2014

# New Building & Building Renovation Cabling

## Information Technology (IT) Department
## City of Augusta Georgia

This document gives guidance to installing cabling that is for the exclusive use of the IT Department for City projects. Installers will consult with the Information Technology Department on all projects.

Check the City of Augusta website for updates to this document at least every thirty (30) days. The document can be located at the following location. http://www.augustaga.gov/IT

*Infrastructure Group - Augusta Richmond County Rev. 2.3.1*

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## GENERAL

The content of this document references specifications that apply to cabling and spaces that are for use exclusive by the Information Technology Department (IT). Access to MDF and IDF locations will be controlled by IT and all access methods and keys to rooms and cabinets will be managed by the IT department. Other cabling and spaces should be addressed separately, e.g., security systems, and should be addressed by the building owner or Marshal's Office. The IT department will assist other departments if requested but guidelines in this document do not address any requirements other than those for use by the IT department only.

As part of the architectural drawings we ask that a diagram that shows only the IT cabling, power, and space requirements be included. Those requirements would include the low voltage layout, location of cable outlets, copper cabling, fiber cabling, internal and external conduits, power outlets, outlets on generator power, fire suppression used for IDF and MDF, IDF specifications, MDF specifications, backboards, cable rack locations, MDF and IDF dimensions, and server or cable cabinet locations. The architectural drawing must be approved by the IT department before any construction begins or contractor bids are released.

All new buildings and building renovations will use CAT6 rated cable to accommodate data and voice, (both initial and future needs) and no single use wiring plans (i.e., voice only or data only) will be acceptable without prior approval from the Information Technology Department.

**All cabling and all cable associated items such as jacks, faceplates, patch panels, racks, cabinets, cable suspension devices, labeling, conduit and certifications will be supplied and installed by the contractor as part of the overall building cost design and construction.**

**For overall specifications please see sections under heading "System Cabling Specifications".**

All cabling and parts will be installed so as to be in compliance with Georgia State Electrical and Fire codes and standards.

Cabling infrastructure will be approved by the Information Technology Department. Final architectural drawings will be submitted for review in soft file format in Microsoft Visio or AutoCAD DWG.

If any preferences, specification, or requirements set forth in this document result in a disproportionate increase in related expenses please contact your designated Information Technology contact for additional clarification or reconsideration.

## OUTSIDE CABLING AND CONDUIT

This section constitutes the Information Technology Departments general outside cabling and conduit requirements for data and telephone services for new buildings and for renovation of existing buildings where expanded services to the building will be required.

A. Planning and Design

The planning process will include the data and telephone service needs. The Information Technology Department will assist in the specifications for telephone and data service and will be contacted to be sure cabling needs have been reviewed, and the design for all telecommunications systems approved.

B. General Guidelines for Outside Conduit and Cabling

1. Outside Conduit
   The conduit specifications noted below represent the connection from the building main distribution facility room to the appropriate network pathway. In general, the following conduit will be required:
   a. Two outside pathways will be installed to the most appropriate right of ways.
   b. A minimum of one 4" PVC conduit (with pull string)
   c. A minimum of one 4" PVC conduit with a minimum of three 1” innerducts (with pull strings) for data/video cable
   d. One spare (empty) 4” PVC conduit with a minimum of three 1” innerducts (with pull strings)

   - Conduits should be a minimum schedule 40 or 80 based on location.
   - Conduits will terminate in an appropriate sized in-ground enclosure or vault and meet ANSI/SCTE 77 specifications for underground enclosures.
   - All conduits will be watertight and free of water.
   - Any variation to above stated sizing must be approved by the Information Technology Department.

2. Outside Cabling

   Outside cabling will be enclosed in PVC conduit as noted above unless otherwise agreed upon. General guidelines for outside cabling from the building main distribution facility room to the nearest pathway are noted below:

   a. The telephone cable shall be 24 gauge jelly-filled cable. The pair’s quantity will be 50 or 100 and shall be determined by the Information Technology Department.
   b. Fiber cabling will include a minimum of 96 strands for single-mode and 48 strands for multi-mode installations.

C. Planning and Design

The planning process will include the data and telephone service needs. The Information Technology Department will assist in the specifications for telephone and data service and will be contacted to be sure cabling needs have been reviewed, and the design for all telecommunications systems approved.

D. Cost Estimates

1. New Buildings and Renovations

For new buildings and renovation projects the conduit, common equipment, and cabling costs for data and telephone will be supplied and installed by the contractor as part of the overall project cost.

E. Leased Circuits

If there is a current or future need for leased common carrier circuits (i.e., T1) from a telecommunications provider; then a "common carrier entrance conduit" must be provided. The cabling will be provided by the telecommunications provider; however, the conduit from the buildings telephone equipment room to the nearest point of presence (i.e., manhole or telephone pole) will be included, installed and paid for as part of the building project. This conduit is for the telecommunications providers use only and should not be confused with the other conduit requirements as noted in A.1 above.

## INSIDE CABLING AND CONDUIT

This section constitutes the Information Technology Departments general requirements. For overall specifications please see sections under heading “System Cabling Specifications.”

A. General Guidelines for Inside Cabling and Conduit

a. The general guideline for installing inside cabling for new buildings require the contractor to provide all labor and materials for installation of the interior building cable system including interior conduit.
b. Labeling shall conform to ANSI/TIA/EIA-606A standards.
c. Label each outlet, cable, and patch panel with permanent self-adhesive labels. Labels must be machine printed.
d. All conduits in swabbed free of debris and moisture before wires are pulled.
e. Seal all conduits watertight after conduits or duct banks are complete.
f. Non-conduit systems are preferred for horizontal cabling above ceilings (i.e. cable tray systems or j-hooks)
g. All interior conduit ends will be sealed to be watertight.

B. Building Cabling Infrastructure Requirements

1. General

a. All buildings will provide one dedicated communications main distribution facility room (MDF) and if needed one or more dedicated intermediate distribution facility rooms (IDF). At a minimum each floor will have one distribution facility.
b. MDF and IDF rooms in multiple-floor buildings should be stacked vertically and centrally located unless cabling length requirements cannot be met.
c. The MDF will be at least 8'x8' in size and each IDF must be at least 8'x8'. These are the minimum acceptable sizes. Each MDF/IDF will be furnished with appropriately sized panels of 3/4" thick A-C plywood void-free and capable of supporting attached equipment. The plywood should be fire-rated for a minimum of two hours and the fire rating must be clearly labeled and visible for inspection. The size and number of the panels and mounting location will be determined by the Information Technology Department.
d. These rooms must be dust and static free and, provide air conditioning or air flow so that the temperature remains between 64 and 75 degrees Fahrenheit, relative humidity shall be between 30% and 55%, security (i.e., a lockable door), and lighting.
e. Each distribution facility will be equipped with separate electrical outlets for IT use only, each with a dedicated power circuit. Outlets will have a duplex NEMA 5-20R, a single L5-20R, and a single L6-20R receptacle for each cabinet. Receptacles will be located in proximity to room's backboard, rack or in cabinet. Receptacle types are determined by load requirements in each MDF/IDF. Consult with the Information Technology Department for each room's requirement. The main outlets should be no more than 18 inches apart.
f. Each distribution facility should also have a minimum of duplex 5-15R receptacles on the two adjacent walls.
g. All UIC Telecommunications Equipment and raceways will be properly grounded in accordance with ANSI/TIA/EIA-607, the NFPA 70 (National Electric Code), and all other applicable codes and regulations.
h. The Major components for the telecommunications grounding and bonding infrastructure are as follows:
    1. The bonding conductor for telecommunications.
    2. The Telecommunications Main Grounding Busbar (TMGB)
    3. The Telecommunications Grounding Busbar (TGB)
    4. The Telecommunications Bonding Backbone (TBB)
    5. The Telecommunications Bonding Backbone Interconnecting Bonding Conductor (TBBIBC)
    6. The conductors used to bond the components to the TMGB & the TGB's.
i. A fire suppression system will be installed in all MDF and IDF rooms. The clean agent suppression system must meet the National Fire Protection Agency's rating for type A, B, and C fires. All requirements for the suppression system are to be included in the suppression system solution.

Examples of requirements would be the lock out/abort switch, manual pull station, control panel, wiring, ventilation, and installation.

j. Each IDF and MDF must be provided with a means of wiring egress. It is recommended that this can be accomplished by providing four 4" "home run" conduits running from MDF to IDF #1 to IDF #2, etc., or by providing two 3" conduit sleeves in each IDF/MDF room. However, if this latter sleeve approach is used, there must be an unobstructed path for as many as 100 wires to travel from MDF to IDF #1, IDF #1 to IDF #2, etc. Under no circumstances shall any conduit contain more than two (2) 90 degree bends nor exceed 180 degree total bending angle without the installation of pull box(s) to accomplish the above.
k. A copper pair cable will be installed to each floor's distribution facility. All copper pairs will originate in the MDF. The number of pairs per floor will be determined by the building size and requirements but a minimum of 25 pairs per floor will be installed. An appropriately sized copper pair cable for the MDF will terminate on a 66/110 block located on the rooms backboard near the Telco providers dmarc and terminate on an analog patch panel. All MDF to IDF's copper pair cabling will originate from a patch panel in the MDF rack or cabinet and terminate on an analog patch panel in each IDF rack or cabinet. When multiple patch panels are required they should be installed stacked one on the other in the rack or cabinet.
l. Patch panels shall provide capacity to accommodate all installed cables plus twenty percent for future growth.

C. Work Station Cabling Runs

1. General

a. Station cabling runs should be plenum CAT6 type cable and should be installed in 1" minimum conduit. Under no circumstances shall any conduit contain more than two 90 degree bends nor exceed 180 degree total bending angle without the installation of pull box(s) to accomplish the above. The station receptacle box shall be a minimum of 1.75" deep.
b. Conduit, at a minimum, shall run from a receptacle box (as marked on the building plans) to at least stubbed above the ceiling, conduit will have the appropriate bushing to protect cables and then unobstructed wiring egress to the appropriate IDF located on the same floor. When running conduit from the receptacle box to the IDF or MDF a maximum of six CAT6 cables are allowed per run, attaching daisy chained connections are not allowed. The receptacle must be within 300 cable feet of the wiring frame. If divided raceway is used to serve both electrical and communication, the raceway must be metal. Under no circumstances should cable be installed below ceiling in

an exposed fashion, i.e., all surface mounted cable should be enclosed in conduit.

c. Cables shall not be tie wrapped or routed along electrical or gas conduit. Station cable runs above a suspended ceiling shall be in a cable tray, or be secured to the wall directly above the suspended ceiling or to the concrete ceiling structure every three feet by cable hangers. Cable ties must be trimmed off cleanly at the locking hole. Hook and loop fasteners may be used. Cables shall be secured at every corner. Cables shall be run in a uniform fashion and shall not be woven among other utilities.
d. At the receptacle box end, enough additional cable (slack) must be left to reach the farthest corner of the wall, plus five feet. At the IDF/MDF end, at least 10 feet of additional cable (slack) must be provided past the center point of the appropriate voice or data racks as determined in B.2.
e. Each cabling run must be individually labeled (tagged) with permanent self-adhesive labels. All cabling must be labeled; hand written labels are not acceptable.
f. At the receptacle box end cable labeling must identify the MDF or IDF where it terminates.
g. Each cabling run must be tested and certified in compliance with industry standards.
h. All CAT6 cabling runs will terminate on the appropriate sized patch panel.
i. A printout of the certification testing must be provided to the Information Technology department. Electronic versions may be submitted if they are in an acceptable format.
j. A minimum of two CAT6, 4 pair UTP blue cables shall be run from the receptacle box to the appropriate IDF/MDF.
k. No cabling runs will exceed 300 cable feet (receptacle box to serving IDF/MDF wiring frame).
l. Cable color will be blue for all cabling except those cables specified for wireless equipment connections which will be yellow.

D. Distribution Specifications

The MDF shall be connected to each IDF with a separate multi-mode, twelve strands, OFNP type (optical fiber, non-metallic, and plenum) fiber optic cable enclosed in innerduct. This fiber optic cable shall have at least 30 feet of additional cable (slack) on each end upon entering each IDF/MDF room. This fiber shall not have a bending radius exceeding the bending radius specs of the cable manufacturer. Fiber cables shall be terminated in rack mounted LIU patch panel.

E. Execution

1. Work Station Jack Installation - Surface Mount

Station jacks shall be installed in accordance with industry standard specifications. They shall be mounted approximately one foot from the floor (unless specified otherwise). The modular jack opening shall face out, down, or to

either side, but not up. Where the opening faces out, the notch for the locking tab shall be on the bottom.

2. Work Station Jack Installation – Flush Mount

   Station jacks shall be installed in metal or plastic outlet boxes in the wall. The boxes must be secured in the wall so that no movement occurs during installation use or during normal use. The jack and wall plate must be secured to the box by metal screws. The jack shall be oriented so the locking tab is facing downward.

3. Work Station Jacks

   Each station jack will be blue in color and the face plate white, ivory, or metal. Only one color face plate shall be used throughout the project. Station jack types should conform to EIA/TIA 568B specifications for CAT6 cabling.

## INSIDE CABLING – DATA SERVICES

This section constitutes the Information Technology Departments general requirements. For overall specifications please see sections under heading "System Cabling Specifications".

1. The inside cabling specifications for data services will be determined based on the specific functional requirements of the building. The Information Technology Department will provide consultation and preliminary planning guidance to assist the designers in providing the cabling requirements on a case-by-case basis for each building.
2. Drawings of all cabling clearly labeled should be provided to the Information Technology Department in soft copy format using Microsoft Visio or AutoCAD format.
3. All cabinets, racks, and common equipment used by Augusta's Information Technology Department will be for their use exclusively. All keys and key copies associated with this equipment will be given to and kept by the Information Technology Department.
4. The Contractor shall install equipment and materials in accordance with applicable standards, codes, requirements, and recommendations of national, state, and local authorities having jurisdiction, National Electrical Code (NEC), and with the manufacturer's printed instructions.

## SYSTEM CABLING SPECIFICATIONS

A. General

The following sections are to be used for guidance in the installation of indoor and outdoor cabling for the City of Augusta's data and telecommunications use. Any questions regarding the specifications or items not listed should be directed to the Information Technology Department.

Unless otherwise recommended by the manufacturer, all fiber cables will be run in innerduct where applicable.

B. Industry Requirements

The following installation, documentation, component, and system industry specification s shall be met or exceeded

- ANSI/TIA/EIA-568-B.1 and addenda
  *"Commercial Building Telecommunications Cabling Standard Part 1: General Requirements"*
- ANSI/TIA/EIA-568-B.2 and addenda
  *"Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted Pair"*
- ANSI/TIA/EIA-568-B.3 and addenda
  "Commercial Building Telecommunications Cabling Standard Part 3: Optical Fiber Cabling and Components Standard"
- ANSI/TIA/EIA-569-B and addenda
  *" Commercial Building Standard for Telecommunications Pathways and Spaces"*
- ANSI/TIA/EIA-606-A and addenda
  *" Administration Standard for the Telecommunications Infrastructure of Commercial Buildings"*
- ANSI-J-STD-607-A and addenda
  *" Commercial Building Grounding and Bonding Requirements for Telecommunications"*
- ANSI/TIA/EIA-526-7
  *"Measurement of Optical Power Loss of Installed Single Mode Fiber Cable Plant"*
- ANSI/TIA/EIA-526-14A
  *"Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant"*
- IEC/TR3 61000-5-2 - Ed. 1.0 and amendments
  *"Electromagnetic compatibility (EMC) Part 5: Installation and mitigation guidelines Section 2: Earthing and cabling"*
- ISO/IEC 11801:2002 Ed2.0 and amendments
  *" Information Technology Generic cabling for customer premises"*
- CENELEC EN 50173:2000 and amendments
  *" Information Technology Generic cabling systems*

C. Generic Specification for Tight Buffer Optical Fiber Cables for Indoor Distribution

1. General Considerations

   a. The cable must meet the requirements of the National Electrical Code® (NEC) ® Section 770.
   b. Non-Plenum Applications - Applicable Flame Tests: UL 1666. Cables shall be listed OFNR (OFCR).

c. Plenum Applications - Applicable Flame Test: NFPA 262. Cables shall be listed OFNP (OFCP).
d. Finished cables shall conform to the applicable performance of the Insulated Cable Engineers Association, Inc. (ICEA) *Standard for Fiber Optic Premises Distribution Cable* (ICEA S-83-596).

2. Fiber Specifications

Detailed information on the cabled performance of the fiber types available for this cable design can be found in the following sections: "Generic Specification for Single-mode Optical Fiber in Tight Buffer Cables" and "Generic Specification for Multimode Optical Fiber in Tight Buffer Cables."

3. Cable Construction

a. The coated fiber shall have a low friction slip layer placed between the acrylate coating of the optical fiber and the thermoplastic buffer. The diameter of the thermoplastic buffer coating shall be 900 ± 50 μm.
b. The fiber coating and buffer shall be removable with commercially available stripping tools in a single pass for connectorization or splicing.
c. Cables with 2 to 24 Fibers
   - Layered strength yarns shall serve as the tensile strength member of the cable.
   - A ripcord may be applied between the strength yarns and the outer jacket to facilitate jacket removal.
   - The outer jacket shall be extruded over the strength yarns for physical and environmental protection. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness. The jacket shall be smooth, as is consistent with the best commercial practice.
d. Riser and Plenum
   - The fibers shall be stranded around a dielectric strength yarn. For cables containing 12-24 fibers, the fibers shall be arranged in two layers.
   - The dielectric strength yarn shall be over coated with a thermoplastic, when required, to achieve dimensional sizing to accommodate and support the 900 μm buffered fibers.
e. Cables with 24 to 54 Fibers: Unitized Riser and Plenum Constructions
   - The buffered fibers shall be grouped in 6-fiber subunits.
   - The fibers shall be stranded around a dielectric strength yarn in the subunit.
   - Layered strength yarns shall serve as the tensile strength member of the subunit.
   - A ripcord may be applied between the strength yarns and the subunit jacket to facilitate jacket removal.

- The subunit jacket shall be extruded over the strength yarns for physical and environmental protection. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness. The jacket shall be smooth, as is consistent with the best commercial practice.
- The subunits shall be stranded around a dielectric central member. A ripcord shall be inserted beneath the outer jacket to facilitate jacket removal. The outer jacket shall be extruded around the subunits.

f. Outer Cable Jacket
- The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
- The nominal thickness of the cable outer jacket shall be sufficient to provide adequate cable protection while meeting the mechanical, flammability, and environmental test requirements of this document over the life of the cable.
- The cable jacket color shall be orange for cables containing multimode fiber except for cables containing 50/125 µm Laser Optimized Fiber, which shall have an aqua colored jacket. The cable jacket color shall be yellow for cables containing single-mode fiber.
- The cable shall be all dielectric except as noted below.
- The indoor distribution cable specified herein shall be available with an optional interlocking armor made of aluminum. The interlocking armor for riser cables may be left uncoated or may have a PVC jacket. The interlocking armor for plenum cables shall have a PVC jacket. The color of the armor jacket (if specified for riser cables), shall match the jacket color of the optical fiber cable located inside of the armor. The armor for these cables shall be comparable to liquid tight flexible metal conduit if jacketed, or flexible metal conduit if not. The interlocking armor and jacket option will be specified on the purchase order. Cables with interlocking armor shall be available in fiber counts up to 72 fibers.

g. Identification
- The individual fibers shall be color-coded for identification. The optical fiber color coding shall be in accordance with EIA/TIA-598, "Optical Fiber Cable Color Coding." The coloring material shall be stable over the temperature range of the cable, shall not be susceptible to migration, and shall not affect the transmission characteristics of the optical fibers. Color-coded buffered fibers shall not adhere to one another.
- When buffered fibers are grouped into individual subunits, each subunit jacket shall be numbered for identification, with the exception of filler subunits where used. The number shall be repeated at regular intervals. The subunit jacket color shall be orange for subunits containing multimode fibers except for subunits containing 50/125 µm Laser Optimized Fiber,

which shall have an aqua colored subunit jacket, yellow for subunits containing single-mode fibers, and white for filler subunits.

- The outer jacket for all dielectric cable shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet. The marking shall be in contrasting color to the cable jacket.
- Cables with a PVC jacket over interlocking armor shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet. The marking shall be in contrasting color to the cable jacket. The cable jacket color shall match the color of the core optical fiber cable.

4. Cable Specifications

a. Temperature Range
   - Non-Plenum Applications. The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for riser cables shall be -10 °C to +60 °C. The operational temperature range for riser cables shall be -20 °C to +70 °C. Testing shall be in accordance with FOTP-3.
   - Plenum Applications. The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for plenum cables shall be 0 °C to +60 °C. The operational temperature range for riser cables shall be 0 °C to +70 °C. Testing shall be in accordance with FOTP-3.

b. Crush Resistance.
   - When tested in accordance with FOTP-41, “Compressive Loading Resistance of Fiber Optic Cables,” the cable shall withstand a minimum compressive load of 100 N/cm (57 lbf/in) applied uniformly over the length of the compression plate. While under compressive load, the fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

c. Cyclic Flexing
   - When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The jacket shall not crack, split, or tear.

d. High and Low Temperature Bend
   - When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at low temperatures of -10 °C for riser cables and 0 °C for plenum cables. The cable shall also withstand four full turns at a high

temperature of +60 °C for both riser and plenum cables. The mandrel diameter shall be the greater of 20 times the cable OD or 150 mm. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

e. Impact Resistance
- When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations spaced a minimum distance of 150 mm. The impact energy shall be 2.94 N•m. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The jacket shall not crack, split or tear.

f. Temperature Cycling
- When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after the second cycle at the extreme operational temperatures shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). The change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling.

g. Twist-Bend
- When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting and bending. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or 0.60 dB at 1300 nm (multimode).

h. Tensile and Fiber Strain
- When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, “Measurement of Fiber Strain in Cables under Tensile Load,” a length of cable shall be tested to the rated tensile load. For riser cables < 12f the rated tensile load is 660 N (148 lbf) and for riser cables > 12f the rated tensile load is 1320 N (297 lbf). For plenum cables < 12f the rated tensile load is 440 N (99 lbf) and for plenum cables >12f the rated tensile load is 660 N (148 lbf). While under the rated tensile load, the fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load) the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). After the tensile load is removed, the fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

i. Quality Assurance Provisions
- All optical fibers in cables lengths of 300 m or greater shall be 100 %

attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.

- The cable manufacturer shall be ISO 9001 registered.

D. Generic Specification for Gel-Free Loose Tube Optical Fiber Cables for Inter- and Intrabuilding Applications

1. General Considerations
   a. The cable must meet the requirements of the National Electrical Code® (NEC)® Section 770.
   b. Non-Plenum Applications - Applicable Flame Tests: UL 1666. All-dielectric cables shall be listed OFNR. Interlocking armored cables shall be listed OFCR.
   c. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) *Standard for Indoor-Outdoor Optical Fiber Cable* (ICEA S-104-696).

2. Fiber Specifications
   a. Detailed information on the fiber types available for this cable design can be found in the following documents:
   b. Dispersion Un-shifted and Non-zero Dispersion Shifted Single-mode Fiber: Generic Specification F1, “Generic Specification for Single-mode Optical Fiber in Loose Tube and Ribbon Cables.”
   c. 50/125 µm Multimode Fiber: Generic Specification F2, “Generic Specification for Multimode Optical Fiber in Loose Tube and Ribbon Cables.”

3. Cable Construction
   a. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.
   b. Each buffer tube shall contain up to 12 fibers.
   c. The fibers shall not adhere to the inside of the buffer tube.
   d. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598, "Optical Fiber Cable Color Coding."
   e. The fibers shall be colored with ultraviolet (UV) curable inks. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature ranges, and not subject to fading or smearing onto each other.
   f. Colors shall not cause fibers to stick together.
   g. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA/EIA-598, "Optical Fiber Cable Color Coding."
   h. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.

i. For dual layer buffer tube construction cables, standard colors are used for tubes 1 through 12 and standard colors with stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. The tube color sequence shall start from the inside layer and progress outward.
j. Each buffer tube shall contain a water swellable yarn for water-blocking protection. The water swellable yarn shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. This yarn will preclude the need for other water-blocking material; the buffer tubes shall be gel-free.
k. The optical fibers shall not require cleaning before placement into a splice tray or fan-out kit.
l. The buffer tubes shall be resistant to kinking.
m. Filler rods 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 3.0 mm in outer diameter.
n. 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 of the cable. The GRP rod shall be overcoated with a thermoplastic, when required, to achieve dimensional sizing to accommodate buffer tubes/fillers.
o. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water-blocking yarn(s) shall be applied longitudinally along the central member during stranding.
p. 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.
q. For single layer cables, a water-blocking tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water-blocking tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.
r. 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-blocking tape shall be applied longitudinally over both the inner and outer layers with each being held in place with a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.
s. The cable shall contain at least one ripcord under the sheath for easy sheath removal.
t. The tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.

u. A flame-retardant tape may be applied to provide additional resistance to flame propagation for higher fiber count cables.
v. Cables shall be sheathed with flame-retardant polyvinyl chloride (PVC). Jacketing material shall be applied directly over the tensile strength members and water-blocking tape. The PVC shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
w. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
x. Cable jackets shall be marked with the manufacturer's name or file number, month and year of manufacture, 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, flame rating, and listing marking. The actual length of the cable shall be within -0/+1% of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.
y. 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 will differ from the previous numbering sequence, and a tag will be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color will be yellow; the secondary choice will be blue.
z. The maximum pulling tension shall be 2670 N (600 lbf) during installation (short term) and 801 N (180 lbf) long term installed.
aa. The cable specified herein shall be available in two sheath designs.
bb. Un-armored, all-dielectric cables shall be listed OFNR and shall be as described previously in this section.
cc. Interlocking armored cables shall be as described previously in this section but shall also include an interlocking aluminum armor applied helically around the outside of the cable jacket. The interlocking armor may be left un-jacketed or may have a PVC outer jacket. The color of the armor jacket (if specified), shall match the jacket color of the optical fiber cable located inside of the armor. The armor for these cables shall be comparable to liquid tight flexible metal conduit if jacketed or flexible metal conduit if not jacketed. Because of the interlocking metallic armor, this cable shall be listed OFCR. The interlocking armor and outer jacket options will be specified on the purchase order. Cables with interlocking armor shall be available in fiber counts up to 288 fibers.

4. Cable Specifications
    a. Temperature Range.
        - The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for the cable shall be -10 °C to +60 °C. The operating temperature range for the cable shall be -40 °C to +70 °C. Testing shall be in accordance with FOTP-3.
    b. Tensile Loading and Fiber Strain
        - When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, “Measurement of Fiber Strain in Cables Under Tensile Load,” a length of cable shall be tested to the rated tensile load. The rated tensile load shall be 2670 N (600 lbf). While under the rated tensile load, the fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load) the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). After the tensile load is removed, the fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).
    c. Compressive Loading Test
        - When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220 N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within five minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.40 dB at 1550 nm for single-mode fibers and 0.60 dB at 1300 nm for multimode fiber.
    d. Cyclic Flexing Test
        - When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks, splits, tears or other opening shall be present on the inner or outer surface of the jacket. No visible cracks greater than 5 mm in the armor shall be present.
    e. Twist Test
        - When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters will withstand 10 cycles of

mechanical twisting. The fiber shall not experience an attenuation change greater than

- 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). No cracks or splits in the jacket shall be present when inspected under 5X magnification.

f. High and Low Temperature Bend

- When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at test temperatures of -10 °C and +60 °C. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

g. Impact Resistance

- When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations separated by at least 150 mm. The impact energy shall be 4.4 N•m. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The presence of visible cracks, splits, tears, or other openings on the outer surface of the jacket constitute a failure.

h. Temperature Cycling

- When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after 2 cycles at extreme operational temperatures (-40 °C to +70 °C) shall not exceed 0.40 dB/km at 1550 nm (singlemode) or 0.60 dB/km at 1300 nm (multimode). The change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling after the last low and last high temperature.

i. Water Penetration

- When tested in accordance with FOTP-82, “Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable”, a one meter length of unaged cable shall withstand a one meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end.

j. Cold Impact Test

- When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations separated by at least 150 mm. The impact energy shall be 2.9 N•m. The cable shall be conditioned for at least 4 hours at the minimum installation temperature (-10 °C). The presence of visible cracks on either the inner or outer surface of the jacket constitutes a failure. No optical measurements are required.

k. Quality Assurance Provisions

- All optical fibers in cables lengths of 1000 m or greater shall be 100 % attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm

and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.

- The cable manufacturer shall be TL 9000 registered.

E. Generic Specification for Tight Buffer Optical Fiber Cables for Indoor Breakout Applications

1. General Considerations
   a. The cable must meet the requirements of the National Electrical Code® (NEC) ® Section 770.
   b. Non-Plenum Applications - Applicable Flame Tests: UL 1666. Cables shall be listed OFNR.
   c. Plenum Applications - Applicable Flame Test: NFPA 262. Cables shall be listed OFNP.
   d. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) *Standard for Fiber Optic Premises Distribution Cable* (ICEA S-83-596).

2. Fiber Specifications
   a. Detailed information on the cabled performance of the fiber types available for this cable design can be found in the following documents:
      - Dispersion Un-shifted Single-mode Fiber: Generic Specification F3, "Generic Specification for Single-mode Optical Fiber in Tight Buffer Cables."
      - 50/125 µm Multimode Fiber: Generic Specification F4, "Generic Specification for Multimode Optical Fiber in Tight Buffer Cables."

3. Cable Construction
   a. The coated fiber shall have a low friction slip layer placed between the acrylate coating of the optical fiber and the thermoplastic buffer. The diameter of the thermoplastic buffer coating shall be 900 ± 50 µm.
   b. The fiber coating and buffer shall be removable with commercially available stripping tools in a single pass for connectorization or splicing.

4. Cable Subunits
   a. The 900 µm buffer shall be white (natural) in color.
   b. Each individual fiber shall be surrounded with strength yarn for mechanical strength. The strength yarn shall not be braided. Talc shall be applied to the strength yarn to prevent adhesion of the subunit jacket material and to facilitate the mechanical stripping of the subunit jacket.
   c. A thermoplastic jacket shall be applied to each individual fiber with the strength yarn to obtain a nominal diameter of 1.65, 2.0, or 2.9 mm as specified for each cable (only one size of unit per cable). The subunit jacket color shall be aqua for 50/125 µm Laser Optimized Fiber. The subunit jacket color shall be yellow for cables containing single-mode fiber.

5. Central Member and Ripcord
    a. The subunits shall be stranded around a dielectric central member. The central member may be over coated with thermoplastic material to facilitate the manufacture of a concentric cable core. Higher fiber count cables may have the subunits arranged in two layers.
    b. A ripcord shall be placed between the subunits and the outer jacket to facilitate outer jacket removal.

6. Cable Jacket:
    a. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
    b. The cable jacket color shall be aqua for cables containing multimode fiber 50/125 µm Laser Optimized Fiber. The cable jacket color shall be yellow for cables containing single-mode fiber.
    c. The nominal thickness of the cable outer jacket shall be sufficient to provide adequate cable protection while meeting the mechanical, flammability, and environmental test requirements of this document over the life of the cable.
    d. The cable shall be all-dielectric.

7. Identification
    a. Each subunit shall be numbered on the subunit jacket for identification. The number shall be repeated at regular intervals.

8. Jacket Printing
    a. The outer cable jacket shall be marked with the manufacturer's name or ETL file number, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every two feet. The marking shall be in contrasting color to the cable jacket.

9. Cable Specifications
    a. Temperature Range.
        - Non-Plenum Applications. The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for riser cables shall be -10 °C to +60 °C. The operational temperature range for riser cables shall be -20 °C to +70 °C. Testing shall be in accordance with FOTP-3.
        - Plenum Applications. The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for plenum cables shall be 0 °C to +60 °C. The operational temperature range for riser cables shall be 0 °C to +70 °C. Testing shall be in accordance with FOTP-3.

b. Crush Resistance
   - When tested in accordance with FOTP-41, “Compressive Loading Resistance of Fiber Optic Cables,” the cable shall withstand a minimum compressive load of 100 N/cm (57 lbf/in) applied uniformly over the length of the compression plate. While under compressive load, the fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

c. Cyclic Flexing
   - When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute. The fiber shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The jacket shall not crack, split, or tear.

d. High and Low Temperature Bend
   - When tested in accordance with FOTP-37, "Fiber Optic Cable Bend Test, Low and High Temperature," the cable shall withstand four full turns around a mandrel at low temperatures of -10 °C for riser cables and 0 °C for plenum cables. The cable shall also withstand four full turns at a high temperature of +60 °C for both riser and plenum cables. The mandrel diameter shall be the greater of 20 times the cable OD or 150 mm. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

e. Impact Resistance
   - When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand a minimum of 2 impact cycles at 3 locations spaced a minimum distance of 150 mm. The impact energy shall be 2.94 N•m. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). The jacket shall not crack, split or tear.

f. Temperature Cycling
   - When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation after the second cycle at the extreme operational temperatures shall not exceed 0.40 dB/km at 1550 nm (single-mode) or 0.60 dB/km at 1300 nm (multimode). The change in attenuation is measured with respect to the baseline values measured at room temperature before temperature cycling.

g. Twist-Bend
   - When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting and bending. The fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or 0.60 dB at 1300 nm (multimode).

h. Tensile and Fiber Strain
- When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," and FOTP-38, "Measurement of Fiber Strain in Cables under Tensile Load," a length of cable shall be tested to the rated tensile load. For riser cables $\leq$ 12f the rated tensile load is 660 N (148 lbf) and for riser cables > 12f the rated tensile load is 1320 N (297 lbf). For plenum cables $\leq$ 12f the rated tensile load is 440 N (99 lbf) and for plenum cables >12f the rated tensile load is 660 N (148 lbf). While under the rated tensile load, the fiber shall not experience a measured fiber strain greater than 60% of the fiber proof test level. After being held at the residual load (30% of the rated tensile load) the fiber shall not experience a measured fiber strain greater than 20% of the fiber proof test level nor an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode). After the tensile load is removed, the fibers shall not experience an attenuation change greater than 0.40 dB at 1550 nm (single-mode) or greater than 0.60 dB at 1300 nm (multimode).

i. Quality Assurance Provisions
- All optical fibers in cables lengths of 300 m or greater shall be 100 % attenuation tested. The attenuation shall be measured at 850 nm and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.
- The cable manufacturer shall be ISO 9001 registered.

F. Generic Specification for Single-mode Optical Fiber in Tight Buffer Cables

1. General Fiber Specifications
   a. All fibers in the cable must be usable and meet required specifications.
   b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
   c. Each optical fiber shall consist of a germania-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.
   d. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 $GN/m^2$).
   e. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
   f. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

2. Single-mode (Dispersion Un-shifted) with Low Water Peak The single-mode Low Water Peak fiber utilized in the optical fiber cable shall meet EIA/TIA-492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-

Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652. (Categories A, B, C and D), “Characteristics of a single-mode optical fiber cable.”

| | | |
|---|---|---|
| **Geometry** | | |
| 2.1 | Cladding Diameter (µm) | 125.0 ± 0.7 |
| 2.2 | Core-to-Cladding Concentricity (µm) | ≤ 0.5 |
| 2.3 | Cladding Non-Circularity | ≤ 0.7 % |
| 2.4 | Mode Field Diameter (µm)<br>1310 nm<br>1550 nm | <br>9.2 + 0.4<br>10.4 ± 0.5 |
| 2.5 | Coating Diameter (µm) | 245 ± 5 |
| 2.6 | Colored Fiber Nominal Diameter (µm) | 249 - 259 |
| 2.7 | Fiber Curl radius of curvature (m) | > 4.0 m |
| **Optical** | | |
| 2.8 | Cabled Fiber Attenuation (dB/km)<br>1310 nm<br>1383 ± 3 nm<br>1550 nm | <br>≤ 0.65<br>≤ 0.65<br>≤ 0.50 |
| 2.9 | Point discontinuity (dB)<br>1310 nm<br>1550 nm | <br>≤ 0.05<br>≤ 0.05 |
| 2.10 | Macrobend Attenuation (dB)<br>Turns / Mandrel OD<br>1 / 32 ± 2 mm<br>100 / 50 ± 2 mm<br>100 / 50 ± 2 mm<br>100 / 60 ± 2 mm | <br><br>< 0.05 at 1550 nm<br>< 0.05 at 1310 nm<br>< 0.05 at 1550 nm<br>< 0.05 at 1625 nm |
| 2.11 | Cable Cutoff Wavelength ( λ ccf ) (nm) | < 1260 |
| 2.12 | Zero Dispersion Wavelength (λo) (nm) | 1302 ≤ λo ≤ 1324 |
| 2.13 | Zero Dispersion Slope (So) (ps/(nm²•km)) | ≤ 0.092 |
| 2.14 | Total Dispersion (ps/(nm•km))<br>1285-1330 nm<br>1550 nm<br>1625 nm | <br>≤ 3.8<br>≤ 17.5<br>≤ 21.6 |
| 2.15 | Cabled Polarization Mode Dispersion $(ps/\sqrt{km})$ | ≤ 0.2 |
| 2.16 | IEEE 802.3 GbE - 1300 nm Laser Distance (m) | up to 5000 |
| 2.17 | Water Peak Attenuation: 1383 ± 3 nm (dB/km) | ≤ 0.65 |

3. Single-Mode (Dispersion Un-shifter) Bend Improved Optical Fiber
   a. The single-mode Low Water Peak fiber utilized in the optical fiber cable shall meet EIA/TIA492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU-T G.652.D “Characteristics of a single-mode optical fiber cable,” and ITU-T G.657, Table A, “Characteristics of a Bending Loss Insensitive Single Mode Optical Fiber for Access Networks.”

| | | |
|---|---|---|
| **Geometry** | | |
| 3.1 | Cladding Diameter (µm) | 125.0 ± 0.7 |
| 3.2 | Core-to-Cladding Concentricity (µm) | ≤ 0.5 |
| 3.3 | Cladding Non-Circularity | ≤ 0.7 % |
| 3.4 | Mode Field Diameter (µm)<br>1310 nm<br>1550 nm | <br>8.6 + 0.4<br>9.8 ± 0.5 |
| 3.5 | Coating Diameter (µm) | 245 ± 5 |
| 3.6 | Colored Fiber Nominal Diameter (µm) | 249 - 259 |
| 3.7 | Fiber Curl radius of curvature (m) | ≤ 0.65 |
| **Optical** | | |
| 3.8 | Cabled Fiber Attenuation (dB/km)<br>1310 nm<br>1383 ± 3 nm<br>1550 nm | <br>≤ 0.65<br>≤ 0.65<br>≤ 0.5 |
| 3.9 | Point discontinuity (dB)<br>1310 nm<br>1550 nm | <br>≤ 0.05<br>≤ 0.05 |
| 3.10 | Macrobend Attenuation (dB)<br>Turns / Mandrel OD<br>1 / 20 ± 2 mm<br>1 / 20 ± 2 mm<br>10 / 30 ± 2 mm<br>100 / 60 ± 2 mm | <br><br>< 1.5 at 1625 nm<br>< 0.50 at 1550 nm<br>< 0.05 at 1550 nm<br>< 0.01 at 1625 nm |
| 3.11 | Cable Cutoff Wavelength ( $\lambda_{ccf}$ ) (nm) | < 1260 |
| 3.12 | Zero Dispersion Wavelength (λo) (nm) | 1302 ≤ λo ≤ 1322 |
| 3.13 | Zero Dispersion Slope (So) (ps/(nm²•km)) | ≤ 0.089 |
| 3.14 | Total Dispersion (ps/(nm•km))<br>1285-1330 nm<br>1550 nm<br>1625 nm | <br>≤ 3.5<br>≤ 17.4<br>≤ 21.3 |
| 3.15 | Cabled Polarization Mode Dispersion $(ps/\sqrt{km})$ | ≤ 0.2 |
| 3.16 | IEEE 802.3 GbE - 1300 nm Laser Distance (m) | up to 5000 |
| 3.17 | Water Peak Attenuation: 1383 ± 3 nm (dB/km) | ≤ 0.65 |

G. Generic Specification for Single-Mode Fiber in Loose Tube and Ribbon Cables

1. General Fiber Specifications
   a. All fibers in the cable must be usable and meet required specifications.
   b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
   c. Each optical fiber shall consist of a germania-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

d. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m$^2$).
e. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
f. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

2. Single-mode (Dispersion Un-shifted)
   a. The single-mode fiber shall meet EIA/TIA-492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652 (Categories A, B, C & D), "Characteristics of a single-mode optical fiber cable."

| **Geometry** | | |
|---|---|---|
| 2.1 | Cladding Diameter (µm) | 125.0 ± 0.7 |
| 2.2 | Core-to-Cladding Concentricity (µm) | ≤ 0.5 |
| 2.3 | Cladding Non-Circularity | ≤ 0.7 % |
| 2.4 | Mode Field Diameter (µm)<br>1310 nm<br>1550 nm | <br>9.2 ± 0.4<br>10.4 ± 0.5 |
| 2.5 | Coating Diameter (µm) | 245 ± 5 |
| 2.6 | Colored Fiber Nominal Diameter (µm) | 249 - 259 |
| 2.7 | Fiber Curl radius of curvature (m) | ≥ 4.0 m |

| **Optical** | | |
|---|---|---|
| 2.8 | Cabled Fiber Attenuation (dB/km)<br>1310 nm<br>1550 nm | <br>≤ 0.4<br>≤ 0.3 |
| 2.9 | Point discontinuity (dB)<br>1310 nm<br>1550 nm | <br>≤ 0.05<br>≤ 0.05 |
| 2.10 | Macrobend Attenuation (dB)<br>Turns / Mandrel OD<br>1 / 32 ± 2 mm<br>100 / 50 ± 2 mm<br>100 / 50 ± 2 mm<br>100 / 60 ± 2 mm | <br><br>< 0.05 at 1550 nm<br>< 0.05 at 1310 nm<br>< 0.05 at 1550 nm<br>< 0.05 at 1625 nm |
| 2.11 | Cable Cutoff Wavelength ( $\lambda_{ccf}$ ) (nm) | < 1260 |
| 2.12 | Zero Dispersion Wavelength (λo) (nm) | 1302 ≤ λo ≤ 1324 |
| 2.13 | Zero Dispersion Slope (So) (ps/(nm²•km)) | ≤ 0.092 |
| 2.14 | Total Dispersion (ps/(nm•km))<br>1285-1330 nm<br>1550 nm<br>1625 nm | <br>≤ 3.8<br>≤ 17.5<br>≤ 21.6 |
| 2.15 | Cabled Polarization Mode Dispersion $(ps/\sqrt{km})$ | ≤ 0.2 |
| 2.16 | IEEE 802.3 GbE - 1300 nm Laser Distance (m) | up to 5000 |
| 2.17 | Water Peak Attenuation: 1383 ± 3 nm (dB/km) | ≤ 0.4 |

3. Non-zero Dispersion-shifted Fiber for Long-haul Telecommunications Applications
   b. The non-zero dispersion-shifted single-mode fiber utilized in the optical fiber cable shall meet ITU recommendation G.655, "Characteristics of a Non-Zero Dispersion Shifted Single-Mode Optical Fiber and Cable," (Tables A, B, C &D)

| **Geometry** | | | |
|---|---|---|---|
| 3.1 | Cladding Diameter | (µm) | 125.0 ± 0.7 |
| 3.2 | Core-to-Cladding Concentricity | (µm) | ≤ 0.5 |
| 3.3 | Cladding Non-Circularity | | ≤ 0.7 % |
| 3.4 | Mode Field Diameter – 1550 nm | (µm) | 9.62 ± 0.4 |
| 3.5 | Effective Area, $A_{eff}$ (Characterized): | ($\mu m^2$) | 72 |
| 3.6 | Coating Diameter | (µm) | 245 ± 5 |
| 3.6 | Colored Fiber Nominal Diameter | (µm) | 249 – 259 |
| 3.8 | Fiber Curl radius of curvature | (m) | ≥ 4.0 m |

| **Optical** | | | |
|---|---|---|---|
| 3.9 | Cabled Fiber Attenuation –1550 nm | (dB/km) | ≤ 0.3 |
| 3.10 | Point discontinuity – 1550 nm | (dB) | ≤ 0.05 |
| 3.11 | Macrobend Attenuation<br>Turns / Mandrel OD<br>1 / 32 ± 2 mm<br>1 / 32 ± 2 mm<br>100 / 60 ± 2 mm<br>100 / 60 ± 2 mm | (dB) | <br><br>< 0.50 at 1550 nm<br>< 0.50 at 1625 nm<br>< 0.05 at 1550 nm<br>< 0.05 at 1625 nm |
| 3.12 | Cable Cutoff Wavelength ( $\lambda_{ccf}$ ) | (nm) | < 1480 |
| 3.13 | Total Dispersion<br>1530 - 1565 nm<br>1565 - 1625 nm | (ps/(nm•km)) | <br>2.0 to 6.0<br>4.5 to 11.2 |
| 3.14 | Cabled Polarization Mode Dispersion $(ps/\sqrt{km})$ | | ≤ 0.1 |

H. Single-Mode (Dispersion Un-shifter) Bend-Improved Fiber

   a. The single-mode bend-improved optical fiber utilized in the optical fiber cable shall meet ITU-T G.652, Table D "Characteristics of a single-mode optical fiber cable," and ITU-T G.657, Table A, "Characteristics of a Bending Loss Insensitive Single Mode Optical Fiber for Access Networks."

| **Geometry** | | | |
|---|---|---|---|
| 4.1 | Cladding Diameter | (µm) | 125.0 ± 0.7 |
| 4.2 | Core-to-Cladding Concentricity | (µm) | ≤ 0.5 |
| 4.3 | Cladding Non-Circularity | | ≤ 0.7 % |
| 4.4 | Mode Field Diameter<br>1310 nm<br>1550 nm | (µm) | <br>8.6 + 0.4<br>9.8 ± 0.5 |

| | | |
|---|---|---|
| 4.5 | Coating Diameter (µm) | 245 ± 5 |
| 4.6 | Colored Fiber Nominal Diameter (µm) | 249 - 259 |
| 4.7 | Fiber Curl radius of curvature (m) | > 4.0 m |

| **Optical** | | |
|---|---|---|
| 4.8 | Cabled Fiber Attenuation (dB/km)<br>1310 nm<br>1550 nm | <br>≤ 0.4<br>≤ 0.3 |
| 4.9 | Point discontinuity (dB)<br>1310 nm<br>1550 nm | <br>≤ 0.05<br>≤ 0.05 |
| 4.10 | Macrobend Attenuation (dB)<br>Turns Mandrel OD<br>1 20 ± 2 mm<br>1 20 ± 2 mm<br>10 30 ± 2 mm<br>100 60 ± 2 mm | <br><br>< 1.5 at 1625 nm<br>< 0.50 at 1550 nm<br>< 0.05 at 1550 nm<br>< 0.01 at 1625 nm |
| 4.11 | Cable Cutoff Wavelength ( λ ccf ) (nm) | < 1260 |
| 4.12 | Zero Dispersion Wavelength (λo) (nm) | 1302 ≤ λo ≤ 1322 |
| 4.13 | Zero Dispersion Slope (So) (ps/(nm²•km)) | ≤ 0.089 |
| 4.14 | Total Dispersion (ps/(nm•km))<br>1285-1330 nm<br>1550 nm<br>1625 nm | <br>≤ 3.5<br>≤ 17.4<br>≤ 21.3 |
| 4.15 | Cabled Polarization Mode Dispersion $(ps/\sqrt{km})$ | ≤ 0.2 |
| 4.16 | IEEE 802.3 GbE - 1300 nm Laser Distance (m) | up to 5000 |
| 4.17 | Water Peak Attenuation: 1383 ± 3 nm (dB/km) | ≤ 0.4 |

I. Generic Specification for Multimode Optical Fiber in Tight Buffer Cables

1. General Fiber Specifications
   a. All fibers in the cable must be usable and meet required specifications.
   b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.
   c. Each optical fiber shall consist of a germania-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design, manufactured by the Outside Vapor Deposition (OVD) process.
   d. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m$^2$).

e. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
f. The attenuation specification shall be a maximum value for each cabled fiber at 23 ± 5 °C on the original shipping reel.

2. OM3-Grade 50/125-Micron Fiber - 300
   a. The fiber shall meet the requirements of EIA/TIA-492AAAC, "Detail Specification for 850nm Laser-Optimized, 50 µm Core Diameter/125-µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers."
   b. The fiber shall have the same specified performance and geometry values as standard 50/125 µm fiber (section 4.1) except as noted below.

| | | |
|---|---|---|
| 5.1 | Cabled Fiber Attenuation (dB/km)<br>850 nm<br>1300 nm | <br>≤ 3.0<br>≤ 1.0 |
| 5.2 | Cabled Effective Modal Bandwidth (MHz•km)<br>850 nm | <br>> 2000 |
| 5.3 | IEEE 802.3 GbE Distance (m)<br>1000BASE-SX Window (850 nm)<br>1000BASE-LX Window (1300 nm) | <br>up to 1000<br>up to 600 |
| 5.4 | IEEE 802.3 10 GbE Distance (m)<br>10GBASE-S Window (850 nm) | <br>up to 300 |
| 5.5 | OFL Bandwidth (MHz•km)<br>850 nm<br>1300 nm | <br>> 1500<br>≥ 500 |

3. OM3-Grade 50/125-Micron Fiber – 550
   a. The fiber shall meet the requirements of EIA/TIA-492AAAC, "Detail Specification for 850nm , 50 µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers."
   b. The fiber shall have the same specified performance and geometry values as standard 50/125 µm fiber (section 4.1) except as noted below.

| | | |
|---|---|---|
| 6.1 | Cabled Fiber Attenuation (dB/km)<br>850 nm<br>1300 nm | <br>≤ 3.0<br>≤ 1.0 |
| 6.2 | Cabled Effective Modal Bandwidth (MHz•km)<br>850 nm | <br>> 5350 |
| 6.3 | IEEE 802.3 GbE Distance (m)<br>1000BASE-SX Window (850 nm)<br>1000BASE-LX Window (1300 nm) | <br>up to 1000<br>up to 600 |
| 6.4 | IEEE 802.3 10 GbE Distance (m)<br>10GBASE-S Window (850 nm) | <br>up to 600 |
| 6.5 | OFL Bandwidth (MHz•km)<br>850 nm<br>1300 nm | <br>> 1500<br>≥ 500 |

1) As predicted by minEMBc, per TIA/EIA 455-220 and IEC 60793-1-49, for *high performance laser-based systems* (up to 10 GB/s).

4. OM3-Grade 50/125-Micron Fiber – 600
   a. The fiber shall meet the requirements of EIA/TIA-492AAAC, "Detail Specification for 850nm Laser-Optimized, 50µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers."
   b. The fiber shall have the same specified performance and geometry values as standard 50/125 µm fiber (section 4.1) except as noted below.

| | | |
|---|---|---|
| 3.4.1 | Cabled Fiber Attenuation (dB/km)<br>850 nm<br>1300 nm | <br>≤ 3.0<br>≤ 1.0 |
| 3.4.2 | Cabled Effective Modal Bandwidth (MHz•km)<br>850 nm | <br>> 5350 |
| 3.4.3 | IEEE 802.3 GbE Distance (m)<br>000BASE-SX Window (850 nm)<br>1000BASE-LX Window (1300 nm) | <br>up to 1000<br>up to 600 |
| 3.4.4 | IEEE 802.3 10 GbE Distance (m)<br>10GBASE-S Window (850 nm) | <br>up to 600 |
| 3.4.5 | OFL Bandwidth (MHz•km)<br>850 nm<br>1300 nm | <br>> 1500<br>≥ 500 |

1) The 550m distance is equivalent to a 4700 EMB system with standards-compliant transceiver and fiber characteristics, 3.0 dB/km cable attenuation and 1.0 dB total connector loss.
2) The fiber shall support 10BASE-FL (10 Mb/s) and 100BASE-FX (100 Mb/s) transmission up to a distance of 2000 m

5. Performance Comparison Chart

Multimode optical fiber performances referenced in this specification.

| Fiber Type | Maximum Attenuation 850/1300 nm (dB/km) | Minimum OFL BW 850/1300 nm (MHz•km) | Minimum Effective Modal BW 850 nm (MHz•km) | 1 GbE Distance 850/1300 nm (meters) | 10 GbE Distance 850 nm (meters) |
|---|---|---|---|---|---|
| 50/125 µm Laser-optimized -150 | 3.0/1.0 | 700/500 | > 950 | 220/550 | 150[2] |
| 50/125 µm Laser-optimized -300 | 3.0/1.0 | 1500/600 | > 2000 | 750/600[1] | 300[2] |
| 50/125 µm Laser-optimized -550 | 3.0/1.0 | 1500/600 | > 4700 | 1000/600[1] | 550[3] |
| 50/125 µm Laser-optimized -600 | 3.0/1.0 | 1500/600 | > 5350 | 1000/600[1] | 600[4] |

1) Guaranteed distance for Gigabit Ethernet compliant systems.

2) Guaranteed distance for 10 Gigabit Ethernet compliant systems.
3) The 550m distance is equivalent to a 4700 EMB system with standards-compliant transceiver and fiber characteristics, 3.0 dB/km cable attenuation, and 1.0 dB total connector loss.
4) The 500m distance is equivalent to a 5350 EMB system with standards-compliant transceiver and fiber characteristics, 3.0 dB/km cable attenuation, and 1.0 dB total connector loss.

## J. Generic Specification for Simplex Optical Fiber (Single-Mode) No-Epoxy, No-Polish Connectors

1. General Considerations
   This document covers the specifications and performance for field-installable single-mode ST® compatible, SC and LC connectors.

2. References
   The following documents may be used as references.
   a. TIA/EIA-455-A — Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components (FOTPs)
   b. TIA/EIA-604-2 — Fiber Optic Connector Intermateability Standard, FOCIS-2 (ST Compatible)
   c. TIA/EIA-604-3A — Fiber Optic Connector Intermateability Standard, FOCIS-3 (Type SC)
   d. TIA/EIA-604-10A — Fiber Optic Connector Intermateability Standard, FOCIS-10 (Type LC)

3. Connector Characteristics
   a. Design Features
   - Strain relief: For ST compatible, SC and LC connectors, the connector will provide a strain relief mechanism for installation onto a single fiber cable that contains strength elements. The fiber within the body of the connector will be isolated mechanically from cable tension, bending and twisting.
   - Intermateability: The connector will be designed in compliance with the appropriate TIA/EIA FOCIS document.
   - Mating Style: The ST compatible, SC, and LC connectors shall secure to the field fiber via a rotating cam which shall be situated on the connector body and the camming action shall be performed with the use of a connector terminating tool designed for that purpose. Upon rotation of the cam, the connector shall then be permanently secured to the fiber by the crimping of the connector lead in tube via the connector terminating tool.
   - Ferrule Type: The connector ferrule shall be made from a homogenous polymer or ceramic material.

4. Installation
   - Installation on field fiber: The connector will contain a mechanical splice and require one handheld tool kit to assemble all three connector types.
   - The connector installation tool kit will contain an integrated continuity test systems (CTS), which will give immediate Go/No-Go feedback of successful connectivity.

- The cleaver and connector installation tool shall not require a fiber handler.
- Installation rate: The ST compatible and SC connectors shall be installable upon 900 µm buffered fiber in one minute or less and upon 1.6, 2.0, 2.6, or 3 mm jacketed cable, if applicable, in three minutes or less total time.
- Installation rate: The LC connector shall be installable upon 900 µm buffered fiber in one minute or less.
- Installation polishing: The connector will not require polishing of the end face in the field. Connectors will have a factory-polished fiber stub in the connector ferrule.
- Installation type: The connector installation will not require the use of epoxies.
- Fiber protection: The connector's factory stub fiber will be secured with epoxy to protect the bare fiber from the ingress of air or waterborne contaminants and will secure the fiber in the ferrule micro-hole.

5. Packaging Requirements
   - The connector will be packaged individually or in an organizer pack to adequately protect the connector.
   - Each connector will be equipped with a protective dust cap that does not contaminate the connector end face.
   - The packaging will indicate the supplier part number, connector type, and date code.

6. Performance Requirements
   - Insertion Loss: When tested in accordance with FOTP-171, connectors will be consistently capable of insertion losses ≤ 0.2 dB (average) and ≤ 0.5 dB (maximum) when installed in accordance with the manufacturers recommended procedure.
   - Reflectance: When tested in accordance with FOTP-107, connectors will be consistently capable of reflectance values of ≤ -40 dB for SPC polished connectors and ≤ -50 dB for UPC polished connectors when installed in accordance with the manufacturer's recommended procedure.
   - Performance Testing Values: The SC, LC, and ST compatible connector will comply with the values presented in Table 1.

**Table 1. Connector Performance**

| Test | Test Method (FOTP #) | Test Conditions | Requirement* |
|---|---|---|---|
| **Insertion Loss (IL)** | 171 | concatenation method | Average: 0.2 dB<br>Max IL : 0.5 dB |
| **Return Loss (RL)** | 107 | coupler with power source and meter | Minimum RL: ≤-40 dB SPC<br>-55 dB UPC |
| **Low Temp Soak** | 188 | 4 days @ 0ₒC | Max IL : 0.75 dB<br>Min RL: 26 dB |

| | | | |
|---|---|---|---|
| **Temperature Life** | 4 | 4 days @ 60oC | Max IL : 0.75 dB<br>Min RL: 26 dB |
| **Humidity** | 5 | 4 days @ 40oC RH 90-95% | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Impact** | 2 | 8 impacts from 1.8 meters (height) | Max IL : 0.75 dB<br>Min RL: 26 dB |
| **Strength of Coupling Mechanism** | 185 | 33 N at 0° for 5 seconds | Max IL : 0.75 dB<br>Min RL: 26 dB |
| **Durability** | 21 | 500 rematings, clean every 25 | Max IL : 0.75 dB<br>Min RL: 26 dB |
| **Cable Retention 0°** | 6 | 0.5 lb. on 900 µm buffered fiber for 5 seconds | Delta IL: ≤ 0.5 dB<br>Max IL: 0.75 dB<br>Min RL: 26 dB |
| **Cable Retention 90°** | 6 | 0.5 lb. on 900 µm buffered fiber for 5 seconds | Delta IL: ≤ 0.5 dB<br>Max IL: 0.75 dB<br>Min RL: 26 dB |
| **Flex** | 1 | ±90° for 100 cycles @ 0.5 lb. load on 900 µm buffered fiber | Max IL : 0.75 dB<br>Min RL: 26 dB |
| **Twist** | 36 | 10 cycles 5 turns, 0.5 lb. load on 900 µm buffered fiber | Max IL : 0.75 dB<br>Min RL: 26 dB |

K. Generic Specification for Simples Optical Fiber (Multimode) no-Epoxy, No-Polish Connectors

1. General Considerations
   a. This document covers the specifications and performance for field-installable multimode (62.5 um and 50 um) ST® compatible, SC, and LC connectors.

2. References
   The following documents may be used as references

   a. EIA/TIA-455-A — Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components (FOTPs)

   b. TIA/EIA-604-2 — Fiber Optic Connector Intermateability Standard, FOCIS-2 (ST Compatible)

   c. TIA/EIA-604-3A — Fiber Optic Connector Intermateability Standard, FOCIS-3 (Type SC)

   d. TIA/EIA-604-10A — Fiber Optic Connector Intermateability Standard, FOCIS-10 (Type LC)

3. Connector Characteristics
   a. Design Features

- Strain relief: For ST compatible, LC and SC connector types, the connector shall provide a strain relief mechanism for installation on a single fiber cable that contains strength elements. The fiber within the body of the connector shall be isolated mechanically from cable tension, bending and twisting.
- Intermateability: The connector shall be designed to comply with the appropriate TIA/EIA FOCIS document.
- Mating Style: The ST compatible, SC and LC connectors shall secure to the field fiber via a rotating cam which shall be situated on the connector body and the camming action shall be performed with the use of a connector terminating tool designed for that purpose. Upon rotation of the cam, the connector shall then be permanently secured to the fiber by the crimping of the connector lead in tube via the connector terminating tool.
- Ferrule Type: The connector ferrule shall be made from a homogenous polymer or ceramic material.

b. Installation Type
- Installation rate: The ST compatible and SC connectors shall be installable upon 900 µm buffered fiber in one minute or less and upon 1.6, 2.0, 2.6, or 3 mm jacketed cable, if applicable, in three minutes or less total time.
- Installation rate: The LC connector shall be installable upon 900 µm buffered fiber in one minute or less
- The connector installation tool kit will contain an integrated continuity test systems (CTS), which will give immediate Go/No-Go feedback of successful connectivity.
- The cleaver and connector installation tool shall not require a fiber handler.
- Installation on field fiber: The connector shall contain a mechanical splice and require one tool kit to assemble all four connector types.
- Installation polishing: The connector shall not require polishing of the end face in the field. Connectors shall have a factory-polished fiber stub in the connector ferrule.
- Installation type: The connector installation shall not require the use of epoxies.
- Fiber protection: The connector crimp-on mechanism shall protect the bare fiber from the ingress of air or waterborne contaminants and shall secure the fiber in the ferrule micro-hole.

c. Packaging Requirements
- The connector shall be packaged individually or in an organizer pack to adequately protect the connector.
- Each connector shall be equipped with a protective dust cap that does not contaminate the connector end face.
- The packaging shall indicate the supplier part number, connector type, and date of manufacture.

4. Performance Requirements
   a. Insertion Loss

- When tested in accordance with FOTP-171, connectors shall be consistently capable of insertion losses ≤ 0.1 dB (average) and ≤ 0.5 dB (maximum) when installed in accordance with the manufacturers recommended procedure.

b. Performance Testing Values

The connector shall comply with the values presented in Table 1.

**Table 1. Connector Performance**

| Test | Test Method (FOTP #) | Test Conditions | Requirement* |
|---|---|---|---|
| **Insertion Loss (IL)** | 171 | concatenation method | Average: 0.1 dB<br>Max IL : 0.5 dB |
| **Return Loss (RL)** | 107 | coupler with power source and meter | Minimum RL: ≤-20 dB<br>Minimum RL: ≤-26 dB LOMMF |
| **Low Temp Soak** | 188 | 4 days @ 0ºC | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Temperature Life** | 4 | 4 days @ 60ºC | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Humidity** | 5 | 4 days @ 40ºC RH 90-95% | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Impact** | 2 | 8 impacts from 1.8 meters (height) | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Strength of Coupling Mechanism** | 185 | 33 N at 0° for 5 seconds | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Durability** | 21 | 500 rematings, clean every 25 | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Cable Retention 0°** | 6 | 0.5 lb. on 900 µm buffered fiber for 5 seconds | Delta IL: ≤ 0.5 dB<br>Max IL: 0.75 dB<br>Min RL: 20 dB |
| **Cable Retention 90°** | 6 | 0.5 lb. on 900 µm buffered fiber for 5 seconds | Delta IL: ≤ 0.5 dB<br>Max IL: 0.75 dB<br>Min RL: 20 dB |
| **Flex** | 1 | ±90° for 100 cycles @ 0.5 lb. load on 900 µm buffered fiber | Max IL : 0.75 dB<br>Min RL: 20 dB |
| **Twist** | 36 | 10 cycles 5 turns, 0.5 lb. load on 900 µm buffered fiber | Max IL : 0.75 dB<br>Min RL: 20 dB |

L. Generic Category 6 Hardware and Cabling Specifications

1. Cable
   All Category 6 cable shall conform to the following minimum performance standards.

| Parameter | UTP Cable Performance | | |
|---|---|---|---|
| | 100MHZ | 200MHz | 250MHz |
| Insertion Loss (dB) | 19.0 | 27.5 | 31.0 |
| NEXT Loss (dB) | 51.3 | 46.8 | 45.3 |
| PSNEXT Loss (dB) | 49.3 | 44.8 | 43.3 |
| ACR (dB) | 32.3 | 19.3 | 14.4 |
| PSACR (dB) | 30.3 | 17.3 | 12.4 |
| ACR-F (dB) | 34.8 | 28.7 | 26.8 |
| PS ACR-F (dB) | 31.8 | 25.7 | 23.8 |
| Return Loss (dB) | 20.1 | 18.0 | 17.3 |
| Propagation Delay (ns) | 538 | 537 | 536 |
| Delay Skew (ns) | ≤ 45 | ≤ 45 | ≤ 45 |

2. Patch Panels
   - Application: Third-party qualified for 10 Gigabit Ethernet Transmission IEEE 802.3an (TSB-155).
   - Component: Third-party verified for TIA-568-C.2 Category 6 Component.
   - Channel: Third-party verified for ISO 11801 Class EA compliant.
   - Current capacity: qualified for PoE and PoE+ IEEE 802.3at.
   - Manufacturing: 100% factory tested.
   - Nose contact material: Beryllium Copper with Precious Metal plating with Nickel under-plating.
   - Contact performance confirmed over the full range of (FCC Specification) deflection limits.
   - TIA-568-C.2 Category 6 Component.
   - ISO 11801 Class E Compliant Category 6.
   - IEEE 802.3at.
   - UL Listed 1863.
3. Racks/Cabinets (The use of either Racks or Cabinets will be determined by the Information Technology Department)

   a. Racks
   - For rack-mounted installations in a telecommunications room the installer shall use a19 or 23- inch equipment track depending usage of rack.
   - Have 116.8 mm (4.6 in) by 152 mm (6 in) vertical cable channels as side rails in 2.1 m (7 ft) height.
   - Include vertical cable managers mounted on the front of the channels with hinged covers that can handle large quantities of cables and patch cords. Cable managers must retain cables even when covers are removed. Covers are modular in design, which eliminates the need to remove full-length covers for each patch cord change.
   - Have available additional vertical cable manager segments for mounting to the back of the rack to provide additional cable management.

- Have channels capable of utilizing and re-locating ten high capacity, reusable hook and loop cable managers.
- Have cable access holes on side rails, which allow cables to be routed between adjacent racks.
- Have standard 19-inch CEA-310-E mounting holes having a full 45 RMS on front and back of rails.
- Have ladder channel, which acts as a top bracket to easily nest a standard 3 04.8 mm (12 in) ladder tray. The channel must have carriage bolt holes for attaching to the ladder system.
- Have available an optional rack top cable tray which manages cable bundles routed above the rack, and eliminate the need for installing a ladder rack for routing cables. The tray is mounted without the need of tools or hardware and includes up to three (3) separate cable paths featuring removable quarter-turn hook and loop cable managers.
- Be available in two versions, either aluminum or steel with a black finish and utilize black grommets for unused cable openings.
- Have the mounting option of two additional vertical cable management channels 152 mm (6 in) x 2.1 m (7 ft) and 76 mm (3 in) x 2.1 m (7 ft) which can be located between racks. The channel shall include cable retainers, which can be hinged left or right and be located in any position along the channel.
- Have floor mounting holes and a ground lug for 0-6 gauge ground cable provided.
- Have optional 10-outlet (4 ft) power strip for mounting onto the rack
- All installed racks and cabinets will be properly grounded.

b. Cabinets
- Cabinet size and type will be determined by the Information Technology Department.
- For cabinet enclosure installations in a telecommunications room or data center the installer shall have these minimum features listed below: The Horizontal Cable Management shall be mounted above and below each patch panel.
- Have available wire managers with Covers to conceal Equipment Patch Cords
- Be available in a Multi-Access Configuration with pass-through holes for easy routing of cables.

M. System Design Requirements

4. Horizontal Cabling
- The Horizontal Subsystem is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connect or to the horizontal cross-connect in the telecommunications

room. It consists
of the telecommunications outlet/connector, the horizontal cables, optional consolidation point and that portion of the cross-connect in the telecommunications room serving the horizontal cable. Each floor of a building should be served by its own Horizontal Subsystem.

5. Installation
   a. Physical Installation Cable Pathways
      - Pathways shall be designed and installed to meet applicable local and national building and electrical codes or regulations.
      - Grounding / Earthing and bonding of pathways shall comply with applicable codes and regulations.
      - Pathways shall not have exposed sharp edges that may come into contact with telecommunications cables.
      - The number of cables placed in a pathway shall not exceed manufacture specifications, nor, will the geometric shape of a cable be affected.
      - Pathways shall not be located in elevator shafts.
   b. Intrabuilding Cable Routing
      - The backbone subsystem shall include cable installed in a vertical manner between floor telecommunications rooms and the main or intermediate cross-connect in a multi-story building and cable installed horizontally between telecommunications rooms and the main or intermediate cross-connect in a long single story building like a school or factory.
      - Unless otherwise recommended by the manufacturer, all fiber cables will be run in innerduct.
      - Fibers will be terminated in the telecommunications rooms using SC, ST, MT-RJ, or LC connectors in wall mounted interconnect centers or rack mounted panels equipped with sufficient ports, slack storage space and splice trays if required to terminate and secure all fibers.
      - Adequate riser sleeve/slot space shall be available with the ability to ingress the area at a later date in all telecommunications rooms, such that no drilling of additional sleeves/slots is necessary.
      - The backbone cables shall be installed in a star topology, emanating from the main cross-
        connect to each telecommunications room. An intermediatecross-connect may be presentbetween the main cross-connect and the horizontal cross-connect. This is known as a hierarchical star topology.
      - At least one 4-pair balanced twisted-pair, hybrid/bundled or multi-pair cable should be run for each Intrabuilding backbone segment.
      - Optical fiber should be run for any backbone segment greater than 90 m (2 95 ft). If the Intrabuilding backbone segment is less than 90 m (295 ft), and fiber is not routed, the balanced twisted-pair cable shall be category 6 or higher.
      - Backbone pathways shall be installed or selected such that the minimum b end radius of backbone cables is kept within manufacturer specifications both during and after installation.

c. Interbuilding Cable Routing
- The backbone subsystem shall include cable installed between buildings via underground, tunnel, direct-buried, aerial or any combination of these from the main cross-connect to an intermediate cross-connect in a multi-building campus.
- Unless otherwise recommended by the manufacturer, all fiber cables will be run in innerduct.
- Fibers will be terminated in the telecommunications rooms using SC, ST, MT-RJ or LC connectors in wall mounted interconnect centers or rack mounted panels equipped with sufficient ports, slack storage space and splice trays if required to terminate and secure all fibers.
- In an underground system, adequate underground conduit space shall be available and accessible at each building. The conduits shall not exceed a fill factor of 40%.
- All underground systems shall be designed to prevent water runoff from entering the building.
- The backbone cables shall be installed in a star topology, emanating from the main cross-
  connect to each satellite building telecommunications room. All Interbuildi ng cables shall be installed to the applicable codes and regulations.
- Optical fiber shall be run for all Interbuilding backbone segments, and as a recommendation, at least one balanced twisted-
  pair cable should be run for each Interbuilding backbone segment.
- Backbone pathways shall be installed or selected such that the minimum bend radius and pulling tension of backbone cables is kept within cable manufacturer specifications both during and after installation.

d. Horizontal Cable Routing
- All horizontal cables, regardless of media type, shall not exceed 90 m (295 ft) from the telecommunications outlets in the work area to the horizontal cross connect.
- The combined length of jumpers, or patch cords and equipment cables in the telecommunications room and the work area should not
  exceed 10m (33 ft) unless used in conjunction with a multi-
  user telecommunications outlet.
- Two horizontal cables shall be routed to each work area. At least one horizontal cable connected to an information outlet shall be 4-pair, 100 Ω balanced twisted-pair.
- It is recommended that a minimum horizontal cable distance of 15m (49 ft) shall be maintained between the telecommunications room and the work area.
- For installations with consolidation points, a minimum horizontal cable distance of 15m (49 ft) shall be maintained between the

telecommunications room and consolidation point, and 5m (16ft) between the consolidation point and the work area.

- Horizontal pathways shall be installed or selected such that the minimum bend radius of horizontal cables is kept within manufacturer specifications both during and after installation.
- In open ceiling cabling, cable supports shall be provided by means that is structurally independent of the suspended ceiling, its framework, or supports. These supports shall be spaced no more than 1.5 m (5 ft) apart.
- **UTP ONLY**: Telecommunications pathways, spaces and metallic cables, which run parallel with electric power or lighting, which is less than 3kVA, shall be installed with a minimum clearance of 50 mm (2 in).
- **UTP ONLY**: Telecommunications pathways, spaces and metallic cables, which run parallel with electric power or lighting, which is more than 3kVA but less than 6kVA, shall be installed with a minimum clearance of 1.5 m (5 ft).
- **UTP ONLY**: Telecommunications pathways, spaces and metallic cables, which run parallel with electric power or lighting, which is more than 6kVA, shall be installed with a minimum clearance of 3 m (10 ft).
- For voice or data applications, 4-pair balanced twisted-pair or fiber optic cables shall be run using a star topology from the telecommunications room serving that floor to every individual information outlet. The customer prior to installation of the cabling shall approve all cable routes.
- The Contractor shall observe the bending radius and pulling strength requir ements of the 4-pair balanced twisted-
  pair and fiber optic cable during handling and installation.
- Each run of balanced twisted-pair cable between horizontal portion of the cross-connect in the telecommunication closet and the information outlet shall not contain splices.
- In a false ceiling environment, a minimum of 75 mm (3 in) shall be observed between the cable supports and the false ceiling.
- Continuous conduit runs installed by the contractor should not exceed 30.5 m (100 ft) or contain more than two (2) 90 degree bends without utilizing appropriately sized pull boxes.
- All horizontal pathways shall be designed, installed, and grounded to meet applicable local and national building and electrical codes.
- The number of horizontal cables placed in a cable support or pathway shall be limited to a number of cables that will not cause a geometric shape of the cables.
- Maximum conduit pathway capacity shall not exceed a 40% fill. However, perimeter and furniture fill is limited to 60% fill for move and changes.
- Horizontal distribution cables shall not be exposed in the work area or other locations with public access.

e. Work Area Termination

- All balanced twisted-pair cables wired to the telecommunications outlet/ connector, shall have 4-pairs terminated in eight-position modular outlets in the work area. All pairs shall be terminated.
- The telecommunications outlet/connector shall be securely mounted at planned locations.
- The height of the telecommunications faceplates shall be to applicable codes and regulations.

f. Pulling Tension
- The maximum cable pulling tensions shall not exceed manufacturer's specifications.

g. Bend Radius
- The maximum cable bend radii shall not exceed manufacturer's specifications.

h. Slack
- In the work area, a minimum of 300 mm (12 in) should be left for balanced twisted-pair cables, while 1 m (3 ft) should be left for fiber cables.
- In telecommunications rooms a minimum of 3m (10 ft) of slack should be left for all cable types. This slack must be neatly managed on trays or other support types.

i. Cable Tie Wraps
- Tie wraps shall be used at appropriate intervals to secure cable and to provide strain relief at termination points. These wraps shall not be over-tightened to the point of deforming or crimping the cable sheath.
- Hook and loop cable managers should be used in the closet where reconfiguration of cables and terminations may be frequent.

j. Grounding
- All grounding / earthing and bonding shall be done to applicable codes and regulations.

Ground

k. Fire Protection
- Properly installed firestop systems shall be installed to prevent or retard the spread of fire, smoke, water, and gases through the building. This require ment applies to openings designed for telecommunications use that may or may not be penetrated by cables, wires, or raceways.
- Fire-stops shall be done to applicable code.

N. Testing

1. Copper Testing
   - All category 6 field-testing shall be performed with an approved level III balanced twisted-pair field test device.
   - All installed category 6 channels shall perform equal to or better than the minimum requirements as specified by the table below:

| Parameter | Performance @ 100MHz | Performance @ 200MHz | Performance @ 250MHz |
|---|---|---|---|
| **Insertion Loss** | 19.59 dB | 29.01 dB | 33.07 dB |
| **NEXT Loss** | 46.9 dB | 41.8 dB | 40.1 dB |
| **PS NEXT Loss** | 45.6 dB | 40.4 dB | 38.7 dB |
| **ACRN** | 27.3 dB | 12.8 dB | 7.0 dB |
| **PS ACRN** | 26.0 dB | 11.3 dB | 5.6 dB |
| **ACRF** | 31.3 dB | 25.2 dB | 23.3 dB |
| **PS ACRF** | 30.3 dB | 24.2 dB | 22.3 dB |
| **Return Loss** | 14.0 dB | 11.0 dB | 10.0 dB |
| **Propagation Delay** | 548 ns | 547 ns | 546 ns |
| **Delay Skew** | 45 ns | 45 ns | 45 ns |

- Category 3, balanced twisted-pair horizontal and backbone cables, whose length does not exceed 90 m (295 ft) for the basic link, and 100 m (328 ft) for the channel shall be 100% tested according to ANSI/TIA/EIA-568-B.1. Test parameters include wire map plus ScTP shield continuity (when present), insertion loss, length and NEXT loss (pair-to-pair). NEXT testing shall be done in both directions.
- All balanced twisted-pair backbone cables exceeding 90 m (295 ft) or 100 m (328 ft) shall be 100% tested for continuity if applications assurance is not required.
- Category 6 balanced twisted-pair horizontal and backbone cables, whose length does not exceed 90 m (295 ft) for the basic link, and 100 m (328 ft) for the channel shall be 100 percenttested according to ANSI/TIA/EIA-568-
  B.1. Test parameters include wire map plus ScTP shield continuity (when p resent), length, NEXT loss (pair-to-pair), NEXT loss (power sum), ACR-F loss (pair-to-
  pair), ELFEXT loss (power sum), return loss, insertion loss, propagation de lay, and delay skew.

O. Documentation

1. Labeling
   - Horizontal and backbone cables shall be labeled at each end. The cable or its label shall be marked with its identifier.
   - A unique identifier shall be marked on each faceplate to identify it as connecting hardware.
   - Each port in the faceplate shall be labeled with its identifier.
   - A unique identifier shall be marked on each piece of connecting hardware to identify it as connecting hardware.

- Each port on the connecting hardware shall be labeled with its identifier.

2. Drawings
   - As-built drawings shall be supplied by the contractor showing the locations of and identifiers for all:
   - Horizontal cable routing and terminations
   - Telecommunications outlets/connectors
   - Backbone cable routing and terminations

3. Records/Reports
   - The form will be computer based and both soft copies and hard copies shall be part of the As-built package.
   - Cable records must contain the identifier, cable type, termination positions at both ends, splice information, as well as any damaged pairs/conductors.
   - Connecting hardware and connecting hardware position records must contain the identifier, type, damaged position numbers, and references to the cable identifier attached to it.
   - Test documentation on all cable types shall be included as part of the as-built package. All reports shall be generated from the computer-based program used to create the records above. These reports should include but not limited to:
     - Cable Reports
     - Cross-connect Reports
     - Connecting Hardware Reports

4. Warranty
   All channels are to be qualified for linear transmission performance up to 250 MHz to ensure that high-frequency voltage phase and magnitude contributions do not prove cumulative or adversely affect channel performance.

5. System Warranty
   A ten (10) year warranty available for the category 6 structured cabling system shall be provided for an end to-end channel model installation which covers applications assurance, cable, connecting hardware and the labor cost for the repair or replacement thereof.

   - Additional features of the warranty shall include:
     Margin over category 6 channel specifications on all parameters across the entire frequency range of 1-250MHz as noted below:
     - Performance claims based on worst case testing and channel configurations.

6. Product Warranty
   The manufacturer of passive telecommunications equipment used in a manner not associated with the Systems Warranty must have a minimum five (5) year Component Warranty on all of its products. The Products Warranty covers the

components against defects in material or workmanship under normal and proper use.