PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Single mode and multimode fiber optic cables.
B. Composite cables (OCA combined optical fiber and copper conductors).
C. Telephone cables.
D. Fire telephone and emergency trip system cables.
E. Multiple conductor control cables.
F. SCADA DeviceNet cables.
G. Video coaxial cables.
H. Radio coaxial cables.
I. Slotted radio coaxial cables.
J. Public announcement (PA) cables.
K. Category 6 cables.
L. Category 6A cables and patch cables.
M. Outside plant (OSP) Category 6A cables and patch cables.
N. Related equipment:
   1. Optical connectors
   2. Fiber entrance cabinets (FEC)
   3. Fiber patch panels
   4. Category 6/6A patch panels
   5. Outlets, hardware, and connections
   6. Fiber optic patch cords
   7. Pigtail cables
   8. Copper splice cases
9. Terminal blocks

10. Test equipment

1.02 RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures
B. Section 01 33 23, Shop Drawings, Product Data and Samples
C. Section 01 43 00, Quality Assurance
D. Section 01 45 00, Quality Control
E. Section 01 78 44, Spare Parts and Maintenance Materials
F. Section 20 50 13, Raceways for Facility Services
G. Section 20 70 13, Common Materials and Methods for Electronic Services
H. Section 20 70 19, Indoor Cabinets, Racks, Frames and Enclosures
I. Section 20 70 23, Electronic Circuits, Wires, and Cables
J. Section 20 70 26, Common Materials and Methods for Electrical Services
K. Section 20 80 00, Systems Integration Testing
L. Section 20 72 25, Factory and Field Testing
M. Section 20 72 15, General Requirements for System Design
N. Section 26 05 24, Low Voltage Wires and Cables
O. Section 26 05 26, Grounding and Bonding for Electrical Systems
P. Section 27 21 00, Unified Optical Network
Q. Section 28 41 29, Closed Circuit Television System
R. Section 27 20 01, Computer and Communication Subsystems
S. Section 33 83 03, Radio Network/Antenna System
T. Section 33 83 06, Radio Network/Bidirectional Radio Amplifier System
U. Drawing K001, Train Control, Communication Cabinets Power and Grounding Requirements
1.03 MEASUREMENT AND PAYMENT

A. The work specified in this Contract Specifications Section will be paid for under the applicable Bid Items based on the locations where work is performed, as identified in the Form – Description of Bid Items, in accordance with Contract Specifications Section 01 20 00, Price and Payment Procedures.

1.04 REFERENCES

A. American National Standards Institute (ANSI):


2. ANSI/TIA/EIA-568 Commercial Building Telecommunications Cabling Standards Set

3. ANSI/TIA/EIA-758 Customer-Owned Outside Plant Telecommunications Cabling Standard

B. American Society for Testing and Materials International (ASTM):


C. Building Industry Consulting Services International (BICSI):

1. BICSI OSPDRM Outside Plant Design Reference Manual (OSPDRM)


D. California Code of Regulations (CCR):

1. Title 24, Part 3, California Electrical Code

E. Electronics Industries Association (EIA)/Telecommunications Industry Association (TIA):

1. EIA 359 Standard Colors for Color Identification and Coding

2. TIA-455 General Requirements for Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components

3. TIA-455-3 FOTP-3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
4. TIA-455-8  FOTP-8 Measurement of Splice or Connector Loss and Reflectance using an OTDR

5. TIA-455-13  FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies

6. TIA-455-25  FOTP-25 Impact Testing of Fiber Optic Cables

7. EIA/TIA-455-34  FOTP-34 Interconnection Device Insertion Loss Test

8. TIA-455-41  FOTP-41 Compressive Loading Resistance of Optical Fiber Cables


10. TIA-455-88  FOTP-88 Fiber Optic Cable Bend Test

11. TIA-455-91  FOTP-91 Fiber Optic Cable Twist-Bend Test

12. TIA-455-104  FOTP-104 Fiber Optic Cable Cyclic Flexing Test


15. TIA-455-204  FOTP-204 Measurement of Bandwidth on Multimode Fiber

16. EIA TIA-4720000  Generic Specification for Fiber Optic Cable

17. EIA 492AAAD  Detail Specification for 850-nm Laser-Optimized, 50-μm Core Diameter/125-μm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers Suitable for Manufacturing OM4 Cabled Optical Fiber

18. TIA-526-14  Optical Power Loss Measurement of Installed Multi-mode Fiber Cable Plant; Modification of IEC 61280-4-1 edition 2, Fiber-Optic Communications Subsystems Test Procedures- Part 4-1: Installed Cable Plant-Multi-mode Attenuation Measurement

19. TIA-568.0  Generic Telecommunication Cabling for Customer Premises

20. TIA-568.1  Commercial Building Telecommunications Infrastructure Standards
<table>
<thead>
<tr>
<th>21. TIA-568.2</th>
<th>Balanced Twisted Pair Telecommunications Cabling and Components Standard</th>
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<tr>
<td>22. TIA-568.3</td>
<td>Optical Fiber Cabling Components Standard</td>
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<tr>
<td>23. TIA-598</td>
<td>Optical Fiber Cable Color Coding</td>
</tr>
<tr>
<td>24. TIA-569</td>
<td>Commercial Building Standard for Telecommunications Pathways and Spaces</td>
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<tr>
<td>25. EIA TIA-606</td>
<td>Administration Standards for the Telecommunications Infrastructure</td>
</tr>
<tr>
<td>26. TIA-607</td>
<td>Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises</td>
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</tbody>
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F. Insulated Cable Engineers Association, Inc. (ICEA):

1. ICEA S-84-608 Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements

G. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 383 Standard for Qualifying Electric Cables and Splices for Nuclear Facilities
2. IEEE 730 Standard for Software Quality Assurance Processes
3. IEEE 802.3 Standard for Ethernet

H. Military Standard:

1. IAW MIL-STD-188-124-B Military Standard Grounding, Bonding, and Shielding

I. National Electrical Manufacturers Association (NEMA):

1. NEMA WC 70 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
2. NEMA WC 71 Nonshielded Cables Rated 2001-5000V for Use in the Distribution of Electric Energy
3. NEMA WC 74 5-46KV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

J. International Telecommunication Union (ITU-T):

1. G.657 Characteristics of A Bending-Loss Insensitive Single-Mode Optical Fibre and Cable
K. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code 2017
2. NFPA 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
3. NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems
4. NFPA 780 Standard for Installation of Lightning Protection Systems

L. Rural Electrification Administration (REA):

1. REA PE-39 Filled Telephone Cables

M. Underwriters Laboratories (UL):

1. UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords
2. UL 1666 Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
3. UL 1863 Safety Communications Circuit Accessories

1.05 ABBREVIATIONS

AWG American Wire Gauge
CD Chromatic Dispersion
CMP Communications Plenum Rated
DC Direct Current
DMP Designated Matching Products
DS Digital Signal
ETS Emergency Trip System
FEC Fiber Entrance Cabinet
FRPE Flame-retardant Polyethylene
GRP Glass Reinforced Plastic
IAW In Agreement With
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>IP</td>
<td>Internet Protocol</td>
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<tr>
<td>IPP</td>
<td>Internet Protocol Precedence</td>
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<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>LC</td>
<td>Lucent Connector</td>
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<td>LSZH</td>
<td>Low Smoke Zero Halogen</td>
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<tr>
<td>MM</td>
<td>Multimode</td>
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<tr>
<td>NMS</td>
<td>Network Management System</td>
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<tr>
<td>OADM</td>
<td>Optical Add-Drop Multiplexer</td>
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<tr>
<td>OCC</td>
<td>Operations Control Center</td>
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<tr>
<td>OFNP</td>
<td>Optical Fiber Non-Conductive Plenum</td>
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<tr>
<td>OM4</td>
<td>Optical Multimode 4</td>
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<tr>
<td>ONS</td>
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<td>Optical Return Loss</td>
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<tr>
<td>OSA</td>
<td>Optical Spectrum Analyzer</td>
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<tr>
<td>OTDR</td>
<td>Optical Time Domain Reflectometer</td>
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<tr>
<td>OTN</td>
<td>Optical Transport Network</td>
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<tr>
<td>PMD</td>
<td>Polarization Mode Dispersion</td>
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<tr>
<td>PTC</td>
<td>Project Test Center</td>
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<tr>
<td>QoS</td>
<td>Quality of Service</td>
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<tr>
<td>SC</td>
<td>Subscriber Connector</td>
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<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>SDH</td>
<td>Synchronous Digital Hierarchy</td>
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<tr>
<td>SFP</td>
<td>Small Form-Factor Pluggable</td>
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<tr>
<td>SM</td>
<td>Single mode</td>
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<tr>
<td>TCH</td>
<td>Train Control House</td>
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TCR  Train Control Room
TDM  Time Division Multiplexing
ToS  Type of Service
UAN  Unified Administration Network
UON  Unified Optical Network
UPC  Ultra Physical Contact
UTP  Unshielded Twisted Pair
UV   Ultraviolet
VLAN Virtual Local Area Network
VSS  Video Surveillance System
WDM  Wave Division Multiplexing
XFP  Small Form-Factor Pluggable (10 Gigabit)

1.06 SUBMITTALS
A. General: Refer to Contract Specifications Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
B. Submittal Requirements: Before installation of wires and cables, submit complete product data sheets for each type and size of wire and cable required for the project. Provide optical loss calculations for each span of the fiber optic network and indicate total anticipated optical loss in dB between OADM nodes.
C. Factory and Field Test Plans and Reports: Submit factory and field test plans and reports in accordance with Contract Specifications Section 20 72 25, Factory and Field Testing and Contract Specifications Section 20 80 00, Systems Integration Testing. Completed field test reports for all fiber and copper cables shall be submitted to the District for approval.

1.07 QUALITY ASSURANCE AND QUALITY CONTROL
A. Refer to Contract Specifications Section 01 43 00, Quality Assurance, and Contract Specifications Section 01 45 00, Quality Control, for hardware quality assurance requirements and IEEE 730 for software quality assurance requirements.
B. Products shall be manufactured by firms regularly engaged in manufacturing products described in this Section.
C. Field testing shall be performed by persons having five or more years of relevant testing experience.

1.08 DELIVERY, STORAGE, AND HANDLING

1. Provide markings on wire and cable in accordance with applicable NEMA and California Electrical Code requirements. Each item shall be labeled with UL listing approval.

2. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

3. Store wire and cable in a secure and dry storage facility.

4. If fiber optic cable is packaged for shipment, the reels shall be non-returnable wooden reels with a maximum reel diameter of 78 inches. The top and bottom ends of the cable shall be available for testing. Both ends of each cable shall be sealed to prevent the ingress of moisture.

PART 2 – PRODUCTS

2.01 SINGLE MODE FIBER OPTIC CABLE

A. General

1. Outside plant inter-facility cables shall be non-armored, gel-free, water blocking tape, single mode.


3. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Indoor-Outdoor Optical Fiber Cable (ICEA S-104-696).

4. Fiber optic cable assemblies, including jacketing and fibers shall be certified by the manufacturer to have a minimum life of 25 years.

5. Jacket printing: Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information shall include count of fibers, fiber type and size, cumulative footage markers, manufacturer’s designation, plant name (if applicable), and manufacturer’s name.

6. Single mode fiber optic cables shall have a bend performance that meets ITU-T G.657.
7. Single mode terminations shall be anaerobic, or fusion spliced for backbone cabling.

8. Count of optical fibers in each cable run, including fibers reserved for future use and for spares, shall be as indicated.

B. Fiber Specifications

1. Type: Single-mode, loose tube, gel-free, non-armored, Category OS2 rated.

2. Operating wavelength: 1310/1550 nm

3. Attenuation at 1310 nm: 0.35 dB/km, maximum

4. Attenuation at 1383 nm: 0.35 dB/km, maximum

5. Attenuation at 1550 nm: 0.22 dB/km, maximum

6. Polarization Mode Dispersion Link Value: 0.1 maximum.

C. Cable Construction

1. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.

2. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. Buffer tubes shall be resistant to kinking.

3. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598, Optical Fiber Cable Color Coding. The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.

4. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.

5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes.

6. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to prevent buckling of the cable. The GRP rod shall be over coated with a thermoplastic, when required, to achieve dimensional sizing to accommodate buffer tubes/fillers.

7. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or “S-Z,” stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.
8. Two polyester yarn binders shall be applied contra helically and with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

9. Flame-retardant tape may be applied to provide resistance to flame propagation. A water blocking tape shall be applied longitudinally around the outside of the flame-retardant tape.

10. The tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.

11. The jacket material shall be a flame-retardant, low-smoke, zero-halogen (LSZH) insulating compound that is ultraviolet (UV) resistant. Cables shall contain at least one ripcord under the sheath for easy sheath removal.

12. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as is consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

2.02 MULTIMODE FIBER OPTIC CABLE

A. General

1. Inside plant, intra-facility cables shall be 50 microns multimode.

2. Cables shall be manufactured in accordance with TIA-455-13, TIA-455-25, TIA-455-41, TIA-455-177, TIA-455-78, TIA 455-88, TIA 455-91, TIA 455-104, and TIA/EIA 455-171.

3. Finished cables shall conform to the applicable performance requirements of the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Indoor-Outdoor Optical Fiber Cable (ICEA S-104-696).

4. Fiber optic cable assemblies, including jacketing and fibers shall be certified by the manufacturer to have a minimum life of 25 years.

5. Each shipping length of cable shall be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information shall include count of fibers, fiber type and size, cumulative footage markers, manufacturer’s designation, plant name (if applicable), and manufacturer’s name or UL file number.

6. Individual fibers shall be color coded for identification in accordance with EIA TIA-598-A.
7. Count of optical fibers in each cable run, including fibers reserved for future use and for spares, shall be as indicated.

8. Multimode fiber optic cables shall have an OM4 multimode classification and be 550 MHz bend optimized, compliant to the IEC 60793-2-10, Type A1a.3 Fiber, and TIA/EIA-492AAAD standard.

9. Multimode fiber optic cables shall have a bend performance that meets ITU-T G.657.B.

10. Multimode fiber terminations shall be anaerobic or fusion spliced for backbone cabling.

B. Fiber Specifications

1. Type: Tight buffered, graded index multimode cables without armor and with an outer jacket rated for plenum or non-plenum duty as applicable.

2. Operating Wavelength and Bandwidth: 160 MHz·km at 850 nm and 500 MHz·km at 1300 nm.

3. Attenuation at 850 nm: 3.75 dB/km, maximum.

4. Attenuation at 1300 nm: 1.00 dB/km, maximum.

5. Core diameter: 50 μm plus or minus 3.0 μm optimized for 550 meters.

6. Cladding diameter: 125.0 μm plus or minus 2.0 μm.

7. Each tube and buffered fiber shall be color-coded to provide unique and permanently visible identification, in accordance with EIA 359-A.

8. Optical Performance: The attenuation shall be measured in accordance with EIA TIA-455-78. The bandwidth shall be measured in accordance with EIA TIA-455-30 or EIA TIA-455-204.

C. Cable Construction

1. Fibers shall be tight buffered to 900 μm diameter, using a tough elastomeric buffer material.

2. Buffered fibers to be stranded together with dielectric strength members.

3. Inner cable jacket to be pressure-extruded onto cabled fibers and strength members in the core assembly. This jacket material shall be of zero-halogen flame-retardant composition.

4. The jacket material shall be a flame-retardant, LSZH insulating compound that is UV resistant. The outer jacket shall be extruded over the shield in a tight-fitting assembly.
5. A 0.006-inch thick (minimum) corrugated electrolytic chrome coated steel tape, plastic coated on both sides, shall be tightly wrapped, around the inner jacket.

6. A ripcord (or two ripcords) of compatible material shall be built into the cable assembly, to facilitate removal of the wrap and jackets during installation.

2.03 COMPOSITE CABLE

A. Provide composite cables with combined optical fiber and copper conductors. Cables shall be composed of a 2-strand tight buffered fiber and 2 – No. 12 AWG copper conductors, one port assembly with associated connectors. Cables shall be a Designated Matching Product (DMP).

2.04 TELEPHONE CABLES

A. Refer to Section 20 70 23 for Non-IP telephone requirements.

B. Provide Category 6 telephone cables with a minimum of four pairs for inside plant line circuits. Inter-cabinet tie cables shall be UTP, 25, 50 or 100 pair cables as required to meet the active pair count as shown on the Contract Drawings including 50 percent spare pairs. Plenum cable shall be used where required by code(s). Use blue-jacketed cable for data and data/voice cables and green-jacketed cable for voice-only cables.

C. Telephone cables shall be certified by the manufacturer to have a minimum life of 40 years.

D. Category 6 or 6A cables shall be LSZH compliant in accordance with NFPA 70.

2.05 FIRE TELEPHONE AND EMERGENCY TRIP SYSTEM CABLES

A. Fire telephone and emergency trip system cables shall be six pair, 19 AWG solid, soft-annealed, insulated copper conductors with an overall shield. Cables shall meet the requirements of REA Specification PE-39 – Filled Telephone Cables. Fire telephone and emergency trip system cables shall be certified by the manufacturer to have a minimum life of 40 years.

2.06 MULTIPLE CONDUCTOR CONTROL CABLE

A. Provide multiple conductor cable conforming to NEMA WC 70, NEMA WC 71, and NEMA WC 74, approved for use in cable tray, with the following additional requirements:

1. Number of insulated conductors: As indicated in drawings.

2. Insulation: rated for 600V.

3. Overall covering: Cable shall be jacketed over the insulation.
4. Multiple conductors for control wire shall be a minimum of No. 14 AWG stranded copper.

B. Multi-conductor cable shall be made by assembling individual or twisted pairs of insulated conductors into a tight cylindrical form using fillers that are compatible with other materials in the cable. The jacket used shall fit tightly to form a firm assembly.

C. Multi-conductor cable shall be certified by the manufacturer to have a minimum life of 40 years.

D. Cables shall be LSZH compliant in accordance with NFPA-70.

2.07 SCADA DEVICENET CABLE

A. SCADA DeviceNet cable shall be a DMP.

2.08 VIDEO COAXIAL CABLE

A. Provide coaxial cables for analog video signal transmission:

1. 75 ohm characteristic impedance.

2. Double braided copper shield.

3. No. 20 AWG solid copper center conductor.

2.09 RADIO COAXIAL CABLE

A. Provide coaxial cables for radio signal transmission. Coaxial cables shall be size 1/4 inch minimum, jacketed, corrugated, low density foam-filled for trunked radio applications. The minimum design requirements and general characteristics are as follows:

1. 50 ohm characteristic impedance.

2. VSWR shall be 1.2: maximum at center frequency.

3. Minimum bending radius shall be 10 inches.

4. Attenuation shall not exceed 1.8 dB, referenced to MHz.

5. Outer conductor shall be solid copper.

6. Inner conductor shall be copper.

7. The cable shall be permanently identified.

8. Connectors shall be EIA type N jack (female) on both ends.
9. Grounding kits shall be provided to ground all coaxial cables to the tower top, tower bottom, and at the building entrance.

10. Snap-in hanger kits shall be provided to mount coaxial cable directly into holes in the tower support members.

2.10 SLOTTED RADIO COAXIAL CABLE

A. The minimal design requirements and general characteristics of the slotted coaxial cables are as follows:

1. The slotted coaxial cables shall pass the UL 854 and 1581 flame tests (similar to IEEE 383, NES 711/713, and IEC 332-3), UL listed under Article 820 of the National Electrical Code, and all code requirements must be approved by the fire inspector.

2. The slotted coaxial cables shall be jacketed, corrugated foam-filled cables suitable for mounting to a metallic (galvanized steel) messenger wire or hangers.

3. Cable jacket shall offer fire-retardant, hydro-carbon protection, halogen-free performance, low-level smoke and toxic fume emissions. The jacket shall be vertical tested and approved by Underwriters Laboratories.

4. Coupling loss measured at 20 feet shall not exceed the following:

   a. Coupling Loss (dB) @ Frequency Band (MHz).
      
      1) 82 @ 800
      2) 82 @ 900
      3) 73 @ 1800
      4) 72 @ 1900
      5) 71 @ 2200

5. Characteristics impedance shall be 50 ohms.

6. Typical VSWR shall be less than 1.3:1, referenced to 30, 150, 450 and 900MHz.

7. Minimum bending radius shall be 10 x diameter.

8. Attenuation measured at free space shall be less than 1.0 dB per 100 feet, referenced to 900 MHz.

9. Inner and outer conductors shall be copper

10. The cable shall be permanently identified.

11. Slotted coaxial cables shall be factory assembled, tested and furnished in continuous reel lengths of 2300 feet maximum with factory installed EIA type N female connectors on both ends.
12. The outer conductor shall be two layers of mica insulated barrier tape wrapped around the conductor to prevent dielectric material from leaking through the slots under fire conditions.

13. The cable shall have a flooding compound between the jacket and outer conductor barrier tape to prevent entry of water.

2.11 PUBLIC ANNOUNCEMENT (PA) CABLES
A. Provide PA 70V cable for PA speaker and amplifier hookup: No. 16 AWG cable shall cover overall length within station.

1. The PA cable shall be Belden 1307A, West Penn AQC225, No. 16 AWG stranded, grey color, indoor/outdoor, UL listed.

2.12 CATEGORY 6 CABLE
A. Category 6 cable and patch cables shall meet the TIA/EIA 568C standard and conform to the following requirements:

1. Unshielded cables shall only be utilized in non-wayside facilities. Unshielded cables shall be plenum rated with four balanced, unshielded twisted pairs (UTP). Conductors shall be No. 24 AWG solid copper. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.

2. Shielded cables shall be used in wayside facilities. Shielded cables shall be plenum rated with an overall foil tape shield and four balanced, unshielded twisted pairs (F/UTP). Conductors shall be No. 24 AWG solid copper. The shield shall be an aluminum foil tape enclosing a No. 24 AWG tinned copper drain wire. Cable insulation jackets shall be color coded for the service type: blue for data, white for voice, and green for video applications.

3. Cable jackets shall be legibly marked with the following information:
   a. Manufacturer’s name
   b. Copper conductor gauge
   c. Pair count
   d. UL or CSA listing
   e. Manufacturer’s trademark
   f. Category rating, including UTP, F/UTP or ScTP (screened twisted pair)
   g. Sequential foot markings, in one- or two-foot increments

4. Unshielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, No. 24 AWG stranded copper conductors with 50-micron, gold plated RJ-45 male to male connectors and a plenum jacket.
Shielded Category 6 patch cables shall be rated for 250 MHz or better and shall be composed of four, No. 24 AWG stranded copper conductors with shielded 50-micron, gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a No. 24 AWG tinned copper drain wire, and a plenum jacket.

B. General

1. Patch cable length shall meet eight feet unless approved by the Engineer. Patch cable exceeding eight feet shall be run between individual Category 6A patch panels with modular jacks.

2. Outside plant cable (OSP) rated cable shall be required for below-ground conduit installations.

3. Indoor rated cable is permitted for above ground conduit installations where cable is not exposed to the outdoor conditions. In areas where conduit installation is not environmentally controlled or exposed to outdoor conditions, provide grounding in accordance with NEC.

4. Cable installations not in conduit shall be terminated on primary protector blocks equipped with 5-pin solid state or gas protector modules. The protector blocks shall be bonded to the lightning protection ground with a No. 6 AWG or larger ground wire. Terminals and hardware shall be UL-listed, made of a flame-retardant construction, and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks, or RJ connectors. The protector block shall be placed as close to the lightning protection ground as possible.

5. Patch cords shall be factory made, and not spliced and terminated on-site. Patch cords shall have strain-relief RJ-45 non-keyed connectors. Patch cords shall terminate positions of the connector.

C. Category 6A cable and patch cables shall meet with the TIA/EIA 568C standard and conform to the following requirements:

1. Shielded cables shall be used in wayside facilities and for power over Ethernet (PoE/PoE+) connectivity requirements. Shielded cables shall be CMP-rated, plenum-rated with an overall foil tape shield and four-balanced, and unshielded twisted pairs (F/UTP). Conductors shall be No. 23 AWG to No. 24 AWG solid copper. The shield shall be an aluminum foil tape enclosing a No. 23 AWG to No.26 AWG tinned copper drain wire. Cable shields and drain wire shall be installed to connect to the building signal ground in accordance with ANSI-J-STD-607-A.

2. Cable jackets shall be legibly marked with the following information:
   a. Manufacturer’s name
   b. Copper conductor gauge
   c. Pair count
d. UL or CSA listing
e. Manufacturer’s trademark
f. Category rating, including UTP or F/UTP
g. Sequential foot markings, in one- or two-foot increments

3. Shielded Category 6A patch cables shall be CMP-rated, with a plenum-rated jacket rated for 500 MHz or better and shall be composed of four, No. 23 AWG to No. 24 AWG stranded copper conductors with shielded 50-micron, gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a No. 23 AWG to No. 26 AWG tinned copper drain wire.

2.13 OSP CATEGORY 6A CABLE AND PATCH CABLES

A. Cable Length

1. The maximum allowable horizontal cable distance is 90 m of installed cabling, with 100 m of maximum total length including patch cords. Patch cord shall not be longer than 10 feet, and horizontal cable length shall not exceed 290 feet.

B. Cable Entrance Grounding

1. Metallic shields and strength members for OSP cable entering a building shall be connected to the lightning protection ground system. Lightning protection shall meet IAW MIL-STD-188-124-B and NFPA 780.

C. Building Point of Entrance

1. The point of entrance shall be located where “the wire or cable emerges from an external wall, from a concrete floor-slab, or from a rigid metal conduit or an IMC grounded to an electrode IAW 800.400-B.” The Telecommunications Entrance Facility (TEF) is the space housing the point of entrance of the telecommunications service.

D. Copper Cable Entrance

1. OSP copper cable shield, armor, and metallic strength members shall be bonded to the lightning protection ground as close to the building point of entrance as possible with a No. 6 AWG or larger ground wire. A non-bonded splice case shall be used for the transition from OSP-rated cable to interior-rated cable. The splice case shall not be carried through the bonding conductor. If the OSP copper cable is extended past 50 feet (15 m), the metallic strength member shall be bonded to the lightning protection ground as close to the conduit egress point as possible with a No. 6 AWG or larger copper ground wire. The fault protector and associated equipment shall be housed in a junction box with din-rail mounted industrial style patch panel modules to facilitate an indoor and OSP cable demarcation.
E. Copper Protector Block

1. OSP copper cables shall be terminated on primary protector blocks equipped with 5-pin solid state or gas protector modules. The protector blocks shall be bonded to the lightning protection ground with a No. 6 AWG or larger copper ground wire. Terminals and hardware shall be UL-listed, made of a flame-retardant construction, and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks, or RJ connectors. The protector block shall be placed as close to the lightning protection ground as possible.

F. CCTV Remote Junction Box

1. CCTV cameras shall connect to OSP cable via remote junction boxes collocated with camera mounting location. Provide junction box equipment as indicated.

2.14 OPTICAL CONNECTORS

A. Patch Panel Connectors: LC ultra-polished connector (UPC) with 126 µm (single mode) or aqua 127 µm (multimode) ceramic zirconia alignment ferrules shall be used for fiber patch panels. Connector insertion loss shall be nominally 0.3 dB and less than 0.5 dB. LC connectors shall be field installable. Dust caps shall be provided for sleeves.

B. Equipment Connectors

1. Fiber optic connectors shall match and be compatible with equipment terminations. Connector insertion loss shall be nominally 0.3 dB and less than 0.5 dB. Connectors shall be field installable. Dust caps shall be provided for all sleeves.

   a. Equipment connector

      1) LC (Lucent Connector) UPC.

      2. Multimode connectors shall be an aqua multimode LC connector pair with a duplex clip, a 127 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

      3. Single mode connectors shall be a single mode LC connector pair with a duplex clip, a 126 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

2.15 FIBER ENTRANCE CABINETS (FEC)

A. Wall-mounted fiber entrance cabinets (FECs) shall be provided in the TCH and the TCR.
**B.** FECs shall be Designated Matching Products (DMP) and equipped with the accessories specified below:

<table>
<thead>
<tr>
<th>Commercial FEC</th>
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</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
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</tr>
<tr>
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<table>
<thead>
<tr>
<th>BART FEC</th>
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</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

2.16 **FIBER PATCH PANELS**

**A.** Fiber patch panels shall be a complete system of components furnished by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Fiber patch panels shall be Designated Match Products (DMP) with specified accessories. Patch panels shall employ wall-mountable connector housings equipped as follows:

1. Sized to accommodate 48 fibers.

2. Three multi-mode connector panels accommodating 12 fibers with LC connectors.

3. One single-mode connector panel accommodating six fibers with LC connectors.

4. Four splice trays with splice protectors.

5. One splice tray holder.

2.17 **CATEGORY 6/6A PATCH PANELS**

**A.** Category 6/6A Patch Panel Design Requirements:

1. Patch panels shall employ a modular keystone design that utilizes both unshielded Category 6 jacks and shielded Category 6A jacks installed into each panel position. Panels shall have provisions for connection of grounding jumpers from each installed shielded jack to support Category 6A shielded keystone jacks and patch panel to telecommunications grounding bus (TGB).
2. Unshielded Category 6 jacks and shielded Category 6A jacks supplied with the panel shall be modular in design and meet the TIA/EIA-568-C.2 Balanced Twisted – Pair Telecommunications Cabling and Component Standard. Unshielded Category 6 jacks and shielded category 6 jacks shall also be available separately with detailed installation instructions.

3. Panel ports shall have a rectangular, industry standard keystone opening (0.760 inches by 0.580 inches) with a permanent port identifier number under each opening.

4. Panels shall include a compatible cable management of patch cords in the front and horizontal cable management in the rear.

5. Panels with installed jacks shall be backward compatible with existing keystone modular jack systems for fit, form, and function.

6. Panels shall be a Designated Matching Product (DMP).

B. Category 6/6A Patch Panel Performance Requirements:

1. Transmission parameters shall be verified by a UL or ETL testing organization. Transmission testing shall be to 250 MHz for Category 6 and 500 MHz for Category 6A.

2. Panels with unshielded jacks shall meet transmission requirements specified in ANSI/TIA/EIA-568-C (specification limit is 250 MHz).

3. The manufacturer shall provide compliance certificates from a third-party testing organization upon request.

4. Panels shall be UL listed 1863 and CSA certified.

5. Panels shall exceed IEEE 802.3 DTE power specification to four times the rated current limits with no degradation of performance or materials.

6. Panels shall be third party verified to Gigabit Ethernet performance according to IEEE 802.3Z (current draft).

7. Panels shall meet or exceed the four-connector channel performance requirements of ANSI/TIA/EIA-568-C.2 standard. Panels shall support unshielded Category 6 and shielded Category 6A keystone jacks from the same manufacturer.

8. Keystone Jacks: The four-connector channel test configuration shall utilize unshielded Category 6 jacks, patch panels, and patch cords, from the same manufacturer, with qualified unshielded twisted pair (UTP) Category 6 cable.

9. Shielded Keystone Jacks: The four-connector channel test configuration shall utilize shielded Category 6A jacks, patch panels, and patch cords, from the same manufacturer, with qualified shielded (F/UTP) Category 6A cable.
2.18 OUTLETS, HARDWARE, AND CONNECTIONS

A. Work Area Outlets (WAOs): WAOs shall be Category 6/6A keystone jacks with universal wiring (TIA568A/B) mounted in single or dual port faceplates as required when within TIA568C.1 length specifications. Category 6/6A WAOs exceeding TIA568C.1 length specifications can use fiber cable terminated to District approved flush-mounted wall boxes or fiber style keystone jacks with 2 or 3 duplex port face plates as required.

B. Category 6/6A Keystone Jack color:

   1. Wayside Facilities
      a. Red - Analog Telephone
      b. Yellow - Digital Telephone
      c. Purple - IP Telephone (voice only)
      d. Green - Async, T1 Connection
      e. White - Administrative network
      f. Orange - Network Management Systems (NMS) network
      g. Black - Security network
      h. Blue - BARTnet network
      i. Grey - Unassigned
      j. Beige - Unassigned

   2. Central Facilities: Shall be coordinated with the District

C. Fiber Keystone Jack Color:

   1. Shall be coordinated with the District

D. Destination Sign Unit (DSU) Connector Modules: Connector modules for DSU outlets shall be Designated Matching Product. Sign hangers shall be constructed of ASTM A500 Grade B structural steel tubing.

E. Automatic Fare Collection (AFC) Equipment Fiber Interface Box: Telecommunication outlets for AFC equipment fiber cable connection shall be Designated Matching Product. Three dual ST to ST connector sleeve insert modules shall be Designated Matching Products, and be furnished for each AFC equipment Fiber Interface Box.

F. Category 6/6A keystone jacks shall be Designated Matching Products.
2.19 FIBER OPTIC PATCH CORDS

A. Patch cords shall be cable assemblies consisting of optical fiber cable with bend performance that meets ITU-T G.657.B equipped with compatible connectors. Patch cords shall be complete assemblies from manufacturer’s standard product lines. Length shall be as required. Patch cords shall meet the following requirements:

1. Fiber optic patch cords shall be two-fiber zip cord type with a 1.6 mm OD.

2. Cable construction shall allow a small bend radius for installation in space constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket. The fiber core size shall be identified on the outer jacket.

3. Fibers shall be terminated at each end with UPC connectors as specified herein.

4. Patch cords shall have a bend performance that meets ITU-T G.657.

5. Patch cords for single-mode fiber shall be colored yellow.

6. Patch cords for multi-mode shall be colored aqua and OM4 rated unless approved otherwise.

7. Patch cords shall be complete factory fabricated assemblies from manufacturer standard product line. Lengths shall meet manufacturer’s standard lengths. Field fabricated patch cords shall not be used.

2.20 PIGTAIL CABLES

A. Cables used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cables shall be 3.5 dB/km at 850 nm, and 1.0 dB/km at 1300 nm.

2.21 COPPER SPLICE CASES

A. Cases for splicing copper cables shall be of the type capable of being re-opened without disturbing splices, and of being reclosed. Cases shall have devices for centering cable to allow filling compound to cover conductors. Hardware shall be of stainless steel. Cases shall be braced to prevent cracking.

1. Filling Compound: Compound for filling splice cases shall be a polyurethane telephone material that is transparent after curing. The compound shall adhere to conductors and splices but shall be capable of being easily pulled away in a mass from conductors and splices. Compound shall be non-corrosive to conductors and splicing devices and shall not be toxic.
2. Splice Connectors: Connectors shall be sized for the specific conductors to be spliced or tapped. The connector material shall be compatible with the conductor. The tools used for application shall have a positive action that prevents over- or under-crimping.

2.22 TERMINAL BLOCKS

A. Terminal blocks shall be DIN-rail mounted, single, or two level as required by the application, and meet the following requirements:

1. Wire gauge range: No. 28 AWG to No. 12 AWG.
3. Voltage rating: 600 V.
4. Terminal width: 5 or 6 mm.
5. DIN rail: 35 mm.

B. Terminal blocks shall be labeled.

2.23 TEST EQUIPMENT

A. Test equipment shall be turned over to the District in good condition upon completion of testing. A test report including data sheets shall be generated by tester and submitted to the District for approval.

B. Multifunction loss testers shall perform the following instrument functions:

1. Optical power loss (OPL) meter.
2. Power meter.
3. Optical return loss (ORL) meter.
5. Multimode and single mode light sources.
7. Fiber length tester.
8. Video fiber inspection probe.

C. The multifunction loss tester shall be an EXFO FOT-930 MaxTester or equal. The Contractor may use the testers for ORL and optical power loss testing.

D. The optical spectrum analyzer (OSA) shall be optimized for 100 GHz spacing and DWDM network testing. The OSA shall be EXFO model FTB-5230 or equal.
E. The copper and fiber cable analyzer shall provide certification testing meeting EIA/TIA standards. The cable analyzer (copper and fiber) shall be model FLUKE DTX-1800-MSO or equal.

F. Surface Inspection interferometer testing for field fiber connector termination. The surface Inspection interferometer shall be model DAISI Digital Automated Interferometer or equal.

2.24 FACTORY TESTS

A. Refer to Contract Specifications Section 20 72 25, Factory and Field Testing.

B. Cable Tests: Test single mode and multimode fiber optic cables in accordance with EIA RS-455.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate installation of wires and cables with the requirements of Contract Specifications Section 20 70 26, Common Materials and Methods for Electrical Systems, and Section 20 50 13, Raceways for Facility Services.

B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections, including wires for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

C. Do not bend cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the California Electrical Code, NEMA WC 70, NEMA WC 71, and NEMA WC 74.

D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panelboards, equipment cabinets, and control panels. Use nylon bundling straps. Bundle power cables separately from control cables.

E. For wire pulling, comply with the following requirements:

1. Do not pull wires into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use a block and tackle or other mechanical means for pulling conductors smaller than No. 2 AWG in raceways.

2. Use lubricant and installation procedure as recommended by the cable manufacturer.

3. Pulling tension shall not exceed manufacturer’s recommendations. For conduit runs with three bends, provide the Engineer with cable pulling calculations prior to making the pull.
4. Provide masking or other means to prevent obliteration of cable identifications when solid color coating or colored tracers are used.

5. Multiple cables to be installed in a single conduit shall be pulled together.

F. Power and Control Cable Installation in Manholes and Pull Boxes: Route cables along the manhole or hand-hole walls providing the longest possible slack. Form cables closely parallel to the walls so that they do not interfere with duct entrances, supported on brackets and cable insulators spaced at a maximum of four feet. In existing manholes and hand-holes where new ducts are to be terminated or where new cables are to be installed, modify the existing locations of cables, cable supports, and grounding as required providing a properly arranged and supported installation.

G. Wayside Copper Cable: Wayside copper cable shall be homerun from the device such as the telephone in a BLS to the protector blocks in the associated wayside facility. Wayside copper cable splicing is not allowed.

H. Install fiber optic cables as follows:

1. Install horizontal and inter-facility fiber optic cables in conduit. Provide unused conduits with lubricated pull tape or line.

2. Conduit runs for fiber optic cable shall only use pull boxes. Condulets shall not be used.

3. Install each communication cable, including traction power cables, between wayside facilities in the communications section of the system-wide raceway.

4. Install each train control cable between TCRs or TCHs in the train control section of the systemwide raceway.

5. Install lateral cables between the systemwide raceway and wayside facilities in separate conduits.

6. Spare fibers shall be secured and supported neatly with velcro.

7. Terminate backbone and horizontal fiber optic cable to maintain manufacturer-recommended bending radii, pulling tension, and cable support requirements. Cables and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties shall not be used; only velcro or millipede ties are permitted.

8. Service loops shall be provided in communication manholes, above fiber entrance cabinets, and related enclosures. Fiber optic cable runs with a portion of the run exterior to a building shall have a minimum service loop length of 50 feet on each end. Fiber optic cables installed completely inside of a building shall have a minimum service loop length of 12 feet on each end.
I. Fiber optic cable pulling shall comply with the following:

1. Pull on the cable strength members only. Do not pull on the jacket unless it is specifically approved by the cable manufacturer and an approved cable grip is used.

2. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control or at least a breakaway pulling eye.

3. Do not exceed the cable bend radius.

4. Do not twist the cable. Roll the cable off the spool instead of spinning it off the spool end. When laying cable out for a long pull, use a “figure eight” on the ground or use a swivel pulling eye to prevent twisting forces on the cable.

5. Verify that the cable is long enough for the run.

J. Shields of cables shall be grounded at the equipment room end per Specification Section 26 05 26, Grounding and Bonding for Electrical Systems, and Standard Drawing K001.

3.02 CABLE IDENTIFICATION

A. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables, feeders, and power circuits in vaults, pull boxes, manholes, and switchboard rooms, and at terminations of cable or wire.

B. Stamp or print tags or labels to correspond with markings on the Contract Drawings, or mark so that feeder or cable may be readily identified.

C. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.

3.03 CABLE LABELING

A. Provide identification tags or labels for each cable. Markers, tags and labels shall use indelible ink or etching which will not fade in sunlight or in duct applications. Markers, tags, and labels shall not become brittle or deteriorate for 30 years. Label termination panels with cable number or pair identifier for cables in accordance with EIA TIA-606 and as specified. Include installation date to cable labeling and identify the labeling format and provide a complete record to the District with the final documentation. Identify each cable with type of signal being carried and termination points.

B. Affix identification and warning signs and tags to fiber distribution panels, terminal equipment, patch cords, and fiber optic cables.
C. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, in the following locations:

1. Every 100 feet in underground track ways.
2. Every 10 feet in communications equipment areas.
3. At each location where optical cables enter or exit raceways of any sort.
4. On exposed conduit runs under station platforms or in plenums, at intervals of 50 feet.
5. At each manhole location along the communications wayside conduit bank runs.

3.04 SPLICING AND TERMINATION OF FIBER OPTIC CABLES

A. Make splices in fiber optic cable fibers only inside TCRs and TCHs, protected equipment rooms, or in accessible wayside splice enclosures. Submit a description of each type and location of splice that will be used, naming the materials, devices, tools, instruments, and other details.

1. All splices, including splices of pigtails to incoming fibers, shall be the fusion type. Apply protective covering and coating, made of compatible material, to all completed and tested splices.

2. Contain splices within re-enterable splice modules that are designed specifically to accommodate fiber splices and the prescribed extra lengths of fiber. Provide one or more splice modules for each system-wide 144-fiber cable as necessary and mount them in wall-mounted splice cases as indicated. Fibers that are required at each location as shown on the Contract Drawings shall be spliced to lateral fibers that connect to the fiber distribution panel in cabinet 92A.

3. If splices are not made immediately after cable installation, seal the free ends of such cables as recommended by the manufacturer to prevent entrance of moisture and contaminants.

4. Splices along the wayside shall be subject to the approval of the Engineer. Where allowed, make splices in outdoor weatherproof splice enclosures, complete with entry raceways, foundations, mounting hardware, secured access door, and exterior fittings.

5. Equip the interior of wayside splice enclosures with modules and fittings designed to organize the cables, splices, and prescribed extra length of fibers. Make provisions to add a renewable desiccant compound to protect against condensation or migration of water.
6. Optical Cable Terminations at TCRs/TCHs, Vent Structures and Portal Communication Cases (PCCs): Terminate all fibers at the fiber distribution panel within each TCR/TCH, vent structure, and PCC as follows:
   a. Terminate incoming optical fibers using matching single-mode optical fiber pigtail assemblies. Splice such optical fibers to the pigtail assemblies within a splice tray or trays.
   b. Assign and terminate incoming and outgoing optical fibers; spares that are designed to pass through the local site shall be spliced together within a splice tray or trays where designated splices are configured.
   c. Configure terminations to use the least number of splices feasible.

3.05 CATEGORY 6/6A CABLE AND PATCH CORD INSTALLATION

   A. All backbone and horizontal Category 6/6A cable shall be terminated to Keystone style jacks. Maintain Manufacturer-recommended bending radius, pulling tension, and cable support requirements. Cables, wires, and equipment shall be securely and neatly installed. Inside routing shall be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties may not be used; only Velcro or Millipede ties may be used.
   
   B. Category 6/6A data cabling shall be terminated in accordance with the TIA/EIA 568B sequence specification.
   
   C. Category 6/6A patch cords shall be terminated in accordance with the TIA/EIA 568A or TIA/EIA 568B sequence specification.

3.06 CATEGORY 6/6A PATCH PANEL INSTALLATION

   A. Mount patch panels into the designated rack, cabinet, or bracket locations. Surface mount or DIN rail patch panels may be used when the use of rack mount patch panels is not feasible. Category 6/6A industrial DIN rail housing field terminations shall be component compliant to EIA/TIA Category 6/6A performance requirements.
   
   B. Keystone jacks are required for Category 6/6A cable terminations. Terminate the shielded or unshielded jacks as applicable and install into the patch panel according to manufacturer’s instructions.
   
   C. Cable terminations shall have no tensile or bending strain on the installed shielded jacks.
   
   D. Consolidation point equipment, where applicable, shall be fully installed and terminated prior to testing.
   
   E. Panels shall be labeled on front and back with the cable number and port connections for each port. The panel grounding strap shall be installed to connect the cable shield and drain wire to the building signal ground in accordance with ANSI-J-STD-607-A.
F. Install Category 6 unshielded and Category 6A jacks grouped together on panel.

3.07 FIELD TESTS

A. The requirements for test planning, scheduling, performance, recording of data, and reporting of test results shall be as specified in Contract Specifications Section 20 72 25, Factory and Field Testing.

B. Fiber Optic Cable Reel Tests:

1. Fiber Optic Reel tests: Perform the following tests on fiber optic cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the media. Perform optical time domain reflectometer (OTDR) tests with media on the reels and compare factory and field test data.

2. Reel Test Results: Provide results of reel tests to the District at least 10 working days before installation is to commence. Results shall indicate reel number of the media, manufacturer, type and number of fibers tested, and recorded readings. When reel tests indicate that the media does not comply with factory reel test results, remove the media from the job site and replace with compliant media.

C. Fiber Optic Cable Installation Tests:

1. Test all single mode and multimode fiber strands end-to-end for bi-directional attenuation, 850 nm/1300 nm for multimode and 1310 nm/1550 nm for single mode fibers. Conduct tests in compliance with EIA/TIA-526-14 or OFSTP 14, Method B, according to the manufacturer’s instructions for the test set being utilized.

2. Tests must ensure that the measured link loss for each strand does not exceed the “worst case” allowable loss defined as the sum of the connector loss (based on the number of mated connector pairs at the EIA/TIA-568 B maximum allowable loss of 0.75 dB per mated pair) and the optical loss (based on the previously-specified performance standards).

3. After the cable is terminated, perform the following tests:

a. After termination, test each fiber with an OTDR for length, transmission anomalies, and end-to-end attenuation. Perform the test with the following reference values for the loss length testing limits: MM 50 m: -19.4 to -26.5 dB, MM 62.5: -17.5 to -23 dB, and SM: -0 to -9 dbm.

b. Insertion Loss: An OTDR shall be used to measure splice losses and identify events such as bad or dirty connectors, fiber bends, bad splices, and mismatched core sizes. Conduct the test in accordance with ANSI/TIA/EIA-455-34-A-2002, Interconnection Device Insertion Loss Test. Detected problems on a given link shall be corrected and then retested before proceeding with subsequent tests.
c. Optical Power Loss (OPL) and Optical Return Loss (ORL): The specified multifunction loss tester shall be used to measure OPL and ORL on each link. The ORL shall be 20 dB minimum for multimode fiber and 26 dB minimum for single mode fiber.

d. The maximum allowable attenuation for any splice or termination is 0.3 dB.

4. Review end faces of field terminated connectors with a fiber inspection scope following the final polish. Connector end faces with hackles, scratches, cracks, chips, or surface pitting shall be rejected and re-polished or replaced if re-polishing will not remove the end face surface defects. The recommended minimum viewing magnifications for connector ends are 100X for multimode fiber and 200X for single mode fiber.

5. Conduct surface inspection testing of each fiber connector using the DAISI interferometer. The return loss performance of UPC fiber optic connectors shall be 50 dB or higher. Surface inspection testing for manufactured connector pigtails provided with factory certification documentation is not required.

D. Fiber Optic Network End-to-End Testing:

1. General: End-to-end testing shall be performed for links that comprise two or more link segments that are connected via splices or patch cords. In each of the following tests, inspect and clean the fiber connectors before hooking them up to the test equipment. Test patch cords and patch panels shall also be cleaned. Tests shall be performed in both directions for each end-to-end fiber link.

2. Repeat the OTDR, OPL, and ORL tests specified in Section 3.07 herein.

3. Spectral Domain Measurements for UON cables: Use the specified optical spectrum analyzer to measure the following parameters in an end-to-end test of UON DWDM fibers. This test shall be coordinated with and supervised by The District.

a. Chromatic dispersion (CD)

b. Polarization mode dispersion (PMD)

c. Spectral attenuation (multi-lambda)

E. Shielded Category 6/6A Patch Panel Testing:

1. Shielded category 6/6A patch panels shall be tested as part of the installed horizontal or backbone cabling system. Jacks and faceplates shall be assembled complete and properly mounted. Panels shall be terminated and fully dressed with proper cable management.

2. Each link or channel in the cabling system shall be identified and tested individually, using at minimum an industry standard level IIIE tester, capable of testing to TIA/EIA-568-C.2 field test requirements.
3. Each panel port in the cable channel or link shall be tested for the shielded category 6 parameters listed below:

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<tr>
<th>WIRE MAP / CONTINUITY</th>
<th>LENGTH</th>
<th>INSERTION LOSS</th>
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<tr>
<td>NEXT</td>
<td>PSNEXT</td>
<td>ELFEXT</td>
</tr>
<tr>
<td>PSELFEXT</td>
<td>Delay and delay skew</td>
<td>Return loss</td>
</tr>
</tbody>
</table>

Legend:

- ELFEXT: Equal Level Far-End Crosstalk
- NEXT: Near End Cross Talk
- PSELFEXT: Power Sum Equal Level Far-End Crosstalk
- PSNEXT: Power Sum Near End Cross Talk

4. In addition to the above test parameters, the continuity of the cable shield and drain wire shall also be verified.

5. A “pass” indication shall be obtained for each channel or link, using at minimum a level IIIE tester that complies with TIA/EIA-568-C.2 field testing requirements.

F. Category 6/A Cable Testing:

1. General: Test pairs of all installed F/UTP wiring for full compliance with Category 6 and Category 6A UTP specifications regardless of intended use. Provide documentation of test results for conductor pairs of each cable. Perform testing using the specified Category 6/6A cable tester. Test results shall be approved by the District prior to cable activation for voice, video, or data applications.

2. Testing Parameters: Four pairs shall meet the following measured specifications. Inspect cables that do not meet the following specification and re-terminate or replace if necessary, to ensure compliance:

   a. Line map cables to verify pin-to-pin continuity, lack of opens, shorts, and/or polarity reversals.
   
   b. The characteristic cable impedance shall be 100 ohms plus or minus 15 percent at 1 MHz to 100 MHz.

   c. Mutual capacitance of any pair at 1 kHz shall not exceed 17 nF per 1000 feet.

   d. Ambient noise shall be less than or equal to 40 dB.

   e. Signal to noise ratio shall be greater than or equal to 7 dB.

   f. Cable length shall be less than or equal to 90 meters.
G. Multi-Conductor Copper Cable Testing: Insulation resistance test shall be performed on cables between each conductor to grounded shield and shield to ground. Cable manufacturer’s recommended method and values shall be applied. The test shall be made after cable installation, but before splicing or terminating. If the splicing or terminating is not performed immediately after cable installation, a second insulation resistance test shall be made just before splicing or terminating. Each cable installation shall be tested after splices and terminations are complete. No equipment shall be connected to the cable system during tests. If any field tests fail, correct the deficiency and retest. If the test fails again, replace the cable segment.

END OF SECTION 27 13 01