

SECTION 26 05 10
NETWORK COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Related sections include, but not limited to, the following:

1. Division 01, General Requirements.
2. Section 26 05 02, Basic Electrical Requirements.
3. Section 26 05 05, Conductors.
4. Section 26 05 33, Raceways and Boxes.
5. Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems.
6. Section 40 90 00, Instrumentation and Control for Process Systems.
7. Section 40 91 00, Instrumentation and Control Components.
8. Section 40 99 90, Package Control Systems.

1.02 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Electronic Components, Assemblies, and Materials Association (ECA): 310-E, Cabinets, Racks, Panels, and Associated Equipment.
2. Institute of Electrical and Electronic Engineers, Inc. (IEEE): 802.3, Telecommunications and Information Exchange Between Systems—Local and Metropolitan Networks.
3. Insulated Cable Engineers Association (ICEA):
 - a. S-83-596, Optical Fiber Premises Distribution Cable.
 - b. S-87-640, Optical Fiber Outside Plant Communications Cable.
 - c. S-104-696, Indoor-Outdoor Optical Fiber Cable.
4. International Organization for Standardization (ISO): 9001, Quality Management Systems—Requirements.
5. International Telecommunication Union (ITU): T G.652, Characteristics of a Single-mode Optical Fibre and Cable.
6. Internet Engineering Task Force (IETF):
 - a. RFC 2544, Benchmarking Methodology for Network Interconnect Devices.
 - b. RFC 6349, Framework for TCP throughput Testing.
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
8. QuEST Forum (QF): TL 9000, Quality Management Systems.
9. Rural Development Utilities Programs (RDUP):
 - a. 7 CFR 1755.902, Minimum Performance Specification for Fiber Optic Cables.
 - b. 7 CFR 1755.903, Fiber Optic Service Entrance Cables.

10. Telecommunications Industry Association (TIA):
 - a. 526-7, OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
 - b. 526-14, OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
 - c. 568-C.1, Commercial Building Telecommunications Cabling Standards.
 - d. 568-C.3, Optical Fiber Cabling Components Standard.
 - e. 598, Optical Fiber Cable Color Coding.
 - f. 606, Administration Standard for Commercial Telecommunications Infrastructure.
11. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - a. 455-78, FOTP-78 - IEC 60793-1-40 Optical Fibres Part 1-40: Measurement Methods and Test Procedures – Attenuation.
 - b. 455-133, FOTP-133 IEC-60793-1-22 Optical Fibres Part 1-22: Measurement Methods and Test Procedures Length Measurement.
 - c. 492AAAA, Detail Specification for 62.5-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - d. 492AAAB, Detail Specification for 50-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - e. 492AAAC, Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
 - f. 492CAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers.
 - g. 492CAAB, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak.
 - h. 604-2, FOCIS-2 Fiber Optic Connector Intermateability Standard, Type ST.
 - i. 604-3, FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC.
 - j. 604-12, FOCIS-12 Fiber Optic Connector Intermateability Standard, Type MT-RJ.
 - k. 942, Telecommunications Infrastructure Standard for Data Centers.
 - l. TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems-Contains Color.
12. UL: 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

- A. CAT6: Category 6 Network Cable.
- B. CCTV: Closed Circuit Television.
- C. dB: Decibel.
- D. EMB: Effective Modal Bandwidth.
- E. FACP: Fire Alarm Control Panel.
- F. FOCS: Fiber Optic Communication System.
- G. Fusion Splice: Connecting ends of two fibers together by aligning fiber ends and applying electric arc to fuse ends together.
- H. HDMI: High-Definition Multimedia Interface.
- I. Hybrid Cable: Cable containing more than one type of fiber.
- J. LAN: Local Area Network.
- K. m: Micrometer.
- L. Mbps: Megabits per Second.
- M. Mechanical Splice: Connecting ends of two fibers together by means other than fusion.
- N. Megahertz (MHz): One million cycles per second.
- O. MHz: Megahertz.
- P. micro: $\times 10^{-6}$.
- Q. Micron: Micrometer or one millionth meter.
- R. n, nano: $\times 10^{-9}$.
- S. N: Newton.
- T. NIP: Network Interface Panel.
- U. nm: Nanometer—unit of measure equal to one billionth meter.
- V. OFL: Over-filled Launch.
- W. OFN: Nonconductive Optical Fiber Cable.

- X. OFNP: Nonconductive Optical Fiber Plenum Cable.
- Y. OFNR: Nonconductive Optical Fiber Riser Cable.
- Z. OLTS: Optical Loss Test Sets.
- AA. OTDR: Optical Time Domain Reflectometer.
- BB. Plant SCADA System: Plant Supervisory Control and Data Acquisition System.
- CC. Plenum: Air return path of central air handling system, such as open space above suspended ceiling.
- DD. UPS: Uninterruptible Power Supply.
- EE. V ac: Volts Alternating Current.
- FF. WAN: Wide Area Network.

1.04 SYSTEM DESCRIPTION

- A. This section covers requirements for communications networks.
 - 1. The plant network(s) will be used by several systems including the security system, plant business network, and plant SCADA control system.
 - a. FOCS: Function of the FOCS is to transmit digital data between the network nodes over fiber media. Requirements listed identify minimum acceptable system performance.
 - b. CAT6: Function of the CAT6 is to transmit digital data between the network nodes and devices over copper media. Requirements listed identify minimum acceptable system performance.
 - c. Refer to Block Diagrams and Electrical Plans on the Drawings for illustration of the complete network.
 - 2. Contractor shall submit, provide, install, label, and test all network cabling. This shall include all FOCS and all CAT6 cabling. Refer to the Drawings. Network Block diagrams illustrate the fiber cabling, CAT6 cabling, and network connections to the multiple systems.
 - 3. Contractor shall provide network cabling, installation, and testing for the following network components:
 - a. Section 40 91 00, Instrumentation and Control Components.
 - b. All NIPs.
 - c. SCADA server rack.

4. Contractor shall provide network cabling, connection, labeling, and testing for the following network components and systems that will be supplied by others:
 - a. Section 26 09 13, Power Measurement and Control.
 - b. Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems.
 - c. Section 40 99 90, Package Control Systems.
5. Contractor shall be responsible for connecting, labeling, and testing the entire network.
 - a. Contractor shall provide cable connections for the entire network, and all network components.
 - b. Contractor shall be responsible for providing complete testing of the entire network, and all network components.
 - c. Contractor shall provide terminations to, and communications through all components. This shall include testing, test documentation, and testing submittals for the entire completed network. The entire completed network is for all fiber optic cabling, all CAT6 cabling, all fiber and CAT6 terminations, and all components contained on the entire network.
 - d. Contractor shall be responsible for labeling every cable per requirements of TIA/EIA 606-A labeling standards and in accordance with the Network Patching Drawings.
 - e. Cabling shall be installed per ANSI/NECA/BICSI 568-2006, Standard for Installing Commercial Building Telecommunications Cabling.
6. Refer to the Network Drawings and Site Electrical Drawings for routing, cabling, terminations, locations, labeling, and all other information required for fiber optic and CAT6 installation and testing.

1.05 SUBMITTALS

A. Action Submittals:

1. Network Site Layout Diagrams showing access holes with identification belowgrade conduit routings, and innerduct routings, between the access holes, and buildings, with conduit identifications. Cable routing through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identifications. Coordinate with duct bank schedules and cable block diagrams in the Contract Documents.
2. Cable Schedule Showing:
 - a. Cable identification.
 - b. Fiber counts for each cable and identification of used fiber pairs.
 - c. Cable length and attenuation, with two connector pairs and no splice(s), based on TIA 568-C.3, Annex H.

3. Component Data:
 - a. Manufacturer and model number.
 - b. General data and description.
 - c. Engineering specifications and data sheet.
 - d. Scaled Drawings and mounting arrangements.
4. Coordinate with duct bank schedules and cable block diagrams in the Contract Documents.

B. Informational Submittals:

1. Manufacturer's statement that installer is certified to perform installation Work.
2. Contractor Qualifications:
 - a. FOCS Contractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar systems.
 - 1) Statement of Experience:
 - a) List of at least three fiber optic data communications systems comparable to system specified which have been furnished and placed into operation. For each system, provide following information:
 - (1) Description of system hardware configuration including major equipment items, number of nodes, and communication standards implemented.
 - b. FOCS Contractor's Site Representative: Minimum of 5 years' experience installing similar systems. Lead cabling installation personnel shall have BICSI Installer 2 or Technician certification.
 - c. Qualification of Personnel:
 - 1) Resumes identifying management and technical qualifications of supervisory, local service representative, and key personnel.
 - 2) Qualification data of firm and persons to demonstrate capabilities and experience in the following areas:
 - a) Fiber optic cable handling and placement techniques.
 - b) Fiber optic splicing and installation of connections.
 - c) Attenuation testing procedures.
 - d. Sample of Network Test Report, minimum 10 pages that Contractor generated in a previous project.
3. Testing and acceptance plan, 30 days prior to beginning of testing.
4. Network Cable, Network Components, and Network Connection Tests: Test Procedures: Final test procedures, test forms, and checklists.
5. Test Documentation:
 - a. Signed test forms for FOCS and CAT6 network, including:
 - 1) All FOCS and CAT6 networks.
 - 2) All FOCS and CAT6 connections.
 - 3) All FOCS and CAT6 components.

- 4) Fiber Test Results:
 - a) Documentation covering fiber facility testing, not later than 2 days after testing, showing:
 - (1) Manufacturer's tag of attenuation per fiber as recorded from OTDR reading before shipment.
 - (2) Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
6. Manufacturer's Certificate of Compliance, in accordance with Section 01 67 00, Product Requirement.
7. Manufacturer's suggested installation practice.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable:

1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.
2. Outside, Overhead: Minus 20 degrees C to 60 degrees C.
3. Outside, Aboveground in Conduit: Minus 20 degrees C to 60 degrees C.
4. Inside: 0 degree C to 40 degrees C.

B. CAT6 Cable: Minus 20 degrees C to 75 degrees C.

C. Equipment:

1. Outside, Aboveground: Minus 20 degrees C to 60 degrees C.
2. Control Rooms, Equipment Rooms: 30 percent to 55 percent relative humidity, 18 degrees C to 24 degrees C.
3. Other Interior Areas: 0 percent to 100 percent relative humidity, 5 degrees C to 35 degrees C.

1.07 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Fiber Optic Cable:
 - a. ISO 9001 or QF TL 9000 registered, whichever applies to material.
 - b. Minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance.
 - c. Furnish all cable and appurtenances manufactured within 1 year of installation.
2. Patch Cord.
3. Jumper Cable: ISO 9001 and QF TL 9000 registered.

B. CAT6:

1. Cable: In accordance with Section 26 05 05, Conductors.
2. RJ-45 Connector: In compliance with ISO-8877 and TIA 568 standards.

C. Installer Qualifications:

1. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
2. Certified by fiber cable manufacturer.
3. Lead cabling installation personnel shall have BICSI Installer 2 or Technician certification.

D. Tester Qualifications:

1. Fiber Optic:
 - a. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
 - b. BICSI Certification: BICSI Installer 2, Optical Fiber or Technician certification.
 - c. Qualified to test with an OLTS and an OTDR.
2. CAT6:
 - a. BICSI Certification: BICSI Installer 2, Copper or Technician certification.

PART 2 PRODUCTS

2.01 FIBER OPTIC CABLE

A. Single-Mode Fiber Optic Cable:

1. Physical Characteristics:
 - a. Suitable for the installed environment.
 - b. Color-coded fibers according to TIA/EIA-598.
 - c. Color-coded buffer tubes according to TIA/EIA-598.
 - d. Provide the high tensile strength Aramid yarns and/or fiberglass helically stranded evenly around the cable core:
 - 1) No metallic elements whatsoever are allowed in non-armored cable.
 - 2) The jacket or sheath shall be free of holes, splits, and blisters.
 - 3) Fiber Core Diameter: 8.2 micron.
 - 4) Cladding Diameter: 125 micron.

2. Functional Characteristics:
 - a. Fiber Category: Type OS2:
 - b. Individual Fibers:
 - 1) Graded-index for use in ducts, backbone and horizontal distribution systems, and risers, meets or exceeds the requirements of TIA 568 C.3 including the requirements in Performance Characteristics.
 - a) Chromatic Dispersion:
 - (1) Zero-Dispersion Wavelength: Between 1,302 nm and 1,322 nm.
 - (2) Maximum value of dispersion slope at zero dispersion wavelength shall be no greater than 0.093 ps per km-nm².
 - b) Maximum Mean Fiber Loss:
 - (1) 0.4 dB per km at 1310 nm.
 - (2) 0.4 dB per km at 1550 nm.
 - c) Distance Capacity: 1 GB Ethernet at 5000 m at 1310 nm.
 - c. Assembly:
 - 1) Distribution Style with core of individually tight-buffered fibers surrounded by nonmetallic sheath.
 - 2) Cable: Comply with ICEA S-104-696.
 - 3) Water-swallowable strength members
 - 4) Fiber Count: As shown on the Drawings.
 - d. NEC/UL Listing: OFNR
 3. Performance Characteristics:
 - a. Chromatic Dispersion:
 - 1) Zero-Dispersion Wavelength: Between 1,302 nm and 1,322 nm.
 - 2) Maximum value of dispersion slope at zero dispersion wavelength shall be no greater than 0.093 ps per km-nm².
 - b. Maximum Mean Fiber Loss:
 - 1) 0.4 dB per km at 1310 nm.
 - 2) 0.4 dB per km at 1550 nm.
 - c. Distance Capacity: 1 GB Ethernet at 5000 m at 1310 nm.

2.02 INNERDUCT

A. Physical Characteristics:

- a. Type: Annular, corrugated innerduct.
- b. Material: HDPE.
- c. Color Code: Orange, blue, green, brown, white, or grey.
- d. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
- e. Lubrication: Prelubricated.

B. Functional Characteristics:

1. General: Install into all conduits for routing fiber, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.
2. Features:
 - a. Size and Count, in 4-inch Conduit: 3-Innerducts.
 - b. Size and Count, in 2-inch Conduit: 2-Innerducts.

C. Performance Characteristics: None.

2.03 NETWORK INTERFACE PANELS (NIPS)

A. Physical Characteristics:

1. Material: Steel.
2. Finish: Black.

B. Functional Characteristics:

1. Provides secure place to terminate fiber optic cables and CAT6 cables, and mount network servers, patch panels, and other network components.

C. In accordance with the Drawings and the Local Control Panel Schedule in Section 40 90 00, Instrumentation and Control for Process Systems.

D. Performance Characteristics: None.

2.04 LOCAL CONTROL PANELS (LCPS) NEW AND EXISTING

A. Physical Characteristics:

1. Material: Steel.
2. Finish: Black.

B. Functional Characteristics: In accordance with the Drawings and the Local Control Panel Schedule in Section 40 90 00, Instrumentation and Control for Process Systems.

C. Performance Characteristics: None.

2.05 CONNECTORS

A. Physical Characteristics:

1. Comply with TIA/EIA 604-2, TIA/EIA 604-3, TIA/EIA 604-12, and TIA 568-C.3.
2. LC connectors.

B. Functional Characteristics:

1. Pull Strength: 0.2 N minimum.
2. Durability: Sustain minimum 500 mating cycles without violating other requirements.
 - a. Ferrules: Free-floating low loss ceramic.
 - b. Polarizing key on duplex connector systems.

C. Performance Characteristics:

1. Attenuation:
 - a. In accordance with TIA 568-C.3.
 - b. Maximum of 0.75 dB per connector pair.

2.06 FIBER OPTIC PATCHCORDS

A. Physical Characteristics:

1. In accordance with TIA 568-C.3 and TIA/EIA-604-10.
2. Suitable for the installed environment.
3. Cable Rating: OFNR or OFNP.
4. Color: Per standards or as indicated.
5. Type OS2:
 - a. Fiber Core Diameter: 8.2 micron.
 - b. Cladding Diameter: 125 micron.
6. Cable Configuration:
 - a. Two fiber.
 - b. Tight-buffered thermoplastic, single-mode OS2 to match fibers being jumpered.
 - c. Protected with Aramid strength members and enclosed in thermoplastic jacket.
 - d. Connectors:
 - 1) LC both ends:
 - a) Ferrule Material: Ceramic.
7. Length: Standard, to meet requirements shown.

B. Functional Characteristics:

1. In accordance with TIA 568-C.3 and TIA/EIA-604-10.
2. Function: Connect fiber centers to network nodes, such as computer servers.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Connectors:
 - a. Patch Panel End: LC style.
 - b. Equipment End: LC style for network switches; match equipment connector style for other equipment.
 - c. On-axial Pull Strength: 33 N.
 - d. Normal-to-Axial Pull Strength: 22 N.
5. Environmental Condition Operational Range: -10 degree C to 60 degree C.

C. Performance Characteristics:

1. Measured for insertion loss with the following values for each connector:
 - a. Fiber shall be measured for insertion loss with the following values for each connector pair:
 - 1) Typical of 0.15 dB and maximum of 0.25 dB.

2.07 CAT6 PATCHCORDS:

A. Physical Characteristics:

1. In compliance with the Category 6 Cable requirements in Article Cat6 Cable (Type 30), included herein.
2. Wire: Stranded or solid copper.
3. Colors:
 - a. SCADA Network: Blue.
 - b. Business Devices: Green.
4. Connectors:
 - a. Factory pre-terminated.
 - b. Comply with Article Data and Telephone Outlets.

- B. Functional Characteristics: In compliance with the Category 6 Cable requirements in Article Cat6 Cable (Type 30), included herein.
- C. Performance Characteristics: 1000Base-T (Gigabit Ethernet), 100 Base-T, 10 Base-T, FDDI, ATM, PoE ++ IEEE 802.3 bt Type 3 and Type 4 is applicable for max. 10m patch cord applications.

2.08 CAT6 CABLE (TYPE 30)

A. Physical Characteristics:

- 1. General:
 - a. Dielectric Strength: 2.5 kV DC.
 - b. Maximum Contact Resistance: 20 milli-Ohm.
 - c. Voltage Rating: 72 VDC.
 - d. Operating Temperature Range: -20 degree C to 60 degree C.
 - e. Four color-coded, twisted pair wire with separator spline between pairs and aluminum foil shield around each pair.
 - f. Current Rating: 5 amp at 48 volt.
 - g. Connectors:
 - 1) In compliance with Article Data and Telephone Outlets.
 - 2) Shielded when terminating shielded cable.
- 2. 600-Volt:
 - a. Application: Any length or portion of a Type 30 cable internal to switchboard, outdoors and in duct banks, MCC and VFD/AFD enclosures, or enclosure with voltages greater than 300V.
 - b. Category 6 with overall shield, UL listed, and third party verified to comply with TIA/EIA 568.2-D Category 6 requirements.
 - c. Provide four each individually twisted pair, 23 AWG solid copper conductors, with low-smoke zero halogen high-density polyethylene insulation and black thermoplastic jacket.
- 3. 300-Volt:
 - a. Application: All locations, excluding 600-volt applications.
 - b. Category 6, unshielded, UL listed, and third party verified to comply with TIA/EIA 568-C.2 Category 6 requirements.
 - c. Provide four each individually twisted pair, 22 AWG solid copper conductors, with low-smoke zero halogen high density polyethylene insulation and teal thermoplastic jacket.

B. Functional Characteristics:

- 1. General:
 - a. Suitable for outdoor use, when installed in underground/underslab conduit or outdoors. Otherwise, indoor rated is acceptable.

- b. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum, without visible stress or damage to the jacket or insulation.
 - c. Data Category: Category 6.
 - 2. 600-Volt:
 - a. POE Compliant: TIA TSB-184 to 88 meters.
 - 3. 300-Volt:
 - a. POE Compliant: TIA TSB-184 to 85 meters.

C. Performance Characteristics: None.

2.09 HDMI CABLE

A. Physical Characteristics:

- 1. General:
 - a. Color: Black.
 - b. Cable Type: Category 3 (4k) at 60-Hz, 18 Gb/s, HDMI 2.1.
- 2. HDMI Cable (Passive):
 - a. Application: All locations, length less than 15 feet.
 - b. Cable: 28AWG with PCV Jacket, Minimum Bend Radius of 1.5 inches.
- 3. HDMI Cable (Fiber Active Optical Cable):
 - a. Application: All locations, length greater than 15 feet.
 - b. Cable: 30 AWG with PCV Jacket, Minimum Bend Radius of 2 inches.

B. Functional Characteristics:

- 1. HDMI Cable (Passive):
 - a. Category 3 (4k) at 60-Hz, 18 Gb/s, HDMI 2.1.
 - b. Max Supported Video Resolution: 3840 x 2160 @ 60-Hz.
 - c. Operating Temperature: Minus 10 degree C to 50 degrees C (14 degrees F to 122 degrees F).
 - d. Operating Relative Humidity: 0 percent to 90 percent without condensation.
- 2. HDMI Cable (Fiber Active Optical Cable):
 - a. Category 3 (4k) at 60-Hz, 18 Gb/s, HDMI 2.1.
 - b. Max Supported Video Resolution: 3840 x 2160 @ 60-Hz.
 - c. Environmental Conditions:
 - d. Operating Temperature: 0 degree C to 45 degrees C (0 degrees F to 113 degrees F).

- e. Operating Relative Humidity: 10 percent to 85 percent without condensation.

C. Performance Characteristics: Category 3 (4k) at 60-Hz, 18 Gb/s, HDMI 2.1.

2.10 CONDUIT

A. In accordance with Section 26 05 33, Raceways and Boxes.

2.11 DATA AND TELEPHONE OUTLETS

A. Physical Characteristics:

1. 300-Volt Cable CAT6 Outlet/Connector:
 - a. Comply with FCC Part 68.5 and TIA/EIA 568-B.2-1 Category 6.
 - b. UTP outlet/connector shall be UL 1863 listed, nonkeyed, four-pair, constructed of high impact rated thermoplastic housing, third-party verified, and shall comply with TIA/EIA Category 6 requirements.
 - c. Shall comply with TIA/EIA 568-B.2-4.
 - d. Cover Plates: Comply with UL 514C, and TIA/EIA 568-B.1; flush design constructed of high impact thermoplastic material. Provide stenciled lettering for voice and data circuits using thermal ink transfer process.
 - e. Color Coding:
 - 1) Provide data and telephone outlets color coded by network function indicated on the Drawings:
 - a) SCADA Network: Blue.
 - b) Business Network: Green.
2. 600-Volt Cable CAT6 Connector:
 - a. Shielded RJ45 plug with integral C-crimp.
 - b. Performance:
 - 1) Meet or exceed ANSI TIA 568.2-D, IEC 60603.
 - 2) Meet or exceed ANSI TIA 1096 (formerly FCC Part 68).
 - c. Cable Diameter: Up to 0.310 inch.

B. Functional Characteristics:

1. General:
 - a. Provide strain relief boots.
2. 300-Volt Cable CAT6 Outlet/Connector:
 - a. Comply with FCC Part 68.5 and TIA/EIA 568-B.2-1 Category 6.
 - b. Terminate using a 110 style PC board connector, color-coded for both T568A and T568B wiring. Wire each jack T568A or as indicated.
 - c. Comply with TIA/EIA 568-B.2-4.

3. 600-Volt Cable CAT6 Connector:
 - a. Shielded RJ45 plug with integral C-crimp.
 - b. Performance:
 - 1) Meet or exceed ANSI TIA 568.2-D, IEC 60603.
 - 2) Meet or exceed ANSI TIA 1096 (formerly FCC Part 68).
 - c. Operation Temperature: Negative 40 degrees C to plus 85 degrees C.

C. Performance Characteristics:

1. 300-Volt Cable CAT6 Outlet/Connector:
 - a. Comply with FCC Part 68.5 and TIA/EIA 568-B.2-1 Category 6.
 - b. Shall comply with TIA/EIA 568-B.2-4.
2. 600-Volt Cable CAT6 Connector:
 - a. Performance:
 - 1) Meet or exceed ANSI TIA 568.2-D, IEC 60603.
 - 2) Meet or exceed ANSI TIA 1096 (formerly FCC Part 68).

2.12 ACCESSORIES

A. Hardware:

1. Physical Characteristics:
 - a. Cable Clamps: Steel with rubber cushion.
 - b. Strain Relief Boots: Plastic or rubber color to match cable and connector.
 - c. Closures:
 - 1) Outdoors: IP68 watertight.
 - a) Finish: Black.
 - 2) Indoors: Steel.
 - a) Finish: Black
 - d. Fan out kits: As required for fiber optic cable employed.
 - e. Blocking and Grommets: Plastic or rubber.
2. Functional Characteristics:
 - a. Cable Clamps: Self-locking or fastener.
 - b. Strain Relief Boots: Riser and plenum rated.
 - c. Closures:
 - 1) Outdoors: Provide with pigtails, mechanical compression rubber sealing cable grommets, rubber seal, 24 single fusion splice tray and color-coded fan outs.
 - 2) Indoors:
 - a) Provide with pigtails, strain relief clamps, splice tray and color coded fan outs.
 - b) Number of ports as required by the Drawings.
3. Performance Characteristics: None.

B. Labels:

1. Physical Characteristics:
 - a. Self-Laminating Vinyl.
 - b. Color: Black on White.
2. Functional Characteristics: Field printable, field applied labels for data cabling.
3. Performance Characteristics: None.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduit:

1. Ensure installed conduit system conforms to fiber optic system requirements, including:
 - a. Conduits and Innerducts: Size and number.
 - b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts may be installed without exceeding manufacturer's limitations.
 - c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.
2. Expansion Plugs: Seal conduit to stop ingress of water and grit with fabricated expansion plugs.
3. Ensure duct bank, conduit, and other confined routing is free and clear of debris before cable placement.

B. Innerduct:

1. In accordance with manufacturer's recommendations.
2. In all fiber optic conduits and anywhere multiple fiber optic cables share one common conduit.
3. Install no more than one innerduct of each color in single conduit.
4. Terminate innerducts in conduit with fabricated termination kits.
5. Identify innerducts at both ends by methods, such as color-coding or waterproof tags, wired through innerduct wall.
6. Sealing:
 - a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
 - b. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
 - c. Empty Innerducts: After installation, seal with fabricated expansion plugs to stop ingress of water and grit. Remove plugs as required to install cables.

3.02 INSTALLATION

- A. NIP and LCPs: Install securely in field in accordance with manufacturer's installation instructions and as shown on the Drawings.
- B. Cables: Cabling shall be installed per ANSI/NECA/BICSI 568-2006, Standard for Installing Commercial Building Telecommunications Cabling.
- C. Grounding: Grounding shall be installed per NECA/BICSI 607-2011, Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings.
- D. Fiber Optic Cable:
 - 1. Specified fiber counts, routing, origination, and terminating points are indicated on the Drawings.
 - 2. Installation by manufacturer's certified installer.
 - 3. Install cables in accordance with manufacturer's requirements.
 - 4. Install cable directly from shipping reels. Ensure that cable is:
 - a. Not dented, nicked, or kinked.
 - b. Not subjected to pull stress greater than manufacturer's specification.
 - c. Not bent to a radius below manufacturer's minimum bend radius.
 - d. Not subjected to treatment that may damage fiber strands during installation.
 - 5. Cables per Conduit or Innerduct: In accordance with NFPA 70 NEC conduit fill limitations.
 - 6. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Contracting Officer.
 - 7. Splices: Install fiber optic cables in unspliced lengths between fiber centers. Do not splice.
 - 8. Connector: Insertion loss on multimode connections exceeding 0.5 dB not permitted.
 - 9. Identification:
 - a. Identify cable on both ends, in access holes, and pull points.
 - b. In accordance with TIA 606.
 - 10. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.
 - 11. Access Spaces:
 - a. Provide supports for cables in access spaces and hand holes at minimum every 2 feet.
 - b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

- E. NIP and LCPs, Fiber Patch Panels: Install securely in panels in accordance with manufacturer's installation instructions and as shown on the Drawings.
 - 1. Provide supports for cables at minimum every 2 feet.
 - 2. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.
- F. Fiber Cable Terminations:
 - 1. In accordance with TIA 568-C.3.
 - 2. Fan out fiber cable to allow direct connectorization of connectors.
 - a. Sleeve over individual fibers with transparent furcation tubes.
 - b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
 - 3. Break-out Kits:
 - a. Terminate cables using manufacturer-supplied break-out kits.
 - b. Terminate in accordance with manufacturer's recommendations.
 - 4. Slack: Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
 - 5. Connectors:
 - a. Terminate 100 percent of the fibers in each cable to specified connector.
 - b. Connect into fiber management system.
 - 6. Exposed individual fibers is not permitted. All fibers must be installed within a patch panel.
- G. CAT6 Cable:
 - 1. Cable counts, routing, origination, and terminating points are indicated on the Drawings.
 - 2. Installation by BICSI certified installer.
 - 3. Install cables and terminate cables in accordance with manufacturer's requirements.
- H. Data and Telephone Outlets: Terminate UTP cable in accordance with TIA/EIA 568 B.2 and wiring configuration specified.
- I. Patch Cords: Install securely in NIPs per manufacturer's instructions.
- J. Conduit: Install in accordance with Section 26 05 33, Raceways and Boxes.

3.03 LABELING CONVENTIONS

- A. Individual cables and Backbone (Riser) Cables: Label in accordance with Section 26 05 02, Basic Electrical Requirements. At a minimum, every fiber cable, fiber patch cord, CAT6 cable, and CAT6 patch cord/cable shall be labeled in accordance with the Network Patch Drawings on both ends. All

labels shall be included on all fiber and CAT6 network connections drawings. Labeling of every cable shall be per requirements of TIA/EIA 606-A labeling standards.

3.04 FIELD QUALITY CONTROL

A. General:

1. Advise Contracting Officer at least 48 hours in advance of each test. Contracting Officer shall have option to witness and participate actively in tests.
2. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.
4. Outlets, cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.
5. Testing performed on incomplete systems shall be redone on completion of the Work.
6. Document Test Results: Confirm each cable has at least specified number of fibers.
7. Confirm quantities and sizes of conduit and innerduct.
8. Test all CAT6 cables inclusive of connectors and network components.
9. Test all fiber cables inclusive of connectors and network components.

B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.
2. Optical Fiber Cable Testers:
 - a. Field test instrument shall be within calibration period recommended by manufacturer.
 - b. Optical Loss Test Set (OLTS):
 - 1) Single-mode Optical Fiber Light Source: Dual laser light sources with central wavelengths of 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
 - 2) Multi-mode Optical Fiber Light Source: Dual LED light sources with central wavelengths of 850 nm (plus or minus 30 nm) and 1,300 nm (plus or minus 20 nm). Meet launch requirements of TIA/EIA 455-78.
 - 3) Power Meter:
 - a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.
 - b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
 - c) Store reference power measurement.

- d) Save at least 100 results in internal memory.
 - e) PC interface (serial or USB).
 - 4) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.
 - 5) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.
- 3. Optical Time Domain Reflectometer (OTDR):
 - a. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
 - b. Serial and USB ports to transfer data to PC.
 - c. Single-mode OTDR:
 - 1) Wavelengths: 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
 - 2) Event Dead Zone: 2 meters maximum at 1,310 nm and 2 meters maximum at 1,550 nm.
 - 3) Attenuation Dead Zone: 15 meters maximum at 1,310 nm and 15 meters maximum at 1,550 nm.
 - 4) Distance Range: Minimum 10,000 meters.
 - 5) Dynamic Range: Minimum 10 dB at 1,310 nm and 1,550 nm.
 - d. Multi-mode OTDR:
 - 1) Wavelengths: 850 nm (plus or minus 20 nm) and 1,300 nm (plus or minus 20 nm).
 - 2) Event Dead Zone: 1 meter maximum at 850 nm and 2 meters maximum at 1,300 nm.
 - 3) Attenuation Dead Zone: 6 meters maximum at 850 nm and 15 meters maximum at 1,300 nm.
 - 4) Distance Range: 2,000 meters minimum.
 - e. Dynamic Range: Minimum 10 dB at 850 nm and 1,300 nm.
- 4. Fiber Microscope:
 - a. Magnification: 250X or 400X for end-face inspection.
- 5. Integrated OLTS, OTDR, and Fiber Microscope:
 - a. Test equipment that combines into one instrument, such as OLTS, OTDR, and fiber microscope may be used.

C. Conduit Test:

- 1. Test and seal spare conduits.
- 2. Conduit and Innerduct Testing:
 - a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
 - b. If conduit is restricted over full length, advise Contracting Officer.
- 3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

D. Cable Testing:

1. Test procedures and field test instruments shall comply with applicable requirements of:
 - a. LIA Z136.2.
 - b. TIA/EIA 455-78.
 - c. TIA/EAI 455-133.
 - d. TIA 526-7.
 - e. TIA 526-14.
 - f. TIA 568-C.1.
 - g. TIA 568-C.3.
 - h. TIA TSB 140.
2. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.
3. Verify condition of fiber end face.
4. Perform on each cabling link (connector to connector).
5. Perform on each cabling channel (equipment to equipment).
6. Do not include active devices or passive devices within link or channel other than cable and connectors. For example, link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
7. Document Tests:
 - a. OLTS dual wavelength attenuation measurements for single-mode and multimode links and channels.
 - b. OTDR traces and event tables for single-mode and multimode links and channels.

E. Fiber Testing Parameters:

1. Each cabling link shall be in compliance with the following test limits:
 - a. Optical Loss Testing:
 - 1) Single-Mode and Multimode Links:
 - a) Calculate link attenuation by the formulas specified in TIA 568-C.1.
 - b) Values for Attenuation Coefficient (dB/km) are listed in the table below:

Attenuation Coefficient				
Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Single - Mode	1310	.50	1550	.50
Multimode 50/125 µm	850	2.5	1300	1.5

- b. OTDR Testing:
 - 1) Reflective Events: Maximum 0.75 dB.
 - 2) Nonreflective Events: Maximum 0.3 dB.
- c. Magnified Endface Inspection:
 - 1) Visually inspect fiber connections for end-face quality.
 - 2) Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Fiber Test Execution:

- 1. Optical Fiber Cable Testing:
 - a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
 - b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
 - 1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
 - c. Perform Testing:
 - 1) On each cabling segment (connector to connector).
 - 2) On each cabling channel (equipment to equipment).
 - 3) Using high-quality test cords of same fiber type as cabling under test.
 - a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
 - b) Test cords for OTDR testing shall be approximately 100 meter for launch cable and at least 25 meters for receive cable.
- 2. Optical Loss Testing (OLTS):
 - a. Links:
 - 1) Test singlemode at 1310 nm and 1550 nm in accordance with TIA 526-7, Method A.1. One Reference Jumper or equivalent method.
 - 2) Test multimode at 850 nm and 1,300 nm in accordance with TIA 526-14A, Method B, One Reference Jumper, or equivalent method.
 - 3) Perform tests in both directions.
- 3. OTDR Testing:
 - a. Test backbone, horizontal, and centralized links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
 - 1) Single-mode: 1,310 nm and 1,550 nm.
 - 2) Multimode: 850 nm and 1,300 nm.
 - b. Test each fiber link and channel in one direction.

- c. Install launch cable between OTDR and first link connection.
 - d. Install receive cable after last link connection.
- 4. Length Measurement:
 - a. Record length of each fiber.
 - b. Measure optical length using OLTS or OTDR.
- 5. Polarity Testing:
 - a. Test paired duplex fibers in multifiber cables to verify polarity in accordance with subclause 10.3 of TIA/EIA 568-C.1.
 - b. Verify polarity of paired duplex fibers using OLTS.
- 6. Test Results Documentation:
 - a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered.
 - b. Available for inspection by Contractor or Contractor's representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
 - c. Database for Project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered electronically prior to Contractor acceptance of building. Submittal shall include software tools required to view, inspect, and print test reports.
 - d. Circuit IDs reported by test instrument shall match specified label identification.
 - e. Provide in electronic database for each tested optical fiber with the following information:
 - 1) Identification of Site.
 - 2) Name of test limit selected to execute stored test results.
 - 3) Name of personnel performing test.
 - 4) Date and time test results were saved in memory of tester.
 - 5) Manufacturer, model, and serial number of field test instrument.
 - 6) Version of test software and version of test limit database held within test instrument.
 - 7) Fiber identification number.
 - 8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.
 - 9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.
 - 10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.

- 11) Length for each optical fiber as calculated by the OTDR.
- 12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.

G. CAT6 Cable Testing:

1. Electrical performance as required for TIA-568-B including wiremap, cable length, insertion loss, near end crosstalk, power sum near end crosstalk, equal level far end crosstalk, power sum equal level far end crosstalk, return loss, propagation delay, and delay skew.
2. Physical installation shall be certified by the installer, including location of cabling with respect to electrical noise and environmental conditions, grounding of devices, cable bending radii, cable supports, and terminations.
3. Test Equipment: Fluke Networks DTX 1800 or DSX 5000 with permanent link adapters.

H. CAT6 Test Execution:

1. Test results shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
 - a. Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
 - b. Perform Testing:
 - 1) On each cabling segment (connector to connector).
 - 2) Length measurement: Record length of each segment.
 - 3) Insertion loss.
 - 4) Near end crosstalk.
 - 5) Power sum near end crosstalk.
 - 6) Attenuation to crosstalk ratio – near end.
 - 7) Power sum attenuation to crosstalk ratio – near end.
 - 8) Far end crosstalk.
 - 9) Attenuation to crosstalk ratio – far end.
 - 10) Power sum attenuation to crosstalk ratio – far end.
 - 11) Return loss.
 - 12) Wire map.
 - 13) Propagation delay.
 - 14) Delay skew.
2. Test Results Documentation:
 - a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, “as saved in the field-test instrument.” The file format, CSV (comma separated

value), does not provide adequate protection of these records and shall not be used as the primary means of data storage.

- b. Database for Project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered electronically prior to Contractor acceptance of building. Submittal shall include software tools required to view, inspect, and print test reports.
- c. Circuit IDs reported by test instrument shall match specified label identification.
- d. Provide in electronic database for each tested cable with the following information:
 - 1) Identification of Site.
 - 2) Name of test limit selected to execute stored test results.
 - 3) Name of personnel performing test.
 - 4) Date and time test results were saved in memory of tester.
 - 5) Manufacturer, model, and serial number of field test instrument.
 - 6) Version of test software and version of test limit database held within test instrument.
 - 7) Cable identification number.
 - 8) Overall pass/fail evaluation.

I. Diagnosis and Correction:

- 1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.
- 2. Link or channel that fails these requirements shall be diagnosed and corrected.
- 3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.
- 4. Provide final and passing result of tests for links and channels.

J. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of the Contractor.

K. Communication System(s) Functional Tests:

- 1. Upon completion of cable and component installation and testing, and upon acceptance of cable and component testing submittals, the entire Network Communication System shall be tested as a functional system.

2. Test Execution:
 - a. Confirm network can operate under load over a time duration using automatic testing equipment.
 - b. Testing shall conform to RFC 2544 and RFC 6349.
 - 1) Throughput.
 - 2) Burst.
 - 3) Frame loss.
 - 4) Latency.

L. Drawings:

1. Record Copy: Provide at end of Project.
 - a. Include notations reflecting as-built conditions of additions and variations from Drawings provided, such as to cable path and termination point.
 - b. The Drawings are to incorporate test data imported from test instruments.
2. As-Built Drawings:
 - a. Include, but not limited to block diagrams, cable labeling, and cable termination points.
 - b. Include field changes made up to construction completion.

END OF SECTION

