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Construction Specification Manual

Salt River Project

Technical Specification Index – April 2022

Division 27

Division	Title	Updated
DIVISION 27: COMMUNICATIONS		
270120	Operation and Maintenance of Data Communications	New 04/22
270500	Common Work Results for Communications	New 04/22
270513	Communication Services	Revised 04/22
270526	Grounding Bonding for Communications Systems	Revised 04/22
270528	Pathways for Communications Services	Revised 04/22
271100	Communications Equipment Room Fittings	Revised 04/22
271313	Communications Copper Backbone Cabling	New 04/22
271323	Communications Optical Fiber Backbone Cabling	New 04/22
271501.11	Conductors and Cables for Electronic Safety and Security	New 04/22
271513	Communications Copper Horizontal Cabling	New 04/22
271523	Communications Optical Fiber Horizontal Cabling	New 04/22

SECTION 27 01 20

OPERATION AND MAINTENANCE OF DATA COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper and Fiber testers and testing.
 - 2. Labels and labeling.
 - 3. Documentation.

1.2 ACTION SUBMITTALS

- A. Product Data: Manufacturers catalog sheets and specifications for fiber and copper cable testers.

1.3 INFORMATIONAL SUBMITTALS

- A. Test reports.

1.4 QUALITY ASSURANCE

- A. Testing procedures and testers shall comply with applicable requirements of:
 - 1. ANSI/TIA/EIA 568.1-D, Commercial Building Telecommunications Cabling Standard.
- B. Identification and administration work specified herein shall comply with the applicable requirements of the following:
 - 1. ANSI/TIA/EIA – 606-C Administration Standard for Telecommunications Infrastructures.
 - 2. ANSI/TIA/EIA – 569-D, Telecommunications Pathways and Spaces
 - 3. ANSI/TIA/EIA – 568.1-D, Commercial Building Telecommunications Cabling Standard.
 - 4. BICSI Information Transport Systems Installation Methods Manual (ITSIM), current edition.
 - 5. BICSI Telecommunications Distribution Methods Manual (TDMM), current edition.

PART 2 - PRODUCTS

2.1 CABLE TESTERS

A. Cable Tester:

1. The requirements for each category of cabling (Cat5e, Cat6 or Cat6A) and optical fiber links are located in the ANSI/TIA-568 series standards.
2. Test equipment must meet the requirements set forth in the ANSI/TIA-568 series Standard for Field Test Equipment. Copper testers shall be Level IV. Fiber testers shall meet the requirements in ANSI/TIA-568.
3. Field Power Meters shall meet the following:
 - a. Accuracy +/- 0.2 dB
 - b. Resolution 0.01 dB
 - c. Precision +/- 0.15 dB
4. The Field Light source shall meet the following:
 - a. Accuracy +/- 0.01 dB
 - b. Wavelength:
 - 1) 850 +/- 30 nm
 - 2) 1300 +/- 50nm
 - 3) 1310 +/- 30 nm
 - 4) 1550 +/- 30 nm
5. The calibration test equipment shall be current.
6. The software in test equipment shall be current.

B. Acceptable Manufacturers:

1. Fluke.
 - a. Level 4 Fluke DSP series.
2. OptiFiber OTDR
3. DTX-CLT CertiFiber Optical Loss Test Set
4. Alternate test equipment must be approved by client authorized representative and Consultant prior to testing.

C. Labels:

1. Shall meet the legibility, defacement, exposure, and adhesion requirements of UL 969.
2. Shall be preprinted or laser printed type.
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 direct buried services, underground conduits and duct-banks.

6. Acceptable Manufacturers:
 - a. Brothers or equivalent.
7. Provide test documentation in 3-ring binders within 2 weeks after completion of project testing. Binders shall be clearly marked on outside front cover and spine with words Test Results, project name, and date of completion (month and year).
 - a. Major heading tabs, Horizontal and Backbone, shall divide binder.
 - b. Each major heading shall be further sectioned by test type.
 - c. Within horizontal and backbone sections, divide by tabs scanner test results by category, optical fiber attenuation test results, and continuity test results.
 - d. Present test data within each section in sequence listed in administration records.
8. Provide test equipment by name, manufacturer, model number and last calibration date at the end of document. Unless manufacturer specifies more frequent calibration cycle, annual calibration cycle shall be required on test equipment used for this installation.
9. Test document shall detail test method used and specific settings of equipment during test. Scanner tests shall be printed on 8 1/2 by 11 inches. Handwritten test results (attenuation results and continuity results) shall be documented on a suitable test form.
10. When repairs and re-tests are performed, note problem found and corrective action taken, and collocate in binder both failed and passed test data.

PART 3 - EXECUTION

3.1 COPPER TESTING

- A. Copper cabling shall be tested and certified after installation as follows and as required for cable manufacturer's warranty.
 1. Twisted-pair copper cable channels shall be tested for continuity as specified below, presence of ac/dc voltage, and performance.
 2. Cabling shall be tested for conformance to horizontal cable specifications as outlined herein and shall be tested per test set manufacturer's instructions utilizing latest firmware and software.
 3. Testing shall include electrical parameters as specified under Product.
 4. Cables and termination hardware shall be 100 percent tested by installation contractor for defects in installation and to verify cable performance under installed conditions.
 5. Conductors of each installed cable shall be verified useable by Contractor prior to system acceptance.
 6. Cables shall be tested per Contract Documents, manufacturer's warranty provisions, and best industry practices. If these are in conflict, comply with most stringent requirements.
 7. Defects in cabling system installation shall be repaired or replaced to ensure 100 percent useable conductors in cables installed, at no additional cost to Owner.

- B. Continuity:
1. Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs and split pairs.
 2. The test shall be recorded as pass/fail as indicated by test unit per manufacturers recommended procedures and referenced to appropriate cable identification number and circuit or pair number.
 3. Faults in wiring shall be corrected and cable re-tested prior to final acceptance.
- C. Length:
1. Each installed cable link shall be tested for installed length using a TDR type device. The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate.
 2. Cable length shall conform to maximum distances set forth in ANSI/TIA-568-C standards and other applicable standards specified in Appendix 1: Codes, Standards, and Informative References.
 3. Cable lengths shall be recorded, referencing cable identification number and circuit or pair number.
 4. For multi-pair cables, shortest pair length shall be recorded as length for cable.
- D. Factory Testing:
1. Every reel of cable shall be tested by cable manufacturer for characteristics specified for cable type in this Section.
 2. Testing shall be performed using a sweep test method and include frequencies specified for cable.
 3. Test reports shall be available electronically, at no additional cost, for a minimum of five (5) years from the date of manufacture.
 - a. Test report shall include the reel number, the date of the test, the Lot number, and test results for Return Loss (RL), Insertion Loss (Attenuation), Pair-to-Pair NEXT, and Power Sum NEXT Pair-to-Pair ELFEXT and Power Sum ELFEXT.
 - b. Test report shall show the "Worst Case Margin" for the listed transmission characteristics.
- E. Test Results:
1. Test results shall be automatically evaluated by equipment, using most up- to-date criteria from TIA-568-C standards and other applicable standards specified in Appendix 1: Codes, Standards, and Informative References, and result shown as pass/fail.
 2. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer. Printed test results shall include tests performed, expected test result and actual test result achieved.
- F. Test Reports: Test reports for factory testing and field test reports for copper cabling installation shall be submitted to the Owner's Representative and manufacturer prior to commissioning voice and data system and final contract payment. Refer to Submittals in this Section.

- G. When saving test results, save the test results by:
 - 1. Telecom Room (MDF, TR)
 - 2. Cable type number followed by an alpha number.
- H. Client reserves the right to inspect and monitor the field tests.
- I. Client will have the right to request the Contractor to perform 10% random test to confirm and verify test results submitted to client.

3.2 OPTICAL FIBER CABLE TESTING

- A. Optical fiber cabling shall be tested and certified after installation as described below and as required for cable manufacturer's warranty.
 - 1. Fiber testing shall be performed on fibers in completed end to end system.
 - 2. Testing shall consist of a bi-directional end to end test in accordance with applicable standards, or a bi-directional end to end test performed by TIA-455-53A and other applicable standards.
 - 3. The system loss measurements shall be provided at 850 and 1300 nanometers for multimode type glass and 1310 and 1550 nanometers for single-mode type glass. These tests shall also include continuity checking of each fiber.
 - 4. For spans greater than 90 meters, each tested span must test to a value less than or equal to value determined by calculating a link loss budget.
 - 5. For horizontal spans less than or equal to 90 meters, each tested span must be less than or equal to 2.0 decibels.
 - 6. The insertion loss for each mated optical fiber connector pair shall not exceed 0.40 decibels.
- B. Pre-Installation Testing:
 - 1. Test optical fiber cable for fibers prior to installation of cable.
- C. Performance Testing:
 - 1. Where links are combined to complete a circuit between devices, test each link from end to end to ensure performance of system. Only a basic link test is required.
 - 2. Contractor can optionally install patch cords to complete circuit and then test entire channel.
 - 3. Test method shall be same used for test described above.
 - 4. The values for calculating loss shall be those defined in applicable TIA standards in Appendix 1: Codes, Standards, and Informative References.
- D. Attenuation Testing:
 - 1. Attenuation testing shall be performed with a stable launch condition using two-meter jumpers to attach test equipment to cable plant. The light source shall be left in place after calibration and power meter moved to far end to take measurements.

- E. Loss Budget:
1. Fiber cabling shall be tested at both wavelengths 850 nm and 1310 nm for multimode and 1300 nm and 1550 nm for single mode.
- F. The link attenuation shall be calculated using:
1. $\text{Link Attenuation Allowance (dB)} = \text{Cable Attenuation (dB)} + \text{Connector loss (dB)} + \text{Splice Insertion Loss (dB)}$.
- G. Where:
1. $\text{Cable attenuation (dB)} = \text{Cable attenuation (dB/km)} \times \text{Length (km)}$.
 2. $\text{Connector loss (dB)} = \text{Number of Connector pairs} \times \text{Allowable connector loss (dB)}$
 $\text{Splice Insertion Loss (dB)} = \text{Number of Splices} \times \text{Allowable Splice loss (dB)}$.
- H. Link Loss:
1. A mated connector to connector interface shall be considered a single connector.
 2. Loss numbers for installed link shall be calculated by taking sum of bi- directional measurements and dividing that sum by two.
 3. Links not meeting requirements of standard shall be brought into compliance by Contractor, at no additional cost to Owner.
- I. Documentation: Following final documentation shall be submitted to the Owner's representative prior to commissioning data system and final contract payment according to Submittals in this Section.
- J. Test Results: Test results shall be automatically evaluated by equipment, using most up-to-date criteria from applicable standards specified and result shown as pass/fail.
1. Test results shall be printed directly from test unit or from a download file using an application from test equipment manufacturer.
 2. The printed test results shall include tests performed, expected test result and actual test result achieved.
- K. When saving test results, will save the test results by:
1. Telecom Room (MDF, TR).
 2. Cable type number followed by an alpha number.
- L. End to End Loss Data:
1. Final documentation shall be submitted to the Owner's representative.
- M. As Installed/ As Built Diagrams:
1. Final documentation shall be submitted to the Owner's representative.
- N. Client reserves the right to inspect and monitor the field tests.
- O. Client will have the right to request the Contractor to perform 10% random test to confirm and verify test results submitted to client.

END OF SECTION

SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Placement of Telecommunications Room (TR) and Main Distribution Frame (MDF) hardware including equipment racks, cable routing hardware, copper and fiber termination equipment, patch cords, and grounding and bonding.
2. Placement of interior SCS pathways including conduit, pull boxes and metallic raceway systems.
3. Installation and termination of horizontal cabling including copper cabling, coaxial cabling, and fiber optic cabling.
4. Testing, identification, and administration for the above SCS systems.

B. Work includes furnishing materials, accessories, connectors, supports, electrical protection, equipment, tools, setup, preparation, labor, supervision, incidentals, transportation, storage, and related items and appurtenances, and performing operations necessary to complete the Work as indicated on the Drawings and specified herein.

1. Work shall be conducted in coordination with Owner, Contractor, and other installation trades.

C. It is the intent and purpose of this specification to have, upon completion of the Project, "turn-key" Structured Cabling Systems (SCS) designed, built, coordinated, and integrated with the existing building systems and complete and operable in respects. Completely install, connect, and test systems, equipment, devices, etc., shown or noted or required to final connections and leave ready for satisfactory operation.

1. Provide minor items that may have been inadvertently omitted from the design but are nonetheless necessary to accomplish the above intent.

D. SCS designs for client buildings on and off campus shall be approved by the client Facilities Department for standard and design structure. Design outside of these client standards must be approved and include a written agreement for the design from the client Facilities Department.

E. Minimum composition requirements and/or installation methods for the following materials and work are included in this Section:

1. Cables.
2. Factory Assembled Products.
3. Compatibility of Related Equipment.
4. Special Tools and Kits.

5. Firestop and Penetration Seals.
6. Anchoring and Supports.
7. Grounding and Bonding.
8. Cutting and Patching.
9. Concealment.
10. Equipment Modification.

1.2 DEFINITIONS

- A. General: Every effort has been made to use industry standard terminology throughout this specification, but industry standard terminology is not used by manufacturers, and, in many cases, industry standard terminology does not exist.
1. Notify the Client Facilities personnel and/or the Consultant/Engineer to define terminology used in specifications if they believe questions could arise.
- B. Approved/Approval - Written permission to use a material or system.
- C. SCS Contractor - Structured Cabling Systems Contractor performing work under Division 27.
- D. Consultant - SCS consultant for Division 27.
- E. Equal/Equivalent - Equally acceptable as determined by client or Consultant/Engineer.
- F. Final Acceptance – Client acceptance of the project from Contractor.
- G. Furnish - Supply and deliver to installation location.
- H. Inspection - Visual observation at job site by client or Consultant/Engineer.
- I. Install - Mount and connect equipment and associated materials ready for use.
- J. Jack - Modular connector for station cabling medium (UTP copper, fiber, coax) at work-area outlet.
- K. Outlet - Box and faceplate to accommodate up to six (6) modular jacks at the work area.
- L. Provide - Furnish and install complete with all details and ready for use.
- M. Relocate - Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use.
- N. Replace - Remove and provide new item.
- O. Telecommunications - Work specified in Division 27.
- P. Where this Division 27 indicates work to be performed by the words “shall” or “secure” or other performance functions, it shall be assumed that such work shall be performed by the SCS Contractor performing work under Division 27.

1.3 QUALITY ASSURANCE

- A. Work and materials shall conform to and be installed, inspected, and tested in accordance with the governing rules and regulations of federal, state, and local government agencies.
- B. Installations, materials, equipment, and workmanship shall conform to the Drawings and Specifications, and applicable provisions of the following regulations, codes, and standards including applicable addenda (references to regulations, codes, and standards mean the latest edition, amendment and revisions to the regulations, codes, and standards in effect on the date of the Contract Documents):
 - 1. ANSI/NEC (NFPA 70)
 - 2. NESC (IEEE)
 - 3. National Life Safety Code (NFPA 101)
 - 4. ASTM Standards
 - 5. IEEE Standards
 - 6. NEMA Standards
 - 7. ANSI/TIA – Telecommunications Cabling Standards including, but not limited to, 568, 569, 598, 455 Series, 492 Series, 526 Series, 604 Series, 606, 607, 758-A, TSB-140, FIP 174, FIP 175, FIP 176, S-83-596, S-87-640.
 - 8. FCC Code of Federal Regulations (CFR)
 - 9. Applicable Municipal codes
 - 10. Applicable codes and regulations of other authorities having lawful jurisdiction pertaining to the work required.
 - 11. Americans with Disabilities Act (ADA)
 - 12. Client Cabling Standards
 - 13. BICSI Telecommunications Distribution Methods Manual, Telecommunications Cabling Installation Manual, Customer-Owned Outside Plant Manual, LAN and Internetworking Design Manual, AV Design Reference Manual.
- C. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to Owner.
 - 1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- D. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and Specifications take precedence where this design is more stringent than codes and ordinances.
- E. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.4 REGULATORY REQUIREMENTS

- A. The Contract Documents and phases of construction completed are to be governed by applicable provisions of the “Williams-Steiger Occupational Safety and Health Act of 1970, Public Law 91-596” and the latest amendments including:
 - 1. Reporting/Investigating Accidents.
 - 2. Enforcement of Program.
 - 3. Telecommunications 1910.268.
 - 4. Hazard Communication 1910.1200.
 - 5. Confined Space 1910.146.
 - 6. Lockout/Tagout 1910.147.
 - 7. Asbestos 1910.1001.
 - 8. Assured Grounding 1926.404.
 - 9. Portable Metal Ladders 1910.26.
 - 10. Electrical Protection 1910.268.
 - 11. Exposure and Medical Records 1910.20.
 - 12. Emergency Evacuation 1910.38.
- B. Comply with Owner-specific safety requirements.
 - 1. Receive training if working in hazardous areas.
 - 2. Provide hazards training certificates.
 - 3. Inspect work sites for hazards regularly.
 - 4. Provide safety program documents.
- C. Comply with National Electrical Safety Code NESC C2-1997 including, but not limited to:
 - 1. Section 42, General Rules for Employees.
 - 2. Section 43, Additional Rules for Communications Employees.

1.5 DRAWINGS AND SPECIFICATIONS

- A. It is the intention of the Drawings and Specifications to call for finished Work, tested and ready for operation in complete accordance with applicable codes, regulations, standards, and ordinances.
- B. The Drawings and Specifications are complimentary, and what is called for in either shall be binding as though called for by both. Should a conflict arise between the Drawings and Specifications, such conflict shall be brought to the attention of the Owner and Consultant for resolution. If Contractor fails to notify Owner or Consultant in writing of conflict between the Drawings and Specifications, Contractor shall be subject to re-work the area of conflict at the Contractor’s cost.
- C. Omissions from the Drawings or Specifications, or the incorrect description of details of Work which are evidently necessary to carry out the intent of the Drawings and Specifications, or which are customarily performed, shall not relieve the Contractor from performing such omitted or incorrectly described detail of the Work.

1. Work shall be performed as verified in field measurements, field construction criteria, material catalog numbers and similar data checked and coordinated with each Shop Drawing by the Contractor.
- D. The SCS and technology Drawings are diagrammatic and indicate general design, layout, and arrangement of equipment and various systems. Being diagrammatic, the Drawings may not necessarily show details such as pull-boxes, conduit runs or sizes, etc., necessary for a complete and operable system. Unless detailed dimensioned drawings are included, exact locations are subject to approval of Owner.
- E. Do not scale project Drawings for dimensions. Take dimensions and measurements from the site and actual equipment to be furnished. Dimensions, measurements, and the location and existence of underground equipment shall be verified in the field since actual locations, distance, and elevations will be governed by actual field conditions. Contractor shall be responsible for measurements taken from the field.

1.6 WORKMANSHIP, WARRANTY, AND SUPPORT

- A. Materials and workmanship shall meet or exceed industry standards and be fully guaranteed for one full year from final acceptance for each project. Cable integrity and associated terminations shall be thoroughly inspected, fully tested and guaranteed as free from defects, transpositions, opens/shorts, tight kinks, damaged jacket insulation, etc.
- B. Materials warranty on parts and labor to repair/replace defective SCS materials specified herein. This warranty only applies to materials provided by Contractor and does not apply to materials provided by Owner.
 1. Duration: One year from date of Substantial Completion.
- C. Berk-Tek/Ortronics materials warranty on parts and labor to repair/replace defective SCS station cabling materials. The installer/contractor shall be certified by Berk-Tek/Ortronics to provide the materials warranty.
 1. Duration: 25 years from date of Substantial Completion.
- D. Contractor shall be responsible for and make good, without expense to Owner, any defects arising during this warranty period that are due to defective materials or appliances, improper installation, or poor workmanship.
 1. During the warranty period, provide labor required to repair or replace defects in the SCS system, at no cost to Owner.
 2. During the warranty period, provide new materials to repair or replace defects in the SCS system, at no cost to Owner.

PART 2 - PRODUCTS

2.1 COMPATIBILITY OF MATERIALS AND EQUIPMENT

- A. General: Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.

2.2 MATERIALS AND EQUIPMENT

- A. Materials and equipment shall be new, free from defects, installed in accordance with manufacturer's current published recommendations in a neat manner and in accordance with standard practices of the industry.
- B. Where no specific material, apparatus, or appliance is mentioned, standard, first-class product made by reputable manufacturer regularly engaged in the production of such material may be used providing it conforms to the contract requirements and meets the approval of Owner's Representative and/or the Consultant.
- C. Materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, in accordance with NFPA 255.
- D. Materials shall meet or exceed the following minimum requirements:
 - 1. Where applicable, materials and equipment shall bear the label and listing of UL. Application and installation of all listed equipment and materials shall be in accordance with such labeling and listing.
 - 2. Equipment shall meet all applicable FCC regulations.
 - 3. Electrical equipment and systems shall meet UL standards and requirements of the NEC. This listing requirement applies to the entire assembly. Modifications to equipment to suit the intent of the specifications shall be performed in accordance with these requirements.
 - 4. The listing of a manufacturer as "acceptable" does not include acceptance of a standard or catalogued item of equipment. Equipment and systems must conform to the specifications and meet the quality of the specified item.
 - 5. Materials and equipment shall bear the manufacturer's name or trademark and model/serial number permanently marked.

2.3 CABLES

- A. SCS cabling inside the building shall be UL listed and marked type CM, CMR, CMP, CATV, CATVR or CATVP and shall be installed in accordance with latest NEC articles 300-22, 800-49, 800-50, 800-51, 800-52, 800-53, and 820. The substitutions listed in articles 800.154 and 820.154 shall be permitted.

2.4 FACTORY ASSEMBLED PRODUCTS

- A. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for the final assembled unit.
 - 1. Components of an assembled unit need not be products of the same manufacturer.
 - 2. Constituent parts, which are alike, shall be the product of a single manufacturer.
 - 3. Components shall be compatible with each other and with the total assembly for intended service.
 - 4. Guarantee performance of assemblies of components and shall repair or replace elements of the assemblies as required to deliver the specified performance of the complete assembly.

2.5 FIRESTOPS AND PENETRATION SEAL MATERIALS

- A. General: Comply with provisions of Section 07 84 13 "Penetration Firestopping."
- B. Use qualified systems to firestop through penetrations in fire-rated walls and floors for pipes, cables, conduits, ducts, inner-ducts, and cable trays.
- C. Firestopping for openings through fire and smoke -rated walls and floor assemblies shall be listed or classified by an approved independent testing laboratory for "Through-Penetration Firestop Systems." The system shall meet the requirements of "Fire Tests of Through-Penetration Firestops" designated by ASTM E814.
- D. Inside all conduits, the firestop system shall consist of a dielectric, water-resistant, non-hardening, permanently pliable/re-enterable putty along with appropriate damming or backer materials (where required). Sealant shall be capable of being removed and reinstalled and must adhere to penetrants and common construction materials, and shall be capable of allowing normal cable movement without being displaced.
- E. Foam sealant shall meet all fire test and hose stream test requirements of ASTM E-119 and shall be UL classified as a wall opening protective device.
- F. Provide devices/systems fire tested by a third party according to ASTM E 814 (or UL 1479) tested under positive pressure.
- G. Provide specific combinations of materials installed and supported or anchored.
- H. Provide only material combinations that are qualified by independent agencies based on the material's performance when tested in a particular configuration.
- I. Match the thickness (and/or depth) of firestop materials to that recommended by the manufacturer.
- J. Thickness of materials must be established by formal ASTM E814 or UL 1479 tests.
- K. Firestop for fire-rated floors and walls:
 - 1. 3M Fire Protection
 - 2. Specified Technologies, Inc. (STI)

2.6 ANCHORING MATERIALS AND SUPPORTS

- A. Metal bars, plates, channel, tubing, etc. shall conform to ASTM Standards:
 - 1. Steel plates, shapes, bars, and grating – ASTM A36
 - 2. Cold-formed steel tubing – ASTM A500
 - 3. Hot-rolled steel tubing – ASTM A501
 - 4. Steel pipe – ASTM A53, Schedule 40, welded
- B. Metal fasteners shall be zinc-coated.
- C. Anchoring Materials:
 - 1. Structural Steel.
 - 2. Steel Channel: Galvanized or painted.
 - 3. Uni-Strut.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Installers shall be thoroughly competent and skilled, and work shall be executed in strict accordance with the best practice of the trades.
- B. Good workmanship and appearance shall be considered of equal importance with SCS operation. Lack of quality workmanship shall be considered sufficient reason for rejection of a system in part or in its entirety.
 - 1. Carefully lay out Work in advance and install in a neat and workmanlike manner in accordance with recognized good practices and standards.
 - 2. Provide workers who are skilled in their craft, and a competent Project Manager who shall be on-site full time.

3.2 EXAMINATION

- A. Prior to commencing Work, examine the Project site carefully, including drawings showing existing systems and equipment. Contractor shall be fully informed of and shall identify utility, state, and local requirements that will affect the SCS work.
- B. Contractor shall become familiar with the local conditions under which the Work is to be performed and correlate the on-site observations with the requirements of the Drawings and Specifications.
 - 1. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.
- C. It shall be Contractor's responsibility to determine if the installation of the proposed systems will affect the operation or code compliance of existing systems.

1. With Owner's approval, relocate, modify, or otherwise revise existing SCS systems as required to maintain operational integrity and code compliance.
- D. Before ordering materials or doing project work, verify measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the Drawings.
1. Discrepancies found shall be promptly submitted in writing to the Owner and Consultant for consideration before proceeding with the Work.

3.3 PREPARATION

- A. The approximate locations of existing and new SCS outlets, cabling and equipment will be indicated on Drawings; however, the Drawings are not intended to give complete and accurate information. Field verify existing outlets and cabling prior to submitting quote. Determine the exact location after thoroughly examining the general building plans and by actual measurements before and during construction, subject to the approval of Owner's authorized representative and/or the Consultant.
- B. Before Work commences, visit the site, and identify the exact routing for horizontal pathways and equipment placement. Verify dimensions, locating the Work and its relation to existing work, existing conditions and their relation to the Work and man-made obstructions and conditions, etc. affecting the completion and proper execution of the work as indicated on Drawings and in Specifications.
- C. If core drills are required, the exact core locations shall be identified and coordinated with Owner's authorized representative and the consultant.
- D. Equipment locations shall be coordinated with Owner, other trades, and existing conditions to eliminate interference with required clearances for equipment maintenance and inspections.
- E. Coordinate work with Owner, other trades, and existing conditions to determine exact routing of cable, cable tray, hangers, conduit, etc., before fabrication and installation.

3.4 GENERAL INSTALLATION REQUIREMENTS

- A. Install SCS cabling and equipment to facilitate maintenance and repair or replacement of equipment components. Provide easy, safe and code mandated clearances at equipment racks and enclosures, and other equipment requiring maintenance and operation. Coordinate with Owner exact location and mounting height of equipment in finished areas, such as equipment racks, termination equipment, communication, and electrical devices. As much as practical, connect equipment for ease of disconnecting, with a minimum of interference with other installations.
- B. Coordinate ordering and installation of materials and equipment with long lead times or having major impact on Work by other trades so as not to delay the job or impact the schedule.

- C. Set equipment to accurate line and grade, level equipment and align equipment components. Work shall be installed level and plumb, parallel, and perpendicular to other building systems and components.
- D. Provide scaffolding, rigging, hoisting and services necessary for delivery, installation and erection of materials, equipment, and apparatus furnished into the premises. These items shall be removed from premises when no longer required. Use of Owner's owned supplies and equipment is strictly prohibited.

3.5 CABLES

- A. Telecommunication's pathways shall be dedicated for use for Owner's facilities voice, data, CATV, intercom, audio, video, security, and sound masking systems only. No other cabling type may be placed in SCS pathways.
- B. Horizontal cabling terminating within a single faceplate must be routed to and terminated in the same Telecommunications Room.
- C. Consolidation points and multi-user SCS outlet assembly (MUTOA) configurations for horizontal cabling are not currently supported by Owner and will not be permitted.

3.6 CUTTING AND PATCHING

- A. General: Comply with provisions of Section 01 73 00 "Execution."
- B. Provide cutting, patching and core drilling, etc., as necessary for SCS work. Locate holes and outlets to be drilled and coordinate with work of other trades. Obtain approval of Owner prior to cutting or core drilling holes greater than 3/4" in structural members.
- C. Cut and drill from both sides of walls and/or floors to eliminate splaying.
- D. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering and other finished surfaces. Patch openings and damaged areas equal to existing surface finish.
- E. Cut openings in prefabricated construction units in accordance with manufacturer's instructions.
- F. Openings for electrical work shall be carefully caulked or grouted as required. Spare conduits shall be tightly capped.
- G. Cutting in the building construction made necessary to admit work, repair defective materials, defective workmanship, or by neglect to properly anticipate their requirements, shall be done in accordance with the Specifications with no additional cost to Owner. Patching shall be complete in every detail. Actual work involved in these repairs shall be performed by skilled workers in the trades involved.
- H. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.7 CONCEALMENT

- A. Use existing conduit and cable trays where possible and practicable. Conceal project work above ceilings and in walls, below slabs, and elsewhere throughout building. If concealment is impossible or impracticable, notify Owner and/or the Consultant before starting that part of the work and install only after approval.

3.8 EQUIPMENT MODIFICATION

- A. Where existing equipment is to be modified, furnish materials and labor as necessary to modify or add to the equipment. Modifications shall be performed neatly with factory parts and assemblies approved for the application. Modification shall in no way jeopardize the compliance of existing equipment with governing codes and regulations.

3.9 FIRESTOPS AND PENETRATION SEALS

- A. General: Comply with provisions of Section 07 84 13 "Penetration Firestopping."
- B. New and existing penetrations through fire-rated walls, floors, ceilings, etc. shall be sealed to prevent the spread of smoke, fire, toxic gas, or water through the penetration before, during, or after a fire. The fire rating of penetration seal shall be at least that of the wall, floor, or ceiling into which it is installed, so the original fire rating is maintained. The installation shall provide an air and watertight seal. This includes existing SCS cables and pathways to remain within the project area.
- C. New and existing conduit and sleeve openings used for the project shall be waterproofed or fireproofed upon cable placement through such passageways in compliance with Arizona Building and Fire Codes and Owner standards.
- D. Patch openings remaining around and inside new and existing conduit sleeves and cable penetrations to maintain the integrity of fire-rated wall, floor, ceiling, etc.
- E. Manufacturer's installation standards shall be closely followed (minimum depth of material, use of ceramic fiber, procedures, etc.).
- F. Brick, Concrete, and Concrete Masonry Walls:
 - 1. Provide metallic sleeving systems for routing of cables through these surfaces.
 - 2. Ensure that sleeve extends from the front and back of the wall only far enough to attach the required bushing or collar.
 - 3. Secure sleeves in place according to manufacturer's specifications.
 - 4. Provide firestop seal between sleeve and wall, but do not use firestopping material to support or secure sleeve.
 - 5. Firestop around inner-duct used to contain fiber optic cable through a wall.
 - 6. Firestop ends of sleeving or inner-duct after installation of cable, without exception.
- G. Floor Openings:
 - 1. Install firestop materials to stop openings between sleeving (or other supporting material) and core.

2. Thru floor penetrations within the Telecommunications Rooms or intending to support the SCS shall include EZ path product in a quantity that is equal to or greater than the capacity of the opening it is serving.
 3. If rectangular openings exist in concrete floors, use steel sleeving to fashion opening before installing firestopping materials.
- H. Cable Trays: New cable tray pathways shall not penetrate fire-rated walls. Cable tray shall stop within 6 inches of the wall and fire-rated wall shall include EZ path product in a quantity that is equal to or greater than the capacity of the tray it is serving.
1. Close cable tray penetrations with a qualified firestopping system.
 2. Install the system according to the manufacturer's instructions.
 3. Ensure that system provides proper support and relief of firestop materials.
 4. Firestop materials must be easily removable if required.
 5. Firestopping materials must provide for installation of cable through the opening without the replacement of material.
 6. Use of intumescent sheets of approximately .5-inch maximum thickness is preferred.
- I. Fire-Rated Gypsum board Partitions:
1. Sleeve penetrations of gypsum walls used for cable routing if cable is not in conduit or innerduct (fiber).
 2. Firestop seal between sleeve, conduit, or inner-duct and wall on both sides of the wall.
 3. Use qualified firestop systems to seal penetrations in gypsum wallboard assemblies.
 4. Verify that penetration conditions fall within the following firestop system parameters:
 - a. Hourly rating.
 - b. Opening size.
 - c. Annular space.
 5. Install the firestop system symmetrically on both sides of the wall.
 6. Install the materials according to manufacturer-tested methods.
 7. Box out gypsum penetrations used for cable trays.
 8. Firestop gypsum box with qualified system.
 9. Use identical guidelines for penetrations of hollow lath or plaster surfaces.
- J. Other Firestopping:
1. Firestop through penetrations according to the guidelines for the basic construction of the two outermost layers of the combination wall.
 2. Firestop load-bearing stud walls that are part of combination walls by enclosing (i.e., boxing) the penetration in the cavity.
 3. Firestop partial penetrations according to the recommendations for the type of wall being penetrated.
 4. Firestop penetrations which violate the fire-rating integrity of vertical shafts.
 5. Firestop openings around outlet boxes installed in fire-rated walls, on both sides.

- K. Firestop Installation Methods:
 - 1. Use drop cloths to protect other surfaces when installing.
 - 2. Firestop completely around each cable individually – do not stop bundles of cables.
 - 3. If using putty around a vertical penetration, use putty to build flooring of seal, fill with fiber or rock wool to required thickness, then top with putty according to Manufacturer’s specifications.
 - 4. The methods used shall incorporate qualities that permit the easy removal or addition of conduits or cables without drilling or use of special tools.
 - 5. The product shall adhere to itself to allow repairs to be made with the same material and to permit the vibration, expansion and/or contraction of items passing through the penetration without cracking, crumbling, and resulting reduction in fire rating.
- L. The installed firestop system shall meet the requirements of “Fire Tests of Through-Penetration Firestops” designated ASTM E814.
- M. Spare conduits shall be plugged with expandable plugs.
- N. Firestop system shall be submitted to Owner at the preconstruction meeting with a list or map of each location and system number used for the Project.

3.10 ANCHORING METHODS

- A. Anchor and brace cabling, material, and equipment as required by codes, regulations, and standards. Provide required supports, beams, angles, hangers, rods, bases, braces, straps, struts, and other items to properly support project work. Supports shall meet the Owner’s approval.
- B. Supports shall be fabricated from structural steel, steel channel, or uni-strut, rigidly bolted or welded to present a neat appearance.
- C. Fastenings and supports shall be adequate to support loads with ample safety factors.
- D. Fasten hanger rods, conduit clamps, outlet boxes, and pull-boxes to building structure.
- E. Use toggle bolts, spider type expansion anchors, or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls.
- F. Use lead expansion shields or expansion anchors or preset inserts in solid masonry walls.
- G. Use self-drilling anchors or lead expansion anchor on concrete surfaces.
- H. In pre-cast structures, use cast-in inserts wherever possible. Expansion anchors can be used with caution, but only with prior approval.
- I. In cast-in-place concrete, use expansion anchors, preset inserts, or self-drilling masonry anchors.

- J. Use lead expansion anchors or preset inserts on metal surfaces.
- K. Do not fasten supports to fire protection piping or mechanical piping, ceiling support wires, ductwork, mechanical equipment, or conduit.
- L. Power-actuated anchors, plastic or fiber expansion anchors, and drive pin anchors are prohibited.
- M. Do not drill structural steel members.
- N. Where necessary and with Owner's approval, modify studs, add studs, add framing, or otherwise reinforce studs in metal stud walls and partitions as required to suit project Work. If necessary, in stud walls provide special supports from floor to structure above.
- O. For precast panels/planks and metal decks, support communication work as determined by manufacturer and Owner.
- P. Provide heavy gage steel mounting plates for mounting Work. Mounting plates shall span two or more studs. Size, gauge, and strength of mounting plates shall be sufficient for equipment size, weight, and desired rigidity.
- Q. Support surface mounted cabinets, enclosures, and panel boards with a minimum of four anchors.

3.11 GROUNDING AND BONDING

- A. Comply with provisions of Section 27 05 26 "Grounding and Bonding for Communications Systems."

END OF SECTION

SECTION 27 05 13
COMMUNICATION SERVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Fiber-optic cable systems.
 2. Voice communication cable system.
 3. Data communication cable system.
 4. CATV communication cable system.
 5. Associated conduit raceway distribution and equipment rack/cabinet system.
- B. Provide and test cable and conduit support system, fiber-optic, voice, data and CATV cables, associated connectors, patch panels, equipment racks, grounding system, patch cords, etc., as indicated on the Drawings and in the Specifications.
- C. Include Work shown on the Drawings and in the Specifications. The Drawings and Specifications are intended to agree with each other. Discrepancies shall be brought to the attention of the Consultant for correction. No omission from Drawings shall release the Contractor from furnishing equipment, materials, or services required by the Contract Documents.
- D. Collaborate and work in partnership with the cable manufacturer, the connectivity manufacturer, and the distributor to provide the Owner with UL or ETL independently verified cabling installation that is guaranteed to perform at levels above and beyond the EIA/TIA 568B.1 Standards, as per the minimum acceptable full channel performance specification contained herein.
1. The partnership shall make available optional UL or ETL independent testing and verification of the completed installation.
 2. The partnership shall provide full written certification of the installation to the Owner upon completion.
- E. Document deviation, alteration or substitution from the Drawings and Specifications and submit as a voluntary alternate to the base bid.
1. Approval of requests for substitution of products, processes, or procedures other than those specified shall be contingent upon submission of fully acceptable documentation to the Owner and Engineer.
- F. Protect equipment and materials from damage during his installation process. Equipment, material and/or facilities damaged by the Contractor during, due to, or in the performance of the Work shall be replaced or repaired at the expense of the Contractor, as directed by the Engineer.

1.2 ACTION SUBMITTALS

- A. General: Index submittals and reference to the Specifications.
- B. Product Data: Manufacturers' data and dimension sheets, giving pertinent physical and engineering data including weights, and cross-sections. Include the following:
 - 1. Schedule of labels for the following:
 - a. Backbone and Horizontal cable labels
 - b. Grounding and Bonding conductor labels
 - c. Faceplate labels
 - d. Patch Panel labels
 - e. Fiber Enclosure labels
 - f. Termination Block labels
 - g. Conduit into telecommunications room labels
 - h. Racks, Cabinets, and Cable Tray labels
- C. Shop Drawings: Bind in one hardcover, 3-ring binder indexed to this Division. Include the following:
 - 1. Elevation plans depicting the final rack configurations for each of the telecommunication's rooms and proponent server areas.
 - 2. Changes in proposed cable routing, proposed through-wall penetrations, and significant changes that deviate from the Contract Documents.
 - 3. Outlet locations with heights of information outlets.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: To include in O&M manuals.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Firms regularly engaged in manufacture of communication cabling system equipment whose products have been in satisfactory use in similar service for not less than five years.
- B. Installer Qualifications:
 - 1. Installers shall be fully capable and experienced in communication cabling system specified. Contractor and subcontractors engaged in communication cabling installation shall have experience in this business for not less than five years and shall have successfully completed a minimum of five projects of similar size.
 - 2. Specify, in bid, subcontractors who shall be utilized on this Project. Subcontractors' company name, contact and responsibilities shall be listed.
 - 3. Employ a Registered Communication Distribution Designer (RCDD) who shall be responsible to the Engineer and Owner for Work performed by the Contractor and subcontractors. The RCDD shall have the authority of the Contractor to make immediate decisions regarding implementation of changes to the Project as directed by the Owner or Engineer.

4. If, in the opinion of the Engineer or Owner, the RCDD does not possess or demonstrate adequate qualifications to support the Project, the Owner reserves the right to require the Contractor to assign an RCDD who, in the Owner's opinion, possesses the skill necessary to complete the Project.
5. Client's preference is to utilize a contractor that can extend the manufacturer's warranty associated with the product set that is their standard. If a contractor is not certified by the manufacturer, then a waiver request must be submitted for approval.

C. Supervisor Qualifications:

1. Supervisor shall be a manufacturer certified and a BICSI registered cabling installation technician, NJATC installer technician, BICSI RCDD or Engineer-approved equal and have a minimum of two years' experience.
2. Supervisor shall maintain documentation in accordance with requirements.
3. Supervisor shall provide reports to the RCDD, Engineer and Owner for quality of installation and compliance with requirements.
4. Journeymen and Apprentices performing work shall be enrolled in or have completed the BICSI, registered cabling installation technician, NJATC installer technician, or Engineer-approved equal course.

1.5 COORDINATION

- A. Materials and equipment shall be ordered in ample quantities for delivery at the proper time. If items are not on the Project in time to expedite completion, the Owner may purchase said equipment and materials and deduct the cost from the Contract Sum.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Provide materials of similar class or service by one manufacturer.

2.2 MATERIALS

- A. General: Electrical materials and equipment shall be new and of the type and quality specified and shall be listed by UL and bear their label where standards have been established, in compliance with the applicable standards of NEC (NFPA 70), NFPA, ANSI, IEEE, IPCEA and NEMA. Replace or repair nonconforming, damaged, or defective items at no extra cost to the Owner.
- B. Materials for which the UL label is not normally available shall be mounted in separate enclosures and wired to the labeled units in an acceptable manner.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. General: Perform labor in a thorough and workman like manner, to the satisfaction of the Owner and Engineer.
- B. Staff the Project with sufficient skilled workers, including a fully qualified superintendent Project Manager, to complete the Work in the time allotted. Project Manager shall be qualified to supervise Division 27 work.
- C. Cooperative Work:
 - 1. Cooperative Work includes general supervision and responsibility for proper location and size of work related to this Division but provided under other Sections of the Specifications.
 - 2. Installation of sleeves, inserts, and anchor bolts for work under each Section in this Division.
- D. Correct without additional cost to Owner any work requiring alteration due to lack of proper supervision or failure to make proper provision in time. Correct without charge damage to adjacent work caused by the alteration.

END OF SECTION

SECTION 27 05 26

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grounding Electrode System.
 - 2. Busbars.
 - 3. Bonding Accessories.
- B. Related Requirements:
 - 1. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

- A. General: Refer to Section 27 05 00 "Common Work Results for Communications."
- B. BCT: Bonding conductor for telecommunications.
- C. TGB: Telecommunications grounding busbar.
- D. TMGB: Telecommunications main grounding busbar.

1.3 ACTION SUBMITTALS

- A. Product Data: Manufacturer's technical data sheets, specifications, performance data and installation instructions for products referenced in this Section.
- B. Shop Drawings: Depict the requirements for fabrication and installation. Include plans, elevations, sections, details, and attachments to other work.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty Information: Include details of manufacturer's warranty, extended warranty, and replacement policies.
- B. Field quality-control reports. Include the following:
 - 1. Result of the ground-resistance test, measured at the point of BCT connection.
 - 2. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. Include preventative maintenance instructions.
- B. Maintenance Contracts.
- C. Project Record Documents:
 - 1. CAD Files: Provide CAD files in dwg or dgn formats showing locations of grounding and bonding infrastructure. Include the following:
 - 2. Ground rods.
 - 3. Ground and roof rings.
 - 4. BCT, TMGB, TGBs, and routing of their bonding conductors.
 - 5. Include room numbers on Floor Plans.
 - 6. Submit Record Documents within 5 business days of final cable testing.
 - 7. Red Line Drawings: Retain one (1) E size set of floor plans on site during work hours showing installation progress labels noted. Make drawings available for examination during construction meetings and field inspections.
- D. Warranties for manufactured components specified in this Section.

1.6 QUALITY ASSURANCE

- A. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- B. Material and work specified herein shall comply with the applicable requirements of the current revision of the following:
 - 1. ANSI/TIA-568 - Commercial Building Telecommunications Cabling Standard.
 - 2. ANSI/TIA-569 - Telecommunications Pathways and Spaces.
 - 3. ANSI/TIA-606 - Administration Standard for the Telecommunications Infrastructure
 - 4. BICSI – Telecommunications Distribution Methods Manual.
 - 5. J-STD-607-A - Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
 - 6. NFPA 70 - National Electric Code.
- C. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to Owner.
 - 1. Report immediately to Client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to furnish and install material which complies with these codes and regulations.
- D. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and specifications take precedence where this design is more stringent than codes and ordinances.

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

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- E. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.7 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Grounding system shall be designed for high reliability. Therefore, the grounding system shall meet the following criteria:
 - 1. Local electrical codes shall be adhered to.
 - 2. The grounding system shall comply with ANSI/TIA-942 and JSTD-607-A.
 - 3. Grounding conductors shall be copper.
 - 4. Lugs, HTAPs, grounding strips, and busbars shall be UL Listed and made of premium quality tin-plated electrolytic copper that provides low electrical resistance while inhibiting corrosion.
 - 5. Antioxidant shall be used when making bonding connections in the field.
- B. Two-hole lugs shall be utilized. Lugs shall be irreversible compression and meet NEBS Level 3. Lugs with inspection windows shall be used in non-corrosive environments so that connections may be inspected for full conductor insertion (battery rooms are the exception where windowless lugs may be used).
- C. Die index numbers shall be embossed on compression connections to allow crimp inspection.
- D. Cable assemblies shall be UL Listed and CSA Certified. Cables shall be a distinctive green or green/yellow in color, and jackets shall be UL, VW-1 flame rated.

2.2 GROUNDING AND BONDING MATERIALS

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. General: Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
- C. Mechanical Connectors: Bronze.

- D. Bonding Conductor: 6 AWG minimum copper
- E. Grounding equipment shall be UL listed for that purpose.

2.3 GROUNDING ELECTRODE SYSTEM

- A. Grounding Electrode System:
 - 1. When required the Grounding Electrode System shall meet the following:
 - a. Active grounding system constantly replenishing moisture into the soil.
 - b. Provide low resistance to ground.
 - c. Provide season to season stability.
 - d. Be maintenance-free for 30 years.
 - e. Contain no hazardous materials or chemicals.
- B. Approved Manufacturers:
 - 1. Chatsworth.
 - 2. Panduit.
 - 3. Or approved equal.

2.4 WALL MOUNTED BUSBARS

- A. Telecommunications Main Grounding Busbar (TMGB):
 - 1. Telecommunications Main Grounding Busbar (TMGB) shall be constructed of .25" (6.4 mm) thick solid copper bar.
 - 2. The busbar shall be 4" (100 mm) high and 20" (510 mm) long and shall have 30 attachment points (two rows of 15 each) for two-hole grounding lugs.
 - 3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 27 lugs with 5/8" (15.8 mm) hole centers and 3 lugs with 1" (25.4 mm) hole centers.
 - 4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4" (100 mm) standoff from the wall.
 - 5. The busbar shall be UL Listed as grounding and bonding equipment.
- B. Telecommunications Grounding Busbar (TGB):
 - 1. Telecommunications Grounding Busbar (TGB) shall be constructed of .25" (6.4 mm) thick solid copper bar.
 - 2. The busbar shall be 2" (50 mm) high and 12" (300 mm) long and shall have 9 attachment points (one row) for two-hole grounding lugs.
 - 3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 6 lugs with 5/8" (15.8 mm) hole centers and 3 lugs with 1" (25.4 mm) hole centers.
 - 4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4" (100 mm) standoff from the wall.
 - 5. The busbar shall be UL Listed as grounding and bonding equipment.
- C. Approved Manufacturers:

1. Chatsworth.
2. Panduit.
3. Or approved equal.

2.5 BONDING ACCESSORIES

A. Two Mounting Hole Ground Terminal Block:

1. Ground terminal block shall be made of electroplated tin aluminum extrusion.
2. Ground terminal block shall accept conductors ranging from #14 AWG through 2/0.
3. The conductors shall be held in place by two stainless steel set screws.
4. Ground terminal block shall have two 1/4" (6.4 mm) holes spaced on 5/8" (15.8 mm) centers to allow secure two-bolt attachment to the rack or cabinet.
5. Ground terminal block shall be UL Listed as a wire connector.

B. Compression Lugs:

1. Compression lugs shall be manufactured from electroplated tinned copper.
2. Compression lugs shall have two holes spaced on 5/8" (15.8 mm) or 1" (25.4 mm) centers, as stated below, to allow secure two bolt connections to busbars.
3. Compression lugs shall be sized to fit a specific size conductor, sizes #6 to 4/0, as stated below.
4. Compression lugs shall be UL Listed as wire connectors.

C. Antioxidant Joint Compound:

1. Oxide inhibiting joint compound for copper-to-copper, aluminum-to-aluminum or aluminum-to-copper connections.

D. C-Type, Compression Taps:

1. Compression taps shall be manufactured from copper alloy.
2. Compression taps shall be C-shaped connectors that wrap around two conductors forming an irreversible splice around the conductors; installation requires a hydraulic crimping tool.
3. Compression taps shall be sized to fit specific size conductors, sizes #2 AWG to 4/0, as stated below.
4. Compression taps shall be UL Listed.

E. Pedestal Clamp with Grounding Connector:

1. Pedestal clamp shall be made from electroplated tinned copper or bronze. Installation hardware will be stainless steel.
2. Pedestal clamps shall be sized to fit a specific size conductor, size #6 and/or 2/0, as stated below.
3. Pedestal clamp installation hardware shall be sized to attach to round and/or square raised access floor pedestals that are 1-1/8" to 1-3/4" in diameter, as stated below.
4. Pedestal clamp shall provide straight (in-line) or cross (intersection) support for up to two conductors.

5. Pedestal clamp shall be UL Listed as grounding and bonding equipment.
- F. Pipe Clamp with Grounding Connector:
1. Pipe clamp shall be made from electroplated tinned bronze. Installation hardware will be stainless steel.
 2. Pipe clamp shall be sized to fit up to two conductors ranging in size from #6 to 250 MCM; conductors must be the same size.
 3. Pipe clamp installation hardware shall be sized to attach to pipes, sizes 1" to 6" (.75" to 6.63" in diameter), as stated below.
 4. Pipe clamp shall be UL Listed as grounding and bonding equipment.
- G. Equipment Ground Jumper Kit:
1. Kit includes one 24" L insulated ground jumper with a straight two-hole compression lug on one end and an L-shaped two-hole compression lug on the other end, two plated installation screws, an abrasive pad and a .5 once tube of antioxidant joint compound.
 2. Ground conductor is an insulated green/yellow stripe #6 AWG wire.
 3. Lugs are made from electroplated tinned copper and have two mounting holes spaces .5" to .625" apart that accept 1/4" screws.
 4. Jumper will be made with UL Listed components.
- H. Approved Manufacturers:
1. Chatsworth.
 2. Panduit.
 3. Or approved equal.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."
- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.1 EXAMINATION

- A. Prior to project Work, examine the project site carefully, including drawings showing existing systems and equipment.
 1. Contractor shall be fully informed of and shall identify utility, state, and local requirements that will affect the SCS work at the project site.
- B. It shall be the Contractor's responsibility to determine if the installation of the proposed systems will affect the operation or code compliance of existing systems.

1. With Owner's approval, relocate, modify, or otherwise revise existing SCS systems as required to maintain operational integrity and code compliance.
- C. Become familiar with the local conditions under which the work is to be performed and correlate the on-site observations with the requirements of the Drawings and Specifications.
1. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.
- D. Before ordering materials or doing project work, verify measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the project drawings. Discrepancies found shall be submitted in writing to the Consultant for consideration before proceeding with the Work.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Outdoor grounding and bonding connections:
1. Outdoor grounding and bonding (earthing) connections shall be accomplished using exothermic welding.
- B. Wall-Mount Busbars:
1. Attach busbars to the wall with appropriate hardware according to the manufacturer's installation instructions.
 2. Conductor connections to the TMGB or TGB shall be made with two-hole bolt- on compression lugs sized to fit the busbar and the conductors.
 3. Each lug shall be attached with stainless steel hardware after preparing the bond per manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
 4. Wall-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.
- C. Rack-Mount Busbars and Ground Bars:
1. When a rack or cabinet supports active equipment or type of shielded cable or cable termination device requiring a ground connection, add a rack-mount horizontal or vertical busbar or ground bar to the rack or cabinet.
 - a. The rack- mount busbar or ground bar provides multiple bonding points on the rack for rack and rack-mount equipment.
 2. Attach rack-mount busbars and ground bars to racks or cabinets per the manufacturer's installation instructions.
 3. Bond the rack-mount busbar or ground bar to the room's TMGB or TGB with appropriately sized hardware and conductor.
- D. Ground Terminal Block:
1. Every rack and cabinet shall be bonded to the TMGB or TGB.

2. Minimum bonding connection to racks and cabinets shall be made with a rack-mount two-hole ground terminal block sized to fit the conductor and rack and installed per manufacturer recommendations.
3. Remove paint between rack/cabinet and terminal block, clean surface and use antioxidant between the rack and the terminal block to help prevent corrosion at the bond.

E. Pedestal Clamp:

1. At minimum, bond every sixth raised access floor pedestal with a minimum #6 AWG conductor to the TMGB or TGB using a pedestal clamp sized to fit the pedestal and the conductor and installed per the manufacturer's recommendations.
2. If pedestal clamps are used to construct a signal reference grid, bond the signal reference grid to the TMGB or TGB and bond each rack and/or cabinet to the signal reference grid using a compression tap or similar non-reversible bonding component sized to fit both conductors.
3. Remove paint between the pedestal and pedestal clamp, clean surface and use antioxidant between the pedestal and the clamp to help prevent corrosion at the bond.
4. Remove insulation from conductors where wires attach to the pedestal clamp.

F. Pipe Clamp:

1. Bond metal pipes located inside the data center computer room with a minimum #6 AWG conductor to the TMGB or TGB using a pipe clamp sized to fit the pipe and the conductor and installed per the manufacturer's recommendations.
2. Remove paint between the pipe and pipe clamp, clean surface and use antioxidant between the pipe and the clamp to help prevent corrosion at the bond.
3. Remove insulation from conductors where wires attach to the pipe clamp.

G. Equipment Ground Jumper Kit:

1. Bond equipment to a vertical rack-mount busbar or ground bar using ground jumper per the manufacturer's recommendations.
2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack-mount busbar or ground bar to help prevent corrosion at the bond.

3.3 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 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

SECTION 27 05 28

PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Telecom Outlets (TO).
 - 2. Horizontal Distribution Systems.
 - 3. Station Conduits, Service Entrance Conduits, and Riser Conduits
 - 4. Boxes and enclosures.
- B. Related Requirements:
 - 1. Section 07 84 13 "Penetration Firestopping."
 - 2. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

1.3 ACTION SUBMITTALS

- A. Product Data: For features, ratings, and performance of each component specified. List manufacturer, part number, and quantity of each component.
 - 1. Surface pathways
 - 2. Wireways and fittings.
 - 3. Boxes, enclosures, and cabinets.
 - 4. Conduit Bushings.
 - 5. Cable tray, fittings, and accessories. Include load data.
- B. Shop Drawings:
 - 1. Include dimensioned plan and elevation views of equipment rooms, labeling each individual component. Show raceway assemblies, method of field assembly, workspace requirements, and access for cable connections.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer's instructions for storage, handling, protection, examination, preparation, operation, and installation of products. Include application conditions or limitations of use stipulated by product testing agency.

- B. 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.
 - 3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

1.5 QUALITY ASSURANCE

- A. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- B. Material and Work specified herein shall comply with the applicable requirements of the current revision of the following:
 - 1. ANSI/TIA-568 - Commercial Building Telecommunications Cabling Standard.
 - 2. ANSI/TIA-569 - Telecommunications Pathways and Spaces.
 - 3. ANSI/TIA-606 - Administration Standard for the Telecommunications Infrastructure
 - 4. BICSI – Telecommunications Distribution Methods Manual.
 - 5. J-STD-607-A - Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
 - 6. NFPA 70 - National Electric Code.
- C. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to client.
 - 1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- D. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and Specifications take precedence where this design is more stringent than codes and ordinances.
- E. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.6 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 “Common Work Results for Communications.”

PART 2 - PRODUCTS

2.1 PATHWAY MATERIALS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

2.2 TELECOM OUTLETS (TO)

- A. New construction TO consists of one (1) 4-11/16" square by 2-1/8" deep flush mounted box. Each outlet box shall have a EMT conduit stubbed above the drop ceiling or extended into the hallway cable tray. Conduit's size is as follows:
 - 1. For Outlets with 3 or less cables, use a 1" EMT conduit.
 - 2. For Outlets with 3-6 cables, use a 1.25" EMT conduit.
 - 3. For other sizes, calculate fill ratio at 40% for proper sized conduit.
- B. Existing surface-mounted construction TO typically consists of surface-mounted raceway including base, cover, end fitting, entrance end fitting, and (2) 1" EMT conduits stubbed out top of entrance end fitting to above ceiling or out to nearest hallway distribution system. Size of the raceway is site dependent based on number of conductors to be installed.
- C. The intent of the installation of the TOs which consist of the raceway is as follows:
 - 1. Where ceilings are accessible, the raceway and entrance end fitting shall extend above the ceiling and the conduits installed above the ceiling in the room to the nearest hallway distribution system.
 - 2. Where ceilings are partially accessible, or if the Drawings and/or Specifications indicate installation of access panels, the raceway shall extend above the ceiling and the conduits installed above the ceiling in the room to the nearest hallway distribution system.
 - 3. Where ceilings are inaccessible or no ceilings exist, the raceway shall extend up as close to the ceiling as practical to allow installation of conduits as high as possible to the nearest hallway distribution system.

2.3 HORIZONTAL DISTRIBUTION SYSTEMS

- A. Conduit System (Renovations only, where conduit exists)
 - 1. Provide conduits secured to wall above corridor ceilings as shown on the Drawings or as specified herein for installation of telecommunications cables exposed conduit.

2. Corridor conduits shall be 4" EMT, furnished in 10-foot lengths wherever possible, with no sharp edges, reamed as necessary, evenly supported at two locations per 10-foot section spacing. Conduits shall be sized and quantified to account for handling cables in TO conduits at 40% fill back to the TR and/or ER rooms. Verify size prior to installation. Bushings and/or connectors on ends of EMT are required.
3. Conduits shall be installed stacked and attached to walls unless conditions exist which prohibit this type of installation. When this condition exists, mount conduits side-by-side supported with 3/8" rod attached to building structure utilizing unistrut channel to form a trapeze. Double nut the top and bottom at the unistrut. Utilize conduit clamp to secure conduits to unistrut.
4. Provide measured pull line in each conduit rated at 1200 lbs. minimum. Increments must be in 12" steps.
5. Grounding of conduits is not required per NEC #250-33, Exception No. 2. shall be painted except conduit above suspended ceilings or in mechanical, electrical or telecommunication rooms. Color to match that of surface installed upon or as directed by Owner's Representative. Coordinate with other trades prior to painting.
6. Provide restorable fire stops inside and around conduits as recommended by UL1479 or ASTM E814 for conduits penetrating fire-rated construction. Fire rated construction to be verified with AHJ.

B. Corridor Cable Tray System:

1. Complete wall mounted or suspended wire basket tray system and necessary accessories shall be provided as shown on plans. Install entire wire basket tray system in accordance with manufacturer's minimum installation practices and local governing codes.
2. Coordinate installation of cable tray with other trades to allow a minimum of 12" above, 12" in front, and 12" below of clearance from piping, conduits, ductwork, etc. Allowance must be provided for access to the tray with reasonable room to work. Obstructions to the tray must be minimized and cannot block more than 6 feet of the tray at point in the run.
3. Cable tray shall not be loaded beyond 60% of manufacturer's recommended load capacity.
4. Where a new tray distribution system encounters a wall, install sufficient 4" EMT sleeves through the wall so cabling does not exceed 20% fill.
5. Where cable tray is exposed below ceiling, install the appropriate solid bottom inserts to conceal cables.
6. Install cable tray dropouts where large quantities of cables exit the distribution system.
7. Wire basket tray shall be a minimum width of 18" x 4" high. Tray must be sized upwards if fill ratio requirements need to be met to facilitate sufficient growth capacity for migration cable plant to coexist in same tray as existing cable plant.

C. Approved Manufacturers:

1. Cablofil.
2. Or approved equal.

- D. Telecommunication Room Cable Tray System:
 - 1. TR cable tray shall completely wrap walls within the room. Cable tray shall extend over equipment frames.
 - 2. Cable tray shall be a minimum width of 2" high x 12" wide. Cable tray may be sized upwards if fill ratio requirements need to be met based on cable quantities.
- E. Open pathway/trays shall be installed a minimum of six (6) inches away from light fixture or other source of EMI (Electromagnetic Interference).
- F. Pathways shall be grounded per NEC Article 250.
- G. Provide external grounding strap at expansion joints, sleeves and crossover and at other locations where pathway/tray continuity is interrupted.
- H. Support pathways from building construction. Do not support pathways from ductwork, piping, or equipment hangers.
- I. Install cable tray level and straight unless noted on Drawings.
- J. Approved Manufacturers:
 - 1. Chatsworth
 - 2. Or approved equal.

2.4 STATION CONDUITS

- A. Station conduit is defined as conduit that originates at the TO and rises within the walls or is exposed from a raceway and extends up into the drop ceiling or over to the hallway distribution system.
- B. Provide station conduits from TOs to above the drop ceiling or extend over to the hallway distribution systems consisting of 1" EMT minimum or appropriate size as shown on the Drawings or as specified herein for installation of telecommunications cables.
- C. Provide an insulating press fit bushing on telecommunications conduits including interconnecting nipples and stub to distribution system. To prevent conflicts with other cables or conduits to cable tray, the conduit shall be stubbed not less than 6" above or below conduit/cable tray center line. Where space permits, every effort shall be made to bend station conduits down such that the flow of installed cables promotes the minimum length back to the TR and the least number of bends in the cables. Bushings must be rated to be used in an environmental air handling space (Plenum).
- D. Provide measured pull line in 12" increments in each empty conduit to hallway distribution system.
- E. Indelibly mark station conduit at hallway distribution end with Room # that conduit serves.
- F. The use of 90-degree electrical pulling elbows is prohibited.

- G. Do not include more than two 90-degree bends between pulling points when installing station conduit runs. If the path of the station conduits requires more than 180 degrees of total bends, installation of an appropriately sized junction box is required. See 2.4 for junction box requirements.
- H. Place an appropriately sized junction box in each individual station conduit run that exceeds 100 feet in length.
- I. The use of a third bend in a conduit is only acceptable if:
 - 1. The total conduit run is reduced by 15%.
 - 2. The conduit size is increased to the next trade size.
 - 3. One of the bends is located within 12" of the cable feed end.

2.5 JUNCTION BOX REQUIREMENTS FOR STATION CONDUITS

- A. If the station conduit route exceeds the 180 degree of total bends limitation, an appropriately sized junction box is required within a straight section of the conduit run.
- B. Each station conduit run requires a separate junction box. The sharing of a junction box by multiple conduits is prohibited.
- C. A junction box shall not be used in place of a bend. Junction boxes in station conduit paths shall be installed within a straight section of the conduit run.

2.6 SERVICE ENTRANCE CONDUITS

- A. Minimum of (4) 4" IMC conduits shall be installed from the nearest utility tunnel on outside of the building as shown on the Drawings. Terminate entrance conduits entering ER rooms from below grade to extend 4" above finished floor. Location of entrance conduits shall be within 12" of room corners.
- B. Terminate entrance conduits entering ER rooms from above ceiling height to extend 4" below finished ceiling or 12" above cable tray.
- C. Terminate entrance conduits entering an ER rooms from below ceiling height to extend 4" into the room.
- D. Entrance conduits shall be continuous into the building and to the ER. Securely fasten entrance conduits to the building to withstand cable placing operation. Do not include more than two 90-degree bends between pulling points when installing entrance conduits.
- E. On exterior wall penetrations, seal both sides of the wall around outside of conduit with hydraulic cement to prevent water from entering the building. Seal the inside of the conduit on both sides with conduit plugs, water plugs, or duct sealer to prevent water, vapors, or gases from entering the building.

2.7 PATHWAY REQUIREMENTS FOR ENTRANCE CONDUITS

- A. If the entrance conduits exceed the 180 degree of total bends limitation, an appropriately sized junction box, manhole, or handhole is required.
- B. As-built drawings of entrance conduit path required to be submitted to Owner's Representative before covered with soil.

2.8 RISER CONDUITS

- A. Riser conduits shall only be used when noted on the Construction Documents for special applications only. As a rule, riser conduits are not required for the riser system. However, when required:
 - 1. Minimum of (2) 4" conduits shall be installed between the ER room and each TR room as shown on the Drawings.
 - 2. Conduits entering ER and TR rooms shall be reamed or bushed and terminated not more than 4" from entrance wall and within 12" of room corners.
 - 3. Conduits entering ER and TR rooms from below floor shall be terminated not more than 4" above finished floor.
 - 4. Conduits for riser cables shall be continuous and separate from other conduit or enclosed raceway systems. Do not include more than two 90-degree bends between pulling points when installing riser conduits. Where junction boxes are required, locate in accessible areas, such as above suspended ceilings in hallways.
 - 5. Conduits shall not be less than 4" trade size and be equipped with a measured pull line at 12" increments rated at a minimum 1200-pound test.
 - 6. Provide restorable fire stops inside and around conduits as recommended by UL1479 or ASTM E814 for conduits penetrating fire-rated construction. Fire-rated construction to be verified with AHJ.
 - 7. Provide an insulating press fit bushing on telecommunications riser conduits. Bushings must be rated to be used in an environmental air handling space (Plenum).
 - a. Manufacturer of insulating bushing on telecommunication conduits shall be Arlington or equal.
 - 8. Riser conduits shall not be used for the distribution of horizontal cables.

2.9 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
 - E. Cut sleeves to length for mounting flush with both surfaces of walls.
 - F. Furnish and install pipe sleeves as shown on the drawings or as needed to provide pathway and maintain wall rating. The sleeves shall extend 4" above the floor and a minimum of 2" below the bottom of the ceiling slab. The inner edges of the sleeve shall be reamed, providing a smooth surface to prevent damage to cable insulation. Sleeves shall be equipped with metal caps to ensure fireproofing between floors and/or insulated bushings when occupied with cable. Not applicable to EZ Path System.
 - G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
 - H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section 07 92 00 "Joint Sealants."
 - I. Fire-Rated-Assembly Penetrations:
 - 1. General: Comply with requirements in Division 07 Section 07 84 13 "Penetration Firestopping."
 - 2. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials.
 - J. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
 - K. 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.
 - L. Underground, Exterior-Wall 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 mechanical sleeve seals.
- 2.10 SLEEVE-SEAL INSTALLATION
- A. Install to seal exterior wall penetrations.
 - B. Use 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.

2.11 MISCELLANEOUS

- A. Raceway systems shall be bonded to the telecommunication grounding system per NEC Article 250, EIA/TIA 607 Standard, and Division 27, Section 27 05 26 "Grounding and Bonding for Communications Systems".
- B. Provide a 1/8" nylon or polypropylene line in conduits.
- C. Where cable tray is specified or conduits are routed back to MDF or IDF Rooms or extended beyond the stub-out (greater than 3' from wall), install grounding bushing and bond to telecommunication grounding system.

2.12 FIRESTOPPING

- A. General: Comply with requirements in Division 07 Section 07 84 13 "Penetration Firestopping."
- B. In buildings, floor/ceiling assemblies, stairs, and elevator penetrations shall be sealed with a 2-hour fire stop assembly at a minimum, unless otherwise noted.
- C. Contact Owner's Representative to identify walls which are fire-rated construction. Walls shall be sealed with a 2-hour fire stop assembly at a minimum.
- D. Communication pathways requiring fire stopping shall utilize removable/re-usable fire stopping putties for ease of moves, adds, and changes.
- E. Fire stopping penetrations shall conform to the recommended practices listed in UL1479 or ASTM.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."
- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.1 EXAMINATION

- A. Prior to project Work, examine the project site carefully, including drawings showing existing systems and equipment.
 - 1. Contractor shall be fully informed of and shall identify utility, state, and local requirements that will affect the SCS work at the project site.
- B. It shall be the Contractor's responsibility to determine if the installation of the proposed systems will affect the operation or code compliance of existing systems.

1. With Owner's approval, relocate, modify, or otherwise revise existing SCS systems as required to maintain operational integrity and code compliance.
- C. Become familiar with the local conditions under which the work is to be performed and correlate the on-site observations with the requirements of the Drawings and Specifications. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.
- D. Before ordering materials or doing project work, verify measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the project drawings. Discrepancies found shall be submitted in writing to the Consultant for consideration before proceeding with the Work.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications' equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping and sheet metal HVAC ductwork systems.

3.3 CABLE LADDER

- A. Cable ladders shall be installed per manufacturer's instructions, utilizing product series accessories and components.
- B. Cable ladders, supports and brackets shall be cleanly cut, deburred, and sharp edges removed.
- C. Verify installed loading requirements and install the raceway system per the manufacturer's recommendations. Provide additional load capacity to support a 2X growth factor.
- D. Install end caps, mounting spacers, couplings, hangers, brackets, dropouts, connectors, supports, and other manufacturer's accessories as required to provide a complete and functioning installation.

3.4 CONDUIT

- A. Conduit shall be sized per Table 1 below, or as noted on the Drawings. Where sections of conduit runs are longer than 100'-0", or have more than 180 degrees of bends, or have a reverse bend (greater than 90 degrees), pull boxes shall be provided and installed. Bends in conduit larger than 2" shall be long sweep type. Except where specifically noted, the inside radius of bends shall not be less than:
1. Six times the internal diameter for conduits 2" and smaller.
 2. Ten times the internal diameter for conduits 2-1/2" and larger.

B. Table 1:

ID in mm	Trade Size	Cable Outside Diameter in inches (mm)									
		40% FILL									
		0.225	0.245	0.275	0.300	0.320	0.355	0.590	0.732	0.880	0.940
		(5.72)	(6.22)	(6.98)	(7.62)	(8.13)	(9.02)	(15.0)	(18.6)	(22.4)	(23.9)
16	1/2	1	1								
21	3/4	5	4	3	3	2	2				
27	1	8	7	5	4	4	3	1			
35	1-1/4	15	12	10	8	7	6	2	1		
41	1-1/2	20	17	13	11	10	8	2	1	1	1
53	2	33	28	22	18	16	13	4	3	2	1
63	2-1/2	58	49	39	33	29	23	8	5	3	3
78	3	88	75	59	50	43	35	12	8	5	5
91	3-1/2	116	97	77	65	57	46	16	10	7	6
103	4	148	125	99	83	73	59	21	14	9	8

- C. Conduits entering telephone and data closets shall terminate as close as possible to the wall through which the conduits enter, unless otherwise noted. In-floor conduit shall terminate 4" AFF or curb unless noted otherwise. Conduits shall be left clean, dry, and free of debris or other obstructions, with insulated grounding bushings installed.
- D. Pull boxes shall be sized and installed per BISC Standards.
- E. Conduit, sleeves, and stubs through fire rated floors and walls shall be rigid galvanized steel conduit with insulated and/or grounding bushings per specifications. Conduit sleeves shall extend a minimum of 6" beyond each wall surface. Upon completion of the work, install fire stop per specifications and codes.
- F. Furnish and install pipe sleeves as shown on the Drawings. Sleeves shall extend 4" above the floor and a minimum of 2" below the bottom of the ceiling slab.
1. The inner edges of the sleeve shall be reamed, providing a smooth surface to prevent damage to cable insulation.
 2. Sleeves shall be equipped with metal caps to ensure fireproofing between floors and/or insulated bushings when occupied with cable.
- G. Feeder conduit should enter from the top or bottom, close to one side; never in the center. Distribution conduit should enter in the center.

Project Name
Project Number

Deliverable
Issue Date

- H. Conduit for outlets shall turn toward the main pathway and have an insulated bushing installed.

END OF SECTION

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Communication Racks and Rack Cable Management.
2. Telecommunications Room Cable Tray.
3. Service Entrance Conduit.
4. Backboards.
5. Grounding and Labeling.

B. Related Requirements:

1. Section 07 84 13 "Penetration Firestopping."
2. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."**

1.3 ACTION SUBMITTALS

- A. Product Data:** For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment rack and cabinets. 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.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates:** For floor-mounted cabinets, 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. 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.

1.5 QUALITY ASSURANCE

- B. Strictly adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- C. Material and work specified herein shall comply with the applicable requirements of the current revision of the following:
 1. ANSI/TIA-568 - Commercial Building Telecommunications Cabling Standard.
 2. ANSI/TIA-569 - Telecommunications Pathways and Spaces.
 3. ANSI/TIA-606 - Administration Standard for the Telecommunications Infrastructure
 4. BICSI – Telecommunications Distribution Methods Manual.
 5. J-STD-607-A - Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
 6. NFPA 70 - National Electric Code.
- D. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to client.
 1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- E. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and Specifications take precedence where this design is more stringent than codes and ordinances.
- F. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.
- G. 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. Installation Supervision: Installation shall be under the direct supervision of a BICSI Trained and Certified Technician, who shall be present at times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

1.6 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

1.7 COORDINATION

- A. 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 telephone switch and LAN equipment.
- B. 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.
- C. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.8 WORKMANSHIP, WARRANTY, AND SUPPORT

- A. Materials and workmanship shall meet or exceed industry standards and be fully guaranteed for one full year from final acceptance for each project. Cable integrity and associated terminations shall be thoroughly inspected and guaranteed as free from defects.
- B. Furnish a written warranty to Owner for a minimum of:
 1. Materials warranty on parts and labor to repair/replace defective SCS materials specified herein. This warranty only applies to materials provided by Contractor and does not apply to materials provided by Owner.
 2. Duration: One year from date of Substantial Completion.
- C. The Contractor shall be responsible for and make good, without expense to Owner, and all defects arising during this warranty period that are due to imperfect materials, appliances, improper installation, or poor workmanship.

- D. During the warranty period, provide labor required to repair or replace defects in the SCS system, at no cost to Owner.
- E. During the warranty period, provide new materials to repair or replace defects in the SCS system, at no cost to Owner.

PART 2 - PRODUCTS

2.1 EQUIPMENT ROOM FITTINGS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
- C. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.2 TOOLS AND EQUIPMENT

- A. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.3 EQUIPMENT FRAMES

- A. 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 standard, 19-inch (480-mm) mounting.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
- B. Floor-Mounted Racks: Modular-type, aluminum construction.
 - 1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug.
 - 2. Guardrail on each side of rack at bottom, rack base dust cover.

3. Baked-polyester powder coat finish. Gray finish for client Communication Engineering equipment/black finish for client Facilities/Network Management Equipment.

C. Modular Freestanding Cabinets:

1. Removable and lockable side panels.
2. Hinged and lockable front and rear doors.
3. Adjustable feet for leveling.
4. Screened ventilation openings in the roof and rear door.
5. Cable access provisions in the roof and base.
6. Grounding bus bar.
7. Roof-mounted, 550-cfm (260-L/s) fan with filter, (if requested by client).
8. Power strip.
9. Baked-polyester powder coat finish.
10. Cabinets keyed alike.

D. Modular Wall Cabinets:

1. Wall mounting.
2. Steel or aluminum construction.
3. Treated to resist corrosion.
4. Lockable front and rear doors.
5. Louvered side panels.
6. Cable access provisions top and bottom.
7. Grounding lug.
8. Roof-mounted, 250-cfm (118-L/s) fan.
9. Power strip.
10. Cabinets keyed alike.

E. Modular Freestanding Rack:

1. Floor mounting installation kit.
2. Aluminum / steel construction.
3. Epoxy – Polyester Hybrid Powder Coat Paint.
4. E/A-210D compliant universal hole pattern.
5. Rack base dust cover.
6. Equipment guard rails.

F. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.

4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

G. Approved Manufacturer:

1. Chatsworth.
2. Or approved equal.

2.4 TELECOMMUNICATIONS ROOM CABLE TRAY

A. Telecommunication Room Cable Tray System:

1. TR cable tray shall completely wrap walls within the room. Cable tray shall extend over equipment frames.
2. Cable tray shall be a minimum width of 2" high x 12" wide. Cable tray may be sized upwards if fill ratio requirements need to be met based on cable quantities.

B. Open pathway/trays shall be installed a minimum of six (6) inches away from light fixture or other source of EMI (Electromagnetic Interference).

C. Pathways shall be grounded per NEC Article 250.

D. Provide external grounding strap at expansion joints, sleeves and crossover and at other locations where pathway/tray continuity is interrupted.

E. Support all pathways from building construction. Do not support pathways from ductwork, piping, or equipment hangers.

F. Install cable tray level and straight unless noted on the construction drawings.

G. Approved Manufacturer:

1. Chatsworth
2. Or approved equal.

2.5 SERVICE ENTRANCE CONDUITS

A. Minimum of (4) 4" IMC conduits shall be installed from the nearest utility tunnel on outside of the building as shown on the Drawings. Terminate entrance conduits entering ER rooms from below grade to extend 4" above finished floor. Location of entrance conduits shall be within 12" of room corners.

B. Terminate entrance conduits entering ER rooms from above ceiling height to extend 4" below finished ceiling or 12" above cable tray.

C. Terminate entrance conduits entering an ER rooms from below ceiling height to extend 4" into the room.

- D. Entrance conduits shall be continuous into the building and to the ER. Securely fasten entrance conduits to the building to withstand cable placing operation. Do not include more than two 90-degree bends between pulling points when installing entrance conduits.
- E. On exterior wall penetrations, seal both sides of the wall around outside of conduit with hydraulic cement to prevent water from entering the building. Seal the inside of the conduit on both sides with conduit plugs, water plugs, or duct sealer to prevent water, vapors, or gases from entering the building.

2.6 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, painted with two (2) coats of fire retardant paint (stamp) 3/4 by 48 by 96 inches (19 mm by 1220 mm by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section 06 10 53 "Miscellaneous Rough Carpentry."

2.7 LABELING

- A. 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.

2.8 FIRESTOPS AND PENETRATION SEAL MATERIALS

- A. General: Comply with provisions of Section 07 84 13 "Penetration Firestopping."
- B. Use qualified systems to firestop through penetrations in fire-rated walls and floors for pipes, cables, conduits, ducts, inner-ducts, and cable trays.
- B. Firestopping for openings through fire and smoke -rated walls and floor assemblies shall be listed or classified by an approved independent testing laboratory for "Through-Penetration Firestop Systems." The system shall meet the requirements of "Fire Tests of Through-Penetration Firestops" designated by ASTM E814.
- C. Inside conduits, the firestop system shall consist of a dielectric, water-resistant, non-hardening, permanently pliable/re-enterable putty along with appropriate damming or backer materials (where required). Sealant shall be capable of being removed and reinstalled and must adhere to penetrants and common construction materials and shall be capable of allowing normal cable movement without being displaced.
- D. Foam sealant shall meet fire test and hose stream test requirements of ASTM E-119-73 and shall be UL classified as a wall opening protective device.
- E. Provide devices/systems fire tested by a third party according to ASTM E 814 (or UL 1479) tested under positive pressure.
- F. Provide specific combinations of materials installed and supported or anchored.

- G. Provide only material combinations that are qualified by independent agencies based on the material's performance when tested in a particular configuration.
- H. Match the thickness (and/or depth) of firestop materials to that recommended by the manufacturer.
- I. Thickness of materials must be established by formal ASTM E814 or UL 1479 tests.
- J. Firestop for fire-rated floors and walls:
 - 1. 3M Fire Protection.
 - 2. Specified Technologies, Inc. (STI).

2.9 ANCHORING MATERIALS AND SUPPORTS

- A. Metal bars, plates, channel, tubing, etc. shall conform to ASTM Standards:
 - 1. Steel plates, shapes, bars, and grating – ASTM A36.
 - 2. Cold-formed steel tubing – ASTM A500.
 - 3. Hot-rolled steel tubing – ASTM A501.
 - 4. Steel pipe – ASTM A53, Schedule 40, welded.
- B. Metal fasteners shall be zinc-coated.
- C. Anchoring Materials:
 - 1. Structural Steel.
 - 2. Steel Channel: Galvanized or painted.
 - 3. Uni-Strut.

2.10 GROUNDING AND BONDING MATERIALS

- A. General: Comply with requirements of Section 27 05 26 "Grounding and Bonding for Communications Systems.
- B. Mechanical Connectors: Bronze.
- C. Bonding Conductor: 6 AWG minimum copper.
- D. Grounding equipment shall be UL listed for that purpose.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.2 EXAMINATION

- A. Prior to project Work, examine the project site carefully, including drawings showing existing systems and equipment.
 - 1. Contractor shall be fully informed of and shall identify utility, state, and local requirements that will affect the SCS work at the project site.
- B. It shall be the Contractor's responsibility to determine if the installation of the proposed systems will affect the operation or code compliance of existing systems. With Owner's approval, relocate, modify, or otherwise revise existing SCS systems as required to maintain operational integrity and code compliance.
- C. Become familiar with the local conditions under which the work is to be performed and correlate the on-site observations with the requirements of the Drawings and Specifications. No allowance will be made for claims of concealed conditions which the Contractor, in exercise or reasonable diligence in examination of the site, observed or should have observed.
- D. Before ordering materials or doing project work, verify measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of unverified differences between actual dimensions and the measurements indicated on the project drawings. Discrepancies found shall be submitted in writing to the Consultant for consideration before proceeding with the Work.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Racks and Cable Management:
 - 1. Assemble racks and cable management per manufacturer's instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.
 - 2. Racks must be attached to the floor in four places using appropriate floor mounting anchors. When placed over a raised floor, threaded rods should pass through the raised floor panels and be secured in the structural floor below.
 - 3. Racks shall be grounded to the TGB using appropriate hardware provided by the contractor. The ground will meet local code requirements and will be approved by the Authority Having Jurisdiction (AHJ).
 - 4. In seismic areas, the rack should have additional bracing as required by building codes and the recommendations of a licensed structural engineer.
 - 5. Ladder rack may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.

6. The equipment load should be evenly distributed and uniform on the rack. Place large and heavy equipment towards the bottom of the rack. Secure equipment to the rack with equipment mounting screws.
- B. Pathway Installation in Communications Equipment Rooms:
1. 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.
 2. Install cable trays to route cables if conduits cannot be located in these positions.
 3. Secure conduits to backboard when entering room from overhead.
 4. Extend conduits 3 inches (76 mm) above finished floor.
 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- C. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.
- D. Vertical cables shall be supported for a ladder or rings by use of cable ties 24" on center. If messenger strand cable is utilized for cable support, the cable shall be grounded to the telecommunication grounding system at both ends and shall not be used as a grounding conductor.
- E. Backbone cables spanning more than three floors shall be securely attached at the top of the cable run with a wire mesh grip and on alternating floors, or as required by local codes.
- F. Entrance Facilities:
1. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
 2. Install underground pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Section and BICSI Chapter 9 Telecommunications Entrance Facilities and Termination.
- G. Install underground entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems."
1. Comply with NECA 1.
 2. Comply with BICSI TDMM for layout and installation of communications rooms.
 3. Cable Tray: Comply with NEMA VE2 and TIE/EIA-569 series.
 4. Bundle, lace and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- H. Firestopping:
1. In buildings, floor/ceiling assemblies, stairs, and elevator penetrations must be sealed with a 2-hour fire stop assembly at a minimum, unless otherwise noted.

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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2. Contact Owner's Representative to identify walls which are fire-rated construction. Walls must be sealed with a 2-hour fire stop assembly at a minimum.
3. Communication pathways requiring fire stopping shall utilize removable/re-usable fire stopping putties for ease of Moves, Adds, and Changes.
4. Fire stopping penetrations shall conform to the recommended practices listed in UL1479 or ASTM.
5. Comply with provisions of Section 07 84 13 "Penetration Firestopping."

I. Grounding:

1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" chapter.
2. Comply with ANSI-J-STD-607-A
3. Locate grounding busbar to minimize length of bonding conductors. Fasten to wall allowing at least 2-inches clearance behind the grounding busbar.
4. Connect grounding busbar with a grounding electrode conductor to match electrical service entrance section up to #3/0 AWG (minimum #2 AWG grounding electrode conductor) from grounding busbar to suitable electrical building ground. (At service entrance switchboard or first building electrical panel.)
5. Bond metallic equipment to the grounding busbar, using not smaller than #6 AWG equipment grounding conductor.
 - a. Bond the shield of the shielded cable to the grounding busbar in communications rooms and spaces.
6. Refer to Division 27 Section 27 05 26 "Grounding and Bonding for Communications Systems" for additional requirements.

J. Identification:

1. Identify system components, wiring and cabling complying with TIA/EIA-606. Comply with requirements in Division 26 Section 26 05 53 "Identification for Electrical Systems. Comply with requirements in Division 09 Section 09 91 23 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
2. See Division 27 Section 27 15 13 "Communications Copper Horizontal Cabling" and Division 27 Section 27 15 23 "Communications Optical Fiber Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 4 (multi-site system) level of administration including optional identification requirements of this standard.
3. Labels shall be preprinted or computer-printed type.

3.4 EQUIPMENT MODIFICATION

- A. Where existing equipment is to be modified, Contractor shall furnish materials and labor as necessary to modify or add to the equipment. Modifications shall be done neatly with factory parts and assemblies approved for the application. Modification shall in no way jeopardize the compliance of existing equipment with governing codes and regulations.

Project Name
Project Number

Deliverable
Issue Date

END OF SECTION

COMMUNICATIONS EQUIPMENT ROOM FITTINGS
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Last Updated:

April 2022

SECTION 27 13 13

COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Intra-Building Copper Backbone (Inside buildings (ISP))
 - 2. Inter-Building Copper Backbone (Between buildings (OSP))
 - 3. Provide sufficient pair count to support 100% expansion at the outlet locations.
- B. Related Requirements:
 - 1. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

1.3 ACTION SUBMITTALS

- A. Product Data: Manufacturer's technical data sheets, specifications, performance data, and installation instructions for each product.
 - 1. Product data for termination and test equipment to be used to perform Work.
 - a. Equipment shall be calibrated with traceability to National Institute of Standards and Technology (NIST) requirements.
 - b. Include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- B. Shop Drawings: Depict requirements for fabrication and installation. Include the following drawings as applicable:
 - 1. Proposed riser and horizontal cabling diagram.
 - 2. Overlay of system components on floor plans.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty Information: Confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
- B. Installation Plan, indicating the following:
 - 1. Equipment and personnel.
 - 2. Materials and staging area.

3. Start and completion dates.
 4. Locations, including building, floor, and room.
- C. Copper cable pulling plans for multi-pair copper cables with a pair count of 25 pairs or greater, that includes, but is not limited to, the following:
1. Each cable run and route.
 2. Date and duration of the pull.
 3. Pulling methodology and equipment setups.
 4. Pulling tension calculations for each pull in the run.
 5. Safety issues and precautions to be taken.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts.
- B. Operation and Maintenance Data. Include preventative maintenance instructions.
- C. Final As-Built Drawings:
1. CAD Files: Provide CAD files in dwg or dgn formats showing floor plans with room numbers and actual backbone cabling and pathway locations and labeling.
 2. Submit Record Documents within 5 business days of final cable testing.
 3. Red Line Drawings: Retain one (1) E size set of floor plans on site during work hours showing installation progress marked and backbone cable labels noted. Make drawings available for examination during construction meetings and field inspections.
- D. Warranties for manufactured components specified in this Section.

1.6 QUALITY ASSURANCE

- A. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- B. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:
1. ANSI/TIA-568 - Commercial Building Telecommunications Cabling Standard.
 2. ANSI/TIA-569 - Telecommunications Pathways and Spaces.
 3. ANSI/TIA-606 - Administration Standard for the Telecommunications Infrastructure
 4. BICSI – Telecommunications Distribution Methods Manual.
 5. J-STD-607-A - Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
 6. NFPA 70 - National Electric Code.

- C. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to Owner.
 - 1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- D. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and Specifications take precedence where this design is more stringent than codes and ordinances.
- E. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.7 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

PART 2 - PRODUCTS

2.1 TOOLS AND EQUIPMENT

- A. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.2 BACKBONE CABLING MATERIALS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

2.3 INTRA-BUILDING COPPER BACKBONE FOR ANALOG/VOICE ONLY

- A. Cable shall be listed for use per the National Electrical Code (NFPA-70). Cable shall comply with one of the following:
 - 1. UL-listed CMR cable: Solid copper conductors with high-density polyolefin insulation and overall low smoke PVC jacket to achieve riser (i.e., non-plenum) rating by UL standards.

2. UL-listed CMP cable: Solid copper conductors with FEP insulation and overall low smoke PVC jacket to achieve plenum rating by UL standards.
3. LSZH cable: Solid copper conductors with non-halogen HDPE insulation and low smoke, zero halogen, compound jacket to achieve LSZH rating by:
 - a. IEC 60754—Part 2.
 - b. IEC 61034—Part 2.
 - c. IEC 60332—Part 2.
 - d. Defence Standard 02-713.

- B. Cable shall meet the requirement of ANSI/TIA-568 series Standards for Category 5e performance.
- C. Description: 25 - 200 pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield
- D. Approved Manufacturers:
 1. Berk-Tek.
 2. Superior Essex.
 3. Or approved equal.

2.4 INTER-BUILDING COPPER BACKBONE FOR ANALOG/VOICE ONLY

- A. Cable shall be manufactured and constructed for use in the Outside Plant Environment.
- B. Cable shall meet the requirement of TIA-568 series Standards for Category 3 performance.
- C. Description: 25 -200 pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.
- D. Voice backbone cables shall have a minimum 10-foot service loop when terminated in the ER and TR and at splice points in telecommunications manholes.
- E. Approved Manufacturers:
 1. Berk-Tek
 2. Superior Essex
 3. Or approved equal.

2.5 BUILDING ENTRANCE PROTECTION

- A. Building entrance protection for copper cabling shall be installed utilizing a two (2) foot fuse link between outside plant cable plant splice and the protector module with IDC-type input and output terminals, 100 pair-pair capacity and female mounting base, equipped with 230-volt solid state protector modules.
 1. Sufficient protector modules shall be provided to completely populate building entrance terminals.

- B. Approved Manufacturers:
 - 1. Circa Telecom
 - 2. Or approved equal.

2.6 MAIN CROSS CONNECT (MC) AND ENTRANCE FACILITY (EF)

- A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568 series standards, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- B. Connecting Blocks: 110-style IDC for Category 5e or Category 6 New Construction. 66-style IDC for renovations when 66 blocks are existing. Provide blocks for the number of cables terminated on the block, plus 25% spare. Integral with connector bodies, including plugs and jacks where indicated.
- C. 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.
- D. 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.
 - 1. Number of Jacks per Field: One for each four-pair UTP cable indicated.
- E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- F. Patch Cords: Factory-made, 4-pair cables in [36-inch (900-mm)] [60-inch (1524-mm)] lengths; terminated with 8-position modular plug at each end or as directed by client. (CLIENT TO MODIFY)
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.

2.7 COAXIAL CABLE

- A. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
- B. RG-11/U: NFPA 70, Type CATV.
 - 1. No. 14 AWG, solid, copper-covered steel conductor.
 - 2. Gas-injected, foam-PE insulation.
 - 3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.

4. Jacketed with sunlight-resistant, black PVC or PE.
 5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
- C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
1. CATV Cable: Type CATV, or CATVP or CATVR.
 2. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
 3. CATV Riser Rated: Type CATVR, complying with UL 1666.
 4. CATV Limited Rating: Type CATVX

2.8 COAXIAL CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Blonder - Tongue.
- B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."
- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. General - Inter and Intra Building Copper Backbone Cable:
1. Comply applicable codes, standards and with local codes and requirements. Identify and adhere to unique codes or requirements governed by the region where the Work is to be performed.
 2. Provide necessary products for installation of Copper Backbone cablings to include cable attachments, etc.
 3. Backbone cable shall be installed following industry standard practices.
 4. Outside Plant Backbone cable shall terminate on Primary protection (per the NEC) upon entering the building.
 5. Cables shall be new and as specified on the drawings. Cables shall be shipped on 1,000 ft. reels or boxed. Coiled cables are not acceptable. Factory shorts and/or factory seconds, salvaged, leftover and reused cables are not acceptable.

COMMUNICATIONS COPPER BACKBONE CABLING

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6. Cables of a given type shall be of a single manufacturer and part number. Unapproved or unacceptable cable shall be removed and replaced at Contractor's expense.
7. 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.
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 ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cables requiring additional length shall be stored in an extended loop or in a "Figure 8" configuration. Do not store additional length in bundled loops. Each individual loop shall be tagged with cable number.
12. Make certain that during the installation and upon completion, cables have been installed in good condition, free from jacket cuts or tears, kinks, twist, knots, sharp bends, etc., or other physical damage.
13. During the installation, do not allow the cables to be exposed to foot, vehicle, or equipment traffic, or be exposed to other form of abuse which shall cause damage to cables, altering the electrical characteristics. Cables exhibiting such damage or an attempt to correct, hide or otherwise conceal such damage, shall result in cables being replaced at the Contractor's expense.
14. Cable pulls shall not exceed 100 feet in length. Cables shall be neatly coiled in a figure "8" pattern at the completion of a pull in preparation for the next pull.
15. Data/telecommunication and fiber-optic cables shall not be stored or installed in an unheated building where the temperature is less than 40°F. The structure and the cable must be brought to a minimum 50°F ambient for a minimum of 48 hours prior to installation of the cables. Failure to observe this precaution may result in damage to the cable and shall result in the cable being replaced at the Contractor's expense.
16. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
17. Maximum of 12" and minimum of 6" of cable shall be stored in back box or raceway.
18. Slack shall be coiled in the box without exceeding the bend radius.
19. Bend radiuses of the horizontal cable shall not be less than four times the outside diameter of the cable.
20. Cable jacket shall be maintained to within 1" of termination points.

B. Cable and Termination Panel Labeling:

1. Install 110-style IDC termination hardware unless otherwise indicated.
2. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

3. Cables may not be spliced. Cabling shall be installed in continuous runs from cross-connect fields to cross-connect fields, to patch panels, workstation outlets, etc. Cabling shall be free from splices, taps, splitters, baluns and other in-line connections.

C. Identification:

1. Label installed cables in accordance with provisions of Section 27 05 00.

D. Cable Support:

1. Secure and support cables at intervals not exceeding 30" and not more than 6" from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
2. Unsupported spans between cable trays and conduit sleeves shall not exceed 12" horizontally, 24" vertically.
3. Provide cable supports and clamps to attach cables to backboards and walls.
4. Attach cables to manhole racks using Owner approved methods.
5. Backbone cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).
6. Cables routed above a suspended ceiling in exposed space, and not installed in a conduit system, shall be supported by a cable tray, channel, or hangers.
7. Cables shall not be supported from ceiling support wires, lighting fixture support wires, ductwork, plumbing line, fire suppression systems, mechanical systems, or electrical conduits. Cables shall not come in contact with ductwork or piping or lay on top of ceiling systems and lighting fixtures.
8. Where cables are routed through inaccessible ceilings, install conduit sleeves extending 1-foot beyond the inaccessible area, sized in accordance with ANSI/TIA/EIA-569-A Guidelines. Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Specification Section 27 05 26 "Grounding & Bonding for Communications Systems".
9. Install conduit sleeves where cables pass through walls. Conduits shall be sized in accordance with ANSI/TIA/EIA-569-A Guidelines, as outlined in Division 27 Section 27 05 28 "Pathways for Communications Systems". Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Section 27 05 26 "Grounding & Bonding for Communications Systems".
10. Cables supported by hangers shall utilize Caddy Cable-Cat hangers or approved equal communication cable hangers. Hangers shall be supported from the building structure. Hangers shall not utilize other system support wires or rods.
11. A maximum of 36 (three groups of 12) cables shall be supported in a single hanger with a spacing of 48" on center. Cables shall be loosely bundled.
12. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
13. 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. Use lacing bars and distribution spools.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections: Engage qualified entity to perform the following:
1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings.
 2. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568 series and Addenda.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of components.
 4. Test UTP 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.
 - a. Fluke (or Equivalent brand) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568 series. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
 - b. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - c. Test cords are to be newly installed prior to Work.
- B. Backbone Cable Testing:
1. Complete end-to-end test results for copper UTP cables installed are required.
 2. Multi-pair copper cable pairs installed shall be tested to TIA-568A, Category 5e or Category 6 equivalent performance specifications. In addition, provide loop resistance measurements in ohms and dB loss at 1KHz, 8KHz, and 256KHz.
 3. Notify Owner at least 24 hours prior to testing to allow observation at the Owner's discretion.
 - a. If Owner confirms intention to observe, a reasonable starting time shall be agreed upon.
 - b. Should Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.
 4. 100% of pairs in backbone copper cables shall be tested for continuity and wire-map.
 5. Testing Format: Test Results must be submitted in two (2) formats. First, must be original file(s) downloaded from tester. Second, the file must be cohesively placed in Excel format with the following fields:
 - a. ER/TR RM # / RM # of drop / Port # / relevant test information in as many fields as necessary.
 6. Record test results and submit to Owner.

END OF SECTION

SECTION 27 13 23

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Intra-Building Optical Fiber Backbone (Inside buildings (ISP)).
 - 2. Inter-Building Optical Fiber Backbone (Between buildings (OSP)).
- B. Related Requirements:
 - 1. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

1.3 ACTION SUBMITTALS

- A. Product Data: Manufacturer's technical data sheets, specifications, performance data and installation instructions for each product.
 - 1. Product data for termination and test equipment to be used to perform Work.
 - a. Equipment shall be calibrated with traceability to National Institute of Standards and Technology (NIST) requirements.
 - b. Include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- B. Shop Drawings: Depict requirements for fabrication and installation. Include the following drawings as applicable:
 - 1. Proposed riser and horizontal cabling diagram.
 - 2. Overlay of system components on floor plans.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty Information: Confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
- B. Installation Plan, indicating the following:
 - 1. Equipment and personnel
 - 2. Materials and staging area
 - 3. Start and completion dates.

4. Locations, including floor, room and building.

- C. Optical fiber cable pulling plans for optical fiber cables that includes, but is not limited to, the following:
1. Each cable run and route.
 2. Date and duration of the pull.
 3. Pulling methodology and equipment setups.
 4. Pulling tension calculations for each pull in the run.
 5. Safety issues and precautions to be taken.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts.
- B. Operation and Maintenance Data. Include preventative maintenance instructions.
- C. Final As-Built Drawings:
1. CAD Files: Provide CAD files in dwg or dgn formats showing floor plans with room numbers and actual backbone cabling and pathway locations and labeling.
 2. Submit Record Documents within 5 business days of final cable testing.
 3. Red Line Drawings: Retain one (1) E size set of floor plans on site during work hours showing installation progress marked and backbone cable labels noted. Make drawings available for examination during construction meetings and field inspections.
- D. Warranties for manufactured components specified in this Section.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Minimum 25 years in business producing products manufactured at a facility in the United States.
- B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer of optical fiber.
- C. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- D. Material and Work specified herein shall comply with the applicable requirements of the current adopted revision of the following:
1. TIA-568 Series Commercial Building Telecommunications Cabling Standard
 2. Bellcore, fiber distributed data interface (FDDI) standards
 3. ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable

4. Color Coding: Provide cabling system color coded in compliance with ANSI/TIA-598-C.
 5. TIA-569 Telecommunications Pathways and Spaces,
 6. TIA-606 Administration Standard for the Telecommunications Infrastructure ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
 7. ISO/IEC 11801
 8. NFPA 70 – National Electric Code
 9. BICSI – Telecommunications Distribution Methods Manual
- E. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to client.
1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- F. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and specifications take precedence where this design is more stringent than codes and ordinances.
- G. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.
- 1.7 REGULATORY REQUIREMENTS
- A. Refer to Section 27 05 00 “Common Work Results for Communications.”
- 1.8 WARRANTY
- A. Manufacturer’s Warranty: Manufacturer agrees to replace or refund the purchase price of products that fail from defects in material and workmanship within the specified warranty period.
- B. Warranty Period: One (1) year from date of Substantial Completion.
- C. Manufacturer’s Extended Warranty: Manufacturer agrees to replace or refund the purchase price of products that are installed by a manufacturer-certified installer that fail from defects in material and workmanship within the specified warranty period.
- D. Warranty Period: Twenty-five (25) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Cables shall be designed for Point to Point applications and shall provide a high level of protection for optical fiber installed in building applications.
- B. Higher optical fiber count cables shall utilize a sub-unitized design with color-coded subunits for easy identification.

2.2 TOOLS AND EQUIPMENT

- A. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.3 BACKBONE CABLING MATERIALS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

2.4 INTRA-BUILDING OPTICAL FIBER BACKBONE (ISP)

- A. Cable shall be listed for use per the National Electrical Code (NFPA-70). Cable shall meet one of the following, per bid document:
 - 1. Indoor Riser Rated Tight Buffer - UL-listed OFNR: Tight buffer optical fibers, aramid strength yarn, and riser-rated outer jacket.
 - 2. Indoor Plenum Rated Tight Buffer UL-listed OFNP cable: Tight buffer optical fibers, aramid strength yarn, and plenum-rated outer jacket.
 - 3. Indoor Low Smoke/Zero Halogen Riser Rated Tight Buffer LSZH cable: Solid copper conductors with non-halogen HDPE insulation and low smoke, zero halogen, compound jacket to achieve LSZH rating.
 - 4. Indoor Armored Riser Rated Tight Buffer - UL-listed OFCR: Tight buffer optical fibers, aramid strength yarn, a riser-rated jacket, aluminum interlocking armor with an overall riser-rated sheath jacket to provide additional protection and security.
 - 5. Indoor Armored Plenum Rated Tight Buffer UL-listed OFCP cable: Tight buffer optical fibers, aramid strength yarn, a plenum-rated outer jacket, aluminum interlocking armor with an overall plenum-rated sheath jacket to provide additional protection and security.

- B. Approved Manufacturers:
 - 1. Corning.

2.5 INTER-BUILDING OPTICAL FIBER BACKBONE (OSP)

- A. Cable shall be manufactured and constructed for use in the Outside Plant Environment. Cable shall meet one of the following, per bid document:
 - 1. Outside Plant (OSP) loose tube dielectric - Dielectric design with MDPE sheath jacket and no metallic elements to provide environmental protection.
 - 2. Outside Plant (OSP) loose tube metallic sheath - Metallic sheath design with MDPE sheath jacket to provide environmental protection. Metallic armor of corrugated polymer coated steel tape to provide added crush protection. Armor shall meet Telcordia requirements for superior armored cable.
- B. Buffer Tubes and Optical Fibers:
 - 1. Industry standard buffer tubes stranded around a central strength member and compatible with standard hardware, cable routing, and fan-out kits.
 - 2. Optical fibers shall be industry-standard color coded and separated into 12-fiber color-coded binder groups surrounded by plastic core tubes
- C. Water Blocking:
 - 1. OSP Fiber Cables are available as either fully dry or dry core with gel in the buffer tubes. The bid document will specify the cable type.
 - a. Dry water-blocking compound suitable for underground conduit, direct burial, and aerial applications in cable and buffer tubes.
 - b. Dry water-blocking compound suitable for underground conduit, direct burial, and aerial applications with gel filled buffer tubes.
- D. Approved Manufacturer:
 - 1. Corning.

2.6 INTER-BUILDING CENTRAL TUBE BACKBONE (OSP)

- A. Cable shall be manufactured and constructed for use in the Outside Plant Environment and shall meet one of the following, per bid document.
 - 1. Outside Plant (OSP) Central Tube loose tube dielectric - Dielectric design with medium-density polyethylene (MDPE) sheath jacket over a central buffer tube with longitudinal polyester ripcords and no metallic elements to provide environmental protection.
 - 2. Outside Plant (OSP) loose tube metallic sheath - Metallic sheath design with medium-density polyethylene (MDPE) sheath jacket over a central buffer tube with longitudinal polyester ripcords and metallic armor of corrugated polymer coated steel tape to provide added crush protection. Armor shall meet Telcordia requirements for superior armored cable.

B. Buffer Tubes and Optical Fibers:

1. Central tube of polybutylene terephthalate (PBT) material, containing optical fibers, with 2 dielectric longitudinal outer strength members extending length of cable.
2. Optical fibers shall be industry-standard color coded and separated into 12-fiber color-coded binder groups and industry-standard color coding.

C. Water Blocking:

1. OSP Fiber Cables are available as either fully dry or dry core with gel in the buffer tubes. The bid document will specify the cable type.
 - a. Dry water-blocking compound suitable for underground conduit, direct burial, and aerial applications in cable and buffer tubes.
 - b. Dry water-blocking compound suitable for underground conduit, direct burial, and aerial applications with gel filled buffer tubes.

D. Approved Manufacturer:

1. Corning.

2.7 INTRA-BUILDING BACKBONE INDOOR/OUTDOOR (ISP/OSP)

A. Indoor/Outdoor Cables - Cable shall be listed for use indoors per the National Electrical Code (NFPA-70) and shall meet both of the following, per bid document.

1. Indoor Riser Rated Tight Buffer - UL-listed OFNR: Tight buffer optical fibers, aramid strength yarn, and riser-rated outer jacket.
2. Indoor Low Smoke/Zero Halogen Riser Rated Tight Buffer UL-listed OFN(LS) cable: Solid copper conductors with non-halogen HDPE insulation and low smoke, zero halogen, compound jacket to achieve LSZH rating.

B. Approved Manufacturer:

1. Corning.

2.8 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER – 50/125 μm – 300 (OM3)

A. Multimode, 50/124-micrometer, OM3, optical fiber cable at a minimum. Coordinate exact strand count with client prior to installation.

B. Conductive cable shall be aluminum armored type.

C. Jacket:

1. Jacket color: Aqua for indoor, Black for OSP
2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

- D. Specifications:
 - 1. TIA/EIA-492AAAC.
 - 2. IEC 60793-2-10.
- E. Geometry Requirements:
 - 1. Core:
 - a. Diameter: $50.0 \pm 2.5 \mu\text{m}$.
 - b. Non-Circularity: No more than 5 percent.
 - 2. Cladding:
 - a. Diameter: $125 \pm 1 \mu\text{m}$.
 - b. Non-Circularity: No more than 1 percent.
 - 3. Core-to-Cladding Concentricity: No more than $1.5 \mu\text{m}$.
 - 4. Coating Diameter: Primary, Uncolored; $242 \pm 5 \mu\text{m}$.
 - 5. Colored Fiber Nominal Diameter: Between 253 and 259 μm .
- F. Optical Requirements:
 - 1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
 - 2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
 - 3. Cabled Effective Modal Bandwidth: No less than 2000 MHz·km at 850 nm.
 - 4. IEEE 802.3z GbE Distance:
 - a. Up to 1000 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
 - 5. IEEE 802.3ae 10 GbE Distance: Up to 300 m at 850 nm.
 - 6. OFL Bandwidth:
 - a. No less than 1500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
 - 7. Numerical Aperture: 0.200 ± 0.015 .

2.9 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER 50/125 μm Fiber – 550 (OM4).

- A. Specifications:
 - 1. TIA/EIA-492AAAD.
- B. Conductive cable shall be aluminum armored type.
- C. Jacket:
 - 1. Jacket color: Aqua for indoor, Black for OSP
 - 2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

D. Geometry Requirements:

1. Core:
 - a. Diameter: $50.0 \pm 2.5 \mu\text{m}$.
 - b. Non-Circularity: No more than 5 percent.
2. Cladding:
 - a. Diameter: $125 \pm 1 \mu\text{m}$.
 - b. Non-Circularity: No more than 1 percent.
3. Core-to-Cladding Concentricity: No more than $1.5 \mu\text{m}$.
4. Coating Diameter: Primary, Uncolored; $242 \pm 5 \mu\text{m}$.
5. Colored Fiber Nominal Diameter: Between 253 and 259 μm .

E. Optical Requirements:

1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
3. Cabled Effective Modal Bandwidth: No less than 4700 MHz·km at 850 nm.
4. IEEE 802.3z GbE Distance:
 - a. Up to 1100 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
5. IEEE 802.3ae 10 GbE Distance: Up to 550 m at 850 nm.
6. OFL Bandwidth:
 - a. No less than 3500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
7. Numerical Aperture: 0.200 ± 0.015 .

2.10 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER 50/125 μm Fiber – 600 (OM4).

A. Specifications: TIA/EIA-492AAAD.

B. Conductive cable shall be aluminum armored type.

C. Jacket:

1. Jacket color: Aqua for indoor, Black for OSP.
2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

D. Geometry Requirements:

1. Core:
 - a. Diameter: $50.0 \pm 2.5 \mu\text{m}$.
 - b. Non-Circularity: No more than 5 percent.

2. Cladding:
 - a. Diameter: $125 \pm 1 \mu\text{m}$.
 - b. Non-Circularity: No more than 1 percent.
3. Core-to-Cladding Concentricity: No more than $1.5 \mu\text{m}$.
4. Coating Diameter: Primary, Uncolored; $242 \pm 5 \mu\text{m}$.
5. Colored Fiber Nominal Diameter: Between 253 and $259 \mu\text{m}$.

E. Optical Requirements:

1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
3. Cabled Effective Modal Bandwidth: No less than 5350 MHz·km at 850 nm.
4. IEEE 802.3z GbE Distance:
 - a. Up to 1100 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
5. IEEE 802.3ae 10 GbE Distance: Up to 600 m at 850 nm.
6. OFL Bandwidth:
 - a. No less than 3500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
7. Numerical Aperture: 0.200 ± 0.015 .

2.11 SINGLE MODE OPTICAL FIBER (DISPERSION UN-SHIFTED) WITH LOW WATER PEAK.

A. Specifications:

1. TIA/EIA-492CAAB.
2. ITU G.652 (Categories A, B, C, and D).

B. Conductive cable shall be aluminum armored type.

C. Jacket:

1. Jacket color: Yellow for indoor, Black for OSP
2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40".

D. Geometry Requirements:

1. Cladding:
 - a. Diameter: Between $125.0 \pm 0.7 \mu\text{m}$.
 - b. Non-Circularity: No more than 0.7 percent.
2. Mode Field Diameter:
 - a. $9.2 \pm 0.4 \mu\text{m}$ at 1310 nm.
 - b. $10.4 \pm 0.5 \mu\text{m}$ at 1550 nm.

3. Core-to-Cladding Concentricity: No more than 0.5 μm .
4. Coating Diameter: 245 \pm 5 μm .
5. Fiber Curl: Radius of curvature no less than 4.0 m.

E. Optical Requirements:

1. Cabled Fiber Attenuation:
 - a. No more than 0.65 dB/km at 1310 nm.
 - b. No more than 0.65 dB/km at 1383 \pm 3 nm.
 - c. No more than 0.50 dB/km at 1550 nm.
2. Point Discontinuity: No more than 0.05 dB at 1310 nm and 1550 nm.
3. IEEE 802.3z GbE Distance: Up to 5000 m at 1300 nm.

2.12 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Corning Cable Systems.
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths or lengths directed by client.
- D. Cable Connecting Hardware:
 1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604 series. Comply with TIA/EIA-568 series.
 2. Quick-connect, simplex and duplex, UNICAM connectors. Insertion loss not more than 0.75 dB.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. General - Inter and Intra Building Optical Fiber Backbone Cable:
 1. Comply applicable codes, standards and with local codes and requirements. Identify and adhere to unique codes or requirements governed by the region where the work is to be performed.
 2. Provide necessary products for installation of Fiber Backbone cabling to include cable attachments, etc.
 3. Backbone cable shall be installed following industry standard practices.

4. Installations shall comply with:
 - a. ANSI/TIA-568 Series Commercial Building Telecommunications Cabling Standard.
 - b. ANSI/TIA-569 Telecommunications Pathways and Spaces.
 - c. ANSI/TIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
 - d. BICSI – Telecommunications Distribution Methods Manual.
 - e. J-STD-607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
 - f. NFPA 70 – National Electric Code.
5. Cables shall be new and as indicated on Drawings. Cables shall be shipped on 1,000 ft. reels. Coiled cables are not acceptable. Factory shorts and/or factory seconds, salvaged, leftover and reused cables are not acceptable.
6. Cables of a given type shall be of a single manufacturer and part number. Unapproved or unacceptable cable shall be removed and replaced at Contractor's expense.
7. 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.
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 ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cables requiring additional length shall be stored in an extended loop or in a "Figure 8" configuration. Do not store additional length in bundled loops. Each individual loop shall be tagged with cable number.
12. Make certain that during the installation and upon completion, cables have been installed in good condition, free from jacket cuts or tears, kinks, twist, knots, sharp bends, etc., or other physical damage.
13. During the installation, do not allow the cables to be exposed to foot, vehicle, or equipment traffic, or be exposed to other form of abuse which shall cause damage to cables, altering the electrical characteristics. Cables exhibiting such damage or an attempt to correct, hide or otherwise conceal such damage, shall result in cables being replaced at the Contractor's expense.
14. Cable pulls shall not exceed 100 feet in length. Cables shall be neatly coiled in a figure "8" pattern at the completion of a pull in preparation for the next pull.
15. Data/telecommunication and fiber-optic cables shall not be stored or installed in an unheated building where the temperature is less than 40°F. The structure and the cable must be brought to a minimum 50°F ambient for a minimum of 48 hours prior to installation of the cables. Failure to observe this precaution may result in damage to the cable and shall result in the cable being replaced at the Contractor's expense.
16. Slack shall be coiled in the box without exceeding the bend radius.

- B. Cable and Termination Panel Labeling:
1. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
 2. Label the installed cables in accordance with Section 27 05 00 "Common Work Results for Communications Systems."
- C. Cable Support:
1. Secure and support cables at intervals not exceeding 30" and not more than 6" from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 2. Unsupported spans between cable trays and conduit sleeves shall not exceed 12" horizontally, 24" vertically.
 3. Provide cable supports and clamps to attach cables to backboards and walls.
 4. Attach cables to manhole racks using Owner approved methods.
 5. Backbone cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).
 6. Cables routed above a suspended ceiling in exposed space, and not installed in a conduit system, shall be supported by a cable tray, channel, or hangers.
 7. Cables shall not be supported from ceiling support wires, lighting fixture support wires, ductwork, plumbing line, fire suppression systems, mechanical systems, or electrical conduits. Cables shall not come in contact with ductwork or piping or lay on top of ceiling systems and lighting fixtures.
 8. Where cables are routed through inaccessible ceilings, install conduit sleeves extending 1-foot beyond the inaccessible area, sized in accordance with ANSI/TIA/EIA-569-A Guidelines. Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Specification Section 27 05 26 "Grounding & Bonding for Communications Systems".
 9. Install conduit sleeves where cables pass through walls. Conduits shall be sized in accordance with ANSI/TIA/EIA-569-A Guidelines, as outlined in Division 27 Specification. Section 27 05 28 "Pathways for Communications Systems." Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Specification Section 27 05 26 "Grounding & Bonding for Communications Systems".
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 11. A maximum of 36 (three groups of 12) cables shall be supported in a single hanger with a spacing of 48" on center. Cables shall be loosely bundled.
 12. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 13. 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. Use lacing bars and distribution spools.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections: Engage qualified entity to perform the following:
1. Visually inspect optical fiber jacket materials for NRTL certification markings.
 2. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568 series and Addenda.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of components.
 4. Bi-directional splice loss of a single splice must not exceed 0.13 dB when measured with an OTDR at 1310nm and 1550nm.
 5. Fiber Loss: Optical Cable with Single Mode Fiber.
 - a. Attenuation at 1310 nm = 0.5 dB/mi max
 - b. Attenuation at 1550 nm = 0.4 dB/mi max
 6. Multi-Mode (50 / 125 UM) and Single-Mode (8.7 / 125 UM) Fiber-Optic Cable testing:
 - a. Fiber-optic cables shall be fully tested for continuity and attenuation, utilizing a fiber-optic power meter and fiber-optic LED/laser light source. The fiber-optic test equipment shall be capable of testing multi-mode and/or single-mode fiber cable.
 - b. The fiber-optic test equipment shall be an electronic micro-controller with automatic self-testing and data storage. Provide shop drawings, catalog cut sheets and operational procedures describing the test equipment proposed to be utilized, for the Architect's review and approval.
 - c. Fiber conductor shall be tested with the cable completely installed and in final placement, with connector installed. The "LC" pigtailed shall be inspected for proper termination techniques, workmanship, labeling, etc., and verified to be free from visual defects, such as scratches and chips. Connector installations exhibiting defected and/or improper assembly procedures shall be replaced at the Contractor's expense.
 7. Each fiber shall be tested in both directions, with both readings recorded. The worst-case reading shall be utilized to determine acceptability of the fiber.
 8. Attenuation shall be recorded for each fiber at 850 and 1,300 nm for multi-mode fiber-optic cable, and at 1,310 nm and 1,550 nm for single-mode fiber-optic cable. Fiber-optic cable link test procedures shall be based upon EIA/TIA-568A series standard procedures. The technician performing the fiber-optic verification tests should periodically check and verify the reference dB loss.
 9. The Fluke fiber-optic cable test report shall provide the following information:
 - a. Contractor's name.
 - b. Test Equipment Identification: Manufacturer, model number, and serial number.
 - c. Client/Owner identification.
 - d. Date test performed.
 - e. Cable manufacturer and part number.
 - f. Cable identification number.
 - g. Cable location (i.e., building - from/to).
 - h. Cable description (i.e., number of fibers, S/M, M/M).

- i. Name, signature and date of signature of the technician performing the tests.
 - j. Cable length.
 - k. Proper conductor termination verification, both ends.
 - l. Link attenuation (loss) measurement in dB per fiber.
 - m. Reference dB.
 - n. Visual connector (both ends) inspection verification.
 - o. Calculated fiber loss based on fiber length and factory OTDR readings.
 - p. Calculated optical attenuation per connector pair (fiber link attenuation loss measurement), less the calculated fiber loss, less the reference dB, equals optical attenuation per connector pair.
 - q. Test results (i.e., pass/fail).
10. Maximum optical attenuation per connector pair for multi-mode fiber connectors shall be 0.5 dB or less when measured at 850/1,300 nm in accordance with ANSI/EIA/TIA-526-14A, Method A.1. Maximum optical attenuation per connector pair for single-mode fiber connectors shall be 0.5 dB or less when measured at 1,310/1,550 nm in accordance with ANSI/EIA/TIA-526-7, Method B. (NOTE: It is recognized by the Engineer that this specification is much more stringent than the EIA/TIA-568A Annex "H" Standard.) Reflection shall be ≥ 45 dB.

B. Backbone Cable Testing:

1. Complete end-to-end test results for Fiber Optic cables installed are required.
2. Fiber optic cable must be visually inspected and optically tested on the reel upon delivery to the installation site. Using an Optical Time Domain Reflectometer (OTDR), an access jumper with like fiber, a pigtail, and a mechanical splice, fibers shall be tested for continuity and attenuation.
3. Testing for continuity and attenuation on the reel must confirm factory specifications to ensure that the fiber optic cable was not damaged during shipment. The test results must match the results of the factory-attached tag on the reel, or the fiber shall not be used. Reel data sheet must be provided showing test results.
4. End to end (bi-directional) test measurements shall be provided for single-mode and multimode fibers (2 wavelengths per test are required). Test results must be submitted for review as part of the installation inspection requirements. Test results shall be in paper form and electronic form and must contain the names and signatures of the technicians performing the tests.
5. Testing shall be performed on 100% of the fibers in the completed end-to-end system. TIA-568, provides the technical criteria and formulae to be used in fiber optic testing. Note however, that UH fiber must be tested, rated, and guaranteed for Ethernet GigaSPEED 1000B-X performance.
6. Additionally, fiber optic cable links must pass installation and performance tests both recommended and mandated by the cable manufacturer.
7. Notify Owner at least 24 hours prior to testing to allow observation at the Owner's discretion.
 - a. If Owner confirms intention to observe, a reasonable starting time shall be agreed upon.
 - b. Should Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.

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8. Testing Format: Test Results must be submitted in two (2) formats. First, must be original file(s) downloaded from tester. Second, the file must be cohesively placed in Excel format with the following fields:
 - a. ER/TR RM # / RM # of drop / Port # / relevant test information in as many fields as necessary.
9. Record test results and submit to Owner.

END OF SECTION

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CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UTP cabling.
2. RS-232 cabling.
3. RS-485 cabling.
4. Control-voltage cabling.
5. Control-circuit conductors.
6. Fire alarm wire and cable.
7. Identification products.

B. Related Requirements:

1. Section 27 05 00 "Common Work Results for Communications."

1.2 DEFINITIONS

A. General: Refer to Section 27 05 00 "Common Work Results for Communications."

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote- control and signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product

B. Shop Drawings:

1. Cabling administration drawings and printouts.
2. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- B. 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.

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 06 10 53 - "Miscellaneous Rough Carpentry."

2.3 UTP CABLE

- A. Description: 100-ohm, four-pair UTP, covered with a blue thermoplastic jacket.
 - 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA-568-C.1 for performance specifications.
 - 3. Comply with TIA-568-C.2, Category 6.
 - 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, General Purpose: Type CM or Type CMG.
 - b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
 - c. Communications, Riser Rated: Type CMR, complying with UL 1666.
 - d. Communications, Limited Purpose: Type CMX.
 - e. Multipurpose: Type MP or Type MPG.
 - f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
 - g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.4 UTP CABLE HARDWARE

- A. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.

- B. Connecting Blocks: 110-style for Category 6. 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.

2.5 RS 232 CABLE

- A. Standard Cable: NFPA 70, Type CM.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Polypropylene insulation.
 - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 - 4. PVC jacket.
 - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. PE insulation.
 - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with NFPA 262.

2.6 RS-485 CABLE

- A. Standard Cable: NFPA 70, Type CM.
 - 1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Flame Resistance: NFPA 262, Flame Test.

2.7 CONTROL VOLTAGE CABLE

- A. Paired Cable: NFPA 70, Type CMG.
 - 1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.

2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

2.8 CONTROL CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway or power-limited cable, complying with UL 83, concealed in building finishes.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF in pathway, complying with UL 83.

2.9 FIRE ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
 1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor [with outer jacket] with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated.

2.10 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.
- B. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems and Security."

2.11 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.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPORTS

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. Minimum conduit size shall be 3/4 inch. Control and data-transmission wiring shall not share conduits with other building wiring systems.
 - 2. Comply with requirements in Section 26 05 36 "Cable Trays for Electrical Systems."
 - 3. Comply with requirements in Section 27 05 36 "Cable Trays for Communications Systems."
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring on Racks and within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM's "Cabling Termination Practices" chapter. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
 - 2. Install lacing bars and distribution spools.
 - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
 - 4. Install conductors parallel with or at right angles to sides and back of enclosure.
 - 5. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in enclosure onto terminal blocks.
 - 6. Mark each terminal according to system's wiring diagrams.
 - 7. Make connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1 and NFPA 70.

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- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
- D. Install UTP cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- E. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
 - 4. 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.
 - 5. Maintain minimum cable bending radius during installation and termination of cables.
 - 6. 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.
 - 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
 - 9. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.
- F. UTP Cable Installation: Install using techniques, practices, and methods that are consistent with Category 6 rating of components and that ensure Category 6 performance of completed and linked signal paths, end to end.
 - 1. Comply with TIA-568-C.2.
 - 2. Install 110-style IDC termination hardware unless otherwise indicated.
 - 3. Do not untwist UTP cables more than 1/2 inch from point of termination to maintain cable geometry.
- G. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
 - 2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 35 inches apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 26 05 29 "Hangers and Supports for Electrical Systems."

3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

H. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Cable 72 inches long shall be neatly coiled not less than 12 inches in diameter below each feed point.

I. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-C recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communication cables in grounded metallic pathways 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.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic pathways and 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.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal pathway.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated pathway system. This system shall not be used for other wire or cable.
- C. Wiring Method:

1. Cables and pathways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain other wire or cable.
 2. Fire-Rated Cables: Use of two-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is not permitted.
 3. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or pathway as signaling line circuits.
- D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another for supervisory circuits. Color code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
- H. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
- 3.5 POWER AND CONTROL CIRCUIT CONDUCTORS
- A. 120-V Power Wiring: Install according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. Minimum Conductor Sizes:
1. Class 1 remote-control and signal circuits, No. 14 AWG.
 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.
- 3.6 CONNECTIONS
- A. Comply with requirements in Section 27 05 00 "Common Work Results for Communications Systems" for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

- A. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
- B. Comply with TIA-569-C, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article

3.8 GROUNDING

- A. For communication wiring, comply with J-STD-607-A and with BICSI TDMM's "Grounding, Bonding, and Electrical Protection" chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Section 27 05 26 "Grounding and Bonding for Communications Systems."

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in 28 05 53 "Identification for Electrical Safety and Security."

3.10 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Visually inspect UTP and optical-fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of components.
 - 3. Test UTP 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.
 - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

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END OF SECTION

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COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Copper Horizontal Cables.

1.2 DEFINITIONS

- A. General: Refer to Section 27 05 00 "Common Work Results for Communications."
- B. 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.
- C. A Work Area includes the components that extend from the telecommunications outlet/connectors to the station equipment.
 - 1. Horizontal (to desktop) cable shall consist of Category 6 or 6A copper cable for Data and Voice applications.
 - 2. At corporate, engineering, and campus facilities, horizontal cabling to typical work area outlets (including offices, cubicles and conference rooms) shall consist of two Category 6 cables serving each outlet.
 - 3. Outlets for wall-mounted or other "telephone only" installations shall consist of one Category 6 cable as a minimum.
 - 4. Outlets for wireless access points (APs) shall consist of two Category 6A cables as a minimum.

1.3 ACTION SUBMITTALS

- A. Product Data: Manufacturer's technical data sheets, specifications, performance data and installation instructions for each product.
 - 1. Product data for termination and test equipment to be used to perform Work.
 - a. Equipment shall be calibrated with traceability to National Institute of Standards and Technology (NIST) requirements.
 - b. Include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- B. Shop Drawings: Depict requirements for fabrication and installation. Include the following drawings as applicable:

- a. Proposed riser and horizontal cabling diagram.
- b. Overlay of system components on floor plans.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty Information: Confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
- B. Installation Plan, indicating the following:
 1. Equipment and personnel.
 2. Materials and staging area.
 3. Start and completion dates.
 4. Locations, including floor, room and building.
- C. Copper cable pulling plans for multi-pair copper cables with a pair count of 4 pairs or greater, that includes, but is not limited to, the following:
 1. Each cable run and route.
 2. Date and duration of the pull.
 3. Pulling methodology and equipment setups.
 4. Pulling tension calculations for each pull in the run.
 5. Safety issues and precautions to be taken.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts.
- B. Operation and Maintenance Data. Include preventative maintenance instructions.
- C. Final As-Built Drawings:
 1. CAD Files: Provide CAD files in .dwg or .dgn formats showing floor plans with room numbers and actual horizontal cabling and pathway locations and labeling.
 2. Submit Record Documents within 5 business days of final cable testing.
 3. Red Line Drawings: Retain one (1) E size set of floor plans on site during work hours showing installation progress marked and horizontal cable labels noted. Make drawings available for examination during construction meetings and field inspections.
- D. Cable Schedule.
- E. Cabling Administration Drawings.
- F. Warranties for manufactured components specified in this Section.

1.6 QUALITY ASSURANCE

- A. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
- B. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:
 - 1. ANSI/TIA-568 Series Commercial Building Telecommunications Cabling Standard
 - 2. ANSI/TIA-568-C.1 Commercial Building Telecommunications Cabling Standard
 - 3. ANSI/TIA-568-C.2 Balanced Twisted-Pair Telecommunications Cabling
 - 4. ANSI/TIA-569 Telecommunications Pathways and Spaces
 - 5. ANSI/TIA-606 Administration Standard for the Telecommunications Infrastructure
 - 6. ANSI-J-STD-607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecomm.
 - 7. BICSI Telecommunications Distribution Methods Manual Components Standards
 - 8. NFPA 70 National Electric Code
 - 9. ISO/IEC 11801 Generic Cabling for Customer Premises
 - 10. CENELEC EN-50173 Generic Cabling Systems
- C. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to client.
 - 1. Report immediately to client facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.
- D. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and Specifications take precedence where this design is more stringent than codes and ordinances.
- E. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.7 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 "Common Work Results for Communications."

PART 2 - PRODUCTS

2.1 TOOLS AND EQUIPMENT

- A. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.2 HORIZONTAL CABLING MATERIALS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

2.3 PERFORMANCE REQUIREMENTS

- A. Maximum allowable horizontal cable length shall be 295 feet (90 m).
 - 1. Maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment.
 - 2. Maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.
- B. The maximum allowable horizontal cable length for RG6 coaxial cable shall be 150 feet. Install coaxial cable in distances that do not exceed maximum allowable distance.

2.4 UTP HORIZONTAL CABLE

- A. Cable shall be listed for use per the National Electrical Code (NFPA-70). Cable shall comply with one of the following:
 - 1. UL-listed CMR Cable: Solid copper conductors with high-density polyolefin insulation and overall low smoke PVC jacket to achieve riser (i.e., non-plenum) rating by UL standards.
 - 2. UL-listed CMP Cable: Solid copper conductors with FEP insulation and overall low smoke PVC jacket to achieve plenum rating by UL standards.
 - 3. LSZH Cable: Solid copper conductors with non-halogen HDPE insulation and low smoke, zero halogen, compound jacket to achieve LSZH rating by:
 - a. IEC 60754—Part 2.
 - b. IEC 61034—Part 2.
 - c. IEC 60332—Part 2.
 - d. Defence Standard 02-713.

- B. Cable shall meet the requirement of ANSI/TIA-568 series Standards for Category 6 performance.
- C. Description: Category 6, four pair UTP, covered with a blue thermoplastic jacket.
- D. Approved Manufactures: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berk-Tek.
 - 2. Superior Essex.
 - 3. Or approved equal.

2.5 UTP CABLE HARDWARE

- A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- B. 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.
 - 1. Number of Jacks per Field: One for each four-pair UTP cable indicated.
- C. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- D. Workstation Outlets: Four port-connector assemblies mounted in single faceplate.
 - 1. Stainless Steel Faceplate:
 - 2. For use with snap-in jacks accommodating combination of UTP, optical fiber, and coaxial work area cords.
 - 3. Flush mounting jacks, positioning the cord at a 90-degree angle.
 - 4. Legend: Machine printed, in the field, using adhesive-tape label for cable.
 - 5. Legend: Snap-in, clear-label covers and machine-printed paper inserts for faceplate.
- E. Patch Cords: Factory-made, four-pair cables in lengths as directed by client; terminated with eight-position modular plug at each end.
- F. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
- G. Patch cords shall have color-coded boots for circuit identification.
- H. Manufactures: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ortronics.

2.6 COAXIAL CABLE

- A. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
- B. RG-6/U: NFPA 70, Type CATVP.
 - 1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
 - 2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
 - 3. Jacketed with Copolymer jacket.
 - 4. Suitable for indoor installations.
- C. RG59/U (Plenum Rated): NFPA 70, Type CMP.
 - 1. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
 - 2. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
 - 3. Copolymer jacket.
- D. RG-11/U: NFPA 70, Type CATV.
 - 1. No. 14 AWG, solid, copper-covered steel conductor.
 - 2. Gas-injected, foam-PE insulation.
 - 3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
 - 4. Jacketed with Copolymer jacket.
 - 5. Suitable for indoor installations.
- E. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
 - 1. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
- F. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belden CDT Inc.; Electronics Division.
 - 2. CommScope, Inc.
 - 3. Berk-Tek A Nexans Company.

2.7 COAXIAL CABLE HARDWARE

- A. Coaxial Cable Connectors:
 - 1. Type "F" Connectors.

2. Type BNC Connectors.
- B. Coaxial Cable Adapters:
1. Function: Outlets shall provide data and radio frequency (RF) video connectivity for signals transmitted on coaxial cable.
 2. Modular BNC Coupler: 50-ohm impedance module designed for data applications.
 3. M-Series F-81 Coaxial Coupler: 75-ohm module designed for video applications.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ortronics.
 2. Blonder – Tongue.
 3. Pico Macom.

2.8 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606 and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Division 26 Section 26 05 53 "Identification for Electrical Systems."
- C. Cable identification shall be by means of permanently applied, pre-printed, wraparound wire markers (i.e., "Brady-Wrap" B-292, LAT-18, or LAT-19 self-laminating markers). These labels must withstand the requirements of UL 969 as outlined in the EIA/TIA-606 Standard.
- D. Patch panel labels shall be pre-printed and enclosed in self-adhesive clear strips (Panduit, Ortronics or as accepted by the Engineer).
- E. Data/Telecommunications Outlet Face Plates: Permanent, clear, pre-printed laminated label with black lettering (Brady Label #CL-311-621 or LAT-7-722-10, or as accepted by the Engineer).

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."
- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.2 PREPARATION

- A. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- B. Data/telecommunication and fiber-optic cables shall not be stored or installed in an unheated building where the temperature is less than 40°F.
- C. The structure and the cable shall be brought to a minimum 50°F ambient for a minimum of 48 hours prior to installation of the cables. Damaged cable shall be replaced at Contractor's expense.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply applicable codes, standards and with local codes and requirements. It is the responsibility of the contractor to identify and adhere to unique codes or requirements governed by the region where the Work is being performed.
- B. Cable shall be installed following industry standard practices.
- C. Horizontal cabling shall be installed from the work area outlet location to the nearest Telecommunications Space.
- D. Horizontal cabling shall be terminated on a patch panel in the telecommunication space which is the same category rating as the Cable (i.e. Cat 6 cable terminates on Cat 6 panels).
- E. Do not exceed the maximum pulling tension or the minimum bending radius for twisted pair cables per manufacturer's specifications.
- F. Test horizontal links per the ANSI/TIA-568 Requirements.
- G. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
- H. Cables may not be spliced. Cabling shall be installed in continuous runs from cross-connect fields to cross-connect fields, to patch panels, workstation outlets, etc. Cabling shall be free from splices, taps, splitters, baluns and other in-line connections.
- I. Cables shall be new and as specified on the drawings. Cables shall be shipped on 1,000 ft. reels or boxed. Coiled cables are not acceptable. Factory shorts and/or factory seconds, salvaged, leftover and reused cables are not acceptable. Cables of a given type shall be of a single manufacturer and part number. Unapproved or unacceptable cable shall be removed and replaced at Contractor's expense.
- J. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- K. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

- L. Cables requiring additional length shall be stored in an extended loop or in a "Figure 8" configuration. Do not store additional length in bundled loops. Each individual loop shall be tagged with cable number.
- M. Ensure during installation and upon completion, cables have been installed in good condition, free from jacket cuts or tears, kinks, twist, knots, sharp bends, etc., or other physical damage.
 - 1. During installation, do not allow the cables to be exposed to foot, vehicle or equipment traffic, or be exposed to other form of abuse which shall cause damage to cables, altering the electrical characteristics.
 - 2. Cables exhibiting such damage or an attempt to correct, hide or otherwise conceal such damage, shall be replaced at the Contractor's expense.
- N. Cable pulls shall not exceed 100 feet in length. Cables shall be neatly coiled in a figure "8" pattern at the completion of a pull in preparation for the next pull.

3.4 UTP CABLE INSTALLATION

- A. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.
- B. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 48 inches apart.
 - 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- C. Installation of Cable Routed Exposed under Raised Floors:
 - 1. Install plenum-rated cable only.
 - 2. Install cabling after the flooring system has been installed in raised floor areas.
 - 3. Coil cable 6 feet long in Figure 8 configuration not less than 12 inches in diameter below each feed point.
- D. Group connecting hardware for cables into separate logical fields.
- E. Separation from EMI Sources:
 - 1. Comply with BICSI TDMM and TIA/EIA-569 for separating unshielded copper voice and data 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.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceway 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.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. 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:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

F. Cable Support:

1. Secure and support cables at intervals not exceeding 30" and not more than 6" from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
2. Unsupported spans between cable trays and conduit sleeves shall not exceed 12" horizontally, 24" vertically.
3. Provide cable supports and clamps to attach cables to backboards and walls.
4. Attach cables to manhole racks using Owner approved methods.
5. Horizontal cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).
6. Cables routed above a suspended ceiling in exposed space, and not installed in a conduit system, shall be supported by a cable tray, channel, or hangers.
7. Cables shall not be supported from ceiling support wires, lighting fixture support wires, ductwork, plumbing line, fire suppression systems, mechanical systems, or electrical conduits. Cables shall not come in contact with ductwork or piping or lay on top of ceiling systems and lighting fixtures.
8. Where cables are routed through inaccessible ceilings, install conduit sleeves extending 1-foot beyond the inaccessible area, sized in accordance with ANSI/TIA/EIA-569-A Guidelines. Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Specification Section 27 05 26 "Grounding and Bonding for Communications Systems."
9. Install conduit sleeves where cables pass through walls. Conduits shall be sized in accordance with ANSI/TIA/EIA-569-A Guidelines, as outlined in Division 27 Specification. Section 27 05 28 "Pathways for Communications Systems."
 - a. Install insulated conduit bushing on both ends of sleeve and ground conduit per Division 27 Specification Section 27 05 26 "Grounding and Bonding for Communications Systems."
10. Cables supported by hangers shall utilize Caddy Cable-Cat hangers or approved equal communication cable hangers. Hangers shall be supported from the building structure. Hangers shall not utilize other system support wires or rods.

11. A maximum of 36 (three groups of 12) cables shall be supported in a single hanger with a spacing of 48" on center. Cables shall be loosely bundled.
12. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
13. 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. Use lacing bars and distribution spools.

3.5 FIRESTOPPING

- A. Comply with requirements in Division 07 Section 07 84 13 "Penetration Firestopping."
- B. Comply with TIA/EIA-569 series, "Firestopping."
- C. Comply with BICSI TDMM, Chapter 11 "Firestopping Systems" Article.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."
 1. Administration Class: 4.
 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. 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.
- C. Comply with requirements in Division 09 Section 09 91 23 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 4 level of administration.
- E. 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.
- F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling.

1. Identify labeling convention and show labels for telecommunications closets, horizontal 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.
2. Follow convention of TIA/EIA-606-A. Furnish electronic record of drawings, in software and format selected by Owner.

G. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination point.
2. Exposed Horizontal Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
3. 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.
4. 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.

H. 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/EIA-606-A.

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

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections: Engage qualified entity to perform tests and inspections.

B. Notify Owner at least 24 hours prior to testing to allow observation at the Owner's discretion.

1. If Owner confirms intention to observe, a reasonable starting time shall be agreed upon.
2. Should Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.

C. Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings.
2. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568 series and Addenda.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of components.

- D. Tests:
1. Test Equipment:
 - a. Fluke (or Equivalent brand) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568 series. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
 - b. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 1) Test cords shall be new.
 2. Test for each cable. Perform the following tests according to TIA/EIA-568 series.
 - a. Wire map.
 - b. Length (physical vs. electrical, and length requirements).
 - c. Insertion loss.
 - d. Near-end crosstalk (NEXT) loss.
 - e. Power sum near-end crosstalk (PSNEXT) loss.
 - f. Equal-level far-end crosstalk (ELFEXT).
 - g. Power sum equal-level far-end crosstalk (PSELFEXT).
 - h. Return loss.
 - i. Propagation delay.
 - j. Delay skew.
- E. Prepare test and inspection reports and submit to Owner.

END OF SECTION

SECTION 27 15 23

COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Optical fiber horizontal cables.

1.2 DEFINITIONS

- A. General: Refer to Section 27 05 00 "Common Work Results for Communications."

1.3 ACTION SUBMITTALS

- A. Product Data: Manufacturer's technical data sheets, specifications, performance data and installation instructions for each product.
 - 1. Product data for termination and test equipment to be used to perform Work.
 - a. Equipment shall be calibrated with traceability to National Institute of Standards and Technology (NIST) requirements.
 - b. Include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- B. Shop Drawings: Depict requirements for fabrication and installation. Include the following drawings as applicable:
 - a. Proposed riser and horizontal cabling diagram.
 - b. Overlay of system components on floor plans.

1.4 INFORMATIONAL SUBMITTALS

- A. Sample Warranty Information: Confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.
- B. Installation Plan, indicating the following:
 - 1. Equipment and personnel.
 - 2. Materials and staging area.
 - 3. Start and completion dates.
 - 4. Locations, including floor, room and building.
- C. Optical fiber cable pulling plans for multi-pair copper cables with a pair count of 4 pairs or greater, that includes, but is not limited to, the following:
 - 1. Each cable run and route.

2. Date and duration of the pull.
3. Pulling methodology and equipment setups.
4. Pulling tension calculations for each pull in the run.
5. Safety issues and precautions to be taken.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Contracts.

B. Operation and Maintenance Data. Include preventative maintenance instructions.

C. Final As-Built Drawings:

1. CAD Files: Provide CAD files in .dwg or .dgn formats showing floor plans with room numbers and actual horizontal cabling and pathway locations and labeling.
2. Submit Record Documents within 5 business days of final cable testing.
3. Red Line Drawings: Retain one (1) E size set of floor plans on site during work hours showing installation progress marked and horizontal cable labels noted. Make drawings available for examination during construction meetings and field inspections.

D. Warranties for manufactured components specified in this Section.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Minimum 25 years in business manufactured at a facility in the United States.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer of optical fiber.

C. Adhere to Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of the current adopted revision of the following:

1. TIA-568 Series Commercial Building Telecommunications Cabling Standard
2. Bellcore, fiber distributed data interface (FDDI) standards
3. ANSI/ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable
4. Color Coding: Provide cabling system color coded in compliance with ANSI/TIA-598-C.
5. TIA-569 Telecommunications Pathways and Spaces,
6. TIA-606 Administration Standard for the Telecommunications Infrastructure

7. ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
8. ISO/IEC 11801 – Generic Cabling for Customer Premises
9. NFPA 70 – National Electric Code
10. BICSI – Telecommunications Distribution Methods Manual

E. Modifications required by the referenced codes, rules, regulations, and authorities shall be made by the Contractor without additional charge to client.

1. Report immediately to client Facilities personnel and/or the Consultant/Engineer, in writing, part of the SCS design which does not conform to the requirements of these codes or regulations, or otherwise be held responsible to provide and install material which will comply with these codes and regulations.

F. Applicable codes and ordinances and local interpretations take precedence when they conflict with or are more stringent than the SCS design. Drawings and specifications take precedence where this design is more stringent than codes and ordinances.

G. Materials, appliances, equipment, and devices shall conform to the applicable standards of Underwriters Laboratories (UL), and shall be listed by UL if a UL listing category has been established. Furnish products that have been tested and qualified to meet the rating criteria by UL or other testing firm acceptable to authority having jurisdiction.

1.7 REGULATORY REQUIREMENTS

- A. Refer to Section 27 05 00 “Common Work Results for Communications.”

1.8 WARRANTY

- A. **Manufacturer’s Warranty:** Manufacturer agrees to replace or refund the purchase price of products that fail from defects in material and workmanship within the specified warranty period.
- B. **Warranty Period:** One (1) year from date of Substantial Completion.
- C. **Manufacturer’s Extended Warranty:** Manufacturer agrees to replace or refund the purchase price of products that are installed by a manufacturer-certified installer that fail from defects in material and workmanship within the specified warranty period.
- D. **Warranty Period:** Twenty-five (25) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TOOLS AND EQUIPMENT

- A. Furnish special installation equipment, tools, or kits necessary to properly complete the SCS system installation.

1. This may include, but is not limited to, tools for pulling, splicing, terminating, and testing the cables, communication devices, stands for cable reels, cable wenchers, assembly, and adjustment devices, etc.

2.2 HORIZONTAL CABLING MATERIALS, GENERAL

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.
- B. Equipment and materials shall be of the quality and manufacture indicated. Equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

2.3 PERFORMANCE REQUIREMENTS

- A. Unless otherwise indicated, horizontal (to desktop) cable shall consist of OM3 or OM4 laser optimized 50/125 micrometer micron optical fibers and shall extend distance of low-cost 850 nanometers vertical cavity surface-emitting laser (VCSEL) based electronics, supporting the following list of application standards.
 1. Cable shall support dual speed 1 gigabit per second/10 gigabits per second ports, allowing incremental upgrades of switches and serving with less disruption.
 2. Optical fibers shall be differential mode delay (DMD) tested using a high- resolution test bench that exceeds fiber optic test procedure (FOTP) 220 standards and independently certified by UL.
 3. Optical fiber shall couple sufficient power from light emitting diode (LED) sources to support legacy applications such as Ethernet, token ring, FDDI, Fast Ethernet, and ATM. In addition, 50 micrometer core size shall be directly compatible with laser-based applications, as follows:
 - a. Ethernet from 10 megabits per second to 10 gigabits per second
 - b. Fiber channel from 1 to 10 gigabits per second
 - c. ATM/synchronous optical networking (SONET)/synchronous digital hierarchy (SDH) from OC-1 to OC-192
- B. Cables shall be designed for Point to Point applications and shall provide a high level of protection for optical fiber installed in building applications.
- C. Higher optical fiber count cables shall utilize a sub-unitized design with color-coded subunits for easy identification.
- D. When deemed as a requirement, fiber to the desktop shall require a minimum of 4 strands of fiber. Other fiber optic applications shall be specified with a minimum 100% growth allocation.

2.4 INDOOR UL-RATED, TIGHT BUFFERED DISTRIBUTION CABLE

- A. Cable shall be listed for use per the National Electrical Code (NFPA-70). Cable shall meet one of the following, per bid document:
- B. Basis for Design: Corning optical fiber cable, in strand- count identified on the bid document, and with the appropriate jacket material (OFNR, OFNP or LSZH) for the environment in which the cable will be installed.
- C. Cable Construction:
 - 1. Tight buffer optical fibers, aramid strength yarn, and UL rated outer jacket.
 - 2. Available in either Plenum, Riser or LSZH listing
 - 3. Sheath color-coded to optical fiber type and printed with relevant cable information on cable.
- D. Approved Manufacturer:
 - 1. Corning.

2.5 INDOOR ARMORED, UL RATED, TIGHT BUFFERED DISTRIBUTION CABLE

- A. Basis for Design: Corning optical fiber cable, in strand- count identified on the bid document, and with the metallic armor of the appropriate jacket material (OFNR, OFNP, LSZH) for the environment in which the cable will be installed.
- B. Cable Construction:
 - 1. Tight buffer optical fibers, aramid strength yarn, and UL rated jacket.
 - 2. Interlocking armor spiraling around premises distribution style cable, with an overall sheath jacket to provide additional protection and security.
 - 3. Aluminum armor.
 - 4. Available in either Plenum, Riser or LSZH listing.
 - 5. Sheath color-coded to optical fiber type and printed with relevant cable information on cable.
- C. Approved Manufacturer:
 - 1. Corning.

2.6 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER – 50/125 μm – 300 (OM3)

- A. Multimode, 50/124-micrometer, OM3, optical fiber cable at a minimum. Coordinate exact strand count with client prior to installation.
- B. Jacket:
 - 1. Jacket Color: Aqua for indoor.
 - 2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

- C. Optical Requirements:
 - 1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
 - 2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
 - 3. Cabled Effective Modal Bandwidth: No less than 2000 MHz·km at 850 nm.
 - 4. IEEE 802.3z GbE Distance:
 - a. Up to 1000 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
 - 5. IEEE 802.3ae 10 GbE Distance: Up to 300 m at 850 nm.
 - 6. OFL Bandwidth:
 - a. No less than 1500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
 - 7. Numerical Aperture: 0.200 ± 0.015 .

2.7 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER 50/125 μm Fiber – 550 (OM4).

- A. Jacket:
 - 1. Jacket Color: Aqua for indoor.
 - 2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
 - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.
- B. Geometry Requirements:
 - 1. Core:
 - a. Diameter: $50.0 \pm 2.5 \mu\text{m}$.
 - b. Non-Circularity: No more than 5 percent.
 - 2. Cladding:
 - a. Diameter: $125 \pm 1 \mu\text{m}$.
 - b. Non-Circularity: No more than 1 percent.
 - 3. Core-to-Cladding Concentricity: No more than 1.5 μm .
 - 4. Coating Diameter: Primary, Uncolored; $242 \pm 5 \mu\text{m}$.
 - 5. Colored Fiber Nominal Diameter: Between 253 and 259 μm .
- C. Optical Requirements:
 - 1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
 - 2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
 - 3. Cabled Effective Modal Bandwidth: No less than 4700 MHz·km at 850 nm.
 - 4. IEEE 802.3z GbE Distance:
 - a. Up to 1100 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
 - 5. IEEE 802.3ae 10 GbE Distance: Up to 550 m at 850 nm.

6. OFL Bandwidth:
 - a. No less than 3500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
7. Numerical Aperture: 0.200±0.015.

2.8 MULTIMODE LASER-OPTIMIZED OPTICAL FIBER 50/125 µm Fiber – 600 (OM4).

A. Jacket:

1. Jacket Color: Aqua for indoor.
2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

B. Geometry Requirements:

1. Core:
 - a. Diameter: 50.0±2.5 µm.
 - b. Non-Circularity: No more than 5 percent.
2. Cladding:
 - a. Diameter: 125±1 µm.
 - b. Non-Circularity: No more than 1 percent.
3. Core-to-Cladding Concentricity: No more than 1.5 µm.
4. Coating Diameter: Primary, Uncolored; 242±5 µm.
5. Colored Fiber Nominal Diameter: Between 253 and 259 µm.

C. Optical Requirements:

1. Cabled Fiber Attenuation:
 - a. No more than 2.8 dB/km at 850 nm.
 - b. No more than 1.0 dB/km at 1300 nm.
2. Point Discontinuity: No more than 0.2 dB at 850 nm and 1300 nm.
3. Cabled Effective Modal Bandwidth: No less than 5350 MHz·km at 850 nm.
4. IEEE 802.3z GbE Distance:
 - a. Up to 1100 m at 850 nm.
 - b. Up to 600 m at 1300 nm.
5. IEEE 802.3ae 10 GbE Distance: Up to 600 m at 850 nm.
6. OFL Bandwidth:
 - a. No less than 3500 MHz·km at 850 nm.
 - b. No less than 500 MHz·km at 1300 nm.
7. Numerical Aperture: 0.200±0.015.

2.9 SINGLE MODE OPTICAL FIBER

A. Jacket:

1. Jacket Color: Yellow for indoor.

2. Cable cordage jacket, fiber, unit, type, and group color shall be according to TIA/EIA-598 series.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40”.

B. Geometry Requirements:

1. Cladding:
 - a. Diameter: Between $125.0 \pm 0.7 \mu\text{m}$.
 - b. Non-Circularity: No more than 0.7 percent.
2. Mode Field Diameter:
 - a. $9.2 \pm 0.4 \mu\text{m}$ at 1310 nm.
 - b. $10.4 \pm 0.5 \mu\text{m}$ at 1550 nm.
3. Core-to-Cladding Concentricity: No more than 0.5 μm .
4. Coating Diameter: $245 \pm 5 \mu\text{m}$.
5. Fiber Curl: Radius of curvature no less than 4.0 m.

C. Optical Requirements:

1. Cabled Fiber Attenuation:
 - a. No more than 0.65 dB/km at 1310 nm.
 - b. No more than 0.65 dB/km at 1383 ± 3 nm.
 - c. No more than 0.50 dB/km at 1550 nm.
2. Point Discontinuity: No more than 0.05 dB at 1310 nm and 1550 nm.
3. IEEE 802.3z GbE Distance: Up to 5000 m at 1300 nm.

2.10 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Corning Cable Systems.
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch lengths or lengths directed by client.
- D. Cable Connecting Hardware:
 1. Comply with Optical Fiber Connector Intermate ability Standards (FOCIS) specifications of TIA/EIA-604 series. Comply with TIA/EIA-568 series.
 2. Quick-connect, simplex and duplex, UNICAM connectors. Insertion loss not more than 0.75 dB.

2.11 COMPATIBILITY OF RELATED EQUIPMENT

- A. Equipment and materials installed shall be compatible in respects with other items being furnished and with existing items so that a complete and fully operational system will result.

PART 3 - EXECUTION

3.1 WORKMANSHIP, GENERAL

- A. Refer to Section 27 05 00 "Common Work Results for Communications."
- B. Cable and equipment shall be installed in a neat and workmanlike manner. Methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner or Owner Representative.

3.2 PREPARATION

- A. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- B. Data/telecommunication and fiber-optic cables shall not be stored or installed in an unheated building where the temperature is less than 40°F.
- C. The structure and the cable shall be brought to a minimum 50°F ambient for a minimum of 48 hours prior to installation of the cables. Damaged cable shall be replaced at Contractor's expense.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. General - Optical Fiber Horizontal Cable:
 - 1. Comply applicable codes, standards and with local codes and requirements. Contractor shall identify and adhere to unique codes or requirements governed by the region where the Work is being performed.
 - 2. Provide necessary products for installation of Fiber Horizontal cablings to include cable attachments, etc.
 - 3. Horizontal cable shall be installed following industry standard practices.
 - 4. Installations shall comply with the following:
 - a. ANSI/TIA-568 Series Commercial Building Telecommunications Cabling Standard .
 - b. ANSI/TIA-569 Telecommunications Pathways and Spaces.
 - c. ANSI/TIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
 - d. BICSI Telecommunications Distribution Methods Manual.
 - e. J-STD-607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecomm.
 - f. NFPA 70 National Electric Code.

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5. Cables shall be new and as specified. Cables shall be shipped on 1,000 ft. reels. Coiled cables are not acceptable. Factory shorts and/or factory seconds, salvaged, leftover and reused cables are not acceptable.
6. Cables of a given type shall be of a single manufacturer and part number. Unapproved or unacceptable cable shall be removed and replaced at Contractor's expense.
7. 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.
8. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
9. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
10. Cables requiring additional length shall be stored in an extended loop or in a "Figure 8" configuration. Do not store additional length in bundled loops. Each individual loop shall be tagged with cable number.
11. Make certain that during the installation and upon completion, cables have been installed in good condition, free from jacket cuts or tears, kinks, twist, knots, sharp bends, etc., or other physical damage.
12. Do not allow cables to be exposed to foot, vehicle, or equipment traffic, or be exposed to other form of abuse which shall cause damage to cables, altering the electrical characteristics.
 - a. Cables exhibiting such damage or an attempt to correct, hide, or otherwise conceal such damage, shall be replaced at Contractor's expense.
13. Cable pulls shall not exceed 100 feet in length. Cables shall be neatly coiled in a figure "8" pattern at the completion of a pull in preparation for the next pull.
14. Slack shall be coiled in the box without exceeding the bend radius.

3.4 CABLE SUPPORT

- A. Secure and support cables at intervals not exceeding 30" and not more than 6" from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- B. Unsupported spans between cable trays and conduit sleeves shall not exceed 12" horizontally, 24" vertically.
- C. Provide cable supports and clamps to attach cables to backboards and walls.
- D. Attach cables to manhole racks using Owner approved methods.
- E. Horizontal fiber cabling shall be secured to the cable/ladder tray following manufacturer recommended procedures, and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).
- F. Cables routed above a suspended ceiling in exposed space, and not installed in a conduit system, shall be supported by a cable tray, channel, or hangers.

- G. Cables shall not be supported from ceiling support wires, lighting fixture support wires, ductwork, plumbing line, fire suppression systems, mechanical systems, or electrical conduits. Cables shall not come in contact with ductwork or piping or lay on top of ceiling systems and lighting fixtures.
- H. Where cables are routed through inaccessible ceilings, install conduit sleeves extending 1-foot beyond the inaccessible area, sized in accordance with ANSI/TIA/EIA-569-A Guidelines. Install insulated conduit bushing on both ends of sleeve and ground conduit per Section 27 05 26 "Grounding & Bonding for Communications Systems."
- I. Install conduit sleeves where cables pass through walls. Conduits shall be sized in accordance with ANSI/TIA/EIA-569-A Guidelines, as outlined in Section 27 05 28 "Pathways for Communications Systems." Install insulated conduit bushing on both ends of sleeve and ground conduit per Section 27 05 26 "Grounding & Bonding for Communications Systems."
- J. Cables supported by hangers shall utilize Caddy Cable-Cat hangers or approved equal communication cable hangers. Hangers shall be supported from the building structure. Hangers shall not utilize other system support wires or rods.
- K. A maximum of 36 (three groups of 12) cables shall be supported in a single hanger with a spacing of 48" on center. Cables shall be loosely bundled.
- L. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- M. 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. Use lacing bars and distribution spools.

3.5 IDENTIFICATION

- A. Cable and Termination Panel Labeling
 1. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
 2. Label the installed cables in accordance with Section 27 05 00.

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections: Engage qualified entity to perform tests and inspections.
- B. Notify Owner at least 24 hours prior to testing to allow observation at the Owner's discretion.
 1. If Owner confirms intention to observe, a reasonable starting time shall be agreed upon.
 2. Should Owner not be present at the scheduled commencement time, the Contractor may begin testing as scheduled.
- C. Horizontal Optical Fiber Cable Inspections:

1. Fiber optic cable shall be visually inspected and optically tested on the reel upon delivery to the installation site.
2. Visually inspect optical fiber jacket materials for NRTL certification markings.
3. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568 series and Addenda.
4. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of components.

D. Horizontal Optical Fiber Cable Testing:

1. Bi-directional splice loss of a single splice must not exceed 0.13 dB when measured with an OTDR at 1310nm and 1550nm.
2. Fiber Loss: Optical Cable with Single Mode Fiber.
 - a. Attenuation at 1310 nm = 0.5 dB/mi max
 - b. Attenuation at 1550 nm = 0.4 dB/mi max
3. Multi-Mode (50 / 125 UM) and Single-Mode (8.7 / 125 UM) Fiber-Optic Cable testing:
 - a. Fiber-optic cables shall be fully tested for continuity and attenuation, utilizing a fiber-optic power meter and fiber-optic LED/laser light source. Fiber-optic test equipment shall be capable of testing multi-mode and/or single-mode fiber cable.
 - b. Fiber-optic test equipment shall be an electronic micro-controller with automatic self-testing and data storage.
 - c. Fiber conductor shall be tested with the cable completely installed and in final placement, with connector installed. The "LC" pigtails shall be inspected for proper termination techniques, workmanship, labeling, etc., and verified by the Contractor to be free from visual defects, such as scratches and chips. Connector installations exhibiting defected and/or improper assembly procedures shall be replaced at Contractor's expense.
4. Each fiber shall be tested in both directions, with both readings recorded. The worst-case reading shall be utilized to determine acceptability of the fiber.
5. Attenuation shall be recorded for each fiber at 850 and 1,300 nm for multi-mode fiber-optic cable, and at 1,310 nm and 1,550 nm for single-mode fiber-optic cable. Fiber-optic cable link test procedures shall be based upon EIA/TIA-568A series standard procedures. The technician performing the fiber-optic verification tests should periodically check and verify the reference dB loss.
6. The Fluke fiber-optic cable test report shall provide the following information:
 - a. Contractor's name.
 - b. Test Equipment Identification: Manufacturer, model number, and serial number.
 - c. Client/Owner identification.
 - d. Date test performed.
 - e. Cable manufacturer and part number.
 - f. Cable identification number.
 - g. Cable location (i.e., building - from/to).
 - h. Cable description (i.e., number of fibers, S/M, M/M).

- i. Name, signature and date of signature of the technician performing the tests.
 - j. Cable length.
 - k. Proper conductor termination verification, both ends.
 - l. Link attenuation (loss) measurement in dB per fiber.
 - m. Reference dB.
 - n. Visual connector (both ends) inspection verification.
 - o. Calculated fiber loss based on fiber length and factory OTDR readings.
 - p. Calculated optical attenuation per connector pair (fiber link attenuation loss measurement), less the calculated fiber loss, less the reference dB, equals optical attenuation per connector pair.
 - q. Test results (i.e., pass/fail).
7. Maximum optical attenuation per connector pair for multi-mode fiber connectors shall be 0.5 dB or less when measured at 850/1,300 nm in accordance with ANSI/EIA/TIA-526-14A, Method A.1. Maximum optical attenuation per connector pair for single-mode fiber connectors shall be 0.5 dB or less when measured at 1,310/1,550 nm in accordance with ANSI/EIA/TIA-526-7, Method B. (NOTE: It is recognized by the Engineer that this specification is much more stringent than the EIA/TIA-568A Annex "H" Standard.) Reflection shall be ≥ 45 dB.
- E. Prepare test and inspection reports and submit to Owner.
1. Test Reports shall be in paper form and electronic form, and shall contain the names and signatures of the technicians performing the tests.
 2. Testing Format: Test Results must be submitted in two (2) formats. First, must be original file(s) downloaded from tester. Second, the file must be cohesively placed in Excel format with the following fields:
 - a. ER/TR RM # / RM # of drop / Port # / relevant test information in as many fields as necessary.

END OF SECTION