittance shall not degrade by more than 0.5 dB.

3.10.6 Return loss. When measured in accordance with 4.8.6, the return loss of a standard polish multimode or single mode optical terminus shall not be greater than 37 dB. The return loss of an enhanced polish single mode optical terminus shall be not less than 40 dB.

3.10.7 Ambient light susceptibility. When tested in accordance with 4.8.7, the optical power of the light from the optical ports (after accounting for cable and optical junction losses between the device and the detector) shall be less than -70 dBm.

### 3.11 Physical requirements.

3.11.1 Size. When examined in accordance with 4.9.1, the dimensions and dimensional tolerances for these connectors, backshells, and accessories shall be as specified (see 3.1).

3.11.2 Weight. When tested in accordance with 4.9.2, the weight of the connectors, backshells and accessories shall be as specified (see 3.1).

3.11.3 Color. The external color of the connector shall be as specified in the acquisition document (see 6.2) in accordance with this paragraph. The preferred colors are as specified (see 3.1). All background colors shall be nonreflective (see 4.9.3).

3.11.4 Identification marking. Marking characters shall be a minimum of 2.0 mm in height. When tested in accordance with 4.9.4, the connectors, backshells and accessories shall be marked as specified in 3.11.4.1, 3.11.4.2, or as specified (see 3.1). All marking characters in any face of the connector, backshell, or accessory shall be identifiable. The connector shall also be marked with a yellow band and the phrase "Fiber-Optics" as specified (see 3.1).

3.11.4.1 Connector, backshell and accessory. The connector, backshell and accessory parts shall be identified by a legible and permanent marking applied in accordance with MIL-STD-1285.

3.11.4.2 Terminus location identification. Terminus location shall be designated with identifiable characters as indicated on the applicable specification sheet (see 3.1). Raised characters shall not be used on mating faces. All positions shall be identified on the front of the insert except where space limitations make this impracticable. Location of terminus identifying characters shall be in close proximity to the terminus but need not be placed exactly where indicated on the standard. The preferred color of the terminus location identification character is white. When the background is a color against which white is difficult to distinguish, a color will be chosen for which the identifying character can be easily distinguished. Character position and arrangement shall assure appropriate terminus cavity identification.

3.11.4.3 JAN and J marking. The United States Government has adopted and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the part number except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets, the manufacturer shall remove completely the military part number and the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN" and Registration Number 2,577,735 for the certification mark "J".

3.11.5 Terminus cleaning. After cleaning the terminus in accordance with 4.9.5, the marking requirements of 3.11.4 shall be met; also the requirements of 3.10.1 shall be met before, during, and after the test.

3.11.6 Insert retention axial strength. When tested in accordance with 4.9.6, connector inserts shall withstand an applied minimum pressure of 100 pounds per square inch (69 Mpa) in both the forward direction and the backward direction for a minimum period of one minute without cracking, breaking, or being dislocated from their normal position in the connector shell. No axial displacement detrimental to performance shall be observed between the inserts and their shell body during or after the test exposure. The requirements of 3.10.1 shall be met during and after the test.

3.11.7 Insert retention radial strength. When tested in accordance with 4.9.7, connector inserts shall withstand the clockwise and counter clockwise radial torque specified (see 3.1) when held for a minimum period of one minute in each direction. No rotational displacement detrimental to performance shall be observed between the inserts and their shell body during or after the test exposure.

3.11.8 Terminus retention force. When tested in accordance with 4.9.8, and subjected to axial loads of 22.0 pounds, locked termini shall be retained in their inserts and axial displacements of the termini shall not exceed .012 inch. No damage to termini or inserts shall occur.

3.11.9 Terminus insertion and removal forces. When tested in accordance with 4.9.9, the insertion force and the force required to remove unlocked termini shall not exceed 22.0 pounds.

3.11.10 Maintenance aging. When tested in accordance with 4.9.10, connectors shall show no visible evidence of wear or degradation, which may degrade their ability to perform as specified. The connector insertion loss shall be within the limits specified in 3.10.1.

3.11.11 Coupling forces. When specified (see 3.1) connectors shall be tested in accordance with 4.9.11. The maximum forces for coupling and uncoupling of the connectors shall be as specified (see 3.1).

3.11.12 Coupling torques. When specified (see 3.1) connectors shall be tested in accordance with 4.9.12. The maximum torque for coupling and uncoupling of the connectors shall be as specified (see 3.1).

3.11.13 Mating durability. When tested in accordance with 4.9.13, the connector shall show no defects detrimental to the operation of the connector and shall have mating forces and coupling torques in accordance with 3.11.11 and 3.11.12 respectively. The requirements of 3.10.1 shall be met before and after the test.

3.11.14 Impact. When tested in accordance with 4.9.14, connectors shall show no evidence of broken, loose, deformed or displaced parts, cracks, chips, or other damage, which would result in a degradation of optical performance. Insertion loss shall not exceed the limits specified in 3.10.1.

3.11.15 Twist. When tested in accordance with 4.9.15, the cable/connector interface shall have no damage detrimental to the operation of the cable or connector. The connector insertion loss shall not exceed the limits specified in 3.10.1 before, during, and after the test.

3.11.16 Cable seal flexing. When tested in accordance with 4.9.16, connector strain relief mechanisms shall prevent loss of environmental sealing or other damage, which may impair the connector operation. The requirements of 3.10.1 shall be met before, during, and after the test.

3.11.17 Cable retention. When tested in accordance with 4.9.17, there shall be no evidence of cable jacket damage, cable clamp failure, cable to connector seal damage, distortion or bending of metallic connector parts, or cable disengagement from the clamp. The minimum cable to connector pull-out strength shall be 400 pounds. The requirements of 3.10.1 shall be met before, during, and after the test.

3.11.18 Crush resistance. When tested in accordance with 4.9.18, connectors shall show no broken parts, no degradation of mating-unmating, or no damage to the seals. The connector shall meet the requirements of 3.10.4 before and after the test and the requirements of 3.10.1 before, during, and after the test.

3.11.19 External bending moment. When tested in accordance with 4.9.19, connectors shall show no evidence of damage detrimental to their normal operation nor shall there be any interruption of their ability to perform as specified (see 3.1). The requirements of 3.10.1 shall be met before, during, and after the test.

3.11.20 Temperature life. When tested in accordance with 4.9.20, connectors subjected to the specified accelerated aging exposures shall not exhibit visual evidence of dimensional change, opening of seals, cracking or crazing of components or finishes, identification marking impairment, fusion or seizure of mating parts, leakage or waterproofing compounds, or other effects detrimental to connector operation. No evidence of adhesive degradation shall be present. The requirements of 3.10.1 shall be met before and after the test.

3.11.21 Thermal shock. When tested in accordance with 4.9.21, a post-test visual examination of the tested connectors shall reveal no evidence of connector part dimensional change, no leaking of waterproofing compounds or other apparent loss of sealing capability, no surface or identification marking impairment, no coupling-thread binding or other evidence of mating/unmating incapability and no other damage detrimental to the operation of the connector. Before, during, and after the test, the insertion loss of the mated connector shall be measured and shall be within the limits in 3.10.1. During the thermal stress, the insertion loss of each connector channel shall be measured at the extremes as well as at ambient temperatures and shall be within the limits specified in 3.10.1.

3.11.22 Physical shock. When tested in accordance with 4.9.22, the connectors shall show no evidence of broken, loose, deformed or displaced parts, cracks, chips or other damage, which would result in a degradation of optical performance. Insertion loss shall not exceed the limits in 3.10.1 before and after the test and the requirements of 3.10.2 shall be met before, during, and after the test.

3.11.23 Vibration. When tested in accordance with 4.9.23, there shall be no transient change in optical performance beyond specification limits and there shall be no disengagement of the mated connectors, backing off from the coupling mechanism, evidence of cracking, breaking, or loosening of parts. The requirements of 3.10.2 and 3.10.3 shall be met before, during, and after the test.

3.11.24 Humidity. When tested in accordance with 4.9.24, the connectors shall operate without degradation beyond the performance limits specified in 3.10.1 before, during, and after exposure to the humidity conditions specified. There shall be no visual evidence of deterioration of component parts or constituent materials, loosening of finishes, physical distortion, corrosion of metals, entrapment of materials, separation of bonded surfaces or other damages.

3.11.25 Salt spray. When tested in accordance with 4.9.25, the mated connectors shall not show exposure of base metal or corrosion products, which will adversely affect performance. No visible evidence of salt penetration into the connector sealed area shall be observed. Following the test, insertion loss shall be within the limits in 3.10.1.

3.11.26 Altitude immersion. When tested in accordance with 4.9.26, assembled, mated connectors shall show no deterioration, which will adversely affect performance of the connectors. Insertion loss shall be within the limits in 3.10.1 before and after the test.

3.11.27 Fluid immersion test. When tested in accordance with 4.9.27, visual examination of the test connector shall reveal no swelling or softening of material, no loss of sealing capability or identification marking and no discoloration or other effects detrimental to the intended use of these connectors.

3.11.28 Water pressure/freezing. When tested in accordance with 4.9.28, visual inspection of the test connector shall reveal no penetration of water into the sealed region of the mated connector. The requirements of 3.10.1 shall be met before, during, and after the test.

3.11.29 Sand and dust. When tested in accordance with 4.9.29, the connectors shall show no evidence of physical damage, which will adversely affect the operation of the connector. The change in optical transmittance requirements of 3.10.5 shall be met during and after the test, also the coupling force and coupling torque requirements of 3.11.11 and 3.11.12 shall be met after the test.

3.11.30 Ozone exposure. When tested in accordance with 4.9.30, there shall be no evidence of cracking of plastic and rubber parts or other damage due to ozone exposure that will adversely affect performance.

3.11.31 Flammability. When tested in accordance with 4.9.31, burning and after-flow extinguishing time shall be three seconds maximum. Dripping which will cause flammable material to ignite and violent burning or an explosive type fire shall not occur.

3.12 Assembly instructions. Complete assembly instruction shall be furnished by the vendor with each connector acquired under this specification. Assembly instructions shall include but not be limited to:

- a. Cable preparation-stripping dimensions and tolerances.
- b. List and description of crimping or special tools if required.
- c. Sufficient pertinent dimensions for verification of correct parts; as a minimum the entry openings shall be specified.
- d. Military PIN and manufacturer's ID.

3.13 Workmanship. All details of workmanship shall be in accordance with high-grade fiber-optic connector manufacturing practice when visually examined in accordance with 4.9.32. Connectors and accessories shall be complete, dimensionally uniform and free of manufacturing flaws that would degrade performance, inhibit proper connection to interfacing elements, or otherwise yield an inferior product. The following shall be a minimal level to visual examination to be performed and is not intended to restrict other pertinent workmanship examinations.

- a. Loose termini, insert or other connector parts, which adversely affect the environment sealing, permit cable sealant penetration or degrade optical termini alignment, shall not be permitted.
- b. Peeling or chipping of plating or finish, galling of mating parts indicating excessive wear, nicks, burrs, or other sub-standard connector surface blemishes shall not be permitted.

3.14 Mud test (see 4.10). When specified (see 3.1), the insertion loss, measured following the mud test per paragraph 4.10, shall not increased by more than 0.2 dB.

3.15 Electromagnetic shielding. When tested in accordance with 4.12, the propagated radio frequency (RF) attenuation of the connector shall be not less than 60 dB for frequencies greater than 10 GHz.

#### 4. VERIFICATION

4.1 Verification program. Requirements for the verification program shall be as identified in the qualification instructions (see 6.7).

4.1.1 Assembly plants. Assembly plants must be listed on, or approved for listing on, the applicable qualified products list. The assembly plant shall use only piece parts supplied by the qualified connector manufacturer. No testing other than visual examination is required of certified piece parts obtained from the qualified connector manufacturer, except when there is cause for rejection. All assemblies produced at the assembly plant shall be subjected to examination of the product to assure that the assembly process conforms with that established at the qualified manufacturing plant. Quality control requirements shall be the same as required for the qualified connector manufacturer.

4.1.2 Test equipment and inspection facilities. Requirements for test equipment and inspection facilities shall be as identified in the qualification instructions (see 6.8).

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

- a. Qualification inspection (see 4.4).
- b. Conformance inspection (see 4.7).

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in TIA455 or as specified herein.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production. This inspection shall consist of performing the inspections and optical tests specified in table II. Upon successful completion of Group I testing, Groups II thru IV shall be subjected to their respective tests specified in table II in the sequence shown herein and Group V shall be submitted for qualification test as specified in APPENDIX A.

##### 4.4.1 Reliability and Quality.

4.4.1.1 QPL system. The manufacturer shall establish and maintain a QPL system as described in 3.2.1. Evidence of such compliance is a prerequisite for qualification and verification of qualification.

4.5 Test sample. Fiber-optic connector, backshell, and accessory samples complying with the specified requirements (see 3.1) shall be submitted for qualification. The manufacturer shall provide a counterpart connector for each connector subjected to qualifying tests requiring mating assemblies. The counterpart connectors provided for this purpose shall be either, previously qualified connectors or new connectors submitted for qualification testing. Manufacturers not producing mating connectors shall submit data substantiating that tests were performed with qualified counterpart connectors. For those tests specifying the use of mated connectors, optical and mechanical test assessment shall be made using the assigned counterpart connector for those test measurements as required.

4.5.1 Sample size. Eight mated in-line cable connectors, manufactured by normal production methods shall be provided for qualification testing.

4.5.1.1 Sample preparation. Unless otherwise specified, connectors shall be fully assembled into cable-connector assemblies using the types of cable specified in the applicable connector specification sheet. Connector terminals shall be optically finished with termini properly seated within their inserts. For mated connectors, full sealing capability shall be provided as specified. Connectors shall be provided with backshell, strain relief cable clamp and attached to a 13 feet minimum length of the specified cable type terminated with ST type connectors.

4.5.2 Inspection routine. Connector, backshell, and accessory samples shall be tested in accordance with the sequence of table II. The connector group samples may be tested simultaneously.

4.5.3 Failures. One or more failures shall be cause for refusal to grant qualification approval.

4.5.4 Retention of qualification. To retain qualification, the manufacturer shall verify in coordination with the qualifying activity, the capability of manufacturing products which meet the performance requirements of this specification. Refer to the qualifying activity for the guidelines necessary to retain qualification with respect to this particular specification. The manufacturer shall immediately notify the qualifying activity at any time that the inspection data indicates failure of the qualified product to meet the performance requirements of this specification.

4.6 Materials inspection. Materials inspection shall consist of certification supported by verifying data that materials used in fabricating the delivered fiber-optic connectors are in accordance with the requirements of 3.3 and as specified (see 3.1).

4.7 Conformance inspection. Conformance inspection shall consist of the inspections and optical tests specified for group A inspection (table IV), group B inspection (table V), group C inspection (table VI), and packaging inspection.

4.7.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections.

4.7.1.1 Inspection lot. The inspection lot shall consist of the number of connectors offered for inspection at one time, and all of the same design as covered by one specification sheet.

4.7.1.2 Group A inspection. Group A inspection shall consist of the inspections and optical tests specified in table IV. All connectors, backshells, and accessories of the inspection lot shall be subjected to the inspections and optical tests listed.

4.7.1.2.1 Sampling plan. Group A inspection shall be performed on 100 percent of the delivered product.

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TABLE II. Qualification inspection.

Inspection	Part applicability 1/			Requirement paragraph	Test paragraph
	Connector	Backshell	Accessories		
<u>Group I 2/</u> (All sample units)					
Materials inspection	X	X	X	3.3	4.6
Insertion loss	X	X	X	3.10.1	4.8.1
Size	X	X	X	3.11.1	4.9.1
Weight	X	X	X	3.11.2	4.9.2
Color	X	X	X	3.11.3	4.9.3
Identification marking	X	X	X	3.11.4	4.9.4
Workmanship	X			3.13	4.9.32
Crosstalk	X			3.10.4	4.8.4
<u>Group II</u> (2 sample units)					
Change in optical transmittance	X	X	X	3.10.5	4.8.5
Return loss	X	X	X	3.10.6	4.8.6
Ambient light susceptibility	X	X	X	3.10.7	4.8.7
Insert retention axial strength	X			3.11.6	4.9.6
Insert retention radial strength	X			3.11.7	4.9.7
Terminus retention force	X			3.11.8	4.9.8
Terminus insertion and removal forces	X			3.11.9	4.9.9
Maintenance aging	X			3.11.10	4.9.10
Temperature life	X	X	X	3.11.20	4.9.20
Crush resistance	X	X	X	3.11.18	4.9.18
Fluid immersion	X			3.11.27	4.9.27
Mud test	X	X	X	3.14	4.10
Fungus resistance	X	X	X	3.3.4.6	4.11
<u>Group III</u> (2 sample units)					
Coupling forces	X	X	X	3.11.11	4.9.11
Coupling torques	X	X	X	3.11.12	4.9.12
Twist	X	X		3.11.15	4.9.15
Cable seal flexing	X	X		3.11.16	4.9.16
Cable retention	X			3.11.17	4.9.17
External bending moment	X	X	X	3.11.19	4.9.19
Thermal shock	X			3.11.21	4.9.21
Altitude immersion	X		X	3.11.26	4.9.26
Water pressure/freezing	X		X	3.11.28	4.9.28
Ozone exposure	X		X	3.11.30	4.9.30
Physical shock	X	X		3.11.22	4.9.22
Vibration	X	X		3.11.23	4.9.23

See footnotes at end of table.

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TABLE II. Qualification inspection – Continued.

Inspection	Part applicability <sup>1/</sup>			Requirement paragraph	Test paragraph
	Connector	Backshell	Accessories		
<u>Group IV</u> <sup>2/</sup> (2 sample units)					
Terminus cleaning	X			3.11.5	4.9.5
Electromagnetic effects	X	X	X	3.15	4.12
Coupling force	X	X	X	3.11.11	4.9.11
Coupling torques	X	X	X	3.11.12	4.9.12
Electromagnetic shielding	X	X	X	3.15	4.12
Mating durability <sup>3/</sup>	X			3.11.13	4.9.13
Humidity	X		X	3.11.24	4.9.24
Salt spray	X	X	X	3.11.25	4.9.25
Sand and dust	X	X	X	3.11.29	4.9.29
Impact	X	X	X	3.11.14	4.9.14
Flammability	X	X	X	3.11.31	4.9.31
<u>Group V</u> <sup>2/</sup> (2 sample units)					
Intermateability and interoperability	X	X	X	3.4.3	Appendix A

<sup>1/</sup> X indicates that this test applies.<sup>2/</sup> Sample units: Number indicated means that the number of connectors, backshells or accessories that shall be tested, for example "2 sample units" means 2 connectors and 2 accessories shall be tested when an "X" appears in the part applicability column under "connector" and "accessories".<sup>3/</sup> After every 100 cycles.TABLE III. Sampling plans.

Lot size	Samples
1 – 8	All
9 – 50	5
51 – 90	7
91 – 150	11
151 – 280	13
281 – 500	16
501 – 1200	19
1201 – 3200	23
3201 – 10,000	29

4.7.1.2.2 Rejected lots. If an inspection lot is rejected, the lot shall be screened for that particular defect and defects removed. A new sample shall be selected from table III using the sample size of the next higher lot size. If one or more defects are found in the second sample, the lot shall be rejected and not supplied to this specification.

4.7.1.2.3 Disposition of sample units. Sample units that have failed any of the group A inspection tests may be reworked to correct defects if possible and subjected to group A inspection again. Sample units that pass all tests of group A inspection may be delivered on the purchase order or contract or tested to group B inspection (see 4.7.1.3). Units that have not been corrected shall not be delivered on any order even though the inspection lot submitted is accepted.

TABLE IV. Group A inspection.

Inspection	Part applicability 1/			Requirement paragraph	Test paragraph
	Connector	Backshell	Accessories		
Workmanship	X	X	X	3.13	4.9.32
Size	X	X	X	3.11.1	4.9.1
Weight	X	X	X	3.11.2	4.9.2
Color	X	X	X	3.11.3	4.9.3
Identification marking	X	X		3.11.4	4.9.4
Terminus insertion and removal force	X			3.11.9	4.9.9
Coupling forces	X	X	X	3.11.11	4.9.11
Coupling torques	X	X	X	3.11.12	4.9.12

1/ X: Indicates that this test applies.

4.7.1.3 Group B inspection. Group B inspection shall consist of the inspections and optical tests specified in table V, in the order shown, and shall be made on sample units which have been subjected to and have passed the group A inspection.

4.7.1.3.1 Sampling plan. Samples shall be selected at random from the inspection lot. Sample size shall be in accordance with table III. If one or more defects are found, the lot shall be rejected.

4.7.1.3.2 Sample unit preparation. Connectors shall be fully assembled into cable-connector assemblies using the types of cable specified in MIL-PRF-85045. In case of no qualified sources, the following cable or equivalent shall be used.

2 Channel	PIN M85045/8-B2B, 50 micron core, 125 clad, or equal.
4 Channel	PIN M85045/8-B4B, 50 micron core, 125 clad, or equal.
2 Channel	PIN M85045/8-B2A, 62.5 micron core, 125 clad, or equal
4 Channel	PIN M85045/8-B4A, 62.5 micron core, 125 clad or equal

Connector terminals shall be optically finished with termini properly seated within their inserts. For mated connectors, full sealing capability shall be provided as specified (see 3.1). Connectors shall be provided with backshell, strain relief cable clamp and attached to a six feet length of the specified cable type, and shall be terminated in accordance with the manufacturer's instructions.

4.7.1.3.3 Rejected lots. If an inspection lot is rejected, the contractor may rework the lot to correct the defects or screen out the defective units and resubmit for reinspection. Resubmitted lots shall be inspected using the sample size of the next higher lot size specified in table III. Such lots shall be separate from new lots and shall be clearly identified as reinspected lots.

4.7.1.3.4 Disposition of sample units. Sample units used in Group A or B inspections may be used for Group C inspection or delivered on the contract or purchase order only if the following requirements are met:

- a. The lot is accepted.
- b. The connector has removable termini and the ones that were terminated for testing are replaced with unterminated ones.
- c. The sampling unit passed group B inspection, or the sample unit failed group B inspection but was reworked and successfully retested to group B requirements.

Sample units not meeting criteria a, b, and c above shall not be delivered on the contract or purchase order, or used for group C inspection.

TABLE V. Group B inspection.

Inspection	Part applicability 1/			Requirement paragraph	Test paragraph
	Connector	Backshell	Accessories		
Insertion loss	X			3.10.1	4.8.1
Terminus cleaning	X			3.11.5	4.9.5
Insert retention axial strength	X			3.11.6	4.9.6
Insert retention radial strength	X			3.11.7	4.9.7
Terminus retention force	X			3.11.8	4.9.8
Maintenance aging	X	X	X	3.11.10	4.9.10
Cable retention	X	X		3.11.17	4.9.17

1/ X indicates that this test applies.

4.7.1.4 Periodic inspection. Periodic inspection shall consist of group C. Except where the results of these inspections show noncompliance with the applicable requirements (see 4.7.1.4.1.4), delivery of products, which have passed group B inspection, shall not be delayed pending the results of these periodic inspections.

4.7.1.4.1 Group C inspection. Group C inspection shall consist of the tests specified in table VI in the order shown. Group C inspection shall be performed on sample units of each style and selected from inspection lots that have passed groups A and B inspections. Group C inspection sample shall be representative of production.

4.7.1.4.1.1 Sampling plan. Every 60 months, connector, backshell, and accessory sample units, which have passed group B inspection, shall be selected in sufficient quantity to provide two samples per applicable test group.

4.7.1.4.1.2 Failures. If one or more specimen or sample units fail to pass group C inspection, the sample shall be considered to have failed.

4.7.1.4.1.3 Disposition of sample units. Sample units, which have been subjected to group C inspection, shall not be delivered on the contract or purchase order.

TABLE VI. Group C inspection.

Inspection	Part applicability 1/			Requirement paragraph	Test paragraph
	Connector	Backshell	Accessories		
<u>Group I</u> (2 sample units)					
Color	X	X	X	3.11.3	4.9.3
Identification marking	X	X	X	3.11.4	4.9.4
Impact	X	X	X	3.11.14	4.9.14
Twist	X	X		3.11.15	4.9.15
Cable seal flexing	X	X		3.11.16	4.9.16
Mating durability	X			3.11.13	4.9.13
External bending moment	X			3.11.19	4.9.19
Temperature life	X	X	X	3.11.20	4.9.20
Thermal shock	X			3.11.21	4.9.21
Physical shock	X			3.11.22	4.9.22
Vibration	X	X		3.11.23	4.9.23
Humidity	X		X	3.11.24	4.9.24
<u>Group II</u> (2 sample units)					
Color	X	X	X	3.11.3	4.9.3
Identification marking	X	X	X	3.11.4	4.9.4
Terminus cleaning	X			3.11.5	4.9.5
Salt spray	X	X	X	3.11.25	4.9.25
Water pressure/freezing	X		X	3.11.28	4.9.28
Sand and dust	X	X	X	3.11.29	4.9.29
Crush resistance	X	X	X	3.11.16	4.9.16
Flammability	X	X	X	3.11.31	4.9.31

1/ X indicates that this test applies.

4.7.1.4.1.4 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which are manufactured under essentially the same conditions, with essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all tests and examinations or the test which the original sample failed, at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance and shipment shall be withheld until the group C inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.7.2 Inspection of packaging. The sampling and inspection of the preservation, packing and container marking shall be in accordance with the requirements of MIL-DTL-55330.

4.8 Optical conformance test methods. Cladding shall be removed. In those cases where the fiber coating does not adequately perform this function, an equilibrium mode simulator and cladding mode stripper shall be installed between the source and connector (in that order) as well as between the connector and detector (in that order) when making optical measurements. A one kilometer section of fiber may be substituted for the equilibrium mode simulator and cladding mode stripper between the source and connector if desired. In connectors with one, two, or three optical channels, optical measurements shall be made in rapid succession on each channel. Unless otherwise specified herein, in connectors with four or more channels, optical measurements shall be made in rapid succession on three randomly selected channels.

4.8.1 Insertion loss (see 3.10.1). The initial insertion loss of multimode connectors shall be measured in accordance with method A of TIA455.34, using both 70/70 and overfill launch conditions. For subsequent insertion loss tests, 70/70 launch conditions or equivalent shall be used. The insertion loss of single mode connectors shall be measured in accordance with method B of TIA455.34.

4.8.2 Discontinuities (see 3.10.2). The connector shall be tested in accordance with TIA-455-32. The optical termini of the connector shall be connected through a minimum of 4 meters of optical test cables to an appropriate optical signal source and detector. Unused termini shall be capped. The source shall produce a constant level, static signal easily detected by the detector. The output of the detector shall be monitored for discontinuities while the connector is subjected to a mechanical or environmental test exposure. The detector and monitoring equipment shall possess sufficient sensitivity and high frequency response to detect discontinuities in the optical signal. The monitoring equipment shall include transient capture capability (such as provided by an electronic counter or by an oscilloscope with an adjustable sweep trigger and oscilloscope camera).

4.8.3 Analog modulation (see 3.10.3). The optical termini of the connector shall be connected through a minimum of 4 meters of optical cables to an optical signal source and detector. Unused termini shall be capped. The source shall produce a constant level, static signal easily detected by the detector. The output of the detector shall be monitored for analog modulation while the device under test is subjected to vibration (see 4.9.23). The detector and monitoring equipment shall possess sufficient sensitivity and frequency response to discern analog modulation at the acceptance level. The monitoring equipment shall include signal recording capability (such as provided by a triggerable oscilloscope and an oscilloscope camera).

4.8.4 Crosstalk (see 3.10.4). The termini of the connector shall be connected to a minimum of 4 meters of optical test cables or opaquely capped as appropriate. The input to one optical channel (the active channel) shall be connected via its test cable to an optical signal source, the signal of which shall be either continuous or amplitude modulated. The output port(s) of the other channels (passive channel(s)) shall be connected to test cable(s). The other input ports shall be opaquely capped. The output signal power from both the active and passive channels shall be measured. When there is more than one passive channel, the output of all passive channels shall be summed. This test shall be repeated, making each remaining input port the active channel.

4.8.5 Change in optical transmittance (see 3.10.5). The change in optical transmittance shall be measured in accordance with TIA455.20. The use of a reference fiber to evaluate the change in optical transmittance due to exposure of the cable to the environmental tests is optional. Measurements shall be made before and after environmental tests, and during tests per table VII.

TABLE VII. Measurement frequency.

Test duration (hrs.)	Time(s) after start of test (hrs.)
4 and less	Half way through
More than 4 to 6	1/3 and 2/3 of the way through the test
More than 6	¼, ½, and ¾ of the way through the test

4.8.6 Return loss (see 3.10.6). The return loss shall be measured in accordance with TIA-455-107.

4.8.7 Ambient light susceptibility (see 3.10.7). The optical connector shall be tested in accordance with TIA-455-22. The optical termini of the connector shall be either opaquely capped or connected to a minimum of 4 meters of optical test cables as appropriate. The far ends of these cables shall be either capped or connected to suitable optical power monitoring instruments. The light shall be broad spectrum with infrared, visible, and ultraviolet components and shall illuminate the connector with an irradiance (power density) of  $112 \pm 5$  milliwatts per square centimeter. Light emitting from each optical part of the device under test shall be measured by optical power monitoring equipment, having a broad spectral response compatible with the source.

#### 4.9 Inspection methods.

4.9.1 Size. Each of the dimensions specified (see 3.1) for the connector, backshell, and accessory parts shall be measured using calibrated measuring devices with the precision and accuracy appropriate for the tolerances specified (see 3.1 and 3.11.1).

4.9.2 Weight. The connector, backshell and accessories shall be weighed using calibrated scales having the range, precision and accuracy appropriate for the tolerances specified (see 3.1 and 3.11.2).

4.9.3 Color. The colors of connectors, backshells, and accessories shall be nonreflective (see 3.11.3).

4.9.4 Identification marking. Identification markings on connectors, backshells and accessory parts shall be visually examined and measured for conformance with the requirements of 3.11.4.

4.9.5 Terminus cleaning (see 3.11.5). The optical face of each terminus shall be cleaned according to the instructions supplied by the connector manufacturer. The terminus shall not be removed from its operational position within the connector to facilitate cleaning.

4.9.6 Insert retention axial strength (see 3.11.6). Unmated connector samples shall be tested as follows. The pressure shall be applied as specified (see 3.11.6) and the axial displacement measured (see 3.11.6). The same pressure shall then be applied on the opposite face. Termini positions within the insert may be either empty or filled during the test.

4.9.7 Insert retention radial strength (see 3.11.7). Unmated connector samples shall be tested where specified (see 3.1), for radial strength as described herein. Counterpart test devices for connector shall be supplied by the connector manufacturer, which are capable of applying radial torque forces between the insert and its shell body. Outermost termini positions or other means may be used for application of these torques, however, no damage shall occur to the insert as a result of the test exposure. A radial torque shall be applied as specified (see 3.1).

4.9.8 Terminus retention force (see 3.11.8). Termini shall be inserted into an unmated connector and tested as follows. Termini shall be subjected to axial compressive loads applied to the front face of the terminus tending to push the terminus to the rear of the connector insert. Care must be exercised in the design of the force application mechanism so that it does not physically touch the optical fiber endface. Axial loads shall be applied at a rate of 1.0 lb (4.4 N) per second up to the minimum load specified (see 3.11.8). The specified load shall be maintained for a minimum of 5 seconds. The terminus position shall be measured from the rear of the connector insert while under the specified load and shall not exceed the requirements of 3.11.8. Additionally there shall be no evidence of damage.

4.9.9 Terminus insertion and removal forces. Termini shall be inserted into an unmated connector using a terminus insertion tool and the force required to insert the terminus measured (see 3.11.9). When required, a terminus removal tool shall then be engaged to unlock the terminus. The terminus shall be removed and the force required to remove the terminus measured.

4.9.10 Maintenance aging (see 3.11.10). Unmated connectors shall be tested as follows. Termini shall be inserted and removed from the connector a minimum of ten times. The termini selected for insertion and removal shall be the same termini that are monitored for optical performance testing. Insertion and withdrawal tools shall be as defined in 6.6. The force required to insert each terminus into the connector and the force required to remove each terminus from the connector shall be measured during the first and final maintenance aging cycle. Upon completion, units shall meet the requirements of 3.11.10 and 3.10.1.

4.9.11 Coupling forces. When specified (see 3.1) unmated connector samples shall be tested for axial engagement and disengagement forces as follows. One connector shall be rigidly mounted. The other connector shall be attached to a force gage and brought into position such that the outermost surfaces of the insert caps are in the same plane. The force gage shall be set to zero. An axial force shall be applied such that the connectors mate fully. The force shall be recorded. While in this position, the gage shall be reset to zero and an axial force shall be applied to unmate the connectors and return to starting position (outermost surfaces of the insert caps are in the same plane). The procedure shall be repeated 2 times and all force measurements shall be within the limits specified in 3.11.11.

4.9.12 Coupling torques (see 3.11.12). When specified (see 3.1) unmated connector samples shall be tested as follows. Two mating connectors shall be brought to a position where mechanical mating of the connector body and coupling nut begins. A torque gauge attached to the coupling nut shall be set to zero indication. The connectors shall then be fully coupled and the torque required for mating shall be recorded. The torque gauge shall then be reset to zero indication. The mated connectors shall be fully unmated and the torque required for unmating shall be recorded. The procedure shall be repeated 2 times and all torque measurements shall be within the limits specified in 3.11.12.

4.9.13 Mating durability (see 3.11.13). The terminated assembly made of one cable mounted connector and one wall mount, jam-nut mount or in line connector as specified (see 3.1) shall be mated and unmated in accordance with TIA455.21. One thousand complete (part separating) cycles (mated and unmated) shall be accomplished by hand at an optional rate. The change in insertion loss (see 3.10.1), coupling torque (see 3.11.12) and coupling force (see 3.11.11) after the durability tests shall be measured. The coupling torque and mating forces shall be measured in accordance with the requirements of this specification and the specification sheet. The connector termini may be cleaned prior to insertion loss measurements (see 4.9.5) and shall be so noted on data sheets. Connector coupling hardware shall not require cleaning to meet coupling torque and mating force requirements.

4.9.14 Impact (see 3.11.14). Each connector to be qualified shall be subjected to the test (impact) in accordance with method B, service class severe of TIA455.2.

4.9.15 Twist. Mated cable-connector assemblies shall be tested in accordance with TIA-455-36. Connector-held fixture shall be rotated  $\pm 90$  degrees at a rate of one cycle per five seconds for a total of 1,000 cycles. The cable assemblies shall be stretched with a minimum tension of 11.0 pounds to their maximum lengths and clamped at a distance of about 10 times the cable diameter from the connector to the fixture tabletop. The fixturing and cable clamping are to be done in a manner that does not affect the cable's optical transmittance beyond acceptable limits as specified (see 3.11.15). Measurements shall be taken before and after testing.

4.9.16 Cable seal flexing (see 3.11.16). Unmated cable-connector assemblies, of each type to be qualified shall be tested in accordance with test procedure I, of TIA/EIA-455-1.

4.9.17 Cable retention. Mated connector samples shall be tested in accordance with TIA455.6. The axial tensile load shall be applied up to the load specified (see 3.11.17) and shall be maintained for 10 minutes. Elongation of the cable shall have no effect on the insertion loss while the load is applied for the specified time. Tests and measurements before, during, and after test shall be taken as required by the detail specification.

4.9.18 Crush resistance (see 3.11.18). Cable connector assemblies shall be tested in accordance with TIA455.26. The test load shall be 450 pounds and shall be applied a total of four times, rotating the sample  $90^\circ$  about its axis after each loading. The load shall be applied for a period of 5 to 10 seconds.

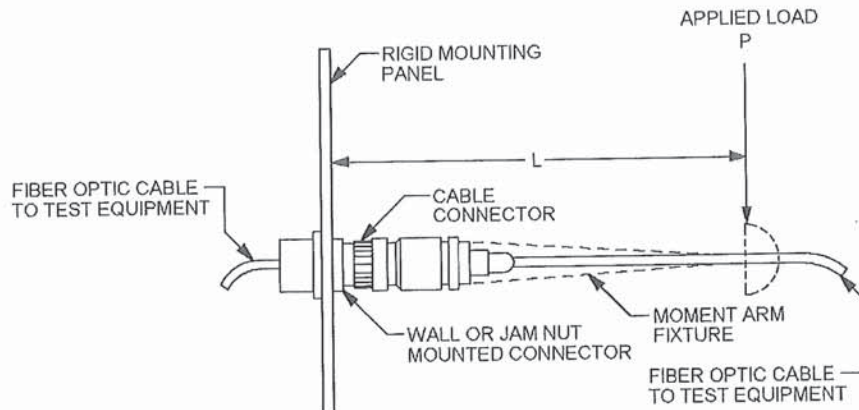
4.9.19 External bending moment (see 3.11.19). The wall or jam-nut mounted connector shall be mounted as in normal service to a rigid panel. Before mating the cable connector to the wall or jam-nut mounted connector, an adapter or test torque arm shall be attached as shown on figure 1. After mating the two connectors, the distance "L" from the point of load application "P" to the mounting panel shall be determined. The load to be applied at point "P" shall then be determined as the bending moment specified divided by the lever arm "L". This load shall be applied at a rate of approximately 49.5 newtons per second until the required load of 71 newton meters is achieved. The applied load shall be held for one minute, and then the load shall be released. Insertion loss of the termini shall be monitored during the test.

4.9.20 Temperature life. Mated connectors shall be tested in accordance with TIA455.4 for 250 hours at  $85^\circ\text{C} \pm 2^\circ\text{C}$ . The change in insertion loss shall be measured during and after the test (3.11.20).

4.9.21 Thermal shock. Cable-connector assemblies (at least one mated and one unmated) shall be tested in accordance with TIA-455-71, schedule C for five cycles. The fiber shall be in accordance with MIL-PRF-49291. The number of fibers shall be given by the specification sheet (see 3.1). The mated and unmated cable-connector assemblies shall be examined for degradations of any sort after testing. The following conditions shall apply:

- a. High test temperature:  $+85^\circ\text{C}$ .
- b. Examination during test: Verify that the optical performance is within the limits specified in 3.10.1.
- c. Examination after test: Examine for compliance to 3.11.21.

4.9.22 Physical shock. Mated cable-connector assemblies shall be tested in accordance with test condition C of TIA-455-14 applying 5 shocks per axis (30 total shocks). The cable shall be clamped to the shock table approximately 8 inches from the rear of the connector. The change in insertion loss shall be measured after the shock test (see 3.11.22).



NOTE: Moment arm fixture shall be of a convenient design.

FIGURE 1. External bending moment test setup.

4.9.23 Vibration. A complete connector assembly shall be mounted as shown on figure 2 or suitable test fixture and vibrated in accordance with EIA/TIA-455-11 as follows; test conditions III at 10 G's and test condition VI, test letter C for 1.5 hours. Specimen cable, using the normal connecting devices of the connector and clamped as shown on figure 2, shall be used. The connector shall be mounted by its normal mounting device. Cable to cable connectors may be held to the jig of figure 2 by a suitable clamp on one half of the connector assembly. The following conditions shall apply:

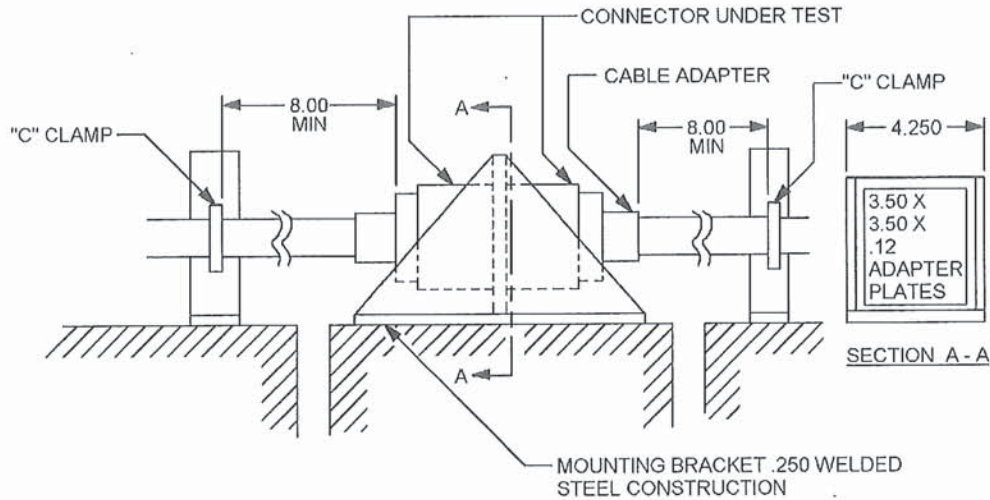
- a. Test condition letter if other than above (see 3.1).
- b. Signal discontinuity (see 4.8.2) and analog modulation (see 4.8.3), shall be monitored during vibration.
- c. Upon completion of the test, the connectors shall be examined for compliance to 3.11.23.

4.9.24 Humidity. Cable-connected assemblies (at least one mated and one unmated), shall be tested in accordance with test method B of TIA/EIA-455-5 for 10 total cycles with 5 including sub cycle. The cable used shall be in accordance with MIL-PRF-85045. Measurements shall be made of the sample after conditioning process and after humidity test (see 3.11.24).

4.9.25 Salt spray (corrosion). Mated cable-connector assemblies shall be tested in accordance with test condition I of TIA/EIA-455-16. After test exposure, the assemblies shall be externally cleaned and examined under 3 power magnification for salt penetration into the connector junction area and damage to external parts (see 3.11.25).

4.9.26 Altitude immersion. Mated connectors shall be tested in accordance with TIA-455-15. Cables used shall be in accordance with MIL-PRF-85045. Fibers used shall be in accordance with MIL-PRF-49291. The change in insertion loss shall be measured after the test (see 3.11.26).

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Inches	mm
.12	3.1
.25	6.4
3.50	88.9
4.25	107.9
8.00	203.2

NOTES:

1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Dimensions and tolerances are in accordance with ASME Y14.5M.

FIGURE 2. Vibration testing setup.

4.9.27 Fluid immersion (see 3.11.27). At least one mated cable-connector assembly shall be tested in accordance with EIA/TIA-455-12. Assemblies shall be immersed in each of the fluids listed in table VIII at the temperature specified for 24 hours. Each assembly shall be completely dried after each immersion. After testing, the assemblies shall be examined for fluid penetration into the shell body and connector junction region. Instead of optical transmittance, insertion loss shall be measured after the test (see 3.10.1).

TABLE VIII. Fluids and test temperature for immersion test.

Fluid	Applicable specification	Test temperature (°C)
Fuel oil	MIL-PRF-16884	33 to 37
Turbine fuel, JP-4	MIL-DTL-5624	20 to 25
Isopropyl alcohol	IT-I-735 (see 6.9)	20 to 25
Hydraulic fluid	MIL-PRF-5606 (see 6.5)	48 to 50
Lubricating oil	MIL-PRF-17331	73 to 77
	MIL-PRF-23699	73 to 77
Coolant fluid, hydrolytically stable, dielectric	MIL-PRF-87252	20 to 25

4.9.28 Freezing water immersion (see 3.11.28). Mated connector assemblies shall be tested in accordance with method A, procedure 1 of EIA455.98 with the following exception, use mated connector assemblies instead of continuous cable. The size of the water vessel shall be such that, when the mated connectors are placed in the vessel, the connectors are within 150 mm of the sides and bottom of the vessel, and within 150 mm of the surface of the water. The change in optical transmittance shall be monitored during and after the test in accordance with 4.8.5. At the completion of the test, the connectors shall be visually examined in accordance with 4.9.32. For exposure at -10 °C, the water is considered completely frozen when the water temperature reading is less than -1°C. The connector assemblies shall be externally cleaned, unmated, examined for water penetration into the connector, mated and optically tested for insertion loss in accordance with limits in 3.10.1.

4.9.29 Sand and dust (see 3.11.29). Mated cable connector assemblies shall be tested in accordance with TIA455.35 except as noted herein. Each connector shall be oriented in the chamber such that the coupling mechanism is in line with the oncoming air flow. The connectors shall be affixed in such a manner that the orientation of the connector does not change throughout the duration of the test. The 16 hour holding period of step 5.5 is not required. Step 5.6 may proceed immediately after reaching temperature stabilization. The change in optical transmittance shall be measured before the dust test, during the 6 hour exposure period of step 5.4, before step 5.6, during the 6 hour exposure period of step 5.6, and after the test. The connector coupling force and coupling torque (see 4.9.11 and 4.9.12) shall be measured after the test. The connector shall be visually examined in accordance with 4.9.32, after cleaning, at the conclusion of the test.

4.9.30 Ozone exposure (see 3.11.30). Mated cable-connector assemblies shall be tested in accordance with TIA-455-189. After test exposure, the assemblies shall be examined for damage.

4.9.31 Flammability (see 3.11.31). Mated and unmated cable-connector assemblies shall be tested in accordance with EIA-364-81 and as specified herein. Mated assemblies shall be exposed to a 0.75 inch (19 mm) flame height applied for ten seconds to the region of the mated pair interface. The change in optical transmittance shall be measured during the test, and after the test once the test sample has returned to room temperature (see 4.8.5). The sample shall then be demated, and the unmated connector assembly with backshell and dust cover exposed to a 1.50 inch (38.1 mm) flame height applied for 60 seconds to the backshell-cable interface region. For connectors with dielectric inserts, the connector samples shall be exposed to a third flame, with a one and one-half inch flame height. The connector samples shall be remated and the flame shall be applied for 60 seconds to the region of the mated pair interface.

4.9.32 Visual examination. Each connector shall be visually examined in accordance with TIA-455-13. Attention shall be given to those assemblies that require a gasket to determine the condition of the gasket. Gaskets missing, twisted, buckled, kinked, or damaged in any way shall be cause for rejection. Each connector shall be visually inspected for the presence of compound between fiber termination end of insert and shell. Examinations shall include the following:

- a) Workmanship meets the requirements of 3.13.
- b) Design and construction meets the requirements of 3.4.1 thru 3.4.6 and the appropriate specification sheet (see 3.1).
- c) Connectors meet the requirements of 3.5 and the appropriate specification sheet (see 3.1).
- d) Backshell accessories meet the requirements of 3.6 and the appropriate specification sheet (see 3.1).
- e) Protective covers and storage receptacles meet the requirements of 3.7 and the appropriate specification sheet (see 3.1).

- f) Cable strength member terminations meet the requirements of 3.8 and the appropriate specification sheet (see 3.1).
- g) Tools are included as required by 3.9 and the appropriate specification sheet (see 3.1).
- h) Assembly instructions are included as required by 3.12 and the appropriate specification sheet (see 3.1).

4.10 Mud test (see 3.14). When specified (see 3.1), a mud bath consisting of a 50/50 mixture of potter's clay and sharp sand mixed with water (10% by weight) shall be contained in a vessel to a depth of 5 inches minimum. Two in-line connectors shall be mated and the insertion loss recorded in accordance with TIA455.20. Decouple and immerse both connectors in the mud bath for 5 minutes minimum. Remove the connectors and clean with water (immersion in the water is allowed). Connectors may be cleaned and dried. Removal of the insert cap for termini cleaning is allowed, but further disassembly of the connectors during cleaning is not allowed. Re-mate and record the received signal using TIA455.20. Insertion loss measured per 4.8.1 shall not exceed the limit specified in 3.14. Repeat the above test for a total of 10 times.

4.11 Fungus resistance (see 3.3.4.6). Connector materials not listed as fungus inert in guideline 4 of MIL-HDBK-454 (see 6.10) shall be tested in accordance with TIA-455-56 for a duration of 28 days.

4.12 Electromagnetic shielding. Electromagnetic shielding testing of receptacles mated to plugs with backshells and of receptacles mated to dust covers shall be conducted as follows. The test specimens (including terminated cable) shall be tested to determine the propagation characteristics (attenuation or conduction) of the specimen assembly. The shielding effectiveness of a shielded enclosure shall be verified in accordance with the procedures specified in IEEE-299 at the discrete frequencies specified in Table IX with the test specimen mounted in position. The test specimen receptacle shall be mounted into the wall (panel) of the shielded enclosure such that the plug or dust cover mates from the inside of the shielded enclosure. The cable(s) from the plug and receptacle shall be extended parallel to the test specimen for a minimum of 2 m on each side of the enclosure wall (panel). The dynamic range of the test setup shall be measured as specified in IEEE-299 at each discrete frequency specified in table IX. The measured level of radio frequency (RF) propagation through the test specimen installed in the shielded enclosure shall be determined in accordance with the procedures specified in IEEE-299 at each discrete frequency specified in table IX.

TABLE IX. Electromagnetic effects test frequencies.

Field propagation	Test frequencies
Planewave	100 MHz
	400 MHz
	1 GHz
Microwave	10 GHz

## 5. PACKAGING

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

## 6. NOTES

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

6.1 Intended use. The fiber-optic connectors specified herein are intended for use with low loss optical fiber cables in military, ground based, fiber-optic data transmission systems.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification.
- b. Specification sheet number, title and date.
- c. Part or Identifying Number (PIN).
- d. Quantity of connectors required.
- e. Inclusion of terminating tools, if desired (see 3.9).
- f. Color (see 3.11.3).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products, which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 83526 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from Defense Supply Center, Columbus, Attn: DSCC-VQP, P. O. Box 3990, Columbus, OH 43218-3990, [vqp.chief@dla.mil](mailto:vqp.chief@dla.mil).

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

6.3.2 Provisions governing qualification SD-6. Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.4 Application information.

6.4.1 Fiber-optic test plugs. Fiber-optic test plugs are plug assemblies that are used to simulate short or long lengths of fiber. This can be accomplished in a number of different ways, i.e., fiber core match or mismatch, fiber numerical aperture match or mismatch, etc. The test plug is simply a fiber-optic connector plug, which uses a short length of the required fiber that is "looped back" in the backshell. These test plugs find applications in many system functions. The following is a partial list:

- a. A test plug containing a fiber with characteristics like that of the deployment fiber can simulate a short length of fiber (low optical loss).
- b. A test plug containing a fiber with characteristics unlike that of the deployment fiber can simulate a long length of fiber (high optical loss).
- c. Using a combination of the above test plugs the user can evaluate the dynamic range of this system.
- d. Can be used in field situations where an Optical Time Domain Reflectometer (OTDR) is not available to determine fault locations.
- e. Allows system checkout to be performed without the actual deployment of cable assemblies.

6.5 Hydraulic fluid. MIL-PRF-5606 has been utilized successfully in the past.

6.6 Maintenance aging. MIL-HDBK-81969/46, MIL-HDBK-81969/47 and MIL-HDBK-81969/48 have provided satisfactory results for previous acquisitions.

6.7 Verification program. Evidence of compliance to a verification program established and maintained in accordance with MIL-STD-790 or comparable standard will be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification. The verification system procedures, planning and all other documentation and data that comprise the verification system must be available to the Government for review. The Government may perform any necessary inspections, verifications and evaluations to ascertain conformance to the requirements and adequacy of the implementing procedures.

6.8 Test equipment and inspection facilities. Provision for test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspections must be the responsibility of the contractor.

6.9 Isopropyl alcohol. Federal Specification TT-I-735 has provided satisfactory results when utilized in the past.

6.10 Fungus resistance. It was found that utilization of requirement 4 of MIL-HDBK-454 yielded satisfactory results in the past.

6.11 Subject term (key word) listing.

Backshells  
Cable, fiber optic  
Covers, protective  
Epoxies  
Inserts  
Optical performance requirements  
Strain relief, cable  
Termini  
Test plugs

6.12 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals is available on their website at <http://www.epa.gov/epaoswer/hazwaste/minimize/chemlist.htm>. Further information is available at the following EPA site: <http://www.epa.gov/epaoswer/hazwaste/minimize/>. Included in the EPA list of 31 priority chemicals are cadmium, lead, and mercury. Use of the materials on the list should be minimized or eliminated unless needed to meet the requirements specified herein (see section 3).

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

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APPENDIX A

PROCEDURE FOR INTERMATEABILITY AND INTEROPERABILITY QUALIFICATION INSPECTION

A.1 SCOPE.

A.1.1 Scope. This appendix provides additional information on the intermateability and interoperability qualification inspections. When specified (see 3.1) this appendix is a mandatory part of intermateability and interoperability for this specification. The information contained herein is intended for compliance.

A.1.2 Applicability. This appendix applies to sample preparation, submittal and inspection under this specification for qualification to the requirements of intermateability and interoperability.

A.2 APPLICABLE DOCUMENTS.

A.2.1 Government documents.

A.2.1.1 Specifications, standards and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARD

MIL-STD-2042 - Fiber Optic Cable Topology Installation Standard Methods For Naval Ships

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

A.3 QUALIFICATION SAMPLE.

A.3.1 Test sample. Fiber-optic connector, backshell, and accessory samples complying with the specified requirements (see 3.1) shall be submitted for qualification. The manufacturer shall provide a counterpart connector for each connector subjected to qualifying tests requiring mating assemblies. The counterpart connectors provided for this purpose shall be either, previously qualified connectors or new connectors submitted for qualification testing. Manufacturers not producing mating connectors shall submit data substantiating that tests were performed with qualified counterpart connectors. For those tests specifying the use of mated connectors, optical and mechanical test assessment shall be made using the assigned counterpart connector for those test measurements as required.

A.3.2 Sample preparation. Connectors shall be fully assembled into cable-connector assemblies using the types of cable specified in the applicable connector specification sheet. Connector terminals shall be optically finished with termini properly seated within their inserts. For mated connectors full sealing capability shall be provided as specified. The two samples for Intermateability and interoperability testing shall be provided with backshell, strain relief cable clamp and termini to ST jumpers (see figure A-1) for each terminus. The termini to ST jumpers shall be provided on a single fiber cable with a 2 mm outer jacket having a minimum length 6 ft (1.8 meters). Cable assemblies for submission shall be fabricated per Part 5 of MIL-STD-2042. Termini are to be polished using the standard dome polish specified in part

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5. Cable assemblies are to be constructed using multimode cable. The quantity of jumper assemblies provided shall be such to fully populate all connectors provided.

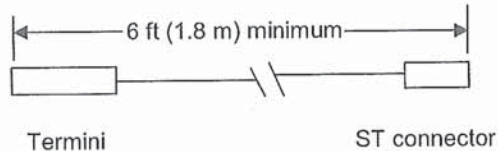


FIGURE A-1 Termini – ST jumper.

A.3.3 Sample submission. Contact Qualifying Activity (DLA Land and Maritime, Columbus, Attn: DLA Land and Maritime-VQP, P. O. Box 3990, Columbus, OH 43218-3990, [vqp.chief@dla.mil](mailto:vqp.chief@dla.mil)) for submission instructions for intermateability and interoperability test samples.

A.3.4 Sample disposition. Test samples submitted shall be retained by the Government as standards for use during future intermateability and interoperability testing. For the purpose of maintaining test standard integrity and security of vendors to certain types of product exposure, test standards will not be loaned outside the Government test lab.

#### A.4 QUALIFICATION INSPECTIONS.

A.4.1 Intermateability. All combinations of fully populated connectors from all manufacturers shall be mated and tested for insertion loss in accordance with 4.8.1. Results shall not exceed the requirements of 3.10.1.

A.4.2 Interoperability. All interchangeable components (backshells, termini and other components as applicable) shall be removed from both qualified and submitted connector plugs and receptacles. At random, interchangeable components shall be inserted into and shall fully populate submitted connector plugs and receptacles (see examples in Tables A-I, A-II, A-III, and A-IV below). These tables are examples based on test variations for one certified device and one candidate device. As additional devices are certified, the amount of test variations will increase in order to test the candidate device to each certified device. If multiple qualified termini exist, all sources will be used at random during test. At random, connector assemblies shall be mated and insertion loss shall be measured in accord with 4.8.1. Results shall not exceed the requirements of 3.10.1.

TABLE A-I. Backshell interoperability test configuration.

Configuration number	Receptacle backshell	Plug backshell
1	Candidate	Candidate
2	Qualified	Candidate
3	Candidate	Qualified

Table A-II verifies connector interoperability using termini from previous qualified source(s) tested in both qualified and candidate plugs & receptacles. Test variation 4 is required for hermaphroditic connectors only.

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TABLE A-II. Connector interoperability test configuration.

Configuration number	Connector	Termini	Connector	Termini
1	Qualified Receptacle	Qualified	Candidate Plug	Qualified
2	Qualified Plug	Qualified	Candidate Receptacle	Qualified
3	Candidate Receptacle	Qualified	Candidate Plug	Qualified
4	Qualified Plug	Qualified	Candidate Plug	Qualified

Table A-III verifies insert cap interoperability using termini from previous qualified source(s). This test verifies interoperability between qualified connectors/candidate insert caps and candidate connectors/qualified insert caps. Test variation between qualified connectors/qualified insert caps and candidate connectors/candidate insert caps were verified by default during connector interoperability (see Table A-II).

TABLE A-III. Connector / insert cap test configuration.

Configuration number	Connector insert cap	Termini	Connector insert cap	Termini
1	Qualified receptacle candidate insert cap	Qualified	Candidate plug qualified insert cap	Qualified
2	Qualified plug candidate insert cap	Qualified	Candidate receptacle qualified insert cap	Qualified

Table A-IV verifies termini interoperability using connectors from previously qualified sources and both qualified and candidate termini.

TABLE A-IV. Termini interoperability test configuration.

Configuration number	Connector receptacle	Termini	Connector plug	Termini
1	Qualified	Qualified	Qualified	Candidate
2	Qualified	Candidate	Qualified	Qualified
3	Qualified	Candidate	Qualified	Candidate

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## CONCLUDING MATERIAL

Custodians:

Army - CR  
Navy - AS  
Air Force - 85  
DLA - CC

Preparing activity:

DLA - CC

Project number (6060-2014-048)

Review activities:

Army - MI  
Navy - SH  
Air Force - 19, 99  
NASA - NA

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