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COMMUNICATIONS CABLELING

SECTION 271500 - COMMUNICATIONS HORIZONTAL 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.

B. Related Drawings
   A. “T” Drawings – Technology Plans

C. Related Sections:
   A. Section 271100 "Communications Equipment Room Fittings".
   B. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.

1.2 SUMMARY

A. Section Includes:
   A. Pathways.
   B. UTP cabling.
   C. Cable connecting hardware, patch panels, and cross-connects.
   D. Telecommunications outlet/connectors.
   E. Cabling system identification products.
   F. Cable management system.

1.3 DEFINITIONS


B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.

C. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

D. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

E. EMI: Electromagnetic interference.

F. IDC: Insulation displacement connector.

G. Ladder Rack/Cable Tray: A fabricated structure consisting of two (2) longitudinal side rails connected by individual transverse members (rungs).

H. LAN: Local area network.
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I. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

J. RCDD: Registered Communications Distribution Designer.

K. Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.

L. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.

M. UTP: Unshielded twisted pair.

1.4 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

   A. TIA-568-C.1 requires that a minimum of two (2) telecommunications outlet/connectors be installed for each work area, unless otherwise specified within the drawing documents.

   B. Horizontal cabling shall contain no transition points or consolidation points between the horizontal cross-connect and the telecommunications outlet/connector.

   C. Bridged taps and splices shall not be installed in the horizontal cabling.

   D. Splitters shall not be installed as part of the horizontal cabling.

B. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

C. If the installation contractor believes that any cabling will exceed the 295 feet, they are to make the technology consultant aware of this prior to installing the cable so that a remedy can be put in place. All cabling that is installed and exceeds the 295 feet may be subject to be removed at the installation contractor’s expense to attain a length less than 295 feet.

1.5 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.

1.6 SUBMITTALS

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

   A. For coaxial cable, include the following installation data for each type used:

   a. Nominal OD.

   b. Minimum bending radius.

   c. Maximum pulling tension.

B. Shop Drawings:
A. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

B. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

C. Cabling administration drawings and printouts.

D. Wiring diagrams to show typical wiring schematics, including the following:
   - Cross-connects.
   - Patch panels.
   - Patch cords.

E. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

F. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   - Vertical and horizontal offsets and transitions.
   - Clearances for access above and to side of cable trays.
   - Vertical elevation of cable trays above the floor or bottom of ceiling structure.
   - Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector. The installation contractor shall be certified by the cable manufacture to install their products and be able to offer an extended 25 product and applications warranty such as:
   - Belden - Partner Alliance CSV
   - Mohawk – Mohawk Accredited Contractor MAC

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

G. Software and Firmware Operational Documentation:
   - Software operating and upgrade manuals.
   - Program Software Backup: On magnetic media or compact disk, complete with data files.
   - Device address list.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   - Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.
   - Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
   - Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: A Nationally Recognized Test Laboratory (NRTL).
   - Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA-569-C.

E. Grounding: Comply with ANSI-J-STD-607-C.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   A. Test optical fiber cables to determine the continuity of the strand end to end. Use optical loss test set.
   B. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
   C. Telecommunications contractor shall request manufacturers lot test data for category four pair products be provided for each shipment.

1.9 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.

1.10 COORDINATION

A. The Telecommunications Contractor shall ensure that the General Contractor and Painting Contractor acknowledge that painting of or over spray any single or group of 4 pair horizontal telecommunications Category 5e or Category 6 cable is not allowed. Any painted or over sprayed cable(s) shall be replaced at the painting contractor’s expense. Painted Cable will not be covered as part of an extended warranty. Painted cable in addition to obscuring the print legend may act as an accelerator or create an additional smoke hazard in the event of a fire and as such this is considered a life safety issue.

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

C. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA-569-C.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   A. Support brackets with cable tie slots for fastening cable ties to brackets.
   B. Lacing bars, spools, J-hooks, and D-rings.
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C. Straps and other devices.
D. Cable management shall employ Velcro straps, cable ties are not allowed.

C. Ladder Rack/Cable Tray:
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:
      a. Belden
      b. WBT Basket Tray
   B. Ladder Rack Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch thick.
      a. Ladder Rack Trays: Nominally 12 inches wide, and a rung spacing of 12 inches.
      b. Must be supported every 10 feet minimally.

D. Conduit and Boxes: Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems."
   A. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2½ inches deep.

2.2 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:
   A.
   B. Belden
      a. Blue - 3613 D15U1000
      b. White - 3612 009U1000
   C. Mohawk
      a. Blue – M57193
      b. White – M56889
   B. Description: 100-ohm, 4-pair UTP, covered with a Blue Plenum rated jacket for data and a White Plenum rated jacket for voice.
      A. Comply with ICEA S-90-661 for mechanical properties.
      B. Comply with TIA -568-C.1 for performance specifications.
      C. Comply with TIA -568-C.2, Category 6.
      D. Cables shall employ at a minimum a cross web separator to enhance crosstalk performance by a minimum of 5 dB beyond the minimum category 6 NEXT and PSNEXT requirements. Cable shall also offer 0.5 dB minimum improvement over category 6 Insertion Loss (IL).

2.3 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:
   A. Belden KeyConnect Workstation Outlets
   B. Belden KeyConnect CAT6+ Modular jacks
      a. White – AX101320 B-24 Bulk 24 pieces per package
   C. Ortronics
      a. OR-S21600 SII,CAT6 Fog White
      b. OR-S21600-88 SII,CAT6 White
B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher. Termination method T568B on both ends of the cabling Permanent Link.

C. Connecting Blocks: 110-style IDC for category 6. Provide blocks for the number of cables terminated on the block, plus twenty-five percent (25%) spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
   A. Number of Terminals per Field: One (1) for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

F. Number of Jacks per Field: One (1) for each four-pair UTP cable indicated, plus spares and blank positions adequate to suit specified expansion criteria. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:
   A. Belden
      a. AX103253  KeyConnect 24 Port Preloaded 1U –
      b. AX103255  KeyConnect 48 Port Preloaded 2U –
   B. Ortronics
      a. OR-PSD66U24 24 Port
      b. OR-PHD66U48 48 Port

G. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

2.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568-C.1, category 6.

B. Workstation Outlets: Multi-port-connector assemblies mounted in single-gang faceplate. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include and are limited to the following:
   A. Belden
      a. AX101786 B-25  KeyConnect White 2 Port  Bulk 25 pieces packaging

C. Faceplates:
   A. Plastic Faceplate: As specified within the Drawings.
   B. For use with snap-in jacks accommodating any combination of UTP work area cords.
   C. Flush mounting jacks, positioning the cord at a 45-degree angle.
   D. Legend: Machine printed, in the field, using adhesive-tape label.
   E. Legend: Snap-in, clear-label covers and machine-printed paper inserts.
   F. Belden KeyConnect Faceplates
      a. AX102660 1 Port Single Gang
      b. AX102655 2 port Single Gang
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2.5 GROUNDING
A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
B. Comply with ANSI-J-STD-607-C.

2.6 IDENTIFICATION PRODUCTS
A. Comply with TIA-606-B and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
B. Comply with requirements in Section 260553 "Identification for Electrical Systems."
C. Labeling for all cabling and termination equipment is described within the drawing package.

2.7 SOURCE QUALITY CONTROL
A. Testing Agency: Engage a qualified testing agency to evaluate cables.
B. Factory test UTP and optical fiber cables on reels according to TIA-568-C.1.
C. Factory test UTP cables according to TIA-568-C.2.
D. Cable will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

2.8 FIBER OPTIC CABLE AND CONNECTIVITY
A. Description: Data Backbone Cabling
B. Telecommunications contractor shall request manufacturers lot test data for optical backbone cable products be provided for each shipment.
C. The Telecommunications Contractor shall ensure that the General Contractor and Painting Contractor acknowledge that painting of or over spray any single or group of 4 pair horizontal telecommunications Category 5e or Category 6 cable is not allowed. Any painted or over sprayed cable(s) shall be replaced at the painting contractor’s expense. Painted Cable will not be covered as part of an extended warranty. Painted cable in addition to obscuring the print legend may act as an accelerant or create an additional smoke hazard in the event of a fire; as such this is considered a life safety issue.
D. 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. Belden Note: Belden is transitioning to a Smart Part Number scheme so in most cases two part numbers are listed:
      a. B9W048T Smart P/N FDSD012P9 SMF OS2 Tight Buffer Indoor Outdoor OFNP
      b. B9W045 Smart P/N FISD006P9 6 fiber OS2 Tight Buffer OFNP
      c. B9W048 Smart P/N FISD012P9 12 fiber OS2 Tight Buffer Indoor OFNP
      d. B9C043 Smart P/N FI3D002P9 2 fiber OM3 Tight Buffer Indoor OFNP
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e. B9B045 Smart P/N FI1D006P9 6 fiber OM1 Tight Buffer Indoor OFNP
f. B9B048 Smart P/N FI1D012P9 12 fiber OM1 Tight Buffer Indoor OFNP
g. FIFDH11PK 12 SMF OS2 and 12 OM1 Tight Buffer Hybrid OFNP
h. FIFDH22PK 24 SMF OS2 and 24 OM1 Tight Buffer Hybrid OFNP

B. Mohawk
a. M9W048T 12 SMF OS2 Tight Buffer Indoor Outdoor OFNP
b. M9W045 6 fiber OS2 Tight Buffer OFNP
c. M9W048 12 fiber OS2 Tight Buffer Indoor OFNP
d. M9C043 2 fiber OM3 Tight Buffer Indoor OFNP
e. M9B045 6 fiber OM1 Tight Buffer Indoor OFNP
f. M9B048 12 fiber OM1 Tight Buffer Indoor OFNP
g. M97685 12 SMF OS2 and 12 OM1 Tight Buffer Hybrid OFNR

C. E. Description: Multimode, OM1 62.5/125, Laser Optimized OM3 50/125 Bend Insensitive and Single Mode OS2 Bend Insensitive, in fiber counts of 2, 6, 12 and 24 fiber, tight buffer 900 um, Indoor Outdoor OFNP or Indoor OFNR rated as called out by product optical fiber cable part number.

A. Comply with ICEA S-83-596 for mechanical properties.
B. Comply with TIA-568-C.3 for performance specifications.
C. Comply with TIA-492AAD for detailed specifications.
D. Maximum Attenuation, Conform to EIA/TIA-455-61:
   a. OM1 62.5/125 3.5 dB/km at 850 nm; 1.2 dB/km at 1300 nm
   b. OM3 50/125 3.25 dB/km at 850 nm; 1.0 dB/km at 1300 nm.
   c. SMF OS2 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm

E. Minimum Overfill Mode Launch (OFL) Bandwidth, Conform to EIA/TIA-455-204:
   a. OM1 62.5/125 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm

F. Minimum Restricted Mode Launch (RML) Modal Bandwidth, Conform to EIA/TIA-455-204:
   a. OM3 50/125 2000 MHz-km at 850nm; 500 MHz-km at 1300 nm

F. Jacket:
A. Jacket Color:
   a. OM1 62.5/125 Orange
   b. OM3 50/125 Aqua
   c. SMF OS2 Yellow.

B. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
C. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

G. Copper Wall Mount Racks and Distribution Racks
A. Belden
   a. XWR-2419-18 24” Wall Mount Swing Out Rack, Hinged 19” Mtg X 18” Fixed Depth
   b. XWR-4819-18 48” Wall Mount Swing Out Rack, Hinged 19” Mtg X 18” Fixed Depth
   c. XWB-2U 2 RU Wall Mount Bracket, Black Mounting Hardware Included
   d. 9511-1902 2U 19” cable Organizer With Saddle Rings
   e. XDRR8419612S01 2 Post Distribution Rack 45U 86.0” Tall X 23.75” Wide; 19” Rack Spacing 6.5” Post taped 12-24 With Cable Access Openings, Top Cable Trough Channel, (2) Cable Waterfalls Mounted In The Top, Ladder Rack Mounting Angle, Painted Black. Packaged unassembled on a box, assembly required.

B. Ortronics
   a. OR-19-21-T18D 24” Wall Mount Rack
   b. OR-19-48-T18D 48” Wall Mount Rack
   c. OR-604004396 2U Wall Mount Bracket
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d. OR-808004818  2U 19" Cable Organizer
e. OR-MM6706  2 Post Distribution Rack

C. Fiber Wall Mount Patch Panels and Splice Enclosures
   a. Belden
      1) AX103928  Stackable Wall Mount Patch Panel
      2) AX103930  Stackable Wall Mount Splice Enclosure
      3) AX104681
      4) AX104682
      5) AX104683
      6) FFSU12SB
      7) FFSU12ST
   b. Ortronics
      1) OR-615SMFC-12P Wall Mnt
      2) OR-615SMFC-24P/S Wall Mnt

EXECUTION

2.9 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   A. Install plenum cable in environmental air spaces, including plenum ceilings.
   B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

2.10 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569-C-7.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569-C for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for installation of conduits and wire ways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:
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A. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
B. Install cable trays to route cables if conduits cannot be located in these positions.
C. Secure conduits to backboard when entering room from overhead.
D. Extend conduits 3 inches above finished floor.
E. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

2.11 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   A. Comply with TIA-568-C.1.
   B. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   C. Install 110-style IDC termination hardware unless otherwise indicated.
   D. MUTOA shall not be used as a cross-connect point.
   E. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for UTP at least 49 feet from communications equipment room.
   F. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   G. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   H. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
   I. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
   J. 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.
   K. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
   L. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
   M. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
   A. Comply with TIA-568-C.2.
   B. Do not untwist UTP cables more than ½ inches from the point of termination to maintain cable geometry.

D. Open-Cable Installation:
   A. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   B. Suspend UTP cable not in a wire way or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart. Vary the support length between 48 and 60 inches to minimize the impact of cables laying on the supports at repeated intervals which may result in Return Loss or NEXT issues.
C. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Separation from EMI Sources:
A. Comply with BICSI TDMM and TIA-569-C for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
B. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
C. 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 2½ inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
D. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
E. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
F. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

2.12 FIRESTOPPING
A. Comply with requirements in Section 074813 "Penetration Fire stopping."
B. Comply with TIA-569-C, Annex A, "Fire stopping."
C. Comply with BICSI TDMM, "Fire stopping Systems" Article.

2.13 IDENTIFICATION
A. All labeling of workstation outlets and patch panels shall be described by the Owner prior to testing and labeling of these devices.
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."
   A. Administration Class: 2.
   B. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
C. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
D. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
E. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration, including optional identification requirements of this standard.

F. Cable Schedule: Post in 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.

G. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA-606-B. Furnish electronic record of all drawings, in software and format selected by Owner.

H. Cable and Wire Identification:
   A. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   B. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   C. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   D. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
      b. Label each unit and field within distribution racks and frames.
   E. Identification within Connector Fields in Equipment Rooms and Wiring Closets: 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. Labeling is described within drawing package.

I. 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.
   A. Cables use flexible vinyl or polyester that flex as cables are bent.

2.14 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   A. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
   B. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
   C. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   D. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
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E.

E. TESTING, IDENTIFICATION AND ADMINISTRATION OF BALANCED TWISTED PAIR INFRASTRUCTURE

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

1.2 SCOPE

A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.

B. This Section includes minimum requirements for:
   1. Copper cabling test instruments
   2. Copper cabling testing
   3. Identification
      a) Labels and labeling
   4. Administration
      a) Test results documentation
      b) As-built drawings

C. Testing shall be carried out in accordance with this document.

D. Testing shall be performed on each cabling link. (100% testing)

E. All tests shall be documented.

1.3 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:
   1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
   2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
   3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
   5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.
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B. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

1. Manufacturer of the connectors or cable.
2. Manufacturer of the test equipment used for the field certification.
3. Training organizations (e.g., BICSI, Association of Cabling Professionals™ Cabling Business Institute located in Dallas, Texas)

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.

1. 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.
2. The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.4 SUBMITTALS

A. Manufacturers catalog sheets and specifications for the test equipment.
B. A schedule (list) of all balanced twisted-pair copper links to be tested.
C. Sample test reports.

1.5 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in tested for:

1. Wire Map
2. Length
3. Propagation Delay
4. Delay Skew
5. DC Loop Resistance – recorded for information only
6. DC Resistance Unbalance – recorded for information only
7. Insertion Loss
8. NEXT (Near-End Crosstalk)
9. PS NEXT (Power Sum Near-End Crosstalk)
10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
12. ACR-F (Attenuation to Crosstalk Ratio Far-End)
13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
14. Return Loss
15. TCL (Transverse Conversion Loss) – recorded for information only
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16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in Part 3. 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 Part 3.

C. 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.

PART 2 - PRODUCTS

2.1 BALANCED TWISTED-PAIR CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

B. Certification tester

1. Accuracy
   a) Level III accuracy in accordance with ANSI/TIA-1152
   b) Independent verification of accuracy
   c) Acceptable manufacturers
      1) Fluke Networks

2. Permanent Link Adapters
   a) RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
   b) Twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures

3. Results Storage
   a) Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below

4. Measurement capabilities
   a) Wire Map
   b) Length
   c) Propagation Delay
   d) Delay Skew
   e) DC Loop Resistance
   f) DC Resistance Unbalance
   g) Insertion Loss
   h) NEXT (Near-End Crosstalk)
   i) PS NEXT (Power Sum Near-End Crosstalk)
   j) ACR-N (Attenuation to Crosstalk Ratio Near-End)
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k) PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
l) ACR-F (Attenuation to Crosstalk Ratio Far-End)
m) PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
n) Return Loss
o) TCL (Transverse Conversion Loss)
p) ELTCTL (Equal Level Transverse Conversion Transfer Loss)
q) Time Domain Reflectometer
r) Time Domain Xtalk Analyzer

C. PC Software
1. Windows® based.
2. Must show when 3 dB and 4 dB rules are applied
3. Re-certification capability, where results must have their Cable IDs suffixed with (RC).
4. Built in PDF export – no additional third party software permitted.
5. Built-in statistical analysis.

2.2 IDENTIFICATION

A. Labels
1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
4. Where insert type labels are used provide clear plastic cover over label.
5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
   a) Brady Corporation
   b) Silver Fox
   c) Brothers

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each Permanent Link.
B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
C. 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.

PART 3 – EXECUTION

3.1 GENERAL
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A. 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.

3.2 BALANCED TWISTED PAIR CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. 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 PC in which the administrative documentation (reports) may be generated.

C. Testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.

D. Permanent Link adapters made from twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures.

E. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6 Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.

F. Wire Map Measurement

1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
   a) Continuity to the remote end
   b) Shorts between any two or more conductors
   c) Reversed pairs
   d) Split pairs
   e) Transposed pairs
   f) Distance to open on shield
   g) Any other miss-wiring

2. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used. Examples are given below:

G. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.

3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

H. Propagation Delay measurement
   1. Is the time it takes for a signal to reach the end of the link.
   2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
   3. The propagation delay of each balanced twisted pair shall be recorded.
   4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

I. Delay Skew measurement
   1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
   2. The delay skew of each balanced twisted pair shall be recorded.
   3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

J. DC Resistance
   1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
   2. Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.

K. DC Resistance Unbalance
   1. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
   2. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all four pairs.

L. Insertion Loss
   1. Is the loss of signal strength over the cabling (in dB).
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Worst case shall be reported for all four pairs in one direction only.
   4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

M. NEXT (Near-End Crosstalk)
   1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
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b) 31.25 – 100 MHz: 250 kHz
c) 100 – 250 MHz: 500 kHz

3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

N. PS NEXT (Power Sum Near-End Crosstalk)
   1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (8 pair possible combinations)
   4. Both worst case and worst margins shall be reported.
   5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
   6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

O. ACR-N (Attenuation Crosstalk Ratio Near-End)
   1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be calculated in both directions.
   4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 12 possible combinations.

P. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)
   1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be calculated in both directions.
   4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 8 possible combinations.
Q. ACR-F (Attenuation Crosstalk Ratio Far-End)
   1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (24 pair to pair possible combinations)
   4. Both worst case and worst margins shall be reported.
   5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
   6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

R. PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End)
   1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (8 pair possible combinations)
   4. Both worst case and worst margins shall be reported.
   5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
   6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

S. Return Loss
   1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
   2. The frequency resolution shall be:
      a) 1 – 31.25 MHz: 150 kHz
      b) 31.25 – 100 MHz: 250 kHz
      c) 100 – 250 MHz: 500 kHz
   3. Shall be measured in both directions. (8 pair possible combinations)
   4. Both worst case and worst margins shall be reported.
   5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
   6. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
   7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

T. TCL (Transverse Conversion Loss)
1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

U. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:
   a) 1 – 31.25 MHz: 150 kHz
   b) 31.25 – 100 MHz: 250 kHz
   c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

3.3 ADMINISTRATION

A. Test results documentation
1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
2. 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 on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include the software tools required to view, inspect, and print any selection of the test reports.
4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).
5. The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information...
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a) The overall Pass/Fail evaluation of the link-under-test
b) The date and time the test results were saved in the memory of the tester
c) The identification of the customer site as specified by the end-user
d) The name of the test limit selected to execute the stored test results
e) The name of the personnel performing the test
f) The version of the test software and the version of the test limit database held within the test instrument
g) The manufacturer, model and serial number of the field-test instrument
h) The adapters used
i) The factory calibration date
j) Wire Map
k) Propagation Delay values, for all four pairs
l) Delay Skew values, for all four pairs
m) DC Resistance values, for all four pairs
n) DC Resistance Unbalance, values for all four pairs
o) Insertion Loss, worst case values for all four pairs
p) NEXT, worst case margin and worst case values, both directions
q) PS NEXT, worst case margin and worst case values, both directions
r) ACR-F, worst case margin and worst case values, both directions
s) PS ACR-F, worst case margin and worst case values, both directions
t) Return Loss, worst case margin and worst case values, both directions
u) TCL, worst case values both directions
v) ELTCTL, worst case values, both directions.
w) Time Domain Crosstalk data if the link is marginal or fails
x) Time Domain Reflectometer data if the link is marginal or fails

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on a CD or DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as-built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-buils shall include all field changes made up to construction completion:
   a) Field directed changes to pull schedule.
   b) Horizontal cable routing changes.
   c) Associated detail drawings.

E. F. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
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a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the
network interface device at the demarcation point. Go off-hook and listen and receive a
dial tone. If a test number is available, make and receive a local, long distance, and digital
subscription line telephone call.

b. Data Tests: These tests assume the Information Technology Staff has a network installed
and is available to assist with testing. Connect to the network interface device at the
demarcation point. Log onto the network to ensure proper connection to the network.

C. Document data for each measurement. Data for submittals shall be printed in a summary report that is
formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer,
saved as text files, and printed along with an electronic copy and submitted.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

2.15 TESTING, IDENTIFICATION AND ADMINISTRATION OF FIBER INFRASTRUCTURE

PART 4 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete test-
ing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work
areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner’s
representative of any additional tests that are deemed necessary to guarantee a fully functional system.
The contractor shall carry out and record any additional measurement results at no additional charge.

1.2 SCOPE

A. This Section includes the minimum requirements for the test certification, identification and admin-
istration of backbone and horizontal optical fiber cabling.

B. This Section includes minimum requirements for:

1. Fiber optic test instruments
2. Fiber optic testing
3. Identification
   a) Labels and labeling
4. Administration
   a) Test results documentation
   b) As-built drawings

C. 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) and the installed condition
of the cabling system and its components with an optical time domain reflectometer (OTDR). The
condition of the fiber end faces shall also be verified.

D. Testing shall be performed on each cabling link (connector to connector).
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E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.
   1. 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.

F. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps.
   1. Optionally, documentation shall also include optical length measurements and pictures of the connector end face.

1.3 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:
   1. ANSI Z136.2, ANSI For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
   3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR
   4. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR
   5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR
   6. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant
   7. ANSI/TIA-526-14-B, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed cable plant- Multimode attenuation measurement
   8. TIA-TSB-4979 Practical Considerations for Implementation of Multimode Launch Conditions in the Field
   9. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
   10. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
   11. ANSI/TIA-568-C.3, Optical Fiber Cabling Components Standard
   12. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements

B. 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. These certificates may have been issued by any of the following organizations or an equivalent organization:
   1. Manufacturer of the fiber optic cable and/or the fiber optic connectors.
   2. Manufacturer of the test equipment used for the field certification or representative.
   3. Training organization e.g. BICSI

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.
   1. 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.
2. The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.4 SUBMITTALS

A. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.

B. A schedule (list) of all optical fibers to be tested.

C. Sample test reports.

1.5 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:

1. Optical loss testing

a) Multimode and Singlemode links

1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0.

   i) Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)
   
   ii) Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)
   
   iii) Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)
   
   iv) Maximum allowable connector_loss = 0.75 dB

   (v) Splice_Attn (dB) = number_of_splices * splice_loss (dB)

   (vi) Maximum allowable splice_loss = 0.3 dB

   The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

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

2. OTDR testing

a) Reflective events (connections) shall not exceed:

1) 0.75 dB in optical loss when bi-directionally averaged

2) -35 dB Reflectance for multimode connections
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3) -40 dB reflectance for UPC singlemode connections

4) -55 dB reflectance for APC singlemode connections

b) Non-reflective events (splices) shall not exceed 0.3 dB.

3. Magnified end face inspection

a) Fiber connections shall be visually inspected to IEC 61300-3-35 Edition 1.0 for end face quality.

b) Scratched, pitted or dirty connectors shall be diagnosed and corrected.

B. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. 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 Part 3.

C. 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.

Note: High Bandwidth applications such as 1000BASE-SX, 10GBASE-SR, and FC1200 impose stringent channel loss limits. Where practical, certification should consider loss length limits that meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.

D. Performance specification for multimode fiber links at 850 nm.

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Bandwidth</th>
<th>1000BASE-SX</th>
<th>10GBASE-SR</th>
<th>FibreChannel 1200-MX-SN-I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>µm</td>
<td>(MHz•Km)</td>
<td>Length (m)</td>
<td>Loss (dB)</td>
</tr>
<tr>
<td>OM 1</td>
<td>62.5</td>
<td>200</td>
<td>275</td>
<td>2.38</td>
</tr>
<tr>
<td>OM 2</td>
<td>50</td>
<td>500</td>
<td>550</td>
<td>3.56</td>
</tr>
<tr>
<td>OM 3</td>
<td>50</td>
<td>2000</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>OM 4</td>
<td>50</td>
<td>47000</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

PART 5 - PRODUCTS

2.1 OPTICAL FIBER CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

B. Optical loss test set (OLTS)

1. Multimode optical fiber light source

271500-26
a) Provide dual LED light sources with central wavelengths of 850 nm (±30 nm) and 1300 nm (±20 nm). VCSEL sources are not permitted per ANSI/TIA-526-14-B.
b) Output power of −20 dBm minimum.
c) The launch shall meet the Encircled Flux launch requirements of ANSI/TIA-526-14-B.
d) The test reference cords must demonstrate an insertion loss ≤ 0.15 dB when mated against each other.
e) Acceptable manufacturers
   1) Fluke Networks

2. Singlemode optical fiber light source
   a) Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).
   b) Output power of −10 dBm minimum.
   c) The test reference cords must demonstrate an insertion loss ≤ 0.25 dB when mated against each other.
   d) Acceptable manufacturers
      1) Fluke Networks

3. Power Meter
   a) Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.
   b) Power measurement uncertainty of ± 0.25 dB.
   c) Store reference power measurements.
   d) Save at least 10,000 results to internal memory.
   e) PC interface (USB).
   f) Acceptable manufacturers
      1) Fluke Networks

4. Optional length measurement
   a) It is preferable to use an OLTS that is capable of measuring the optical length of the fiber using time-of-flight techniques. In the case of MPO/MTP trunk cables, this is not possible.

C. Optical Time Domain Reflectometer (OTDR)
   1. Shall have a bright, color LCD display with backlight.
   2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
   3. Weight with battery and module of not more than 4.5 lb and volume of not more 200 in³.
   4. Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fiber links.
   5. USB port to transfer data to a PC or thumb drive/memory stick.
   6. Multimode OTDR
      a) Wavelengths of 850 nm (± 10 nm) and 1300 nm (+ 35 nm / - 15 nm).
      b) Event dead zones not to exceed 0.7 m at 850 nm and 1300 nm.
c) Attenuation dead zones not to exceed 2.5 m at 850 nm and 4.5 m at 1300 nm.
d) Distance range not less than 9,000 m.
e) Dynamic range at least 28 dB for 850 nm and 30 dB at 1300 nm.
f) Allow bi-directional testing without moving the OTDR to the far end.

7. Singlemode OTDR
   a) Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).
   b) Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.
   c) Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.
   d) Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.
   e) Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.
   f) Allow bi-directional testing without moving the OTDR to the far end.

8. Acceptable manufacturers
   a) Fluke Networks

D. Fiber Microscope
   1. Field of view 420 µm x 320 µm
      a) Video camera systems are preferred.
      b) Camera probe tips that permit inspection through adapters are required.
      c) Test equipment shall be capable of saving and reporting the end face image to IEC 613003-3-35.
   2. Acceptable manufacturers
      a) Fluke Networks

E. Integrated OLTS, OTDR and fiber microscope
   1. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.
   2. Acceptable manufacturers
      a) Fluke Networks

2.2 IDENTIFICATION

A. Labels
   1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
   2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
   3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow so that the labels are easily distinguishable.
   4. Where insert type labels are used provide clear plastic cover over label.
   5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.
   6. Acceptable Manufacturers:
a) Panduit  
b) Silver Fox  
c) W.H. Brady  
d) d-Tools  
e) Brothers

2.3 ADMINISTRATION
A. Administration of the documentation shall include test results of each fiber link and channel.  
B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.  
C. 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.

PART 6 – EXECUTION

3.1 GENERAL
A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.  
B. 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.

3.2 OPTICAL FIBER CABLE TESTING
A. Field-test instruments shall have the latest software and firmware installed.  
B. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.  
C. Fiber end faces shall be inspected using a video scope with a field of view not less than 425 µm x 320 µm.  
   1. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.  
D. Testing shall be performed on each cabling segment (connector to connector).  
E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner’s instructions.  
F. 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. The test reference cords for OLTS testing shall be between 2 m and 5 m in length. The length of the launch and tail fibers for multimode OTDR testing shall be at a least 100 m (328 ft.). For singlemode, the length of the launch and tail fibers will depend on the link under test. As a guide, the following table can be used for determining the length of the launch and tail fibers.

<table>
<thead>
<tr>
<th>Maximum Length of Link (km)</th>
<th>Typical Pulse Width (ns)</th>
<th>Minimum Launch and Tail Cord Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1310 nm</td>
<td>1550 nm only</td>
<td></td>
</tr>
<tr>
<td>0 to 35</td>
<td>0 to 50</td>
<td>≤ 1,000</td>
</tr>
<tr>
<td>35 to 45</td>
<td>50 to 65</td>
<td>3,000</td>
</tr>
</tbody>
</table>
G. Optical loss testing

1. Horizontal/Backbone link
   a) 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.
   b) 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).
   c) 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.

H. OTDR Testing

1. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
   a) Multimode: 850 nm and 1300 nm.
   b) Singlemode: 1310 nm and 1550 nm.

2. Each fiber link and channel shall be tested in both directions.
   a) 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.
   b) 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.

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

4. A tail cable shall be installed after the last link connection.

I. Magnified End face Inspection

1. Fibers shall be inspected using a video scope with a minimum field of view 425 µm x 320 µm to IEC 61300-3-35 Edition 1.0. The following test limits shall be used:
   a) Multimode connectors; Table 6 of IEC 61300-3-35 Edition 1.0
   b) Singlemode field polished connectors; Table 5 of IEC 61300-3-35 Edition 1.0
   c) Singlemode factory polished connectors; Table 3 of IEC 61300-3-35 Edition 1.0
   d) Angled Physical Contact (APC) connectors; Table 4 of IEC 61300-3-35 Edition 1.0

J. Length Measurement

1. The length of each fiber shall be recorded.
2. It is preferable that the optical length be measured using an OLTS or OTDR.

K. Polarity Testing
1. 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.

3.3 IDENTIFICATION
A. Labeling
1. Labeling shall conform to the requirements specified within ANSI/TIA-606-B or to the requirements specified by the Owner or the Owner’s representative.

3.4 ADMINISTRATION
A. Test results documentation
1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The following formats do not provide adequate protection of these records and shall not be used.
   a) Portable document format (PDF)
   b) Word (.doc & .docx)
   c) Comma separated values (.csv)
   d) Excel separated values (.xls & .xlsx)
   e) Text (.txt)

2. 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 on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.

3. The database for the complete project, including twisted-pair copper cabling links, if applicable, 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.

4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).

5. 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
   a) The identification of the customer site as specified by the end-user.
   b) The name of the test limit selected to execute the stored test results.
   c) The name of the personnel performing the test.
   d) The date and time the test results were saved in the memory of the tester.
   e) The manufacturer, model and serial number of the field-test instrument.
   f) The version of the test software and the version of the test limit database held within the test instrument.
   g) The fiber identification number.
   h) The length for each optical fiber.
   i) The index of refraction used for length calculation when using length capable OLTS.
   j) The backscatter coefficient of the fiber under test when using an OTDR.
Yale University

COMMUNICATIONS CABLING

k) 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).

l) Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.

m) The length for each optical fiber as calculated by the OTDR.

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

o) Optional
   1) A picture or image of each fiber end-face
   2) A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD/DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.

2. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-built shall include all field changes made up to construction completion:
   a) Field directed changes to pull schedule.
   b) Field directed changes to cross connect and patching schedule.
   c) Horizontal cable routing changes.
   d) Backbone cable routing or location changes.
   e) Associated detail drawings.

2.16 DEMONSTRATION

A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271500