



*Florida Department of Transportation*

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GOVERNOR

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JARED W. PERDUE, P.E.  
SECRETARY

September 12, 2023

Khoa Nguyen  
Director, Office of Technical Services  
Federal Highway Administration  
3500 Financial Plaza, Suite 400  
Tallahassee, Florida 32312

Re: State Specifications Office  
Section: **633**  
Proposed Specification: **6330201 Communication Cable.**

Dear Mr. Nguyen:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Derek Vollmer to add requirements for CAT 6 and composite cables. Removed duplication with national standards, updated references to those standards, and updated outdated information.

Please review and transmit your comments, if any, within two weeks (10 business days). Comments should be sent via email [daniel.strickland@dot.state.fl.us](mailto:daniel.strickland@dot.state.fl.us).

If you have any questions relating to this specification change, please call me at (850) 414-4130.

Sincerely,

Signature on file

Daniel Strickland, P.E.  
State Specifications Engineer

DS/dh

Attachment

cc: Florida Transportation Builders' Assoc.  
State Construction Engineer

**COMMUNICATION CABLE.****(REV 7-11-23)**

SUBARTICLE 633-2.1.1.1 is deleted and the following substituted:

**633-2.1.1.1 Optical Fiber:** Ensure that the optical fibers used in the cable meet or exceed the Telecommunications Industry Association (TIA) and Electronic Industries Alliance (EIA) TIA/EIA-492-CAAB specification, the U.S. Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900, and International Telecommunication Union ITU-T G.652.D requirements. Use only optical fibers meeting the additional requirements as follows:

Geometry
<del>Cladding Diameter: 125µm, ±0.7 µm</del>
Core-to-Cladding Concentricity: ≤0.5 µm
Cladding Noncircularity: ≤0.7%
Mode Field Diameter: 1,550 nm; 10.4 µm, ±0.5 µm
<del>Coating Diameter: 245 µm, ±5 µm</del>
<del>Colored Fiber Nominal Diameter: 250 µm ±15 µm</del>
Optical
Cabled Fiber Attenuation: 1,310 nm, £0.35 dB/km; 1,550 nm, £0.25 dB/km
<del>Point Discontinuity: 1,310 nm, ≤0.05 dB/km; 1,550 nm, ≤0.05 dB/km</del>
<del>Cable Cutoff Wavelength (<math>\lambda_{ccf}</math>): ≤1,260 nm.</del>
Dispersion: 1,550 nm £18.0 ps/(nm·km)
<del>Macrobend Attenuation: Turns—100; Outer diameter (OD) of the mandrel—50 mm, ±2 mm; £0.03 dB at 1,550 nm</del>
Polarization Mode Dispersion <del>Link Design Value-</del> (PMDQ): ≤0.04 ps/ $\sqrt{\text{km}}$

Ensure that all fiber in the buffer tube is usable fiber that complies with attenuation requirements. Ensure that fibers do not adhere to each other. Ensure that the fiber is free of surface imperfections and inclusions. Ensure that all fiber optic core glass is from the same manufacturer.

SUBARTICLE 633-2.1.1.9.3 is deleted and the following substituted:

**633-2.1.1.9.3 Cable Strength:** Ensure that the fiber optic cable is capable of withstanding a pulling tension of 600 pounds during installation ~~without increasing the fiber attenuation more than 0.8 decibel per mile and without changing other optical fiber characteristics after the tensile load is removed.~~ Ensure that optical fiber is proof-tested by the fiber manufacturer at a minimum of 100 kilo pounds per square inch. Ensure that the cable will withstand 25 impact cycles and the change in attenuation does not exceed 0.2 decibel at

1,550 nanometers when tested according to the requirements as detailed in the TIA--455-25D standard. Ensure that the fiber optic cable can withstand a minimum compression load of 125 pounds per square inch when applied uniformly over the length of the sample at the rate of 0.15 inches to 0.8 inches per minute and maintained for 10 minutes as defined in the TIA/EIA-455-41A standard. ~~Ensure that the change in attenuation will not exceed 0.15 decibel during loading at 1,550 nanometers, and that no fiber displays a measurable change in attenuation after load removal.~~

SUBARTICLE 633-2.1.2.1 is deleted and the following substituted:

**633-2.1.2.1 Splice Enclosures:** Contain all optical fiber splices within a splice enclosure. Ensure that the enclosures provide storage for splices, fiber, and buffer tubes. Ensure that the splice enclosure restores the mechanical and environmental integrity of the fiber optic cable, encases the sheath opening in the cable, and organizes and stores optical fiber. Ensure all hinges and latching devices are stainless steel. Ensure that the enclosure is airtight and prevents water intrusion. Ensure that the splice enclosure can accommodate pressurization and has the ability to be reentered without requiring specialized tools or equipment. Ensure that the enclosure provides fiber and splice organizers including splice trays and strain relief.

Ensure that splice enclosures are hermetically sealed to protect internal components from environmental hazards such as moisture, insects, and UV light. Fiber optic splice enclosures shall also:

Comply with the Telcordia Technologies' GR-771-CORE standard and all applicable NEC requirements.

Provide space for future expansion equal to 100% of the initial utilization.

Provide fiber optic cable penetration end caps to accommodate a minimum installation of two trunk fiber optic cables and two fiber optic drop cables. Ensure that the enclosure end caps are factory-drilled to the proper diameter to accept and seal the fiber optic cable entries. Ensure that the cable entry locations can accommodate an assortment of cables with outside diameters ranging from 0.45 inches to ~~0.7555~~ inches, plus 10%, without jeopardizing the waterproof characteristics of the enclosure.

Ensure that splice enclosures are permanently labeled using machine printed, waterproof labels suitable for outside plant applications.

~~Provide fiber optic splice enclosures meeting the following requirements:~~

<b>Mechanical</b>
<del>Resist compression deformation to a maximum of 300 pounds.</del>
<del>Withstand an impact energy to a maximum of 40 foot-pounds at 0°F.</del>
<del>Axial Tension: 100 pounds for 30 minutes.</del>
<del>Cable Torsion: ten 90-degree rotations.</del>
<del>Cable Flexing: ten 90-degree bends.</del>
<b>Environmental</b>

<del>Hydrostatic Pressure Head: Up to 20 foot-pounds (-9 pounds per square inch).</del>
<del>Withstand 40 freeze/thaw temperature cycles.</del>
<del>Ultraviolet resistant during a maximum 30-day exposure in compliance with the requirements detailed in the ASTM B117 standard.</del>
<del>Chemical</del>
<del>Withstand a 90-day exposure to solutions of 3% sulfuric acid, 0.2 normal of sodium hydroxide, 10% Igepal®, kerosene, and be fungus resistant as required in the ASTM G21 standard.</del>

SUBARTICLE 633-2.1.6.3 is deleted and the following substituted:

**633-2.1.6.3 Packaging, Shipping and Receiving:** Ensure that the packaging and delivery of fiber optic cable reels comply with the following minimum requirements:

1. Ensure cable is shipped on reels of marked continuous length.
2. Ensure each cable is shipped on a separate, strongly constructed reel designed to prevent damage to the cable during shipment and installation.
3. Ensure each reel has a minimum of 6 feet on each end of the cable available for testing.
4. Ensure that all fiber optic cable is continuous and free from damage.
5. Ensure no point discontinuities greater than 0.1 decibel per reel.
6. Submit the transmission loss test results as required by the TIA-455-~~61-A78~~-standard, as well as results from factory tests performed prior to shipping.
7. Ensure that the manufacturer submits the date of manufacture; product and serial numbers; cable data, including the reel length; refraction index; the project name and location; type of fiber and quantity of strands used; technical product data sheets; and reel numbers.

SUBARTICLE 633-2.2 is deleted and the following substituted:

**633-2.2 Twisted Pair Cable:** Use shielded underground and aerial cable. Underground and aerial cables include telephone cables and multiconductor communication cables. ~~with separate support wire conforming to Rural Electrification Administration (REA) Specification PE-39, filled telephone cables. Use shielded aerial copper communication with integral support wire conforming to REA Specification PE-38, aerial telephone cables. Use only No. 22 AWG solid cables for copper connections in traffic signal closed loop systems.~~

~~\_\_\_\_\_~~ **633-2.3 2.2.1 Aerial Cable Support Wire:** Meet the requirements of 632-2.2.  
~~\_\_\_\_\_~~ **633-2.4 2.2.2 Aerial Cable Attachment Hardware:** Meet the requirements of 632-2.3.

633-2.2.3 Telephone Cable: Use aerial telephone cable with separate support wire conforming to Rural Electrification Administration (REA) Specification PE-39, filled telephone cables. Aerial telephone cable must comply with REA Specification PE-38, aerial telephone cables. Use only No. 22 AWG solid cables for copper connections in traffic signal closed loop systems.

Use underground telephone cable conforming to the United States Department of Agriculture (USDA), Rural Utilities Service (RUS) Bulletin 1753F-205 (PE-39), "REA Specification for Filled Telephone Cables".

**633-2.2.4 Multiconductor Cable:** Multi-conductor communication cable is used to carry communication and electrical signals between equipment, including Ethernet data or serial data, low voltage power, and may also be used to energize signaling equipment as part of signaling circuits.

**633-2.2.4.1 Category 6 Cable:** Use polyethylene jacketed Category 6 (CAT -6) cable conforming to the requirement of TIA 568 C.2 with Edison Testing Laboratories (ETL) verification. Cables run outside of equipment enclosures must be shielded cable (F/UTP) using an aluminum foil shield with drain wire and solid copper conductors, and shall be terminated with shielded RJ-45 connectors. Cable which remains within the equipment enclosure where it originates may be un-shielded twisted pair (UTP), include stranded copper conductors, and be terminated with un-shielded RJ-45 connectors. Use straight-through cables when connecting data terminating equipment (DTE) to data communications equipment (DCE), and cross-over cables when connecting DTE to DTE or DCE to DCE. For RJ-45 connector color coding: use TIA T-568B connectors as the standard configuration for straight-through cables and use TIA T-568B on one end and TIA T-568A on the other end for cross over cables.

**633-2.2.4.2 Composite Cable:** Composite cable consists of multiple conductors and cables housed within a single overall UV resistant polyethylene or polyvinyl jacket. The composite cable must carry communication and power to equipment using the type, number of conductors, and wire gauges as shown in the Plans and recommended by the equipment manufacturer. The cable must include an overall metallic shield with drain wire or individual shields with drain wires for each conductor.

SUBARTICLE 633-3.1.8 is deleted and the following substituted:

**633-3.1.8 Installation Testing:** Notify the Engineer of cable testing at least 14 calendar days in advance. Submit the testing procedures to the Engineer for approval prior to commencement of testing. Perform all tests at 1,310 and 1,550 nanometer wavelengths and include the last calibration date of all test equipment with the test parameters set on the equipment in the test documentation. Ensure that the last calibration date of all test equipment is within the last 12 months and that the calibration certificate is maintained in the test equipment case or provided electronically when requested. Test all installed fibers (terminated and un-terminated) using methods identified in this Section. All tests must be conducted with a launch box.

Fibers containing splices, fibers terminated on both ends, terminated on one end, or backbone fibers (inside project limits and continuing outside of project limits) must be bidirectionally tested.

Drop fibers without splices (inside project limits and continuing outside of project limits), with only terminations on one end, and bare fiber on the other must be tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Drop fibers without splices which are unterminated on both ends (inside project limits and continuing outside of project limits) must be tested using a bare fiber adapter and tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Present the results of the OTDR testing (i.e., traces for each fiber) and a loss table showing details for each splice and termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-~~61~~78 standard.

#### **633-3.1.8.1 Optical Time Domain Reflectometer (OTDR) Attenuation**

**Testing:** Perform testing on all fibers to ensure that attenuation does not exceed allowable loss (0.35 db/km for 1310 nanometer wavelength, 0.25 db/km for 1550 nanometer wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

**633-3.1.8.1.1 OTDR Tracing:** Test all fibers with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 nanometer.

**633-3.1.8.1.2 Splice Loss Testing:** Ensure that the splice loss for a SMF fusion splice does not exceed a maximum bidirectional average of 0.1 decibel per splice when measured using an OTDR. Repair or replace splices that exceed allowable attenuation at no cost to the Department.

**633-3.1.8.1.3 Connector Loss Testing:** Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed 0.6 decibel when measured using an OTDR. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.

SUBARTICLE 633-3.2 is deleted and the following substituted:

**633-3.2 Twisted Pair Cable Installation:** Install all materials and equipment according to the latest version of the manufacturer's installation procedures.

~~Install copper communication cables in continuous lengths to and between cabinets and junction boxes. The Contractor may install junctions at intervals less than shown in the Plans; however, the Contractor must provide any additional materials (such as junction boxes, cabinets, risers, and mounting hardware) and labor for additional junctions and terminations at no expense to the Department. Obtain the Engineer's approval for any additional junctions or terminations.~~ Ensure cable drawn through conduit, ducts, drilled holes is protected by a rubber grommet, and is installed in a manner that prevents damage to conductors or insulation. Ensure all connections to outdoor equipment are weatherproof and prevent water intrusion into equipment, connections, and cable entrances. Cables exposed to the elements must be rated for outdoor use.

**633-3.2.1 Cable type and Number of Conductors:** Determine the appropriate cable type and conductor count required for each twisted pair communication cable unless specified in the Contract Documents. Identify all spare conductors.

**633-3.2.2 Number of Cables:** Do not install more than four separate cables at any point on a single support wire.

~~633-3.2.3 Protection of Cable~~ **Telephone Cable:** ~~Ensure cable drawn through conduit, ducts, drilled holes protected by a rubber grommet, or support structures is installed in such a manner as to prevent damage to conductors or insulation.~~ Install telephone cables in continuous lengths to and between cabinets and junction boxes. The Contractor may install junctions at intervals less than shown in the Plans; however, the Contractor must provide any additional materials (such as junction boxes, cabinets, risers, and mounting hardware) and labor for additional junctions and terminations at no expense to the Department. Obtain the Engineer's approval for any additional junctions or terminations.

**633-3.2.4 Multiconductor Cable:** Install multi-conductor communication cable in continuous lengths between cabinets and from cabinets to devices. Separate multi-conductor communication cables from high voltage conductors. Keep cable on the unprotected side of surge suppression devices separate from cable on the protected side to prevent induction of lightning and other high voltage transient currents.

**633-3.2.5 Surge Protective Devices:** Install surge protective devices meeting the requirements of Section 620 on cables entering cabinets or enclosures, and as shown in the Plans, prior to connection of Ethernet switches, PoE injectors, or other equipment.

ARTICLE 633-4 is deleted and the following substituted:

**633-4 Warranty.**

Ensure that the fiber optic cable, the enclosures, ~~and~~ terminations, and twisted pair cables and connectors have a manufacturer's warranty covering defects for a minimum of ~~two~~ 2 years from the date of final acceptance ~~in accordance with 5-11 and Section 608~~. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

ARTICLE 633-6 is deleted and the following substituted:

**633-6 Method of Measurement.**

The quantities to be paid will be: the length, in feet, of fiber optic cable; the number, per each, of fiber optic connections; the number, per each, of fiber optic connection hardware; the number of calendar days from contract time start to final acceptance for fiber optic cable locator; ~~and~~ the length, per foot, of ~~twisted pair~~ telephone cable; and the length, per foot, of multi-conductor communication cable; accepted by the Engineer.

The Contract unit price for communication cable, furnished and installed, will include furnishing, placement, and testing of all material, and for all tools, labor, equipment, installation hardware (such as support wire, cable ties, cable clamps, and lashing wire), supplies, support, personnel training, documentation, and incidentals necessary for a complete installation.

———Payment for conductive cable terminal connectors and conductive cable grounding is considered incidental and shall be included in the price for twisted pair communication cable.

———Fiber optic splices and terminations, as shown in the Plans, shall be measured per each fiber optic connection furnished and installed.

———The price per day for a Fiber Optic Cable Locator, will include all tools, labor, equipment, locating and marking hardware (such as flags, paint, and shovels), supplies, support, personnel training, documentation, and incidentals.

ARTICLE 633-7 is deleted and the following substituted:

**633-7 Basis of Payment.**

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

- Item No. 633- 1      Fiber Optic Cable - per foot.
- Item No. 633- 2      Fiber Optic Connection - each.
- Item No. 633- 3      Fiber Optic Connection Hardware - each.
- Item No. 633- 4      ~~Twisted Pair~~Telephone Cable - per foot.
- Item No. 633- 6      Fiber Optic Cable Locator - per day.
- Item No. 633- 8      Multi-Conductor Communication Cable – per foot.



**COMMUNICATION CABLE.****(REV 7-11-23)**

SUBARTICLE 633-2.1.1.1 is deleted and the following substituted:

**633-2.1.1.1 Optical Fiber:** Ensure that the optical fibers used in the cable meet or exceed the Telecommunications Industry Association (TIA) and Electronic Industries Alliance (EIA) TIA/EIA-492-CAAB specification, the U.S. Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900, and International Telecommunication Union ITU-T G.652.D requirements. Use only optical fibers meeting the additional requirements as follows:

Geometry
Core-to-Cladding Concentricity: $\leq 0.5 \mu\text{m}$
Cladding Noncircularity: $\leq 0.7\%$
Mode Field Diameter: 1,550 nm; 10.4 $\mu\text{m}$ , $\pm 0.5 \mu\text{m}$
Optical
Cabled Fiber Attenuation: 1,310 nm, $\leq 0.35 \text{ dB/km}$ ; 1,550 nm, $\leq 0.25 \text{ dB/km}$
Dispersion: 1,550 nm $\leq 18.0 \text{ ps}/(\text{nm}\cdot\text{km})$
Polarization Mode Dispersion Link Design Value (PMDQ): $\leq 0.04 \text{ ps}/\sqrt{\text{km}}$

Ensure that all fiber in the buffer tube is usable fiber that complies with attenuation requirements. Ensure that fibers do not adhere to each other. Ensure that the fiber is free of surface imperfections and inclusions. Ensure that all fiber optic core glass is from the same manufacturer.

SUBARTICLE 633-2.1.1.9.3 is deleted and the following substituted:

**633-2.1.1.9.3 Cable Strength:** Ensure that the fiber optic cable is capable of withstanding a pulling tension of 600 pounds during installation. Ensure that optical fiber is proof-tested by the fiber manufacturer at a minimum of 100 kilo pounds per square inch. Ensure that the cable will withstand 25 impact cycles and the change in attenuation does not exceed 0.2 decibel at 1,550 nanometers when tested according to the requirements as detailed in the TIA-455-25D standard. Ensure that the fiber optic cable can withstand a minimum compression load of 125 pounds per square inch when applied uniformly over the length of the sample at the rate of 0.15 inches to 0.8 inches per minute and maintained for 10 minutes as defined in the TIA/EIA-455-41A standard.

SUBARTICLE 633-2.1.2.1 is deleted and the following substituted:

**633-2.1.2.1 Splice Enclosures:** Contain all optical fiber splices within a splice enclosure. Ensure that the enclosures provide storage for splices, fiber, and buffer tubes.

Ensure that the splice enclosure restores the mechanical and environmental integrity of the fiber optic cable, encases the sheath opening in the cable, and organizes and stores optical fiber. Ensure all hinges and latching devices are stainless steel. Ensure that the enclosure is airtight and prevents water intrusion. Ensure that the splice enclosure can accommodate pressurization and has the ability to be reentered without requiring specialized tools or equipment. Ensure that the enclosure provides fiber and splice organizers including splice trays and strain relief.

Ensure that splice enclosures are hermetically sealed to protect internal components from environmental hazards such as moisture, insects, and UV light. Fiber optic splice enclosures shall also:

Comply with the Telcordia Technologies' GR-771-CORE standard and all applicable NEC requirements.

Provide space for future expansion equal to 100% of the initial utilization.

Provide fiber optic cable penetration end caps to accommodate a minimum installation of two trunk fiber optic cables and two fiber optic drop cables. Ensure that the enclosure end caps are factory-drilled to the proper diameter to accept and seal the fiber optic cable entries. Ensure that the cable entry locations can accommodate an assortment of cables with outside diameters ranging from 0.45 inches to 0.75 inches, plus 10%, without jeopardizing the waterproof characteristics of the enclosure.

Ensure that splice enclosures are permanently labeled using machine printed, waterproof labels suitable for outside plant applications.

SUBARTICLE 633-2.1.6.3 is deleted and the following substituted:

**633-2.1.6.3 Packaging, Shipping and Receiving:** Ensure that the packaging and delivery of fiber optic cable reels comply with the following minimum requirements:

1. Ensure cable is shipped on reels of marked continuous length.
2. Ensure each cable is shipped on a separate, strongly constructed reel designed to prevent damage to the cable during shipment and installation.
3. Ensure each reel has a minimum of 6 feet on each end of the cable available for testing.
4. Ensure that all fiber optic cable is continuous and free from damage.
5. Ensure no point discontinuities greater than 0.1 decibel per reel.
6. Submit the transmission loss test results as required by the TIA-455-78 standard, as well as results from factory tests performed prior to shipping.
7. Ensure that the manufacturer submits the date of manufacture; product and serial numbers; cable data, including the reel length; refraction index; the project name and location; type of fiber and quantity of strands used; technical product data sheets; and reel numbers.

SUBARTICLE 633-2.2 is deleted and the following substituted:

**633-2.2 Twisted Pair Cable:** Use shielded underground and aerial cable. Underground and aerial cables include telephone cables and multiconductor communication cables.

**633-2.2.1 Aerial Cable Support Wire:** Meet the requirements of 632-2.2.

**633-2.2.2 Aerial Cable Attachment Hardware:** Meet the requirements of 632-2.3.

**633-2.2.3 Telephone Cable:** Use aerial telephone cable with separate support wire conforming to Rural Electrification Administration (REA) Specification PE-39, filled telephone cables. Aerial telephone cable must comply with REA Specification PE-38, aerial telephone cables. Use only No. 22 AWG solid cables for copper connections in traffic signal closed loop systems.

Use underground telephone cable conforming to the United States Department of Agriculture (USDA), Rural Utilities Service (RUS) Bulletin 1753F-205 (PE-39), "REA Specification for Filled Telephone Cables".

**633-2.2.4 Multiconductor Cable:** Multi-conductor communication cable is used to carry communication and electrical signals between equipment, including Ethernet data or serial data, low voltage power, and may also be used to energize signaling equipment as part of signaling circuits.

**633-2.2.4.1 Category 6 Cable:** Use polyethylene jacketed Category 6 (CAT 6) cable conforming to the requirement of TIA 568 C.2 with Edison Testing Laboratories (ETL) verification. Cables run outside of equipment enclosures must be shielded cable (F/UTP) using an aluminum foil shield with drain wire and solid copper conductors, and shall be terminated with shielded RJ-45 connectors. Cable which remains within the equipment enclosure where it originates may be un-shielded twisted pair (UTP), include stranded copper conductors, and be terminated with un-shielded RJ-45 connectors. Use straight-through cables when connecting data terminating equipment (DTE) to data communications equipment (DCE), and cross-over cables when connecting DTE to DTE or DCE to DCE. For RJ-45 connector color coding: use TIA T-568B connectors as the standard configuration for straight-through cables and use TIA T-568B on one end and TIA T-568A on the other end for cross over cables.

**633-2.2.4.2 Composite Cable:** Composite cable consists of multiple conductors and cables housed within a single overall UV resistant polyethylene or polyvinyl jacket. The composite cable must carry communication and power to equipment using the type, number of conductors, and wire gauges as shown in the Plans and recommended by the equipment manufacturer. The cable must include an overall metallic shield with drain wire or individual shields with drain wires for each conductor.

SUBARTICLE 633-3.1.8 is deleted and the following substituted:

**633-3.1.8 Installation Testing:** Notify the Engineer of cable testing at least 14 calendar days in advance. Submit the testing procedures to the Engineer for approval prior to commencement of testing. Perform all tests at 1,310 and 1,550 nanometer wavelengths and include the last calibration date of all test equipment with the test parameters set on the equipment in the test documentation. Ensure that the last calibration date of all test equipment is within the last 12 months and that the calibration certificate is maintained in the test equipment case or provided electronically when requested. Test all installed fibers (terminated and un-

terminated) using methods identified in this Section. All tests must be conducted with a launch box.

Fibers containing splices, fibers terminated on both ends, terminated on one end, or backbone fibers (inside project limits and continuing outside of project limits) must be bidirectionally tested.

Drop fibers without splices (inside project limits and continuing outside of project limits), with only terminations on one end, and bare fiber on the other must be tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Drop fibers without splices which are unterminated on both ends (inside project limits and continuing outside of project limits) must be tested using a bare fiber adapter and tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Present the results of the OTDR testing (i.e., traces for each fiber) and a loss table showing details for each splice and termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-78 standard.

#### **633-3.1.8.1 Optical Time Domain Reflectometer (OTDR) Attenuation**

**Testing:** Perform testing on all fibers to ensure that attenuation does not exceed allowable loss (0.35 db/km for 1310 nanometer wavelength, 0.25 db/km for 1550 nanometer wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

**633-3.1.8.1.1 OTDR Tracing:** Test all fibers with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 nanometer.

**633-3.1.8.1.2 Splice Loss Testing:** Ensure that the splice loss for a SMF fusion splice does not exceed a maximum bidirectional average of 0.1 decibel per splice when measured using an OTDR. Repair or replace splices that exceed allowable attenuation at no cost to the Department.

**633-3.1.8.1.3 Connector Loss Testing:** Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed 0.6 decibel when measured using an OTDR. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.

SUBARTICLE 633-3.2 is deleted and the following substituted:

**633-3.2 Twisted Pair Cable Installation:** Install all materials and equipment according to the latest version of the manufacturer's installation procedures.

Ensure cable drawn through conduit, ducts, drilled holes is protected by a rubber grommet, and is installed in a manner that prevents damage to conductors or insulation. Ensure all connections to outdoor equipment are weatherproof and prevent water intrusion into equipment, connections, and cable entrances. Cables exposed to the elements must be rated for outdoor use.

**633-3.2.1 Cable type and Number of Conductors:** Determine the appropriate cable type and conductor count required for each twisted pair communication cable unless specified in the Contract Documents. Identify all spare conductors.

**633-3.2.2 Number of Cables:** Do not install more than four separate cables at any point on a single support wire.

**633-3.2.3 Telephone Cable:** Install telephone cables in continuous lengths to and between cabinets and junction boxes. The Contractor may install junctions at intervals less than

shown in the Plans; however, the Contractor must provide any additional materials (such as junction boxes, cabinets, risers, and mounting hardware) and labor for additional junctions and terminations at no expense to the Department. Obtain the Engineer's approval for any additional junctions or terminations.

**633-3.2.4 Multiconductor Cable:** Install multi-conductor communication cable in continuous lengths between cabinets and from cabinets to devices. Separate multi-conductor communication cables from high voltage conductors. Keep cable on the unprotected side of surge suppression devices separate from cable on the protected side to prevent induction of lightning and other high voltage transient currents.

**633-3.2.5 Surge Protective Devices:** Install surge protective devices meeting the requirements of Section 620 on cables entering cabinets or enclosures, and as shown in the Plans, prior to connection of Ethernet switches, PoE injectors, or other equipment.

ARTICLE 633-4 is deleted and the following substituted:

**633-4 Warranty.**

Ensure that the fiber optic cable, the enclosures, terminations, and twisted pair cables and connectors have a manufacturer's warranty covering defects for a minimum of 2 years from the date of final acceptance. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

ARTICLE 633-6 is deleted and the following substituted:

**633-6 Method of Measurement.**

The quantities to be paid will be: the length, in feet, of fiber optic cable; the number, per each, of fiber optic connections; the number, per each, of fiber optic connection hardware; the number of calendar days from contract time start to final acceptance for fiber optic cable locator; the length, per foot, of telephone cable; and the length, per foot, of multi-conductor communication cable accepted by the Engineer.

The Contract unit price for communication cable, furnished and installed, will include furnishing, placement, and testing of all material, and for all tools, labor, equipment, installation hardware (such as support wire, cable ties, cable clamps, and lashing wire), supplies, support, personnel training, documentation, and incidentals necessary for a complete installation.

Payment for conductive cable terminal connectors and conductive cable grounding is considered incidental and shall be included in the price for twisted pair communication cable.

Fiber optic splices and terminations, as shown in the Plans, shall be measured per each fiber optic connection furnished and installed.

The price per day for a Fiber Optic Cable Locator will include all tools, labor, equipment, locating and marking hardware (such as flags, paint, and shovels), supplies, support, personnel training, documentation, and incidentals.

ARTICLE 633-7 is deleted and the following substituted:

**633-7 Basis of Payment.**

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

- |                 |   |
|-----------------|---|
| Item No. 633- 1 | Fiber Optic Cable - per foot.                   |
| Item No. 633- 2 | Fiber Optic Connection - each.                  |
| Item No. 633- 3 | Fiber Optic Connection Hardware - each.         |
| Item No. 633- 4 | Telephone Cable - per foot.                     |
| Item No. 633- 6 | Fiber Optic Cable Locator - per day.            |
| Item No. 633- 8 | Multi-Conductor Communication Cable – per foot. |