SECTION 17250

FIBER OPTIC CABLE DISTRIBUTION SUBSYSTEM

PART 1- GENERAL

1.01 DESCRIPTION

A. Section includes requirements for fiber optic cable and associated passive components to provide a complete fiber optic structured cable system for station communications

B. Active components such as media converters and network switches are specified in Sections related to individual station communications subsystems.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1.	ICEA S-87-640	Fiber Optic Outside Plant Communications Cable
2.	TIA-455-177, FOTP-177	Optical Fibers Part 1-43: Measurement Methods and Test Procedures - Numerical Aperture

B. ASTM International (ASTM):

1.	D1248	Specification for Polyethylene Plastic Extrusion Material for Wire and Cable
2.	E814	Test Method for Fire Test of Through - Penetration Fire Stop

C. Code of Federal Regulations (CFR):

1.	7CFR1755.900	RUS Specification for Filled Fiber Optic Cables

D. Telecommunications Industry Association (TIA)/ Electronics Industries Alliance (EIA):

1.	TIA/EIA 455	Standard Test Procedure for Fiber Optic Fiber Cables, Transducers, Sensors. Connecting and Terminating Devices and other Fiber Optic Components
2.	TIA/EIA 455-3, FOTP-3	Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
3.	TIA 455-13, FOTP-13	Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies

4.	TIA/EIA 455-25, FOTP-25	Impact Testing of Fiber Optic Cables and Cable Assemblies
5.	TIA 455-33, FOTP-33-B	Optical Fiber Cable Tensile Loading and Bending Test
6.	TIA/EIA 455-37, FOTP-37	Low or High Temperature Bend Test for Fiber Optic Cable
7.	TIA/EIA 455-41, FOTP-41	Compressive Loading Resistance of Fiber Optic Cables
8.	TIA 455-78, FOTP-78-B	Optical Fibres: Part 1-40, Measurement and Test Procedures - Attenuation
9.	TIA 455-133, FOTP-133	Optical Fibres - Part 1-22: Measurement Methods and Test Procedures - Length Measurement
10.	TIA/EIA 455-81, FOTP-81	Compound Flow (Drip) Test for Filled Fiber Optic Cable
11.	TIA 455-82, FOTP-82	Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
12.	TIA/EIA 455-85, FOTP-85A	Fiber Optic Cable Twist Test
13.	TIA/EIA 455-88, FOTP-88	Fiber Optic Cable Bend Test
14.	TIA 455-91, FOTP-91	Fiber Optic Cable Twist-Bend Test
15.	TIA 455-104, FOTP-104	Fiber Optic Cable Cyclic Flexing Test
16.	TIA/EIA 455-171, FOTP-171	Attenuation by Substitution Measurement - for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
17.	TIA/EIA 455-181, FOTP-181	Lighting Damage Susceptibility Test for Optic Cables with Metallic Components
18.	TIA/EIA-4720000-A	Generic Specification for Fiber Optic Cable
19.	TIA-492AAAA-A	Detail Specification for 62.5-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers
20.	TIA 492-CAAB	Detail Specification for Class IVa Dispersion - Unshifted Single-Mode Optical Fibers with Low Water Peak
21.	TIA 526-7 - OFSTP-7	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

22.	TIA 526-14 OFSTP-14	Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
23.	TIA 568.3	Commercial Building Telecommunications Cabling Standard, components of fiber optic cable systems.
24.	TIA-598	Optical Fiber Cable Color Coding
25.	TIA/EIA-606	Administration Standard for Telecommunications Infrastructure

1.03 DESIGN CONSIDERATIONS

A. Station Communications shall deploy a fiber optic cable distribution as follows:

1. Single-mode fiber optic cable shall be deployed where subsystem products are available. Single-mode fiber optic cable shall be deployed on the station facility and platform grounds inside CER cabinets and between CER and the DC. Single mode fiber optic cable shall also be deployed between stations CER's and between station CER's and wayside systems not located on station or platform grounds.

2. Fiber optic cable shall serve as the backbone medium between the station communications equipment room (CER) and communication distribution cabinet (DC). The fiber cable shall be placed in a physical ring backbone topology. Backbone fiber cables shall consist of 24-strand single-mode fiber cabling, which shall be of outside plant design for outdoor applications and plenum design for indoor applications. All fibers shall be terminated, tested and certified, whether working or spare (dark).

3. There will be no intermediate cross-connect, patching, consolidation point, or other termination of the fiber optic cable between the CER and the DC.

4. The fiber optic backbone will be configured in a physical ring topology. The CER and each field communications distribution cabinet will have physically redundant entrances to facilitate the ring topology.

5. To facilitate future integrated (fiber direct) subsystem devices, single-mode fiber optic backbone cable will be deployed. The minimum cable size will be 24-strand cable.

6. Upon receiving the fiber cable shipment reels at the site, the Contractor shall conduct all necessary testing to verify and demonstrate to the Engineer that the shipped fiber cables are acceptable. All deficient or rejected fiber cabling equipment shall be rejected and returned back to the vendor for substitution.

7. Use of Multi-mode fiber cable and the associated equipment solutions shall be avoided and could only be permitted as an exception (due to

lack of adequate substitute based on single-mode fiber solution) and only if approved by the Engineer.

1.04 SUBMITTALS

A. Refer to Section 17000, Basic Communications Technical Requirements, for related and additional submittal requirements.

B. Submittals shall consist of a complete design description, including detailed drawings, specifications, and submittals of all subsystems and elements within the subsystem. Each calculation, test procedure, final drawing and submittal shall be reviewed and signed by a BICSI Registered Communications Distribution Designer (RCDD). For submittals involving engineering design services required by governing codes and regulations; system design and design calculations shall be sealed and signed in blue ink by a professional engineer, currently registered in the State of California, for the discipline involved. The final design document shall contain sufficient details for construction.

C. Submittals shall include all materials, equipment, assembly and installation required to carry out the functions and purposes indicated in the Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are specially indicated in the requirements of the Specifications.

D. Design submittal shall define interfaces between the systems. This includes both Communications and Signals.

E. Submit equipment lists including a table or list of model and part numbers for all proposed equipment and materials to be used for individual subsystems. Include the expected lead-time for each item while identifying in boldface type the ones with greater than 30 days. Group table or list for each subsystem with functional descriptions of equipment or material included.

1. Quantities by individual work location shall be included.

F. Submit Product Data Sheets with product information in sufficient detail to indicate that components meet these Specifications. The product model shall be indicated explicitly with arrow or underline on the product sheet submitted.

G. Submit calculations for each fiber optic cable span showing link margin and system gain.

H. Schedule: Submit schedule including identification and description of all major system cutover events or integration activities describing techniques, methods, duration and procedures.

I. Submit electrical, mechanical, and network communications block and functional diagrams with corresponding parts list using current AutoCAD standards.

J. Submit cable running lists per subsystem. Lists shall identify the size and type of cable, and identify the termination points of both cable ends. Include cable termination assignments by fiber strand or copper wire. Specify cable labeling (tags) for each cable per end.

K. Submit drawings showing equipment placement within the station. Include floor or wall profiles showing the location of equipment cabinets. Include vertical cabinet profiles showing the assigned placement of equipment within the cabinet. Depict all equipment within a cabinet, whether said equipment is new or existing.

L. Manufacturer Qualifications: Submit manufacturer's qualifications. Include cable manufacturer's ISO 9001 Certification Number.

1.05 QUALITY ASSURANCE

A. Materials, design, installation, and testing shall comply with all applicable Standards included herein. Be familiar with and adhere to the latest editions of these codes, regulations, specifications and standards.

B. Work shall meet or exceed the standards and procedures specified.

C. In the event of conflicts between reference standards, the most stringent provisions shall apply to the Work of this Section.

D. Manufacturer Pre-Qualification Requirements:

1. Obtain Engineer's approval of cable manufacturers and installers. The Provide all data required for Engineer evaluation and shall make the arrangements for any required demonstrations and tests.

2. Qualifications shall be based on the following criteria:

a. Past Performance and Experience: The cable manufacturers shall demonstrate previous successful experience in supplying, testing and installation of fiber optic cable specified herein.

b. Quality Assurance Program

i. The manufacturer of cables, in accordance with the requirements of these technical specifications, shall have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance.

ii. The cable manufacturer shall be ISO 9001 certified.

c. Warranty

i. The manufacturer shall warrant that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established, and generally accepted standards for fiber optic cable for transit applications; and that each such item and every part and component thereof shall comply with the Specifications.

ii. The Contractor shall monitor the manufacturers of the cable to assure that the Engineer approved Quality Assurance Program is being closely adhered to and that the fiber optic cable is being manufactured in accordance with these specifications.

iii. If the cable supplier is not the manufacturer of the fiber, the fiber manufacturer shall be identified.

1.06 DELIVERY, HANDLING, AND STORAGE

A. Packing: Ship cable on non-returnable wooden reels. The diameter of the drum shall be at least 20 times the diameter of the cable. Ship cable shall be shipped on reels substantial to withstand reasonable handling and shall be so designed that the inner end of the cable be accessible, but protected from injury. All ends of the cable shall be sealed to prevent entrance of moisture and securely fastened to prevent them from becoming loose during transit.

B. Marking: Label each reel on the outside flange with the following information:

1. Manufacturer's name
2. Contract name and number
3. Cable identification number
4. Cable length
5. Date of manufacture
6. Copy of the factory test results

PART 2- PRODUCTS

2.01 FIBER OPTIC CABLE

A. General Fiber Optic Cable Specifications:

1. All fibers in the cable shall be usable and meet required specifications.
2. The life expectancy of the cable shall be 25 years for service in a railroad and transit environment.
3. The cable shall be designed for installation in underground conduit, wet or dry environments, including alternating wet and dry conditions.
4. All fiber optic cable run in conduits or duct banks shall be an accepted product of the USDA Rural Utilities Service (RUS) 7 CFR 1755.900 and meet the requirements of ICEA S-87-640.
5. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

6. Each optical fiber shall consist of a germanium-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

7. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).

8. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

9. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

B. Enhanced Single-mode Optical Fiber for Telecommunications Applications:

1. The single-mode fiber utilized in the optical fiber cable shall meet ITU recommendation G.652.D; IEC Standard 60793-2-50 type B.1/G.655-G.655A).3; Telcordia GR-20-CORE; ANSI/ICEA S-87-640; and RUS 7CFR1755.900.

2. Geometry Standards:

a. Cladding Diameter (µm) = 125.0 ± 0.7

b. Core-to-Cladding Concentricity (µm) ≤ 0.5

c. Cladding Non-Circularity ≤ 0.7 %

d. Mode Field Diameter @ 1550 nm (µm) = 10.3 ± 0.5

e. Effective Area, Aeff (Characterized): (µm2) = 72

f. Coating Diameter (µm) = 245 ± 5

g. Colored Fiber Nominal Diameter (µm) = 242 ± 7

h. Fiber Curl radius of curvature (m) > 4.0 m

3. Optical Standards:

a. Cabled Fiber Attenuation @ 1310 nm (dB/km) ≤ 0.35

b. Cabled Fiber Attenuation @ 1550 nm (dB/km) ≤ 0.25

c. Point discontinuity @ 1550 nm (dB) ≤ 0.25

d. Cable Cutoff Wavelength (λccf) (nm) ≤ 1480

e. Total Dispersion (ps/(nm•km))

1300 nm = ≤ 3.0
1530 - 1565 nm = ≤ 18.0

1565 - 1625 nm = ≤ 22.0

f. Cabled Polarization Mode Dispersion (ps/km) ≤ 0.1 max

g. Water Peak Attenuation @1383+/- 3 nm; ≤ 2.1 dB/km

4. Environmental and Mechanical Specifications:

a. Temperature Cycling -60°C to +85°C

b. Temperature-Humidity Cycling -10°C to +75°C, 98 % RH

c. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).

d. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

e. Crush Resistance = 10 kN/m (685 Ib/ft) length of cable.

f. Cable Outside Diameter equal or < 0.65 inch

g. Weight per 1000 linear foot equal or <160lbs

h. Minimum Bending Radius:

Installation, 15X Diameter
Static, 12X Diameter

5. Cable Construction (Jacketed and Armored, Duct or Burial):

a. The cable meets the specifications set forth in Bellcore GR-20-CORE. Cable is listed by RUS to ICEA S-87-640 – ISO 9001 – 14001 – TL 9000 and shall be approved for use by RUS.

b. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be either 2.5 mm or 3.0 mm. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink-back requirements of USDA RUS 7 CFR 1755.900.

c. Each fiber shall be distinguishable by means of color coding in accordance with TIA-598. The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA-598. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1.0 mm. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to

fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

d. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes. In dual layer cables, any filler shall be placed in the inner layer. Fillers shall be nominally 2.5 mm or 3.0 mm in outer diameter.

e. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to provide tensile strength and prevent buckling. The central member shall be over coated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers.

f. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

g. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water wellable yarn(s) shall be applied longitudinally along the central member during stranding.

h. Two polyester yarn binders shall be applied contra-helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.

i. For single layer cables, a water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. I t shall also be free from dirt and foreign matter. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two layer core. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.

j. Cables shall contain two ripcords under the steel armor for easy armor removal. Additionally, armored cables that have an inner sheath shall also contain one ripcord under the inner sheath.

k. Tensile strength shall be provided by the central member, and additional dielectric yams as required. The dielectric yams shall be helically stranded evenly around the cable core.

l. Cables shall have an inner sheath of Medium Density Polyethylene (MDPE). The minimum nominal jacket thickness of the inner sheath shall be 1.0 mm. The inner jacket shall be applied directly over the tensile strength members (as required) and water swellable tape. A water swellable tape shall be applied longitudinally around the outside of the inner jacket.

m. The armor shall be a corrugated steel tape, plastic-coated on both sides for corrosion resistance, and shall be applied around the outside of the water blocking tape with an overlapping seam with the corrugations in register. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.4 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

n. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness.

o. The outer surface of the jacket of each shipping length of cable shall be permanently identified by printing (in a contrasting color) descriptive information on the outer surface of the jacket at intervals of 1500 mm (5 feet) or less. The information shall include identification (Caltrain Communications System), count of fibers, fiber type, date of manufacturing (month and year), manufacturer's part number, manufacturer's name, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code (NESC), fiber count, and fiber type. The actual length of the cable shall be within -0/+1 percent of the length markings. The print color shall be white, with the exception that cable jackets containing one or more co-extruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5mm.

p. If the initial marking fails to meet the specified requirements, i.e., improper text statement, color, legibility, or print interval, the cable may be remarked using a contrasting alternate color. The numbering sequence shall differ from the previous numbering sequence, and a tag shall be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color shall be yellow, with the secondary choice being blue.

C. Multi-mode Fiber for Local Area Network (LAN) Applications:

1. Multimode fibers shall meet EIA/TIA-492AAAA- "Detail Specification for 62.5-|um Core Diameter/125-um Cladding Diameter Class 1a Graded-

Index Multimode Optical Fibers." These fibers shall have the same specified performance and geometry values as noted below:

2. All fibers in the cable shall be usable and meet required specifications.

3. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

4. Each optical fiber shall consist of a germanium-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

5. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 degrees C on the original shipping reel.

6. Geometry:

    a. Core Diameter 62.5 ± 3.0um

    b. Core Non-Circularity ≤ 5 percent

    c. Cladding Diameter 125.0 ± 2.0um

    d. Cladding Non-Circularity < 2.0 percent

    e. Core-to-Cladding Concentricity ≤ 3.0um

    f. Coating Diameter 245 ± 5um

    g. Colored Fiber Nominal Diameter 253 – 259um

7. Optical:

    a. Cabled Fiber Attenuation

        i. 850 nm < 1.0 dB/km

        ii. 1300 nms ≤ 3.5 dB/km

    b. Point discontinuity

        i. 850 nm < 0.2 dB

        ii. 1300nm ≤0.2 dB

    c. Macrobend Attenuation

        i. Turns: 100; Mandrel OD - 75 ± 2 mm, < 0.5 dB at 850 nm

        ii. Turns: 100; Mandrel OD - 75 ± 2 mm, < 0.5 dB at 1300nm

d. Cabled Effective Bandwidth Modal

850 nm, > 385 MHz/km

8. IEEE 802.3 GbE Distance

a. 1000BASE-SX Window (850 nm), up to 500m

b. 1000BASE-LX Window (1300 nm), up to 1000m

9. OFL Bandwidth

a. 850 nm, > 200 MHz/km

b. 1300 nm, > 500 MHz/km

10. Numerical Aperture 0.275 ± 0.015

11. Mechanical Specifications:

a. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).

b. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

c. Crush Resistance = 10 kN/m (685 Ib/ft) length of cable.

d. Cable Outside Diameter < 0.65 inch

e. Weight per 1000 linear foot < 160lbs

f. Minimum Bending Radius

i. Installation, 15X Diameter

ii. Static, 12X Diameter

g. Temperature (Operational)

i. -30 degrees C (-22 degrees F) to +60 degrees C (140 degrees

ii. Continuous operation at -30 degrees C (-22 degrees F) without cracking or becoming brittle

h. Temperature (Storage)

i. -40 degrees F to +158 degrees F on reel

i. Humidity @ 0 to 100 percent, inclusive

j. Tensile Strength

i. Installation @ 2,700 N (600 Ibf)

ii. Static @ 890 N (200 Ibf)

D. Single-mode station distribution fiber optic cable will be Superior Essex #110243T01 or Engineer approved equal.

E. Multi-mode station distribution fiber optic cable will be Superior Essex #130246G01 or Egnineer approved equal.

2.02 FIBER CONNECTORS AND PASSIVE COMPONENTS

A. Fiber Connectors:

1. FDP connectors shall be SC and LC connector type (as required). SC-type connectors shall be the preferred connector for all terminations and equipment interfaces. LC connectors are typically used by the fiber optic connections to the modern Ethernet switches.

2. When available network products use connectors other than SC-type, optical patch cables shall be provided with the corresponding non-SC-type connector on the equipment end, and the SC-type connector on the distribution panel end. Example: SC-to-ST patch cord.

3. Optical parameters of the connectors shall meet the requirements of EIA/TIA-568.

4. SC-type fiber single-mode connectors shall be Hubbell FCSCSQ or approved Equal. SC-type and LC-type fiber connectors and ports for single-mode will be colored yellow. If multi-mode equipment is used, SC-type and LC-type fiber connectors and ports for multi-mode shall be colored orange. Where used, LC-type Single mode connectors shall be Hubbell #FCLCSM or Engineer approved equal.

5. Where used, SC-type fiber Multi-mode connectors shall be Hubbell # #FCSCMQ or approved Equal. Where used, LC-type fiber Multi-mode connectors shall be Hubbell #FCLCMM or Engineer approved equal.

B. Fiber Slack Enclosures:

1. Enclosures shall be NEMA-12 type with hinged cover and securing mechanism.

2. Enclosures shall be sized for 100 feet of cable slack.

3. Hardware

a. Hooks shall be provided to hold cable slack, with coils of required bend radius.

b. Velcro ties to restrain cable shall be utilized.

C. Fiber Distribution Enclosure:

1. Enclosure

a. The enclosure shall house the splice shelf and connector sleeve panels for all optical connections but as a minimum shall provide 48 connections for Single Mode and 48 connections for Multi-mode fibers.

b. All OSP cable jackets and central strength members shall be secured to relieve strain.

c. The enclosure shall be mountable in a standard 19" rack and be no more than 3 rack units high.

2. Fiber enclosure will be Hubbell #FCR350SE or Engineer approved equal.

D. Fiber Distribution Panels:

1. Distribution panels shall be a complete system of components by a single manufacturer.

2. Rack mountable connector housings shall be available for cross-connecting or inter-connecting purposes. The units shall provide for direct connecting and pigtail splicing.

3. Housings shall be mountable in an EIA-310 compatible 18.3 inch rack (19 inch EIA). The unit shall meet the design requirements of TIA-568.

4. Molded plastic parts shall meet flammability requirements of UL 94 V-0.

5. The connector housings shall have a labeling scheme that complies with TIA/EIA-606. The housing shall incorporate labeling via an adhesive backed label and a retractable sliding label panel that pulls out from the bottom front of the housing.

6. Housings shall be manufactured using 16-gauge aluminum and shall be finished with a Two-Tone Gunmetal Grey and/or anodized silver for durability. Installation fasteners shall be included and shall be black in color.

7. The unit shall be capable of connectorization and jumper management. The unit shall be capable of splicing or combination connectorization/splicing with the use of an additional splice tray kit.

8. Fiber Cable Routing: The Unit shall have a fiber routing guide platform located in the rear of the housing. The fiber routing guide platform shall be removable using two plunger style latches so that room can be made for an optional splice tray kit.

9. Jumper Routing:

a. The unit shall have a hinged top jumper management panel capable of locking in the horizontal or vertical position. When the top panel is locked in the horizontal position, it shall act as a jumper routing area in the top front of the housing and shall enclose the top of the housing.

b. When the hinged panel of the unit is locked in the vertical position it shall serve as a horizontal jumper management panel capable of routing jumpers out of the top of the housing. Total height of the housing shall be 5U or less.

10. Fan-Out Devices:

    a. Provisions for mounting up to 12 fiber fan-out devices shall be incorporated into the housing via a removable slack storage platform in the rear of the housing.

    b. Splice capacity shall be 12 splice trays.

11. Units shall include a clamshell-type cable clamping mechanism to provide cable strain relief. The cable clamp shall accept one cable from 0.37 inches-1.12 inches in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with a multiple cable insert. The total cable capacity per clamp shall be five cables (0.4 inches) OD when used with the multiple cable insert. Housing cable clamp capacity shall be two clamps. Additional cable clamps shall be available as an accessory kit.

12. The housing shall have four grommet openings for cable entry in the rear of the housing. The unit shall have two removable panels on both the left and right rear of the housing if more than four cable entries are required.

13. Front and rear doors of the connector housings shall be hinged and removable for ease of cable installation.

14. Access Doors:

    a. The front doors shall be made from tinted polycarbonate.

    b. Front and rear doors shall utilize a single slide latch to provide ready access and closing. An opening shall be provided in the front and rear doors so that an optional key lock kit may be used. The opening shall be filled with a removable plastic insert so that dust may not enter if the optional lock kit is not used. There shall be a removable retaining bracket to prevent the door from being unintentionally slid off the hinges.

15. The housing shall accommodate the future installation of LC, SC, ST, FC, D4, or MTRJ, type connector modules. Each module shall provide twelve connector sleeves.

16. The FDP will be Hubbell #FCR525SPR or Engineer approved equal. FDP adapter panel with 6 SC-type (or LC-type, if required) fiber bulkhead connectors will be Hubbell #FSPSC6 (or FSPLC6, if required) or Engineer approved equal. Adapter panels used for single-mode fiber will have yellow SC-type (or LC-type, if required) bulkhead ports. Adapter panels used for multi-mode fiber will have orange SC-type (or LC-type, if required) bulkhead ports.

E. Splice Shelf:

1. The splice shelf shall accept slide in/out splice trays for a maximum number of connectors and for the fiber types to be installed.

2. Each splice tray shall restrain and protect fusion or mechanical splices.

3. The splice tray shall hold 12 fusion splices and will be Hubbell #STRAY12F or Engineer approved equal.

F. Connector Sleeve:

1. Connector sleeves shall be the SC-type (or LC type, if required). The connector sleeve shall meet TIA-568-B.3 requirements when connecting mated pairs.

2. The FDP shall be fully populated with connector sleeves.

3. Dust Caps shall be provided for all sleeves.

4. Loss across connection shall not exceed the following, with optical attenuators removed:

   a. Single Mode: 0.5 db

   b. Multi-Mode: 0.5 db

5. The FDP sleeves shall be capable of accepting optical attenuators as required for maintaining the Optical Loss budget.

G. Slack Retention:

1. Slack in pigtails and patch cords shall be neatly coiled and retained such that the minimum-bending radius shall not be exceeded.

2. Slack shall be sufficient for accessing splice shelves and connectors.

2.03 OPTICAL FIBER PATCH CORDS AND PIGTAILS

A. Patch cords and pigtails shall be cable assemblies consisting of flexible optical fiber cable with SC (or LC, if required) compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer's standard product lines. Fiber optic jumper cables shall meet the following requirements.

B. Patch Cord Assemblies:

1. The cable construction shall allow a small bend radius for installation in space-constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket.

2. The Patch Cord shall comply with the requirements of TIA-568-B.3.

C. Connectors:

1. One SC-type (or LC-type, if required) duplex connector shall be provided on Patch cords.

2. One SC-type (or LC-type, if required) simplex connector shall be provided on pigtails, with the other end prepared for splicing.

3. SC-type (or LC-type, if required) connectors used for single-mode fiber will be colored yellow. SC-type (or LC-type, if required) connectors used for multi-mode fiber will be colored orange.

D. Fiber Cable:

1. Patch cords and pigtails shall utilize a two-fiber zip-cord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than 6 feet in length. The cable jacket color shall be orange for multi-mode and yellow for single mode cable. The fiber core size shall also be identified on the outer jacket.

2. The optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.

3. Tensile strength of the jacketed cable shall be greater than or equal to 20 lbs.

E. Signle-mode pigtails with SC-type (or LC-type, if required) connector on one end and the other end bare fiber, 3 meters length, shall be Hubbell #FPSCS3SM (or Hubbell #FPLCC3SM, if required) or approved equal. Where used, multi-mode pigtails with SC-type (or LC-type, if required) connector shall be Hubbell #FPSCS3MM (or Hubbell #FPLCS3MM, if required) or Engineer approved equal.

2.04 INNERDUCT

A. Constructed of flame retardant PVC or FCP material and shall meet the following flammability requirements:

1. OSP, inside building horizontal (no more than 50 feet from the point of entrance), and inside building riser inner-duct shall meet the UL 2024 (raceways) flame test.

2. Inner-duct installed in any air plenum environment shall meet NFPA 262-2002.

B. Inner-duct shall have smooth exterior and interior wall, and semi-rigid construction.

C. Inside building horizontal and riser inner ducts shall be flexible and corrugated type.

D. Compatible with the fiber optic cable installed within.

E. Inner diameter shall be 1 inch minimum.

F. Couplers, if used, shall not reduce the inside diameter of the inner-duct.

G. All unused inner-duct shall be preinstalled with lubricated pull tape or line.

H. Inner-duct used to house single-mode fiber cable will be colored yellow. Inner-duct used to house multi-mode fiber cable will be colored orange.

2.05 WIRE PULLING LUBRICANT

A. Wire Pulling Lubricant shall have the following characteristics:

1. Polymer-based

2. Average Coefficient of Friction: ≤ 0.055

3. Temperature Range: -28 degrees F -180 degrees F

4. Compatible with all cable types

2.06 AIR BLOWN FIBER OPTIC SYSTEMS

A. General Fiber Specifications:

1. All fibers in the bundle must be usable and meet required specifications.

2. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

3. Each optical fiber shall consist of high-grade silica, doped as necessary to achieve the required light guiding properties. The fiber shall be a matched clad, step-index design.

4. The fiber shall be coated with a dual layer of ultra-violet cured acrylate resin protective coating. The coating shall be in physical contact with the cladding surface.

5. The attenuation specification shall be a maximum value for each bundled fiber at 23 ± 5 °C on the original shipping reel.

6. The fibers will be contained in a soft inner acrylate layer, an outer harder layer which protects the fibers from damage, and a low friction layer that assists in improved blowing distance, typically in excess of 1000 meters.

7. Fiber bundle units will be available in a range of lengths up to 6000 meters.

B. The main optical, geometrical, and physical characteristics will be compliant with ITU-T Rec. G.652 C/D for Low Water-peak Single-mode Fiber.

1. Geometry Standards:

a. Cladding Diameter (µm) = 125.0 ± 0.7

b. Core Concentricity (µm) ≤ 0.84

c. Cladding Non-Circularity ≤ 1.0 %

d. Mode Field Diameter @ 1310 nm (µm) = 8.8 – 9.6

e. Effective Area, Aeff (Characterized): (µm2) = 72

f. Coating Concentricity (µm) ≤ 12.0

2. Optical Standards:

a. Cabled Fiber Attenuation @ 1310 nm (dB/km) ≤ 0.38

b. Cabled Fiber Attenuation @ 1550 nm (dB/km) ≤ 0.26

c. Point discontinuity @ 1550 nm (dB) ≤ 0.1

d. Attenuation at 1383 nm (dB/km) ≤ 0.35

e. Attenuation Uniformity over 2km (dB/km) ≤ 0.05

f. Dispersion Slope @ ps/(nm2.km) ≤ 0.089

g. Cable Cutoff Wavelength (λccf) (nm) ≤ 1480

h. Total Dispersion (ps/(nm•km)

1285 - 1330 nm ≤ 3.5
1550 nm ≤ 18.0

i. Cabled Polarization Mode Dispersion (ps/km) ≤ 0.5

j. Water Peak Attenuation @ 1383+/- 3 nm; ≤ 2.1 dB/km

C. Environmental and Mechanical Tests and Specifications:

1. Operation / Storage -10°C to +60°C yields ≤ 0.07 db/km @ 1310 and 1550 nm.

2. Condensation tested -10°C to +65°C @ 93% RH for 24 hours x 10 yields ≤ 0.07 db/km @ 1310 and 1550 nm.

3. Water immersion test at +20°C for 2000 hours yields ≤ 0.07 db/km @ 1310 and 1550 nm.

4. Cold tested at -20°C for 96 hours yields ≤ 0.07 db/km @ 1310 and 1550 nm.

5. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).

6. Bend tested @ 40 mm (2 & 4 fibers) or 60 mm (8 fibers) yields no change in attenuation after test.

7. Aged Bend tested (60°C for 1000 hours) 40 mm (2 & 4 fibers) or 60 mm (8 fibers) yields no change in attenuation after test.

8. Tensile Strength tested @ 1W N (9.81x mass of 1km) ≤ 0.4% (max fiber strain)

9. 12 Fiber Outside Diameter ≤ 1.3 mm

10. 12 Fiber Weight ≤ 1.5 g/m

11. 12 Fiber Blowing Distance 1000m typical

12. 12 Fiber Breakout 8 minutes typical

2.07 TECHNICAL SPECIFICATIONS FOR AIR BLOWN FIBER DUCT

A. Air blown fiber tube installed in existing duct, conduit, or inside buildings will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

B. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

Fiber Capacity	O.D (mm)	Nominal Weight (g/m)
2 x 5mm tubes (24 fibers)	12.8-13.8	78
4 x 5mm tubes (48 fibers)	14.8-16.5	116
7 x 5mm tubes (84 fibers)	17.8-19.4	159
12x5mm tubes (144 fibers)	23.0-24.8	234
24x5mm tubes (288 fibers)	32.3-34.4	422

C. The secondary multi-tube duct will include a moisture barrier aluminum shield and outer polyethylene sheath. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:

1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 1; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary assemblies greater than 0.5 mm after a maintained load of 1KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter

4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000m in length.

D. Air blown fiber tube installed outside, direct bury, will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown primary fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

E. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

Fiber Capacity	O.D (mm)	Nominal Weight (g/m)
2 x 5mm tubes (24 fibers)	11.0-13.2	142
4 x 5mm tubes (48 fibers)	18.1-22.3	204
7 x 5mm tubes (84 fibers)	21.6-23.3	278
12x5mm tubes (144 fibers)	28.2-29.5	479
24x5mm tubes (288 fibers)	37.8-39-1	755

F. The secondary multi-tube duct will include a moisture barrier aluminum shield and two (2) heavy duty outer polyethylene sheath layers. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:

1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 2; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary

assemblies greater than 0.5 mm after a maintained load of 2 KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter.

4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000 m in length.

G. Air blown fiber tube installed outside, direct bury, armored, will meet the following criteria:

1. Tubes will be low friction HDPE in small diameters for air blown primary fiber tubes up to 12 fibers per tube.

2. Each 12-fiber primary tube will have an outside diameter (O/D) of 5 mm.

3. A secondary HDPE fiber duct will house multiple primary 5 mm fiber tubes with the following specifications:

Fiber Capacity	O.D (mm)	Nominal Wt (g/m)
2 x 5mm tubes (24 fibers)	11.9	353
4 x 5mm tubes (48 fibers)	18.9	536
7 x 5mm tubes (84 fibers)	21.9	630
12x5mm tubes (144 fibers)	27.1	756
24x5mm tubes (288 fibers)	36.5	1071

H. The secondary multi-tube duct will include an inner polyethylene sheath layer, a corrugated armored layer, and an outer heavy duty polyethylene sheath layer. A ripcord will be included for easy cable access. The following shall apply to all secondary multi-tube assemblies:

1. Maximum tensile strength (N) = 1W; tested in accordance with IEC 60794-1-2 Method E1. There will be no permanent deformation of the primary or secondary assemblies after an applied load of 1.0 (spec.weight kg/km) N at 20 mm/minute.

2. The Crush Rating (KN) = 2; tested in accordance with IEC 60794-1-2 Method E3. There will be no permanent deformation of the primary assemblies greater than 0.5 mm after a maintained load of 3KN for 1 minute.

3. The minimum bend radius (mm) = 12 x diameter.

4. Stress crack resistance will be tested in accordance with BS6469 Section 99.1 with chemical Caflon CF30.

5. Individual fiber tubes will be opaque or translucent for fiber visibility.

6. Secondary multi-tube duct will be available on drums up to 3000m in length.

2.08 SOURCE QUALITY CONTROL - CABLE FACTORY TESTING

A. Factory tests shall be performed in accordance with TIA/EIA -455.

B. Cable shall be tested on-reel prior to shipment.

C. End to end loss shall be recorded for each fiber at 1,310 nm, 1,550 nm and 1,625 nm (for Single-mode).

D. End to end loss shall be recorded for each multi-mode fiber at 850nm, and 1,300 nm.

E. OTDR with hardcopy record shall be provided for each single mode fiber, at 1,300 nm, 1,550 and 1,625 nm.

F. OTDR with hardcopy record shall be provided for each multi-mode fiber, at 850 nm and 1,300 nm.

G. Polarized Modal Dispersion (PMD) for each single mode fiber shall be measured using a PMD analyzer and polarized light source.

H. Chromatic optical dispersion shall be tested for each single mode fiber.

I. Certified copies of tests results shall be submitted to the Engineer as described in these specifications 14 days after completion of each test.

PART 3- EXECUTION

3.01 INSTALLATION

A. All optical cable installation shall be accomplished in accordance with the approved plan.

B. All horizontal and backbone LAN fiber optic cable shall be installed in inner-duct. OSP fiber optic cable shall be installed in inner-duct at locations outside of the wayside trough as indicated in the Contract Drawings, through manholes, and through duct bank conduits. All duct bank four inch communications conduits serving fiber optic cable shall contain four 1 inch inner-ducts each. No more than one OSP fiber optic cable shall be installed in a single inner-duct. The inner-duct shall be installed without coils or twists.

C. Pull locations shall be selected to protect the cable on the reel and in slack loops. Be responsible for protecting cable after working hours where cable installation is not completed during a single shift. Cables damaged due to Contractor's negligence while installing cable shall be replaced.

D. Pull lengths shall be designed to allow a 20 percent margin in cable tensile strength. Do not exceed the lesser of 80 percent of the cable's maximum tensile rating or 600 lbs during installation. No residual tension shall remain on the cable after installation except that due to the cable's weight in the vertical rise. Wire Pulling Lubricant shall be used to reduce tension on the cable during the installation process.

E. If a winch or pulling machine is used during installation, a dynamometer shall be used to monitor the tension on the cable. The dynamometer shall be certified as calibrated and shall hold the peak value of the cable pull. The peak value shall be recorded and forwarded to the Engineer as part of the installation test data submittals.

F. The maximum vertical rise shall be defined as the distance over which the cable is self-supporting. Cable strain relief shall be used at the top of each vertical rise and no less than every time that 80 percent of vertical rise rating of the cable is exceeded.

G. Do not exceed the cable's minimum bend radius for cable under tension or long term installation/storage.

H. Continuity of cable shall be maintained between termination or splice locations shown on the Contract Drawings. Additional splices shall not be allowed without the prior written Engineer approval.

I. Notify the Engineer in writing at least 48 hours in advance of installation of each section of optical cable.

J. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E-814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an Engineer approved manner.

3.02 TERMINATION

A. Slack in Fiber Slack Enclosures (FSE's) shall be carefully coiled in order to avoid violating the short and long term minimum bend radius. Supply a minimum of 150 feet of slack at each termination of the cable inside the FSE.

B. Slack in Fiber Distribution Panels (FDP's) shall be restrained and shall be sufficient for strain relief.

C. The central strength member of cable shall be attached to the FDP. The outer jacket of cable shall be attached to the FDP with a cable clamp.

D. All fiber optic splices shall be fusion splices. Perform splicing at fiber slack enclosures only for the purposes of passing an optical connection through a Communications House. Fusion splicing shall be performed by qualified personnel utilizing a splicer equipped with Local Injection and Detection (LID) to

optimize splices. The loss across each spliced fiber shall be less than or equal to 0.04 db.

E. All fiber optical terminations at communications houses and wayside facilities shall be field or factory terminated.

F. Notify the Engineer in writing at least one week in advance of terminating each section of optical cable.

G. Where armored cable is utilized, the armor shall be grounded to the communications room ground bus at one termination location.

3.03 FIELD QUALITY CONTROL

A. Cable Factory Tests: See Source Quality Control herein.

B. Cable Plant Field Tests:

1. Tests shall be performed after installation is complete.

2. One week advance notice to the Engineer shall be provided.

3. Optical attenuation from FDP to FDP shall be recorded.

4. Every fiber optic cabling link shall be tested in accordance with the field test specifications defined by the TIA-568-B.3 (or by the required network application standards) whichever is more demanding.

5. TIA-568-B.3, shall be used to define the passive cabling network, to include cable, connectors, and splices (if present), between two optical fiber patch panels (connecting hardware). This TIA document shall be used to describe all applicable link segments. Tests shall include the representative connector performance at the connecting hardware associated with the mating of patch cords but not the performance of the connector at the interface with the test equipment.

6. All of the cabling links installed shall be tested and shall pass the requirements of the standards mentioned in above. Any failing link shall be diagnosed and corrected prior to the system acceptance. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance with Section 3.04 below.

7. Trained technicians who have successfully attended a required training program and have obtained a certificate, as proof thereof shall be used to execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

a. The manufacturer of the fiber optic cable and/or the fiber optic connectors

b. The manufacturer of the test equipment used for the field certification

c. Training organizations authorized by BiCSI (Building Industry Consulting Services International), or by the ACP (Association of Cabling Professionals™).

8. Field test instruments for multimode fiber cabling shall meet the requirements of TIA-526-14. The light source shall meet the launch requirements of TIA-455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap (as described in clause 11 of TIA-568) with a Category 1 light source. Field test instruments for single mode fiber cabling shall meet the requirements of TIA-526-7.

9. The test instrument calibration date shall be within the calibration period recommended by the vendor in order to achieve the vendor specified measurement accuracy.

10. The fiber optic launch cables and adapters shall be of high quality and the cables shall not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adapters.

11. The Pass or Fail condition for the link-under test is determined by the results of the required individual tests.

12. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.

13. An Engineer representative shall be invited to perform field-testing. The representative shall be notified of the start date of the testing phase five business days before testing.

14. The Engineer's representative shall select up to five percent of the links installed. The representative (or his authorized delegate) shall test these selected links and the results are to be stored in accordance with the prescriptions in this Section. The results obtained shall be compared to the data provided by the Contractor. If the sample results differ in terms of the pass/fail determination, repeat testing of the affected link under observation of the Engineer.

C. Cable Plant Performance Test Parameters:

1. In compliance to TIA 568, the single performance parameter for field-testing of fiber optic links shall be link attenuation (insertion loss).

2. The link attenuation shall be calculated by the following formulas specified in ANSI/TIA/EIA 568:

a. Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation

b. Cable Attenuation (db) = Attenuation Coefficient (db/km) x Length (km)

c. Connector Attenuation (db) = number of connector pairs x connector loss (db). Maximum allowable connector loss = 0.75 db

d. Splice Attenuation (dB) = number of splices (S) x Splice loss (db). Maximum allowable splice loss = 0.3 db

e. The values for the Attenuation Coefficient are listed below:

i. Single mode (outside plant), 1310nm: 0.5 db/km

ii. Single mode (outside plant), 1550nm: 0.5 db/km

iii. Multimode, 850 nm: 3.5 db/km

iv. Multimode, 1300 nm: 1.5 db/km

f. Link attenuation shall not include any active devices or passive devices other than cable, connectors, and splices, i.e., link attenuation shall not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

g. Test equipment that measures the link length and automatically calculates the link loss based on the above formulas is preferred.

3. The above link test limits attenuation is based on the use of the One Reference Jumper Method specified by TIA-526-7, Method A.1; or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.

4. Multimode distribution links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14. Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation shall be used to determine limit (acceptance) values.

5. Single-mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with TIA-526-7, Method A.1, One Reference Jumper or the equivalent method. All single-mode links shall be certified with test tools using laser light sources at 1310 nm and 1550 nm.

6. Links to be used with network applications that use laser light sources (under-filled launch conditions) shall be tested with test equipment based on laser light sources. This rule shall be followed for cabling systems to support Gigabit Ethernet. Gigabit Ethernet only specifies laser light sources. For Gigabit Ethernet compliant certification (IEEE Std 802.3Z application), use test equipment that uses a VCSEL (Vertical cavity surface emitting laser) at 850 nm (compliant with 1000BASESX) and a FP laser at 1310 nm (compliant with 1000BASELX).

7. Each fiber optical link terminated with an optical adapter system that does not impose a transmission direction because the adapters are not or cannot be ganged shall be tested and documented in both directions since the direction of the signal transmission cannot be predicted at the time of installation.

D. OTDR Testing:

1. All cables shall be OTDR tested at 1310 nm and 1550 nm (for Single-mode) operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.

2. OTDR tests shall be performed utilizing a pulse suppressor such that the FDP termination shall be shown.

3. All OTDR testing procedures and field test instruments shall comply with applicable requirements of:

   a. TIA 455-78

   b. TIA 455-133

4. Each fiber link and channel shall be tested in one direction.

5. A launch cable shall be installed between the OTDR and the first link connection.

6. A receive cable shall be installed after the last link connection.

7. Optical Return Loss (ORL) for each link shall be measured.

8. Fiber Length shall be measured

9. Test Results:

   a. Reflective events shall not exceed -40 dB

   b. Connections shall not exceed 0.75 dB of attenuation

   c. Non-reflective events (splices) shall not exceed 0.3 db

   d. Point discontinuities shall not exceed 0.1 db

   e. ORL shall be less than -30 dB

10. OTDR Test results shall include OTDR link and channel traces and event tables at the required wavelength(s) and the length for each optical fiber as calculated by the OTDR.

11. An Optical Spectrum scan of each link shall be performed using an optical spectrum analyzer and optical switch to examine fiber nonlinear effects including but limited to Brillouin scattering and four wave mixing across the fiber's usable light spectrum.

12. Polarized Modal Dispersion (PMD) for each link shall be measured using a PMD analyzer and polarized light source. Total PMD for each link shall be less than 10 ps.

E. Cable Plant Test Result Documentation:

1. The test result information for each link shall be recorded in the memory of the field tester upon completion of the test.

2. The test result records saved by the test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee shall be made that these results are transferred to the PC unaltered, i.e., "as saved in the tester" at the end of each test. The popular 'csv' format (comma separated, value format) does not provide adequate protection and shall not be acceptable.

3. The database records of all fiber shall be stored and delivered on CD-ROM; this CDROM shall include the software tools required to view, inspect, and print any selection of test reports.

4. A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information.

   a. The identification of the link in accordance with the naming convention defined in the overall system documentation.

   b. The overall Pass/Fail evaluation of the link-under-test including the Attenuation worst-case margin (margin is defined as the difference between the measured value and the test limit value).

   c. The date and time the test results were saved in the memory of the tester.

5. General Information to be provided in the electronic data base containing the test result information for each link:

   a. The identification of site

   b. The overall Pass/Fail evaluation of the link-under-test

   c. The name of the standard selected to execute the stored test results

   d. The cable type and the value of the ‘index of refraction' used for length calculations

   e. The date and time the test results were saved in the memory of the tester

   f. The brand name, model and serial number and calibration data of the tester

g. The revision of the tester software and the revision of the test standards database in the tester

6. The detailed test results data to be provided in the electronic database for each tested optical fiber shall contain the following information.

   a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.

   b. The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).

   c. The link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas specified herein under Cable Plant Performance Test Paragraphs.

END OF SECTION