

SECTION 27 05 44

SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND

CABLING PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
- 2. Sleeve-seal systems.
- 3. Sleeve-seal fittings.
- 4. Grout.
- 5. Silicone sealants.

- B. Related Requirements:

- 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire- resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:

- 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

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- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings in walls:
 - 1. STI EZ Path Series 44 or approved equivalent.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. HOLDRITE.
 - d. Metraflex Company (The).
 - e. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Carbon steel.
 - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION**3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS**

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot- type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 27 13 00
COMMUNICATION SYSTEMS
IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes labeling and identification standards for:
1. Horizontal and backbone cabling, patch cables and termination hardware
 2. Conduits and pathways
 3. Equipment cabinets, racks, frames and enclosures
- B. Telecommunication components and cables shall be labeled, including but not limited to:
1. Telephone Terminal boards
 2. Telecommunications Rooms
 3. Fiber optic cables
 4. Copper cables
 5. Ground points
 6. Cross-connect fields
 7. Conduit pathways
 8. Pull boxes and junction boxes
 9. Equipment racks and cabinets
 10. Copper and fiber patch panels
 11. Patch cables/jumpers
- C. Pathways are defined but not limited to; any conduit, inner duct, underground duct bank, wiring troughs, pull boxes, and any wiring systems used to enclose cabling of any type
- D. Related Requirements:

1. Section 270528 "Pathways for Communications Systems" for conduits, cable trays and accessories.
2. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
3. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber data cabling associated with system panels and devices.
4. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.

5. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber data cabling associated with system panels and devices.
6. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. FO: Fiber Optic
- C. LAN: Local area network.
- D. MM: Multi-Mode
- E. PP: Patch Panel
- F. RCDD: Registered Communications Distribution Designer.
- G. SM: Single-Mode

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
 2. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Label material shall be suitable for intended usage and environment, meeting the legibility, defacement and general exposure requirements listed in UL 969 for indoor and outdoor use. Where insert labels are used the insert label shall be covered with clear cover and securely held in place.
- B. Interior labeling: Printer shall be of the thermal transfer type capable of printing self-laminating labels of various size up to and including 1.5"by 1.5" printable area with a 4.5" self-laminating tail. No non-self-laminating labels shall be approved.
- C. All labels shall be permanent, i.e. will not fade, peel, or deteriorate due to environment or time.
- D. Handwritten labels are not acceptable.

2.2 CONDUITS AND PATHWAYS

- A. Conduits: General-purpose label designed for powdered coated surfaces with an ultra- aggressive adhesive, trade name, "Mondo Bondo" (Brady). Label size shall be appropriate for the conduit size. Font size shall be easily visible from the finished floor.
- B. Innerduct: Polyethylene general-purpose tagging material, Brady part number PTL-12-109 (.75 X 3.00) used with an R4310 ribbon. This tag shall be attached using tie wraps.
- C. Junction boxes (larger than four-inch x four-inch): General-purpose label designed for powdered coated surfaces with an ultra-aggressive adhesive, trade name, "Mondo Bondo", Brady part number PTL-43-483 (1.90 X continuous) used with an R6010 ribbon. Font size shall be easily visible from the finished floor.
- D. Junction boxes (four-inch x four-inch): General-purpose label designed for powdered coated surfaces with an ultra-aggressive adhesive, trade name, "Mondo Bondo", Brady part number PTL-42-483 (1.00 X continuous) used with an R6010 ribbon.

2.3 BACKBONE AND HORIZONTAL CABLE AND TERMINATIONS

- A. Fiber termination hardware (cover): General purpose label designed for powdered coated surfaces, trade name, "Mondo Bondo", Brady part number PTL-42-483 (1.00 X continuous) used with an R6010 ribbon.
- B. Fiber termination hardware (designation strip): Thermal transfer printable label with a permanent acrylic adhesive, Brady part number PTL-10-423 (.75 X .25) used with an R6010 ribbon.

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- C. Patch panels: Gloss white film with a permanent acrylic based adhesive, Brady part number PTL-39-422 (.375 X .60) used with an R6010 ribbon.
- D. 110 Copper termination hardware: Laser printable, non-adhesive label designed for 110 terminal block marking, Brady part number LAT-177-124 (available in various colors).
- E. Modular Faceplate: Highly durable, non-adhesive, polypropylene tag stock used for thermal transfer printing of faceplate designation strip, Brady part number PTL-40-412 (1.938 x .375) used with an R6210 ribbon.
- F. Horizontal cabling, patch cords, inside copper and low pair count (12 strands or less) fiber optic cable: Permanent acrylic adhesive, self-laminating vinyl wire and cable identification, Brady part number PTL-31-427 (1.00 X 1.50 X .50) used with an R4310 ribbon.
- G. Outside plant copper cable: Permanent acrylic adhesive, self-laminating vinyl wire and cable identification, Brady part number PTL-34-427 (1.50 X 6.00 X 1.50) used with an R4310 ribbon.
- H. Inside and outside plant fiber cables: Permanent acrylic adhesive, self-laminating vinyl wire and cable identification, Brady part number PTL-33-427 (1.50 X 4.00 X 1.00) used with an R4310 ribbon.

2.4 EQUIPMENT RACKS AND CABINETS

- A. General purpose label designed for powdered coated surfaces.

PART 3 - EXECUTION

3.1 GENERAL

- A. Identify system components, wiring, and cabling complying with TIA-606-B.

3.2 CONDUITS AND JUNCTION/PULL BOXES

- A. All conduits, inner duct, junction boxes, gutters and pull boxes shall be labeled.
- B. Conduits shall be labeled with the word “communications” and the conduit’s origination room number and destination room number. Permanent room identifiers shall be used.
- C. Label conduit every 50 feet, at each wall and floor penetration and at each conduit termination, such as outlet boxes, pull boxes, and junction boxes, or as otherwise specified in other Sections.
- D. Junction boxes, gutters and pull boxes shall be labeled with identification name or number as determined by Contractor and submitted for approval.

- E. Labels on conduits, junction boxes, gutters and pull boxes shall be machine-generated and easily visible from the finished floor.

3.3 BACKBONE AND HORIZONTAL CABLE AND TERMINATIONS

- A. Label cable terminations on designation strips.
- B. Label all cable at each terminating point.
- C. Label each port of the work area outlet.
- D. Labels shall be self-adhesive and machine generated. Handwritten labels are not acceptable.
- E. Cable identification numbers shall not be duplicated.
- F. Backbone Fiber Cable
 - 1. All fiber riser FOPPs shall be labeled on the front panel as follows:
 - a. FOPP #
 - b. Location: Building, floor, room #
 - c. From: Building, floor, and room #
 - d. Number of 6 port bulkheads installed
 - e. Date installed
 - 2. Each fiber riser cable installed shall be labeled at each end as follows:
 - a. Fiber cable #
 - b. Terminated in: FOPP #
 - c. Bulkhead Positions in FOPP Strands:
 - d. From: Building and Room #
 - e. Type: (SM, MM)
 - f. Strand Count
 - g. Date installed
 - h. Date tested
 - 3. On each FOPP a fiber cable is landed on, the FOPP port identifying sheet provided by the factory shall have the applicable fiber cable # written in the applicable ports, identifying locations for all strands.
 - 4. The following information for each FOPP and each fiber cable installed shall be provided in Table Format. Both a hard copy and electronic copy are to be provided. Electronic information is to be in Excel or compatible format. For each riser FOPP installed:
 - a. FOPP #
 - b. Fiber Cable #
 - c. Location: building, floor, room #
 - d. From: building, floor, room #
 - e. Number of 6 port bulkheads installed
 - f. Intermediate rooms in path:

- g. Type: (SM, MM)
 - h. Strand Count
 - i. Bulkhead Positions in FOPP Strands:
 - j. Date Installed
 - k. Installed By: (Company)
 - l. Date tested
 5. A copy of the above shall be provided with as built documents and to Owner.
 - a. Backbone Copper Cable
 6. All riser terminations including riser patch panels shall be labeled as follows:
 - a. Location: Building, floor, room #
 - b. From: Building, floor, room #
 - c. Pair #, or port # and patch panel # on each termination block
 - d. Identify any bad pairs
 7. Each riser cable installed shall be labeled at each end as follows:
 - a. Cable #
 - b. From: Building, floor, room #
 - c. Pair count
 8. The following information for riser cable installed shall be provided in Table Format. Both a hard copy and electronic copy are to be provided. Electronic information is to be in Excel or compatible format.
 - a. Cable #
 - b. Location: building, floor, room #
 - c. Pair Count
 - d. Intermediate rooms in path
 - e. Manufacturer
 - f. Date installed
 - g. Date Tested
 - h. Installed by: (company)
 9. A copy of the above shall be provided with as built documents and to Owner.
- G. Horizontal Fiber Cable
1. Horizontal fiber cabling shall be installed on FOPPs specified for horizontal fiber only.
 2. Each horizontal fiber FOPP is to be labeled as follows:
 - a. FOPP #
 - b. Location: building, floor, room #
 - c. Areas served by room #
 - d. Number of 6 port bulkheads installed
 - e. Corresponding Work Area outlet port numbers
 - f. Date installed:
 - g. Date Tested:

- h. Installed by (company):
3. Horizontal fiber cabling labeling shall reflect FOPP port to corresponding room fiber outlet/jack.
 4. Work Area outlets vary in ports per outlet configuration. Each outlet shall be labeled with the serving Telecom Room #, FOPP # and sequential numbering from lowest port number to highest port number. Each port shall be individually labeled with it's unique sequential port number.
 5. The following information for each horizontal FOPP and each horizontal fiber cable installed shall be provided in Table Format. Both a hard copy and electronic copy shall be provided. Electronic information is to be in Excel or compatible format.
 6. Horizontal fiber cables:
 - a. Cable #
 - b. FOPP # cable is landed in:
 - c. Work Area outlet ports (by number) provided by cable:
 - d. Type:
 - e. Manufacturer:
 - f. Strand Count:
 - g. Bulkhead Positions in FOPP Strands are Landed On:
 - h. Date Installed:
 - i. Installed By (Company):
 - j. Date Tested:
 7. A copy of the above is to be provided with as built documents and to Owner.
 - a. Horizontal Copper Cable
 8. Each horizontal shall be labeled with a unique designation. The Work Area outlet port/jack labeling shall reflect the corresponding patch panel and port number
 9. Work Area outlets vary in ports per outlet configuration. Ports for each outlet shall be terminated sequentially and with a consistent method on the patch panels.
 10. The following information for each horizontal cable installed shall be provided in Table Format. Both a hard copy and electronic copy are to be provided. Electronic information is to be in Excel or compatible format.
 - a. Work Area outlet port #
 - b. Type: e.g. category 6 UTP
 - c. Location: building, floor, room #
 - d. Serving telecom room
 - e. Corresponding patch panel and port number
 - f. Manufacturer
 - g. Date installed:
 - h. Date Tested:
 - i. Installed by (company):

11. The following color coding scheme shall be used:
 - a. System Patch Cables – UTP and Fiber:
 - b. Data: Blue
 - c. Voice: White
 - d. Security (cameras, ACS panels): Yellow
 - e. PA microphones: Black
 - f. Tenant Systems: Green
 - g. Building Systems: Brown

12. Horizontal Wiring:
 - a. Horizontal: Blue
 - b. Security UTP: Yellow
 - c. Security FO MM: Orange
 - d. Security FO SM: Yellow

13. Intra-building Riser Cables:
 - a. Multi pair Copper: Gray
 - b. Fiber multi-mode: Aqua
 - c. Fiber single mode: Yellow

14. Three copies of a cable record document containing the cable information required on the cable labels shall be delivered to the Owner.

3.4 EQUIPMENT RACKS AND CABINETS

- A. All racks and cabinets shall be properly labeled with permanent typewritten labels, easily visible from finished floor.

- B. Label as indicated on drawings.

END OF SECTION

SECTION 27 05 26:**GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.
 - 4. Grounding labeling.

1.03 DEFINITIONS

- A. BCT: Bonding conductor for telecommunications.
- B. EMT: Electrical metallic tubing.
- C. TBB: Telecommunications bonding backbone
- D. TGB: Telecommunications grounding busbar.
- E. TMGB: Telecommunications main grounding busbar.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. BCT, TMGB, TGBs, TBBs and routing of their bonding conductors.
- B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in operation, and maintenance manuals.

1.07 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2: PRODUCTS**2.01 SYSTEM COMPONENTS**

- A. Comply with J-STD-607-A.

2.02 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Harger Lightning & Grounding.
 - 2. Panduit Corp.
 - 3. Engineer Approved Equal
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Cable Tray Equipment Grounding Wire: No. 6 AWG.
- D. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
- E. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.

5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.03 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Burndy; Part of Hubbell Electrical Systems.
 2. Chatsworth Products, Inc.
 3. Harger Lightning & Grounding.
 4. Panduit Corp.
 5. Engineer Approved Equal
- B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
 1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8 inch centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.04 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Chatsworth Products, Inc.
 2. Harger Lightning & Grounding.
- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-A.
 1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.
 1. Predrilling shall be with holes for use with lugs specified in this Section.

2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.
1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19 in. equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack. See drawings for detailed information concerning rack-mounted horizontal busbars.
 3. Rack-Mounted Vertical Busbar: Designed for mounting inside the vertical wire manager. Vertical busbar shall run the height of the vertical wire manager unless shown otherwise on the drawings. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack. See drawings for detailed information concerning rack-mounted vertical busbars.

2.05 LABELING

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Brother International Corporation.
 2. HellermannTyton.
 3. Engineer Approved Equal
- B. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with J-STD-607-A.

3.03 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 3. The bonding backbone between the TMGB and the TGB in each communications room shall be as detailed on the drawings, but no smaller than No. 3/0 AWG.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.
- C. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- D. Conductor Support:
 - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- E. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Install in telecom cable tray or support at not more than 36-inch intervals where cable tray is not available.
 - 4. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB

3.04 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.05 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - 1. Use crimping tool and the die specific to the connector.
 - 2. Pre-twist the conductor.
 - 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the TMGB with insulated bonding conductor.
- E. Interconnections: Interconnect all TGBs to the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB with a No. 2 AWG bonding conductors.
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.
- H. Electrical Power Panelboards: Where electrical panelboards for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of each panelboard.
- I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.
- J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.06 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 - 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
 - 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.07 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 2. Test the bonding connections of the system using an AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 - 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.
- C. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Design Consultant promptly and include recommendations to reduce ground resistance.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION

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SECTION 27 05 28:**PATHWAYS FOR COMMUNICATIONS SYSTEMS****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Fire Rated Cable Pathways
 - 5. J-Hooks.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Buried communication line marking tape

1.03 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

- A. Product data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Source quality-control reports.

PART 2: PRODUCTS**2.01 METAL CONDUITS AND FITTINGS**

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Alpha Wire.
 - 4. Anamet Electrical, Inc.
 - 5. Electri-Flex Company.
 - 6. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 7. Picoma Industries, Inc.
 - 8. Plasti-Bond.
 - 9. Republic Conduit.
 - 10. Southwire Company.
 - 11. Thomas & Betts Corporation; A Member of the ABB Group.
 - 12. Western Tube and Conduit Corporation.
 - 13. Engineer Approved Equal.
- C. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- D. GRC: Comply with ANSI C80.1 and UL 6.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. EMT: Comply with ANSI C80.3 and UL 797.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
 - 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
- H. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS AND FITTINGS

- A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. AFC Cable Systems; a part of Atkore International.
 2. Allied Tube & Conduit; a part of Atkore International.
 3. Anamet Electrical, Inc.
 4. Arco Corporation.
 5. CANTEX INC.
 6. Carlon; a brand of Thomas & Betts Corporation.
 7. CertainTeed Corporation.
 8. Condux International, Inc.
 9. Dura-Line.
 10. Electri-Flex Company.
 11. Kraloy.
 12. Lamson & Sessions.
 13. Niedax Inc.
 14. RACO; Hubbell.
 15. Engineer Approved Equal.
- C. General Requirements for Nonmetallic Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 2. Comply with TIA-569-D.
- D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- E. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.
- F. Solvents and Adhesives: As recommended by conduit manufacturer.

2.03 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum installation unless otherwise indicated.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Alpha Wire.
 2. Carlon; a brand of Thomas & Betts Corporation.
 3. Dura-Line.
 4. Endot Industries Inc.
 5. Engineer Approved Equal.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.04 FIRE RATED CABLE PATHWAYS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Hilti North America - Firestop Speed Sleeve
 2. Wiremold/Legrand Flamestopper
 3. Specified Technologies Inc. (STI) - EZ Path
 4. Engineer Approved Equal
- B. General Requirements for fire rated cable pathways:
1. Fire rated cable pathway devices shall be used in fire-rated construction for low-voltage, video, data and voice cabling and optical fiber cabling at locations shown on the drawings.
 2. Fire rated cable pathways shall contain a built-in fire sealing system sufficient to maintain the hourly fire-rating of fire rated wall and or floor penetrated.
 3. The self-contained sealing system shall adjust to the installed cable loading and shall permit cables to be installed or removed without the need to remove or reinstall firestop materials.
 4. Fire rated cable pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
 5. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding UL System number installed.
 6. Fire rated cable pathway shall replace conduit sleeves with firestop sealant/putty in walls and floors, and;
 - a. When installed individually in walls/floors, devices shall pass through core-drilled opening utilizing tested wall/floor plates.
 - b. When multiple units are ganged in walls/floors, devices shall be anchored by means of a tested grid.
 7. Cable tray/cabled runway shall terminate at each wall/floor and resume on the other side such that cables pass independently through fire rated pathway devices. Cable tray/cable runway shall be properly supported on each side of the wall/floor.
 8. Fire rated cable pathways shall be UL Classified and/or FM Systems Approved and tested to the requirements of ASTM E814 (UL1479).

2.05 J-HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Erico, Inc.
 2. Panduit Corp.
 3. Engineer Approved Equal.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.
- E. Rated for use with specified cable.
- F. Galvanized steel.

- G. J shape.

2.06 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Adalet.
 2. Carlon; a brand of Thomas & Betts Corporation.
 3. Crouse-Hinds, an Eaton business.
 4. EGS/Appleton Electric.
 5. Erickson Electrical Equipment Company.
 6. FSR Inc.
 7. Hoffman; a brand of Pentair Equipment Protection.
 8. Milbank Manufacturing Co.
 9. Molex Industrial Products Group; Woodhead Brand.
 10. MonoSystems, Inc.
 11. Oldcastle Enclosure Solutions.
 12. O-Z/Gedney; a brand of Emerson Industrial Automation.
 13. Plasti-Bond.
 14. Quazite: Hubbell Power Systems, Inc.
 15. Engineer Approved Equal.
- C. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-D.
 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 4. Device Box Dimensions: 4 11/16 inches square by 3 inches deep.
- D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- H. Hinged-Cover Enclosures and Cabinets: Comply with UL 50 and NEMA 250, with continuous-hinge cover, screw down clamps, padlock hasp and mounting panel unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures:
 - a. Material: Fiberglass.
 - b. Finished inside with radio-frequency-resistant paint.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

4. Accessory feet where required for freestanding equipment.
5. Refer to drawings for required NEMA ratings.

2.07 BURIED COMMUNICATION LINE MARKING TAPE

- A. Underground Communication Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic, tape compounded for direct-burial service not less than 6 inches wide by 4 mils thick. Printed legend shall be indicative of general type of underground line below, such as "CAUTION - BURIED COMMUNICATION LINE BELOW". Tape shall have integral metallic facing or metallic core to allow locating buried tape with electronic detection equipment.

PART 3: EXECUTION

3.01 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: RNC, Type EPC-40-PVC.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Corridors used for traffic of baggage tugs and carts.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Damp or Wet Locations: IMC.
 6. Pathways for Non-Armored-Optical-Fiber Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
 7. Pathways for Non-Armored-Optical-Fiber Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
 8. Pathways for Concealed General-Purpose Distribution of Non-Armored-Optical-Fiber Cable: Plenum-type, optical-fiber-cable pathway.
 9. Pathways for MPO fiber optic trunk cable inside Communication Rooms: Split wall, plenum-type, optical-fiber-cable pathway.
 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and NEMA 250, Type 4 painted steel units in damp or wet locations.
 11. Optical-fiber-cable pathway not required for armored optical fiber.
- C. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper cables, and 1 1/2 inch (25 mm) for optical-fiber cables.
- D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings.

3.02 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
 2. NECA/BICSI 568.
 3. TIA-569-D.
 4. NECA 101
 5. NECA 102.
 6. NECA 105.
 7. NECA 111.
- B. Cabling shall be concealed where possible and shall be installed as follows
1. Cables concealed inside hollow wall construction shall be installed in conduits stubbed into accessible ceiling cavities.
 2. Cables installed in accessible ceiling cavities shall be supported with cable tray or J-Hook supports.
 3. Cables located in rooms with an exposed ceiling structure shall be installed in conduit.
 4. Cables installed above inaccessible ceilings shall be installed in conduit.
 5. It is acceptable to fish flexible metal conduit inside existing hollow walls and above existing inaccessible ceilings.
 6. Cables installed outdoors shall be installed in conduit.
 7. Cables installed in casework shall be installed in conduit.
 8. Route conduit and cables to suit field conditions.
- C. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- D. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- E. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.
- F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

- J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- L. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- O. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- Q. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- R. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 - 2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- T. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.
- U. Install suitable pliable compound to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service pathway enters a building or structure.
 - 3. Where an above grade pathway enters or exits a building structure.

4. Where otherwise required by NFPA 70, Article 300.7 (A).
- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- W. Expansion-Joint Fittings:
 1. Install in each run of aboveground PVC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground metal that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion and seismic joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- X. Fire Rated Pathways
 1. Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer's installation instructions and technical information.
 2. Install systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.
 3. Comply with manufacturer's instructions for installation of products.
 4. Place system stickers on each side of wall penetrations.
- Y. J-Hooks:
 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 4. Space hooks no more than 4 feet o.c.
 5. Provide a hook at each change in direction.

6. Category 6A and fiber optic cable shall not be hung on the same J-Hook, use multiple J-Hooks to separate Category 6A cable from fiber optic cable.
- Z. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- AA. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe of less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Section 312000 "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
 4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete around conduit for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
 5. Buried Communication Line Warning Tape: Bury warning tape approximately 12 inches above all underground communication conduits.

3.04 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.05 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

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SECTION 27 05 29:**HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Steel slotted support systems for communication raceways.
 - 2. Conduit and cable support devices.
 - 3. Support for conductors in vertical conduit.
 - 4. Structural steel for fabricated supports and restraints.
 - 5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - 6. Fabricated metal equipment support assemblies.
 - 7. Design of Seismic restraint systems

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Brackets.
 - 2. Include rated capacities and furnished specialties and accessories.
- B. Shop Drawings: Fabrication and installation details for communications hangers and support systems signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - 1. Trapeze hangers. Include product data for components.
 - 2. Equipment supports.

- C. Delegated-Design Submittal: For hangers and supports for communications systems signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
1. Include design calculations for seismic requirements and code required restraints.
 2. Include seismic restraint details.

1.04 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Ductwork, piping, fittings, and supports.
 3. Structural members to which hangers and supports will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Projectors.
- B. Seismic Qualification Certificates: For hangers and supports for communications equipment and systems, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.05 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

PART 2: PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.
- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface. Provide fittings and accessories that mate and match with steel slotted support systems and are of the same manufacturer.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. B-line, an Eaton business.
 - b. Unistrut; Part of Atkore International.
 - c. Engineer Approved Equal.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
 4. Channel Width: Selected for applicable load criteria.
 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 7. Channel Dimensions: Selected for applicable load criteria.
 8. Provide steel channels with hot-dip galvanized finish for all outdoor locations.
- B. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 1. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Hilti, Inc.

- 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
2. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
- 1) B-line, an Eaton business.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.03 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3: EXECUTION

3.01 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
 2. NECA/BICSI 568.
 3. TIA-569-D.
 4. NECA 101
 5. NECA 102.
 6. NECA 105.
 7. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.02 SUPPORT INSTALLATION

- A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- B. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Use expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- C. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 27 05 36:**CABLE TRAYS FOR COMMUNICATIONS SYSTEMS****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Wire-mesh cable tray.
 - 2. Cable tray accessories.
 - 3. Warning signs.
- B. Related Requirements:
 - 1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of cable tray.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - 2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
- C. Delegated-Design Submittal: For cable tray support and seismic restraints.

1. Cable tray support and seismic-restraint details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting cable tray support and seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.04 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.

PART 2: PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.
- B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
 2. Component Importance Factor: 1.5.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.02 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.03 WIRE-MESH CABLE TRAY

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. B-line, an Eaton business.
2. Chalfant Manufacturing Company.
3. Cooper Industries; Cooper B-Line; GS Metals Corp.
4. Hubbell Incorporated; Wiring Device-Kellems.
5. Legrand US.
6. MP Husky USA Cable Tray & Cable Bus.
7. Chatsworth Products.
8. Engineer Approved Equal.

B. Description:

1. Configuration: steel wire mesh, complying with NEMA VE 1.
2. Width: As indicated on Drawings.
3. Minimum Usable Load Depth: As indicated on Drawings.
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
6. Class Designation: Comply with NEMA VE 1, Class 12A.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
 - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1008/A 1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Electro-galvanized.
 - 1) Hardware: Chromium-zinc plated, ASTM F 1136.

2.04 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, cable drop out fittings and other fittings as indicated, of same materials and finishes as cable tray.

- B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.05 WARNING SIGNS

- A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."
- B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

2.06 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3: EXECUTION

3.01 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Fasten cable tray supports to building structure and install seismic restraints (where applicable).
- F. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- G. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- H. Support bus assembly to prevent twisting from eccentric loading.
- I. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
- J. Support wire-basket cable trays with trapeze hangers or wall brackets. Center hung trapeze hangers shall not be allowed.
- K. Install protective cover over all threaded rod supports to prevent cable damage.

- L. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- M. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
- N. Make changes in direction and elevation using manufacturer's recommended fittings.
- O. Make cable tray connections using manufacturer's recommended fittings.
- P. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
- Q. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- R. Install cable trays with enough workspace to permit access for installing cables.
- S. Install barriers to separate cables of different systems, such as communications and security.
- T. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.02 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

3.03 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with velcro tie wraps every 18 inches (450mm).
- C. Fasten cables on vertical runs to cable trays with velcro tie wraps every 18 inches (450 mm).
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 36 inches (900 mm).
- E. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.
- F. In existing construction, remove inactive or obsolete cables from cable trays.

3.04 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2.

3.05 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications and other low voltage cabling are separated from power circuits by barriers or are installed in separate cable trays.
 - 4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
 - 5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquer in suspect areas.
 - 7. Check for improperly sized or installed bonding jumpers.
 - 8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
- B. Prepare test and inspection reports.

3.06 PROTECTION

- A. Protect installed cable trays and cables.
 - 1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
 - 2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - 3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

SECTION 27 11 00:**COMMUNICATIONS EQUIPMENT ROOM FITTINGS****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Backboards.
 - 2. Telecommunications equipment racks and cabinets.
 - 3. Power distribution units (PDU).
 - 4. Cable runway
- B. Related Requirements:
 - 1. Section 270526 "Grounding and Bonding for Communications Systems" for grounding associated with system panels and devices.
 - 2. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
 - 3. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
 - 4. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber data cabling associated with system panels and devices.
 - 5. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
 - 6. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber data cabling associated with system panels and devices.
 - 7. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.03 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. LAN: Local area network.
- C. RCDD: Registered Communications Distribution Designer.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Delegated-Design Submittal: For seismic restraints.
 - 1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.
 - 3. Detail fabrication, including anchorages and attachments to structure.

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Certificates: For equipment racks and cabinets from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
 - 2. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2: PRODUCTS**2.01 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints.

- B. Seismic Performance: Equipment racks and cabinets shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 061053 "Miscellaneous Rough Carpentry."
- B. Install backboards starting at 12" AFF with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joint, unless noted otherwise on drawings.
- C. Backboards shall be painted with white, fire retardant paint (leaving the certification label exposed and unpainted) on all sides. Backboards shall be painted prior to installation.

2.03 TELECOMMUNICATIONS EQUIPMENT RACKS AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. APC by Schneider Electric
 - 2. Chatsworth Products, Inc.
 - 3. Hubbell Premise Wiring.
 - 4. Leviton Manufacturing Co., Inc.
 - 5. Middle Atlantic Products, Inc.
 - 6. Ortronics, Inc.
 - 7. Panduit Corp.
 - 8. Great Lakes Case & Cabinet Co., Inc.
 - 9. Engineer Approved Equal
- B. General Frame Requirements:
 - 1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Module Dimension: Width compatible with EIA 310-D standard, 19-inch (480-mm) panel mounting.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
- C. 2-Post Open Frame Relay Racks
 - 1. Size: Fully adjustable 19-inch mounting verticals. Overall height shall be 84" with a minimum of 45 RU.
 - 2. Construction:
 - a. Racks shall be manufactured from aluminum extrusion. Each rack shall have two L-shaped top angles, two L-shaped base angles and two C-shaped equipment-mounting channels. The base angles shall be pre-punched for attachment to the floor. Baked-polyester powder coat finish.

- b. Equipment mounting channels shall be 3” deep and punched on the front and rear flange with the EIA-310-D Universal hole pattern, 1-3/4” rack-mount units (RU), to provide 45RU for equipment. Each mounting space (RU) shall be marked and numbered on the mounting channel.
 - c. Equipment attachment points shall be drilled and tapped on both sides with 12-24 mounting holes at universal EIA spacing.
3. Mounting: All racks shall be floor mounted and permanently fixed to the floor with bolt-down kits. Multiple racks shall be connected together.
- Grounding: Provide grounding busbar as shown on drawings. Busbar shall consist of a 19” horizontal ground bar and/or a vertical ground bar installed inside the vertical wire managers. The busbar shall be connected to the perimeter grounding conductor with an irreversible compression fitting. All non-conductive coatings such as paint, lacquer, etc. shall be removed prior to making a ground connection at any point on the rack or cabinet.

D. Data Cabinets:

1. Size: Fully adjustable, front and rear 19-inch mounting verticals. Overall minimum dimensions shall be 30” wide, 42” deep with an overall height of 84”, with at least 45 RU.
2. Panels: Front, side, bottom and top panels shall be fully and easily removable by a latching mechanism. Front and rear panels shall be vented to allow airflow with a keyed locking mechanism, all cabinets shall be keyed alike. Coordinate keying requirements with owner.
3. Construction: The frame shall be made of extruded aluminum. Adjustable front and rear vertical mounting rails shall be drilled and tapped with 12-24 mounting holes at universal EIA spacing.
4. Cable Management: Cabinets shall contain integral vertical cable managers on both sides of the cabinet. Cable management shall run the entire height of the cabinet. If managers are not integral provide vertical cable managers as specified elsewhere in this specification.
5. Mounting: All cabinets shall be floor mounted with adjustable leveling feet and permanently fixed to the floor with bolt-down kits. Multiple cabinets shall be connected together with side panels removed for routing of cables between cabinets, provide ganging kits as required.
6. Grounding: Provide a 19” grounding busbar that accepts 2-hole grounding lugs in the top of each cabinet on the back side of the cabinet. The busbar shall be connected to the perimeter grounding conductor with an irreversible compression fitting. All non-conductive coatings such as paint, lacquer, etc. shall be removed prior to making a ground connection at any point on the cabinet.

E. Server Cabinets:

1. Size: Fully adjustable, front and rear 19-inch mounting verticals. Overall minimum dimensions shall be 30” wide, 48” deep with an overall height of 84”, with at least 45 RU.
 2. Panels: Front, side, bottom and top panels shall be fully and easily removable by a latching mechanism. Front and rear panels shall be vented to allow airflow with a keyed locking mechanism, all cabinets shall be keyed alike. Coordinate keying requirements with owner.
 3. Construction: The frame shall be made of extruded aluminum. Adjustable front and rear vertical mounting rails shall be drilled and tapped with 12-24 mounting holes at universal EIA spacing.
 4. Mounting: All cabinets shall be floor mounted with adjustable leveling feet and permanently fixed to the floor with bolt-down kits. Multiple cabinets shall be connected together with side panels removed for routing of cables between cabinets, provide ganging kits as required.
- Grounding: Provide grounding busbar as shown on drawings. Busbar shall consist of a 19” horizontal ground bar and/or a vertical ground bar installed inside the vertical wire managers. The busbar shall be connected to the perimeter grounding conductor with an irreversible compression fitting. All non-conductive coatings such as paint, lacquer, etc. shall be removed prior to making a ground connection at any point on the rack or cabinet.

F. Co-Location Cabinets:

1. Section Quantity: Co-location cabinets shall be provided with the quantity of sections as shown on the drawings.
2. Size: Fully adjustable front and rear 19-inch mounting verticals. Overall minimum dimensions shall be 30" wide, 42" deep with an overall height of 84". 2-section cabinets shall provide 21 RU per section; 3-section cabinets shall provide 14 RU per section.
3. Panels: Front, side, bottom and top panels shall be fully and easily removable by a latching mechanism. Front and rear section doors shall be vented to allow airflow with a keyed locking mechanism. Each section shall be keyed differently, front and rear doors of the same section shall be keyed alike.
4. Keys: Individual keys shall be provided for each section. A grand master key shall be provided for all sections in all co-location cabinets provided under this project. Coordinate keying requirements with the owner.
5. Construction: The frame shall be made of extruded aluminum. Adjustable front and rear vertical mounting rails shall be drilled and tapped with 12-24 mounting holes at universal EIA spacing. Each compartment in the cabinet shall include two pairs of equipment mounting rails. Mounting rails shall bolt to the supports located near the top and bottom of the compartment and shall be fully adjustable in depth to provide front and rear support for equipment.
6. Cable Management: Cabinets shall include integral vertical cable management pathways that segregate and secure cables from each section.
7. Mounting: All cabinets shall be floor mounted with adjustable leveling feet and permanently fixed to the floor with bolt-down kits. Multiple cabinets shall be connected together with side panels removed for routing of cables between cabinets, provide ganging kits as required.
8. Grounding: Provide a 19" grounding busbar that accepts 2-hole grounding lugs in the top of each section on the back side of the cabinet. Daisy-chain multiple busbars with the top-most busbar being connected to the perimeter grounding conductor with an irreversible compression fitting. All non-conductive coatings such as paint, lacquer, etc. shall be removed prior to making a ground connection at any point on the cabinet.

G. Cable Management Accessories

1. Open Frame Relay Racks
 - a. Vertical: Provide double-sided vertical cable managers with extended fingers on both sides of the rack. Vertical cable managers shall contain cable guides (extended fingers) spaced 1 RU apart allowing front to rear cabling within the manager. Width of cable manager shall be as shown on drawings. Cable manager shall contain a snap-on or hinged cover and extend the full height of the rack.
 - b. Horizontal: Provide horizontal managers at locations shown on drawings. Horizontal managers shall be 3.50" high (2RU) x 19" wide x 6" deep. Horizontal managers shall contain cable guide fingers spaced 1.75" apart with a snap-on or hinged cover.
2. Equipment Cabinets:
 - a. Vertical: Vertical cable management shall be provided on both sides of the mounting rails and located at the front and rear of the cabinet. Vertical cable managers shall contain cable guides (fingers) spaced 1 RU apart.
 - b. Horizontal: Provide horizontal managers at locations shown on drawings. Horizontal managers shall be 3.50" high (2RU) x 19" wide x 6" deep. Horizontal managers shall contain cable guide fingers spaced 1.75" apart with a snap-on or hinged cover.

2.04 POWER DISTRIBUTION UNITS (PDU)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. APC
 2. Raritan (A brand of Legrand)
 3. Tripp-Lite
 4. Panduit
 5. Engineer Approved Equal
- B. Horizontal PDU Type 1:
1. Provide horizontal PDU's as shown on the drawings.
 2. Mounting: Horizontal PDU shall mount on 19" rack rails. PDU shall require no more than 1RU for mounting.
 3. Quantity: See the drawings for the number and type of PDU to provide in each rack and cabinet.
 4. Input: 30A, 120VAC, 1-phase. NEMA L5-30P plug type with 15-foot cord.
 5. Output: 3KW, 120VAC, 1-phase with (12) 5-15/20R outlets, 120VAC.
 6. Overload Protection: (2) 20A circuit breakers protect (6) outlets each
 7. Metering: Integral meter displaying input current.
 8. UL Listed
 9. Basis of Design: Tripp-Lite Model No. PDUMH30
- C. Vertical PDU Type 2:
1. Provide vertical PDU's as shown on the drawings.
 2. Mounting: Vertical PDU's shall be mounted on the interior side wall of the cabinet or cabinet so as not to interfere with cable routing or prohibit the use of mounting equipment to the rear mounting rails. PDU shall utilize 0 RU when installed.
 3. Quantity: See the drawings for the number and type of PDU to provide in each rack and cabinet.
 4. Input: 30A, 208VAC, 3-phase. NEMA L21-30P plug type with 15-foot cord.
 5. Output: 8.6KW, 120/208VAC, 3-phase. Provide the following outlets:
 - a. (36) C13 Outlets, 208VAC
 - b. (6) C19 Outlets, 208VAC
 - c. (6) NEMA 5-15/20R Outlets, 120VAC
 6. Overload Protection: (3) 20A double-pole circuit breakers (1 per output phase)
 7. Metering: Integral meter displaying input current per-phase.
 8. UL Listed
 9. Basis of Design: Tripp-Lite Model No. PDU3MV6L2130
- D. Horizontal PDU Type 3:
1. Provide horizontal PDU's as shown on the drawings.
 2. Mounting: Horizontal PDU shall mount on 19" rack rails. PDU shall require no more than 2RU for mounting.
 3. Quantity: See the drawings for the number and type of PDU to provide in each rack and cabinet.
 4. Input: 30A, 208VAC, 3-phase. NEMA L21-30P plug type with 9.84-foot cord.
 5. Output: 8.6KW, 120/208VAC, 3-phase. Provide the following outlets:
 - a. (12) C13 Outlets, 208VAC
 - b. (6) C19 Outlets, 208VAC
 6. Overload Protection: (3) 20A double-pole circuit breakers (1 per output phase)
 7. Metering: Integral meter displaying input current per-phase.

8. UL Listed
9. Basis of Design: Raritan Model No. PX3-1902R

2.05 CABLE RUNWAY

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Chatsworth Products, Inc. – Universal Cable Runway
 2. Cooper B-Line – Cable Runway
 3. Engineer Approved Equal
- B. Construction: Cable runway shall be manufactured from 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high tubular steel with .065” (1.65 mm) wall thickness. Cable runway (side stringers) will be 9’-11½ “(3.0 m) long. Cross members will be welded in between stringers on 12” (300 mm) intervals/centers beginning 5-3/4” (146 mm) from one end so that there are 10 cross members per cable runway section. There will be 10-1/2” (267 mm) of open space in between each cross member.
- C. UL Listed: Cable runway will be UL Classified for suitability as an equipment grounding conductor only (Contractor shall remove paint or use ground straps at splices and intersections).
- D. Sizes: Provide cable runway sizes as defined on drawings.
- E. Finish shall be epoxy-polyester hybrid powder coat (paint) in black, unless noted otherwise.
- F. Connector Assemblies: Turns, transitions, corners and brackets shall meet the same specification as the cable runway section.
- G. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable runway.
- H. Hardware and Fasteners: Steel, zinc plated matching same color as cable runway section.
- I. Support: Provide a combination of wall mount, data cabinet to cable runway mount, relay rack to cable runway mount and ceiling trapeze cable runway support. The use of a single center hung support rod shall not be allowed.
- J. Grounding: Grounding kits are required to provide a method of bonding cable runway sections and turns together that is independent of the pathway splices. The grounding kit shall be constructed of UL Listed components. The preferred solution is a #6 AWG green insulated stranded copper conductor connected on both ends to ladder rack using two-hole compression lugs and stainless steel hardware.
- K. Accessories: All accessories shall be manufactured from same material as cable runway section. Provide following accessories:
 1. Cable straps used for attaching cable bundles to the cable runway cross members must be reusable with a hook and loop-style closure.
 2. End caps used to cover the ends of cable runway shall be manufactured from a black fire-retardant rubberized material.
 3. End closing kits used to cover the end of cable runway. Kits shall consist of a bar cut to match the width of the cable runway and the hardware required to attach the bar to the end of a length of cable runway.

4. Radius drops used to create a radius to form cables over as the cables exit or enter the cable runway. The extrusion will be formed in a 90° arc with a minimum bend radius of 3" (75 mm). Radius drops will attach to either the side stringer or the cross member of the cable runway using a clevis pin. Provide radius drops at all sections where cable exits runway

2.06 LABELING

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3: EXECUTION

3.01 ENTRANCE FACILITIES

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems" for materials and installation requirements for underground pathways.

3.02 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.
 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of LAN equipment.
 4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
- E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.03 FIRESTOPPING

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems" for fire rated pathways.
- B. Comply with TIA-569-D, Annex A, "Firestopping."

- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.04 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements noted elsewhere in Division 27 for specific labeling requirements.
- B. Labels shall be preprinted or computer-printed type. Provide self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designators.

END OF SECTION

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SECTION 27 13 13:**COMMUNICATIONS COPPER BACKBONE CABLING****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. High pair count Category 5e twisted pair cable.
 - 2. Twisted pair cable hardware, including plugs, jacks, patch panels, and cross-connects.
 - 3. Grounding provisions for twisted pair cable.
 - 4. Cabling identification products.
 - 5. Source quality control requirements for twisted pair cable.
- B. Related Requirements:
 - 1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for data cabling associated with system panels and devices.

1.03 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. LAN: Local area network.
- E. RCDD: Registered Communications Distribution Designer.

1.04 COPPER BACKBONE CABLING DESCRIPTION

- A. Copper backbone cabling system shall provide interconnections between communications equipment rooms and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords used for backbone-to-backbone cross-connection.

- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. Floor Plans: that identify device locations, cable routes and quantities, cable types, riser locations, and references to installation details and diagrams.
 - 3. Diagrams/Elevations: showing room layouts, rack layouts (including rack elevations), riser layouts, etc.
- C. Copper backbone cable testing plan.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices, patch panels and connectors to include in maintenance manuals.

1.08 WARRANTY

- A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final Owner acceptance. Should a failure occur within this warranty period, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.
- B. Extended Warranty: The manufacturer shall guarantee in writing that the copper horizontal cable channels as installed by this contract are free from defects in materials and workmanship and will meet the applicable ANSI/TIA/EIA and ISO/IEC channel transmission requirements in effect at the time of installation and will support any current or future application ratified by IEEE, ANSI, or ISO designed to operate over the applicable ANSI/TIA/EIA-568-B and ISO/IEC 11801 standards in effect at the time of installation. The duration of this warranty shall be for a period of 25 years from date of final Owner acceptance. Defective products shall be repaired or replaced by the manufacturer, at no cost to the Owner.

1.09 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must be a certified installer meeting all requirements for the cable manufacturer's 25 year warranty program and must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair for open and short circuits.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2: PRODUCTS**2.01 PERFORMANCE REQUIREMENTS**

- A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Flame spread shall not exceed 5 ft (1.5 m) when tested in accordance with NFPA 262.
- C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- D. Grounding: Comply with TIA-607-B.

2.02 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated: Type CMP complying with UL 910.

- B. RoHS compliant.

2.03 HIGH-COUNT CATEGORY 5e TWISTED PAIR CABLE

- A. Description: Multi-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 16MHz. See drawings for exact pair count. Total pair count may be achieved by providing multiple cables to achieve overall pair count. 25-pair cable is minimum pair count cable to be provided.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 3. CommScope, Inc.
 - 4. General Cable; General Cable Corporation.
 - 5. Mohawk; a division of Belden Networking, Inc.
 - 6. Engineer Approved Equal
- C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.
- D. Rating: UL-listed Communications Cable Type CMP for plenum application for indoor applications.
- E. Cable Construction:
 - 1. 24 AWG solid, copper conductors.
 - 2. $100 \Omega \pm 15\%$ (1-100 MHz) minimum impedance
 - 3. Unshielded twisted pairs (UTP).
 - 4. PVC insulation with standard telephony color code.
 - 5. Flame retardant PVC jacket.
 - 6. Ripcord for easy jacket removal
 - 7. Jacket color shall be gray
- F. Applications:
 - 1. 10BASE-T through 1000BASE-T Ethernet
 - 2. Power over Ethernet (PoE) – IEEE 802.3af
 - 3. PoE+ – IEEE 802.3at Type 1 and 2
 - 4. ATM and token ring

2.04 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 4. CommScope, Inc.
 - 5. General Cable; General Cable Corporation.

6. Hubbell Premise Wiring.
 7. Leviton Manufacturing Co., Inc.
 8. Mohawk; a division of Belden Networking, Inc.
 9. Engineer Approved Equal
- C. General Requirements for Cable Connecting Hardware:
1. Twisted pair cable hardware shall meet the performance requirements of Category 5e.
 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 3. Cables shall be terminated with connecting hardware of same category or higher.
 4. Source Limitations: Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.
- D. Connecting Blocks: 110-style IDC for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.
- E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.
- F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 48 ports.
 2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
 3. Number of Jacks per Field: Terminate one cable pair per jack unless noted otherwise on drawings.
- G. Plugs and Plug Assemblies:
1. Male; eight position (8P8C); color-coded modular telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable. Terminate one cable pair per jack unless noted otherwise on drawings.
 2. Standard: Comply with TIA-568-C.2.
 3. Marked to indicate transmission performance.
- H. Jacks and Jack Assemblies:
1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable. Terminate one cable pair per jack unless noted otherwise on drawings.
 2. Designed to snap-in to a patch panel or faceplate.
 3. Standard: Comply with TIA-568-C.2.
 4. Marked to indicate transmission performance.

- I. Patch Cords: Factory-made, four-pair cables in required lengths; terminated with an eight-position modular plug at each end. Contractor shall confirm required lengths prior to placing order.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall be manufactured and certified by the same manufacturer of the permanent link cabling.
 - 3. Quantity:
 - a. Provide one (1) patch cord for each terminated port inside the telecommunication rooms. For trunk patch panels, provide one (1) patch cord for each trunk.
 - b. Provide one (1) patch cord for each terminated station outlet.
 - c. Contractor shall coordinate exact length and quantity of each patch cord with network system provider prior to ordering. Submit list of patch cords including color and length for each telecommunication room for approval by Engineer prior to ordering.

2.05 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.06 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.07 SOURCE QUALITY CONTROL

- A. Factory test cables on reels according to TIA-568-C.1.
- B. Factory test cables according to TIA-568-C.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3: EXECUTION

3.01 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters. Conceal raceway and cables, except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to termination points without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install cables parallel with or at right angles to sides and back of enclosure.

3.02 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems".
- C. Comply with Section 270529 "Hangers and Supports for Communications Systems".
- D. Comply with Section 270536 Cable Trays for Communications Systems".
- E. Drawings indicate general arrangement of pathways and fittings.

3.03 INSTALLATION OF COPPER BACKBONE CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.1.
 - 2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM)," Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 6. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section Use lacing bars and distribution spools.
 - 8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - 9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
 - 11. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

12. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
- C. Cable Installation:
1. Comply with TIA-568-C.0 and TIA-568-C.2.
 2. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- D. Group connecting hardware for cables into separate logical fields.
- E. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
 4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.04 FIRESTOPPING

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems."

- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.05 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.06 IDENTIFICATION

- A. Cable Management Software: This contractor shall be responsible for updating the existing airport cable management software program with all communication copper backbone cables installed as part of this project.
- B. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration.
- D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Identification within patch panels in communication equipment rooms: Label each connector and each discrete unit of cable terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.07 FIELD QUALITY CONTROL AND TESTING

- A. General:

1. This Section includes the minimum requirements for the test certification, identification and administration of copper backbone twisted pair cabling.
 2. This Section includes minimum requirements for:
 - a. Copper cabling test instruments
 - b. Copper cabling testing
 - c. Administration
 - d. Test results documentation
 3. Testing shall be carried out in accordance with this document.
 4. Testing shall be performed on each cabling link. (100% testing)
 5. All tests shall be documented.
- B. Requirements
1. All testing procedures and field-test instruments shall comply with the latest version and applicable requirements of ANSI/TIA/EIA standards addressing the testing and administration of Category 3 copper backbone cabling as listed in ANSI/EIA-568-C.2, 6.3 and as adjusted to length measurement.
 2. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests.
 3. The Owner or the Owner's representative shall be invited to witness field-testing.
 - a. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
 4. Manufacturers catalog sheets and specifications for the test equipment.
 5. A schedule (list) of all balanced twisted-pair copper links to be tested.
 6. Sample test reports.
- C. Test Limits and Parameters
1. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be tested for:
 - a. Wire Map
 - b. Length
 - c. Attenuation
 - d. Worst Pair-to-Pair Near End CrossTalk (NEXT) Loss
 2. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in the Copper Backbone Cable Testing section. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with the Copper Backbone Cable Testing section of this specification.
 3. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.
- D. Test Equipment:
1. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

2. Acceptable manufacturers
 - a. Fluke Networks
 - b. Tektronix
 - c. Engineer Approved Equal
- E. Test Records:
1. Administration of the documentation shall include test results of each Permanent Link.
 2. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
 3. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.
- F. Copper Backbone Cable Testing
1. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
 2. Field-test instruments shall have the latest firmware installed.
 3. Permanent Link test results, including the individual frequency measurements from the tester, shall be recorded in the test instrument upon completion of each test for subsequent uploading to a Windows™-based database utility in which the administrative documentation (reports) may be generated.
 4. Permanent Link testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.
 5. Provide test results for each parameter listed under paragraph 3.07-C.1, this section. All tests shall meet or exceed the limits found in ANSI/EIA-568-C.2, 6.3.
- G. Administration:
1. Test Results Documentation
 - a. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests.
 - b. The database for the complete project shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors' software.
 - c. Circuit IDs reported by the test instrument should match the cable label ID.
 - d. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information:
 - 1) The overall Pass/Fail evaluation of the link-under-test
 - 2) The date and time the test results were saved in the memory of the tester
 - 3) The identification of the customer site as specified by the end-user
 - 4) The name of the test limit selected to execute the stored test results
 - 5) The name of the personnel performing the test

- 6) The version of the test firmware and the version of the test limit database held within the test instrument
- 7) The manufacturer, model and serial number of the field-test instrument
- 8) The adapters used
- 9) The factory calibration date
- 10) Provide test results for each parameter listed under paragraph 3.07-C.1, this section.

END OF SECTION

SECTION 27 13 23:**COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. 9/125 micrometer single-mode, armored, indoor optical fiber cable (OS2).
 - 2. Optical fiber cable connecting hardware, patch panels, and patch cords.
 - 3. Cabling identification products.

1.03 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. LAN: Local area network.
- D. RCDD: Registered Communications Distribution Designer.
- E. APC: Angled Physical Contact

1.04 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

- A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, patch panels, connectors, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. Floor Plans: that identify device locations, cable routes and quantities, cable types, riser locations, and references to installation details and diagrams.
 - 3. Diagrams/Elevations: showing room layouts, rack layouts (including elevations), riser layouts, etc.
- C. Fiber optic cable testing plan.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.08 WARRANTY

- A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final Owner acceptance. Should a failure occur within this warranty period, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.
- B. Extended Warranty: The manufacturer shall guarantee in writing that the optical fiber backbone cable channels as installed by this contract are free from defects in materials and workmanship and will meet the applicable ANSI/TIA/EIA and ISO/IEC channel transmission requirements in effect at the time of installation and will support any current or future application ratified by IEEE, ANSI, or ISO designed to operate over the applicable ANSI/TIA/EIA-568-B and ISO/IEC 11801 standards in effect at the time of installation. The duration of this warranty shall be for a period of 25 years from date of final Owner acceptance. Defective products shall be repaired or replaced by the manufacturer, at no cost to the Owner.

1.09 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must be a certified installer meeting all requirements for the cable manufacturer's 25 year warranty program and must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with all other trades and service providers, if applicable.

PART 2: PRODUCTS**2.01 GENERAL REQUIREMENTS**

- A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Flame spread shall not exceed 5 ft (1.5 m) when tested in accordance with NFPA 262.
- C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- D. Grounding: Comply with TIA-607-B.

2.02 9/125 MICROMETER SINGLE-MODE, ARMORED, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

- A. Description: Single mode, 9/125-micrometer, tight-buffered, armored optical fiber cable. Refer to drawings for strand count.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Corning Cable Systems.
 - 3. General Cable; General Cable Corporation.
 - 4. Mohawk; a division of Belden Networking, Inc.
 - 5. Superior Essex Inc.
 - 6. Engineer Approved Equal

- C. General: Fiber optic cable construction shall consist of 8.3 μm single mode optical fibers typically formed in groups of six (6) or twelve (12) fibers each. Size, strand count and routing of fiber optic cables shall be as indicated on the drawings. These groups and individual fibers shall exceed all requirements for ANSI/TIA/EIA-568-B.3 and support high speed communication network applications. These groups assembled to form a single compact core, which is covered by a protective sheath.
- D. Optical Fiber Requirements and Performance:
1. Core Diameter: 8.3 μm
 2. Cladding Diameter: 125 $\mu\text{m} \pm 1\mu\text{m}$
 3. Cladding Non-Circularity: $\leq 1\%$
 4. Core/Cladding Concentricity Error: 0.5 μm
 5. Colored Fiber Diameter: 254 $\mu\text{m} \pm 7\mu\text{m}$
 6. Minimum Bandwidth: 20GHz
 7. Maximum Attenuation:
 - a. 1310nm ≤ 0.65 dB/km
 - b. 1550nm ≤ 0.50 dB/km
- E. Design Specifications: Provide cable suitable for installation in indoor (plenum) environments with tight-buffered cables surrounded by an interlocking armor. Cable jacket shall meet the following specification:
1. Jacket Color: Yellow.
 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
 4. Plenum Applications: Cables shall be UL 910 listed OFNP.
 5. Armor Material: The armor material shall be constructed of aluminum interlocking armor. The armor of each optical cable shall be bonded to the ground busbar located in the rack. An additional outer jacket shall be placed over the armor. The color of the armor jacket shall match the jacket color of the optical fiber cable located inside of the armor.
- F. Single-mode (Dispersion Un-shifted): All single-mode fiber shall support 10 Gigabit Ethernet (10 Gbps) to distances of up to 10,000 meters @ 1310 nm and 40,000 meters @ 1550 nm per IEEE 802.3 performance. The single-mode fiber utilized in the optical fiber cable shall meet TIA-492CAAB, "Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652 "Characteristics of a single-mode optical fiber cable."
- 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." 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 outer 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.

2.03 OPTICAL FIBER CABLE HARDWARE AND PATCH CORDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Belden CDT Networking Division/NORDX.
 2. Corning Cable Systems.
 3. Hubbell Premise Wiring.

4. Optical Cable Corporation.
5. Engineer Approved Equal

B. Patch Panel Housings

1. Fiber Optic housings shall provide a means for securing, strain-relieving, protecting, and labeling of fiber optic cable terminations.
2. Rack-Mount Housing Specifications
 - a. Housings shall be designed for rack-mounted or frame-mounted applications that support conventional cross-connection and interconnection schemes as well as splicing applications.
 - b. Housings shall be available in 1U, 2U, 3U and 4U. See drawings for exact size of housings.
3. The housings shall meet the design requirements of ANSI/TIA/EIA-598 and the plastics flammability requirements of UL 94 V-0.
4. The connector housings shall have a labeling scheme that complies with ANSI/TIA/EIA-606.
5. The housings shall support cross-connection, inter-connection and/or splicing applications and routing schemes in the same housing.
6. The housing shall contain a front compartment whose function is to protect and manage jumpers that interface with the main housing behind it. The front jumper assembly compartment shall be removable and be accessible via a translucent door.
7. The front compartment shall contain jumper egress openings on both sides that are edged with protective pass-through grommets that provide bend radius support for optical fiber jumpers.
8. The rear assembly housing shall be accessible via a hinged door. The door shall contain a routing and cable sub-unit slack storage bracket for interior management of cable sub-units and buffer tubes.
9. The housing shall contain a brushed entry on both sides of the rear of the housing.
10. The housing shall provide means for strain-relieving fiber optic cables both interior to and exterior on the rear assembly housing.
11. The rear of the housing shall contain provisions for routing and maintaining fiber optic cable components, including cable sub-units and buffer tubes, 900 um optical fiber, and buffer tube transition kits.
12. The floor/base of the rear of the housing shall provide holes or slots for the installation (and removal) of fiber retention or slack management clips.
13. The floor/base of the rear assembly housing shall provide holes or slots for the installation (and removal) of transitional strain-relief clips.

C. Wall Mount Single-Panel Housing

1. The single-panel housing shall provide a base enclosure with a front (main) door, and back-plate, as well as top and bottom cable entries.
2. The housing shall provide necessary protection from incidental contact, dust and debris.
3. The housing shall be fully accessible from the front and sides (either left or right depending on mounting orientation of the housing).
4. The housing shall provide all necessary provisions for proper management and administration of optical fiber, fiber optic connectors, splices, cable-subunits, transition kits and other related components.
5. The single-panel housing shall support cross-connection, inter-connection and/or splicing applications and routing schemes in the same housing.
6. The housing shall accommodate direct connector installations or terminations via connector panels. Connector panels shall be held in place via push-pull plungers that are affixed to the housing itself.
7. The housing shall be capable of holding up to one (1) connector panel that loads directly into the side of the housing.
8. The housing shall accommodate pigtail splicing via an internal splice organizer with pigtailed connector panels.

9. The front or main entry of the housing and interior shall be accessible via a solid metal door. The rear or base of the housing shall be accessible via a solid metal back-plate.
10. The housing shall contain openings on both the top and bottom sides of it that allow fiber optic cables to enter the housing in either a through or mid-span configuration. The housing shall provide means for strain-relieving fiber optic cables inside the housing.
11. The housing's interior shall contain provisions for routing and maintaining fiber optic cable components, including cable sub-units and buffer tubes, 900 μm optical fiber, and buffer tube transition kits.
12. The housing's base shall incorporate pre-stamped metal lances for affixing a splice organizer capable of holding 12 to 24 fiber optic splice protectors.
13. Installation of the adapter or connector panel (including loaded connector pigtails) shall not interfere with the internal cable sub-unit routing.
14. The base of the housing, following removal of the back-plate, shall contain corner openings that allow cable sub-units to route between housings in a stacked configuration.
15. Wall-mountable connector housings shall accept an interchangeable connector panel. The connector panel shall have the following characteristics:
 - a. The connector panel shall utilize a single mounting footprint and shall be available with various connector adapters and different adapter counts in each panel.
 - b. The connector panel shall be interchangeable between the rack and wall-mountable hardware being proposed.
 - c. The panel shall be attached to the housing or splice or slack storage cassette with latches to allow quick installation and removal.

D. Fiber Optic Adapter Panels

1. Rack and wall mountable connector housings shall accept an interchangeable connector panel.
2. The adapter panel shall utilize a single mounting footprint and shall be interchangeable between the rack and wall mountable hardware used.
3. The panel shall be attached with two push-pull latches to allow quick installation and removal.
4. The adapter panel shall be available with industry standard single fiber and small form factor multi-fiber adapters, including the SC duplex, LC duplex and MPO.
5. The adapter panel shall accommodate OS2 optical fiber.
6. Pigtailed panel shall consist of an adapter panel as described above, factory-loaded with factory-terminated pigtails, 3 m in length.
7. Blank adapter panels shall be available to fill unused space within housings. Housings shall be supplied with blank adapter panels for all available positions unless the housing is ordered with optical fiber adapters panels pre-installed. The blank panel shall be attached with at least two spring clips to allow quick installation and removal.

E. Fiber Optic Splice Cassettes

1. Rack mountable housings shall accept an interchangeable splice cassette.
2. The splice cassette shall consist of a base constructed from injection-molded black plastic and a removable hinged lid or cover constructed from injection-molded translucent plastic.
3. The splice cassette shall be available with pre-installed connector pigtails and panels.
4. The splice cassette shall allow one connector panel to be installed into the base.
5. The splice cassette shall be able to hold and contain at least one meter of pigtail fiber slack on the interior floor of the base.
6. The splice cassette shall be able to hold and contain up to one meter of 2.0-3.0 mm buffer tube slack or jacketed pigtail slack (up to 24 fiber) on the exterior bottom of the base.
7. The splice cassette shall contain a pivoting (and removable) splice tray above the base in a horizontal position that rotates up into a vertical position at least 90 degrees relative to the base allowing access to the base.
8. The splice tray shall contain one interchangeable splice organizer capable of holding up to (24) splice heat-shrinks, routing tabs and provisions for holding a total of two meters of

- 250 or 900 micron fiber slack and contain slots and provisions for installing cable ties for securing incoming and outgoing buffer tubes and/or jacketed optical fibers.
9. The splice cassette shall contain relief slots for holding up to two buffer tube transition ("fan-out") kits on either side of the base.
 10. The splice cassette shall contain two fiber retention tabs behind the connector panel location to maintain fiber below the connections and adapters in an installed connector panel.
 11. Refer to rack elevation drawings for required Fiber Optic Splice Cassette types.

F. Multi-fiber Push On (MPO) Trunk Connectors

1. The optical fiber backbone cabling system shall utilize a modular solution consisting of factory-terminated trunk assemblies utilizing 12-fiber MPO array connectors, MPO to LC Duplex modules and jumpers, and MPO adapter panels and harnesses.
2. MPO to MPO High-Density Trunk Assemblies:
 - a. Trunks shall be all-dielectric construction.
 - b. Trunks shall be terminated with MPO connectors at both ends, having 12 fibers per ferrule.
 - c. Jacket color and break-out leg jacket color shall be yellow for single-mode fiber assemblies.
 - d. MPO -terminated primary trunks shall have non-pinned MPO connectors on both ends.
 - e. MPO -terminated extender trunks shall have pinned MPO connectors on the end to be interconnected with a primary trunk and non-pinned MPO connectors on the other end.
 - f. The trunk assemblies shall be available in 12, 24, 36, 48, 72, 96, and 144-fiber counts; specific fiber counts to be used shall be specified on the drawings.
 - g. Trunks shall be furcated into 12-fiber legs (subunits). Standard leg length shall be 33 in +3/-0 in.
 - h. Trunk length shall be the distance between furcation points at each end of the cable and shall not be inclusive of the length of the legs at each end.
 - i. Trunk furcation plugs shall incorporate mechanically designed features that allow securing the trunks inside or outside a connector housing.
 - j. The trunk shall incorporate a flexible boot at the back of the epoxy plug, in order to provide a uniformly smooth transition between the plug and the trunk cable.
 - k. The trunk cable shall have a minimum bend radius of five times the cable outside diameter.
 - l. Trunks shall meet the connector performance specifications of TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard, (normative) Annex A.
 - m. Manufacturer shall have a field installable MPO connector offering (to support capabilities to field repair). The field installable MPO connector shall be a no epoxy/no polish style connector.
 - n. Contractor shall field verify the type and lengths of MPO trunk cables, prior to placing order.
3. MPO to LC High-Density Modules (Cassettes)
 - a. Modules shall contain 12 fiber terminations with one 12-fiber cable assembly within a protective housing. Cable assemblies within the modules shall be terminated with an MPO pinned connector at the back and LC connectors at the front.
 - b. Modules shall have shuttered LC adapters at the front, with a shutter door that opens inward. Module shall have self-retracting shutter adapter mechanism that allows a single hand operation. The shutter shall be translucent and shall be VFL compatible.
 - c. Modules shall permit front and rear installation into the patch panel housings.
 - d. Modules shall contain discrete fiber and port identification. This fiber and port identification shall be pad printed on top and bottom of the modules.

- G. Fiber Optic Patch Cords:
1. Single-mode, duplex fiber patch cable shall be LC-LC, yellow.
 2. The single-mode, duplex fiber patch cable shall consist of 9 micron core and a 125 micron cladding. The fiber cladding shall be covered by aramid yarn and OFNR rated, unless otherwise indicated on the drawings.
 3. Contractor shall field verify the type and lengths of patch cables, prior to placing order.
 4. Contractor shall provide all patch cords required to perform the patching as designated on the contract drawings and specifications. Provide one (1) patch cord for each terminated fiber port at both ends. All slack in the patch cords shall be appropriately dressed using vertical and horizontal patch cord organizers to maintain a neat appearance.
 5. Fiber optic patch cords shall be manufactured and certified by the same manufacturer of the permanent link cabling.
- H. UPC Fiber Optic Connector:
1. LC, Single-mode (OS2), UPC, ceramic ferrule, field installable, blue housing, blue boot, pre-polished connector.
 2. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B for Type LC connectors and TIA-604-5-D for Type MPO connectors. Comply with TIA-568-C.3.
 3. Quick-connect, duplex, Type LC connectors. Insertion loss not more than 0.25 dB.
- I. APC Fiber Optic Connector:
1. SC, Single-mode (OS2), APC, ceramic ferrule, field installable, blue housing, blue boot, pre-polished connector.
 2. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B for Type SC connectors. Comply with TIA-568-C.3.
 3. Quick-connect, simplex, Type SC connectors. Insertion loss not more than 0.25 dB.
 4. Angled polished connectors shall be used for Boingo Distributed Antenna Systems (DAS) connectivity.

2.04 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.05 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.06 SOURCE QUALITY CONTROL

- A. Factory test optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
- B. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3: EXECUTION

3.01 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to termination points without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.02 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Comply with NECA 301.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate and test all cables; no cable shall contain unterminated elements. Make terminations only at indicated patch panels.
 - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 36 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 6. Bundle, lace, and train cable to termination points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 - 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 8. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
 - 9. In the communications equipment room, install a 10-foot (3-m) long service loop on each end of cable.
 - 10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 - 11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- C. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in communications equipment rooms with terminating hardware and interconnection equipment.

2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Group connecting hardware for cables into separate logical fields.

3.03 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.04 GROUNDING

- A. Shields/armors shall be grounded according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.05 IDENTIFICATION

- A. Cable Management Software: This contractor shall be responsible for updating the existing airport cable management software program with all communication optical fiber backbone cables installed as part of this project.
- B. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cable and Wire Identification:
 1. Label each cable within 4 inches (100 mm) of each termination, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 2. Label each unit and field within distribution racks and frames.
 3. Identification within patch panels in communication equipment rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware.
- E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:
 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.06 FIELD QUALITY CONTROL AND TESTING**A. General:**

1. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.
2. This Section includes minimum requirements for:
 - a. Fiber optic test instruments
 - b. Fiber optic testing
 - c. Administration
 - d. Test results documentation
3. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS). In addition to OLTS testing the optical fiber cabling may require testing with an optical time domain reflectometer (OTDR), this is defined elsewhere in this section.
4. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps where OTDR testing is required.

B. Requirements:

1. All testing procedures and field-test instruments shall comply with the latest version and applicable requirements of ANSI/TIA/EIA standards addressing the testing and administration of optical fiber cabling.
2. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests.
3. The Owner or the Owner's representative shall be invited to witness field-testing.
 - a. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
4. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source) and optical time domain reflectometer (OTDR), if required.
5. A schedule (list) of all optical fibers to be tested.
6. Sample test reports.

C. Test Limits and Parameters

1. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:
 - a. Optical Loss Testing
 - 1) Multimode and Singlemode links: The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0.
 - a) $\text{Link Attenuation (dB)} = \text{Cable_Attn (dB)} + \text{Connector_Attn (dB)} + \text{Splice_Attn (dB)}$
 - b) $\text{Cable_Attn (dB)} = \text{Attenuation_Coefficient (dB/km)} * \text{Length (Km)}$
 - c) $\text{Connector_Attn (dB)} = \text{number_of_connector_pairs} * \text{connector_loss (dB)}$

- d) Maximum allowable connector_loss = 0.75 dB
- e) Splice_Attn (dB) = number_of_splices * splice_loss (dB)
- f) Maximum allowable splice_loss = 0.3 dB
- g) The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 μm	850	3.5	1300	1.5
Multimode 50/125 μm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. OTDR Testing

- a. In addition to OLTS testing, OTDR testing shall be required for optical fiber cabling containing a splice within the link length of the cable run. Splices made to connect break-out kits and pig tails are not required to be tested by an OTDR.
- b. Reflective events (connections) shall not exceed:
 - 1) 0.75 dB in optical loss when bi-directionally averaged
 - 2) -35 dB Reflectance for multimode connections
 - 3) -40 dB reflectance for UPC singlemode connections
 - 4) -55 dB reflectance for APC singlemode connections
- c. Non-reflective events (splices) shall not exceed 0.3 dB.

3. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described under Optical Fiber Cable Testing section of this specification. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with the Optical Fiber Cable Testing section of this specification.

4. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

D. Testing Equipment:

- 1. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.
- 2. Acceptable manufacturers
 - a. Fluke Networks
 - b. Tektronix
 - c. Engineer Approved Equal

E. Test Records:

1. Administration of the documentation shall include test results of each fiber link and channel.
2. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
3. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

F. Optical Fiber Testing

1. Field-test instruments shall have the latest software and firmware installed.
2. Testing shall be performed on each cabling link (connector to connector).
3. Testing shall be performed on each cabling channel (equipment to equipment) as identified in the contract documents.
 - a. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
4. Testing of the cabling shall be performed using high-quality test reference cords of the same core size as the cabling under test, terminated with reference grade connectors. Reference grade connectors are defined as having a loss not exceeding 0.1 dB for multimode and 0.2 dB for singlemode.
5. OLTS Testing
 - a. Horizontal/Backbone link
 - 1) Multimode links shall be tested in one direction at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-B, one-cord reference method, with an Encircled Flux compliant launch.
 - 2) Singlemode backbone links shall be tested in one direction at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1 (One-cord reference method).
 - 3) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
6. OTDR Testing
 - a. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
 - 1) Multimode: 850 nm and 1300 nm.
 - 2) Singlemode: 1310 nm and 1550 nm.
 - b. Each fiber link and channel shall be tested in both directions.
 - 1) The launch and tail fibers shall remain in place for the measurement in the opposite direction – failing to do so will result in an increase in measurement uncertainty.

- 2) The use of a loop back fiber at the far end with a tail fiber at the near end on the adjacent fiber is permitted for bi-directional testing, so long as the OTDR is able to split the trace automatically into two traces for the two fibers under test.
- c. A launch cable shall be installed between the OTDR and the first link connection.
- d. A tail cable shall be installed after the last link connection.
- 7. Length Measurement
 - a. The optical length of each fiber shall be recorded using an OLTS or OTDR.
- 8. Polarity Testing
 - a. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA 568 C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.
- G. Administration
 - 1. Test results documentation
 - a. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests.
 - b. The database for the complete project shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors' software.
 - c. Circuit IDs reported by the test instrument should match the cable label ID.
 - d. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information
 - 1) The identification of the customer site as specified by the end-user.
 - 2) The name of the test limit selected to execute the stored test results.
 - 3) The name of the personnel performing the test.
 - 4) The date and time the test results were saved in the memory of the tester.
 - 5) The manufacturer, model and serial number of the field-test instrument.
 - 6) The version of the test software and the version of the test limit database held within the test instrument.
 - 7) The fiber identification number.
 - 8) The length for each optical fiber.
 - 9) The index of refraction used for length calculation when using length capable OLTS.
 - 10) The backscatter coefficient of the fiber under test when using an OTDR.
 - 11) Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
 - 12) Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
 - 13) The length for each optical fiber as calculated by the OTDR.

- 14) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements

END OF SECTION

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SECTION 27 15 13:**COMMUNICATIONS COPPER HORIZONTAL CABLING****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. Category 6a twisted pair cable.
 - 2. Twisted pair cable hardware, including plugs and jacks.
 - 3. Cabling identification products.
 - 4. Grounding provisions for twisted pair cable.
 - 5. Source quality control requirements for twisted pair cable.
- B. Related Requirements:
 - 1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for data cabling associated with system panels and devices.

1.03 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. LAN: Local area network.
- E. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- F. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- G. RCDD: Registered Communications Distribution Designer.
- H. UTP: Unscreened (unshielded) twisted pair.

1.04 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Copper horizontal cabling system shall provide interconnections between communications equipment room and the equipment outlet. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords used for horizontal-to-horizontal cross-connection.
 - 1. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 2. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. Floor Plans: that identify device locations, cable routes and quantities, cable types, riser locations, and references to installation details and diagrams.
 - 3. Diagrams/Elevations: showing room layouts, rack layouts (including elevations), riser layouts, etc.
- C. Copper horizontal cable testing plan.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices, patch panels and connectors to include in maintenance manuals.

1.08 WARRANTY

- A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final Owner acceptance. Should a failure occur within this warranty period, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.
- B. Extended Warranty: The manufacturer shall guarantee in writing that the copper horizontal cable channels as installed by this contract are free from defects in materials and workmanship and will

meet the applicable ANSI/TIA/EIA and ISO/IEC channel transmission requirements in effect at the time of installation and will support any current or future application ratified by IEEE, ANSI, or ISO designed to operate over the applicable ANSI/TIA/EIA-568-B and ISO/IEC 11801 standards in effect at the time of installation. The duration of this warranty shall be for a period of 25 years from date of final Owner acceptance. Defective products shall be repaired or replaced by the manufacturer, at no cost to the Owner.

1.09 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must be a certified installer meeting all requirements for the cable manufacturer's 25 year warranty program and must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with all other trades, Owner's LAN equipment suppliers and service providers, if applicable.

PART 2: PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Flame spread shall not exceed 5 ft (1.5 m) when tested in accordance with NFPA 262.
- C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- D. Grounding: Comply with TIA-607-B.

2.02 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated: Type CMP complying with UL 910.
- B. RoHS compliant.

2.03 CATEGORY 6A TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6A cable at frequencies up to 500MHz.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 4. CommScope, Inc.
 - 5. General Cable; General Cable Corporation.
 - 6. Mohawk; a division of Belden Networking, Inc.
 - 7. Superior Essex Inc.
 - 8. Engineer Approved Equal
- C. General Performance Specifications: The minimum requirements for Category 6A cables shall conform to TIA/EIA 568B Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section. Application standards supported should include, but not limited to:
 - 1. 10Base-T through 10GBase-T Ethernet
 - 2. Power over Ethernet (Poe & PoE+) - IEEE 802.3af/at Type 1 & 2
 - 3. 4PPoE+ - IEEE 802.3bt Type 3 and 4 draft D1.2
 - 4. 155Mb/s ATM and token ring
 - 5. HDBaseT Class A & B
 - 6. 550MHz Broadband Video
 - 7. Backwards compatible to legacy protocols and applications.
- D. General Design Specifications: Indoor horizontal cable shall be plenum, Category 6A, Unshielded Twisted Pair (UTP) composed of 23 AWG bare solid-copper conductors, insulated (FEP). The insulated conductors are twisted into pairs and sheathed with a low smoke PVC jacket. Cable shall be classified as a small diameter Category 6A cable meeting the following minimum design specifications:
 - 1. Overall Diameter: $\leq 0.265''$
 - 2. Pair Count: 4
 - 3. Conductor: Solid annealed copper 23 AWG
 - 4. Insulation CMP: FEP
 - 5. Separator: Full Cross-web
 - 6. Jacket CMP: FR, low smoke PVC, blue in color unless noted otherwise
 - 7. Impedance: $100\Omega \pm 15$
 - 8. Velocity of Propagation : CMP: 71%
 - 9. Performance Compliance: UL 444, UL 1666, NFPA 262, ANSI/TIA-568-C.2, Article 800, NEC (NFPA 70)

10. NRTL Programs: UL Verified CAT 6A, UL Listed CMP-LP (0.6)
11. Standard: Comply with TIA-568-C.2 for Category 6A cables.

2.04 CATEGORY 6A TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 2. Belden CDT Networking Division/NORDX.
 3. Berk-Tek Leviton; a Nexans/Leviton alliance.
 4. CommScope, Inc.
 5. General Cable; General Cable Corporation.
 6. Hubbell Premise Wiring.
 7. Panduit.
 8. Engineer Approved Equal
- C. General Requirements for Twisted Pair Cable Hardware:
 1. Comply with the performance requirements of Category 6A.
 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.
- E. Patch Panel: Blank modular patch panels housing numbered jack units with ability to accept an IDC-type keystone jack at each port location. Patch panels containing fixed, irreplaceable jacks are not acceptable.
 1. High density supporting 48 open modular ports
 2. Angled design (flat front patch panels are not acceptable).
 3. 2U mounting height
 4. Labeling areas adjacent to ports.
 5. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
 6. Number of Jacks per Field: One for each four-pair cable indicated.
- F. Punchdown Blocks: Termination blocks for cross-connecting horizontal cabling.
 1. Application: Rated for Category 6A cabling and transmission
 2. Termination: IDC-style capable of terminating 23 AWG solid conductors.
 3. Mounting: Wall or backplane
 4. Labeling: Designation strips or labels for labeling each circuit.
 5. Pair Count: See drawings for pair count requirements
- G. Patch Cords: Factory-made, four-pair cables; terminated with an eight-position modular plug at each end. Contractor shall confirm required lengths prior to placing order.
 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.

2. Patch cords shall be manufactured and certified by the same manufacturer of the permanent link cabling.
3. Quantity:
 - a. Provide one (1) patch cord for each terminated port inside the telecommunication rooms.
 - b. Provide one (1) patch cord for each terminated station outlet.
 - c. Contractor shall coordinate exact length of each patch cord with network system equipment provider and owner prior to ordering. Submit list of patch cords including color and length for each telecommunication room for approval by Engineer prior to ordering.

H. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, Category 6A unshielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.

I. Jacks and Jack Assemblies

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, Category 6A unshielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.
5. Coordinate color types with Engineer prior to ordering.

J. Faceplate

1. Two to Six port, vertical single gang faceplates designed to mount to single gang wall boxes or adapter.
2. Plastic Faceplate: High-impact plastic. Coordinate color with Engineer prior to ordering.
3. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
4. Flush mounting jacks, positioning the cord at a 45-degree angle.
5. Integral, reusable clear plastic label field above and below ports.

K. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.05 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.06 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.07 SOURCE QUALITY CONTROL

- A. Factory test cables on reels according to TIA-568-C.1.
- B. Factory test twisted pair cables according to TIA-568-C.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3: EXECUTION**3.01 WIRING METHODS**

- A. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, where cable trays and J-Hooks may be used. Conceal raceway and cables, except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to termination points without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.02 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."
- C. Comply with Section 270529 "Hangers and Supports for Communications Systems."
- D. Comply with Section 270536 "Cable Trays for Communications Systems."
- E. Drawings indicate general arrangement of pathways.

3.03 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 5. Cables may not be spliced. Secure and support cables at intervals not exceeding 36 inches not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 6. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
 10. In the communications equipment room, install a 10-foot (3-m) long service loop on each end of cable.
 11. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
 12. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
- C. Cable Installation:
1. Comply with TIA-568-C.0 and TIA-568-C.2.
 2. Install cabling with horizontal and vertical cable guides in communications equipment rooms with terminating hardware and interconnection equipment.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Group connecting hardware for cables into separate logical fields.
- E. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

- a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.04 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.05 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-B and NECA/BICSI-607.

3.06 IDENTIFICATION

- A. Cable Management Software: This contractor shall be responsible for updating the existing airport cable management software program with all communications copper horizontal cables installed as part of this project.
- B. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration.

- D. Cable Schedule: Install in a prominent location in each communication equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Identification within patch panels in communication equipment rooms: Label each connector and each discrete unit of cable terminating and connecting hardware.
- F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.07 FIELD QUALITY CONTROL AND TESTING

- A. General:
 - 1. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.
 - 2. This Section includes minimum requirements for:
 - a. Copper cabling test instruments
 - b. Copper cabling testing
 - c. Administration
 - d. Test results documentation
 - 3. Testing shall be carried out in accordance with this document.
 - 4. Testing shall be performed on each cabling link. (100% testing)
 - 5. All tests shall be documented.
- B. Requirements
 - 1. All testing procedures and field-test instruments shall comply with the latest version and applicable requirements of ANSI/TIA/EIA standards addressing the testing and administration of Category 6A copper horizontal cabling.
 - 2. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests.
 - 3. The Owner or the Owner's representative shall be invited to witness field-testing.
 - a. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
 - 4. Manufacturers catalog sheets and specifications for the test equipment.
 - 5. A schedule (list) of all balanced twisted-pair copper links to be tested.
 - 6. Sample test reports.
- C. Test Limits and Parameters

1. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be tested for:
 - a. Wire Map
 - b. Length
 - c. Propagation Delay
 - d. Delay Skew
 - e. DC Loop Resistance
 - f. DC Resistance Unbalance within a pair
 - g. DC Resistance Unbalance between pairs
 - h. Insertion Loss
 - i. NEXT (Near-End Crosstalk)
 - j. PS NEXT (Power Sum Near-End Crosstalk)
 - k. ACR-N (Attenuation to Crosstalk Ratio Near-End)
 - l. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
 - m. ACR-F (Attenuation to Crosstalk Ratio Far-End)
 - n. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
 - o. Return Loss
 - p. TCL (Transverse Conversion Loss)
 - q. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
 - r. PS ANEXT (Power Sum Alien Near-End Crosstalk)
 - s. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
 - t. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
 - u. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
 2. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in the Copper Horizontal Cable Testing section. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with the Copper Horizontal Cable Testing section of this specification.
 3. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.
- D. Testing Equipment
1. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.
 2. Acceptable manufacturers
 - a. Fluke Networks
 - b. Tektronix
 - c. Engineer Approved Equal

E. Administration

1. Administration of the documentation shall include test results of each Permanent Link.
2. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
3. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

F. Copper Horizontal Cable Testing

1. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
2. Field-test instruments shall have the latest firmware installed.
3. Permanent Link test results, including the individual frequency measurements from the tester, shall be recorded in the test instrument upon completion of each test for subsequent uploading to a Windows™-based database utility in which the administrative documentation (reports) may be generated.
4. Permanent Link testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.
5. Alien Crosstalk testing shall be performed using a sampling plan. An acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859-1 for populations of up to 500,000 links shall be used. The following table represents this sampling level.

Total number of links (N)	Sample size (No. of links to test)
3 – 33	3 or 0.1 x N (whichever is greatest)
34 – 3,200	33
3,201 – 35,000	126
35,001 – 150,000	201
150,001 – 500,000	315

6. Disturbed (Victim) links chosen for Alien Crosstalk testing shall be an equal combination of short, medium and long links.
7. Provide test results for each parameter listed under paragraph 3.07-C.1, this section. All tests shall meet or exceed the limits found in ANSI/EIA-568-C.2, 6.3.

G. Administration:

1. Test Results Documentation
 - a. The test results documentation shall be available for inspection by the Owner or the Owner’s representative during the installation period and shall be passed to the Owner’s representative within 5 working days of completion of tests.
 - b. The database for the complete project shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors’ software.
 - c. Circuit IDs reported by the test instrument should match the cable label ID.

- d. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information:
- 1) The overall Pass/Fail evaluation of the link-under-test
 - 2) The date and time the test results were saved in the memory of the tester
 - 3) The identification of the customer site as specified by the end-user
 - 4) The name of the test limit selected to execute the stored test results
 - 5) The name of the personnel performing the test
 - 6) The version of the test firmware and the version of the test limit database held within the test instrument
 - 7) The manufacturer, model and serial number of the field-test instrument
 - 8) The adapters used
 - 9) The factory calibration date
 - 10) Provide test results for each parameter listed under paragraph 3.07-C.1, this section.
- e. For Alien Crosstalk testing, the detailed test results documentation data is to be provided for each tested balance twisted-pair and shall contain the following information:
- 1) The overall Pass/Fail evaluation of the link-under-test
 - 2) The date and time the measurements were made
 - 3) The identification of the customer site as specified by the end-user
 - 4) The name of the test limit selected to execute the stored test results
 - 5) The name of the personnel performing the test
 - 6) The version of the test software
 - 7) PS ANEXT, worst case margin for all four pairs
 - 8) Average PS ANEXT, worst case margin
 - 9) PS AACR-F, worst case margin for all four pairs
 - 10) Average PS AACR-F, worst case margin

END OF SECTION

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SECTION 27 15 23:**COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING****PART 1: GENERAL****1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.02 SUMMARY

- A. Section Includes:
 - 1. 9/125 micrometer, single mode, indoor-outdoor, optical fiber cable (OS2).
 - 2. Optical fiber cable connecting hardware, patch panels, and patch cords.
 - 3. Grounding.
 - 4. Cabling identification products.

1.03 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. RCDD: Registered Communications Distribution Designer.

1.04 OPTICAL FIBER HORIZONTAL CABLING DESCRIPTION

- A. Optical fiber horizontal cabling system shall provide interconnections between communications equipment rooms and the equipment outlet. Cabling system consists of horizontal cables, patch panels, connectors, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. Splices and consolidation/transition points shall not be installed in the optical fiber horizontal cabling.

1.05 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. Floor Plans: that identify device locations, cable routes and quantities, cable types, riser locations, and references to installation details and diagrams.
 3. Diagrams/Elevations: showing room layouts, rack layouts (including elevations), riser layouts, etc.
- C. Fiber optic cable testing plan.

1.06 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.08 WARRANTY

- A. Period: The Contractor shall warranty all labor, workmanship, and materials for a period of one (1) year from the date of final Owner acceptance. Should a failure occur within this warranty period, the Contractor shall provide all labor and materials necessary to restore the system to the condition required for the final test and acceptance for this contract, at no cost to the Owner.
- B. Extended Warranty: The manufacturer shall guarantee in writing that the optical fiber horizontal cable channels as installed by this contract are free from defects in materials and workmanship and will meet the applicable ANSI/TIA/EIA and ISO/IEC channel transmission requirements in effect at the time of installation and will support any current or future application ratified by IEEE, ANSI, or ISO designed to operate over the applicable ANSI/TIA/EIA-568-B and ISO/IEC 11801 standards in effect at the time of installation. The duration of this warranty shall be for a period of 25 years from date of final Owner acceptance. Defective products shall be repaired or replaced by the manufacturer, at no cost to the Owner.

1.09 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must be a certified installer meeting all requirements for the cable manufacturer's 25 year warranty program and must have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with all other trades and service providers, if applicable.

PART 2: PRODUCTS**2.01 PERFORMANCE REQUIREMENTS**

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Flame spread shall not exceed 5 ft (1.5 m) when tested in accordance with NFPA 262.
- C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- D. Grounding: Comply with TIA-607-B.

2.02 9/125 MICROMETER SINGLE-MODE, ARMORED, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

- A. Description: Single mode, 9/125-micrometer, tight-buffered, armored optical fiber cable. Refer to drawings for strand count.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Corning Cable Systems.
 - 3. General Cable; General Cable Corporation.
 - 4. Mohawk; a division of Belden Networking, Inc.
 - 5. Superior Essex Inc.
 - 6. Engineer Approved Equal

- C. General: Fiber optic cable construction shall consist of 8.3 μm single mode optical fibers typically formed in groups of six (6) or twelve (12) fibers each. Size, strand count and routing of fiber optic cables shall be as indicated on the drawings. These groups and individual fibers shall exceed all requirements for ANSI/TIA/EIA-568-B.3 and support high speed communication network applications. These groups assembled to form a single compact core, which is covered by a protective sheath.
- D. Optical Fiber Requirements and Performance:
1. Core Diameter: 8.3 μm
 2. Cladding Diameter: 125 $\mu\text{m} \pm 1\mu\text{m}$
 3. Cladding Non-Circularity: $\leq 1\%$
 4. Core/Cladding Concentricity Error: 0.5 μm
 5. Colored Fiber Diameter: 254 $\mu\text{m} \pm 7\mu\text{m}$
 6. Minimum Bandwidth: 20GHz
 7. Maximum Attenuation:
 - a. 1310nm ≤ 0.65 dB/km
 - b. 1550nm ≤ 0.50 dB/km
- E. Design Specifications: Provide cable suitable for installation in both indoor (plenum) and outdoor environments with tight-buffered cable. Cable jacket shall meet the following specification:
1. Jacket Color: Black.
 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
 4. Plenum Applications: Cables shall be UL 910 listed OFNP.
 5. Armor Material: The armor material shall be constructed of aluminum interlocking armor. The armor of each optical cable shall be bonded to the ground busbar located in the rack. An additional outer jacket shall be placed over the armor. The color of the armor jacket shall match the jacket color of the optical fiber cable located inside of the armor.
- F. Single-mode (Dispersion Un-shifted): All single-mode fiber shall support 10 Gigabit Ethernet (10 Gbps) to distances of up to 10,000 meters @ 1310 nm and 40,000 meters @ 1550 nm per IEEE 802.3 performance. The single-mode fiber utilized in the optical fiber cable shall meet TIA-492CAAB, "Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652 "Characteristics of a single-mode optical fiber cable."
- 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." 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 outer 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.

2.03 OPTICAL FIBER CABLE HARDWARE AND PATCH CORDS

- A. Comply with requirements in Section 271323 Communications Optical Backbone Cabling” for optical fiber cable hardware and patch cords.

2.04 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.05 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.06 SOURCE QUALITY CONTROL

- A. Factory test optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3: EXECUTION**3.01 WIRING METHODS**

- A. Wiring Method: Install cables in raceways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, where cable trays and J-Hooks may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to termination points without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.02 INSTALLATION OF OPTICAL FIBER HORIZONTAL CABLES

- A. Comply with NECA 301.
- B. General Requirements for Optical Fiber Cabling Installation:
 - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate and test all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets and patch panels.
 - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 36 inches and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 6. Bundle, lace, and train cable to termination points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination points. Remove and discard cable if damaged during installation and replace it with new cable.
 8. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
 9. In the communications equipment room, provide a 10-foot (3-m) long service loop on each end of cable.
 10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 11. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
- C. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in communications equipment rooms with terminating hardware and interconnection equipment.
 2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Group connecting hardware for cables into separate logical fields.

3.03 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-C, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.04 GROUNDING

- A. Shields/armors shall be grounded according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.05 IDENTIFICATION

- A. Cable Management Software: This contractor shall be responsible for updating the existing airport cable management software program with all communications optical fiber horizontal cables installed as part of this project.
- B. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

- C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration.
- D. Cable Schedule: Install in a prominent location in each communication equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Identification within patch panels in communications equipment rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware.
- F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.06 FIELD QUALITY CONTROL AND TESTING

- A. General:
 - 1. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.
 - 2. This Section includes minimum requirements for:
 - a. Fiber optic test instruments
 - b. Fiber optic testing
 - c. Administration
 - d. Test results documentation
 - 3. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS). In addition to OLTS testing the optical fiber cabling may require testing with an optical time domain reflectometer (OTDR), this is defined elsewhere in this section.
 - 4. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps where OTDR testing is required.
- B. Requirements:
 - 1. All testing procedures and field-test instruments shall comply with the latest version and applicable requirements of ANSI/TIA/EIA standards addressing the testing and administration of optical fiber cabling.
 - 2. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests.
 - 3. The Owner or the Owner's representative shall be invited to witness field-testing.
 - a. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.

4. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source) and optical time domain reflectometer (OTDR), if required.
5. A schedule (list) of all optical fibers to be tested.
6. Sample test reports.

C. Test Limits and Parameters

1. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:
 - a. Optical Loss Testing
 - 1) Multimode and Singlemode links: The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0.
 - a) $\text{Link Attenuation (dB)} = \text{Cable_Attn (dB)} + \text{Connector_Attn (dB)} + \text{Splice_Attn (dB)}$
 - b) $\text{Cable_Attn (dB)} = \text{Attenuation_Coefficient (dB/km)} * \text{Length (Km)}$
 - c) $\text{Connector_Attn (dB)} = \text{number_of_connector_pairs} * \text{connector_loss (dB)}$
 - d) Maximum allowable connector_loss = 0.75 dB
 - e) $\text{Splice_Attn (dB)} = \text{number_of_splices} * \text{splice_loss (dB)}$
 - f) Maximum allowable splice_loss = 0.3 dB
 - g) The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 μm	850	3.5	1300	1.5
Multimode 50/125 μm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. OTDR Testing
 - a. In addition to OLTS testing, OTDR testing shall be required for optical fiber cabling containing a splice within the link length of the cable run. Splices made to connect break-out kits and pig tails are not required to be tested by an OTDR.
 - b. Reflective events (connections) shall not exceed:
 - 1) 0.75 dB in optical loss when bi-directionally averaged
 - 2) -35 dB Reflectance for multimode connections
 - 3) -40 dB reflectance for UPC singlemode connections
 - 4) -55 dB reflectance for APC singlemode connections

- c. Non-reflective events (splices) shall not exceed 0.3 dB.
 3. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described under Optical Fiber Cable Testing section of this specification. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with the Optical Fiber Cable Testing section of this specification.
 4. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.
- D. Testing Equipment:
 1. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.
 2. Acceptable manufacturers
 - a. Fluke Networks
 - b. Tektronix
 - c. Engineer Approved Equal
- E. Test Records:
 1. Administration of the documentation shall include test results of each fiber link and channel.
 2. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
 3. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.
- F. Optical Fiber Testing
 1. Field-test instruments shall have the latest software and firmware installed.
 2. Testing shall be performed on each cabling link (connector to connector).
 3. Testing shall be performed on each cabling channel (equipment to equipment) as identified in the contract documents.
 - a. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
 4. Testing of the cabling shall be performed using high-quality test reference cords of the same core size as the cabling under test, terminated with reference grade connectors. Reference grade connectors are defined as having a loss not exceeding 0.1 dB for multimode and 0.2 dB for singlemode.
 5. OLTS Testing
 - a. Horizontal/Backbone link

- 1) Multimode links shall be tested in one direction at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-B, one-cord reference method, with an Encircled Flux compliant launch.
- 2) Singlemode backbone links shall be tested in one direction at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1 (One-cord reference method).
- 3) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

6. OTDR Testing

- a. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
 - 1) Multimode: 850 nm and 1300 nm.
 - 2) Singlemode: 1310 nm and 1550 nm.
- b. Each fiber link and channel shall be tested in both directions.
 - 1) The launch and tail fibers shall remain in place for the measurement in the opposite direction – failing to do so will result in an increase in measurement uncertainty.
 - 2) The use of a loop back fiber at the far end with a tail fiber at the near end on the adjacent fiber is permitted for bi-directional testing, so long as the OTDR is able to split the trace automatically into two traces for the two fibers under test.
- c. A launch cable shall be installed between the OTDR and the first link connection.
- d. A tail cable shall be installed after the last link connection.

7. Length Measurement

- a. The optical length of each fiber shall be recorded using an OLTS or OTDR.

8. Polarity Testing

- a. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA 568 C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.

G. Administration

1. Test results documentation

- a. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests.
- b. The database for the complete project shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors' software.
- c. Circuit IDs reported by the test instrument should match the cable label ID.
- d. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information:
 - 1) The identification of the customer site as specified by the end-user.
 - 2) The name of the test limit selected to execute the stored test results.

- 3) The name of the personnel performing the test.
- 4) The date and time the test results were saved in the memory of the tester.
- 5) The manufacturer, model and serial number of the field-test instrument.
- 6) The version of the test software and the version of the test limit database held within the test instrument.
- 7) The fiber identification number.
- 8) The length for each optical fiber.
- 9) The index of refraction used for length calculation when using length capable OLTS.
- 10) The backscatter coefficient of the fiber under test when using an OTDR.
- 11) Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
- 12) Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
- 13) The length for each optical fiber as calculated by the OTDR.
- 14) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements.

END OF SECTION

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