



*Florida Department of Transportation*

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KEVIN J. THIBAUT, P.E.  
SECRETARY

February 12, 2021

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 from the Traffic Engineering and Operations Office to update the fiber optic cable characteristics, performance requirements, connector types, fiber optic jumper description, splice installation, splice testing, and fiber optic cable testing. This proposed spec change is conjunction with Section 7 and 711.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to [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 414-4130.

Sincerely,

Signature on file

Daniel Strickland, P.E.  
State Specifications Engineer

DS/ra

Attachment

cc: Florida Transportation Builders' Assoc.  
State Construction Engineer

**COMMUNICATION CABLE**(REV ~~12-121-210~~)

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
Cladding Diameter: 125 $\mu$ m, $\pm$ 0.7 $\mu$ m
Core-to-Cladding Concentricity: $\leq$ 0.5 $\mu$ m
Cladding Noncircularity: $\leq$ 0.7%
Mode Field Diameter: 1,550 nm; 10.4 $\mu$ m, $\pm$ 0.5 $\mu$ m
Coating Diameter: 245 $\mu$ m, $\pm$ 5 $\mu$ m
Colored Fiber Nominal Diameter: 250 $\mu$ m $\pm$ 15 $\mu$ m
Optical
Cabled Fiber Attenuation: 1,310 nm, $\leq$ 0. <del>35</del> 4 dB/km; 1,550 nm, $\leq$ 0. <del>25</del> 3 dB/km
Point Discontinuity: 1,310 nm, $\leq$ 0.05 dB/km; 1,550 nm, $\leq$ 0.05 dB/km
Cable Cutoff Wavelength ( $\lambda_{\text{cef}}$ ): $\leq$ 1,260 nm.
<del>Total</del> Dispersion: 1, <del>550</del> 625 nm $\leq$ 18 <del>23</del> .0 ps/(nm•km)
Macrobend Attenuation: Turns – 100; Outer diameter (OD) of the mandrel – <del>5</del> 60 mm, $\pm$ 2 mm; $\leq$ 0.0 <del>3</del> 5 dB at 1,550 nm
<del>Cabled</del> Polarization Mode Dispersion ( $\text{PMD}_0$ ): $\leq$ 0.045 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 633-2.1.1.4 is deleted and the following substituted:

**633-2.1.1.4 Strength Member:** Ensure that the fiber optic cable contains a dielectric central ~~and outside elements that strength member and dielectric outside strength member to~~ prevent buckling of the cable and provide tensile strength. Ensure that the fiber optic cable can withstand a pulling tension of 600 lbs. without damage to any components of the fiber optic cable.

SUBARTICLE 633-2.1.1.6 is deleted and the following substituted:

**633-2.1.1.6 Ripcord:** Ensure that the cable contains at least one ripcord under the sheath or alternate method that allows the removal of the sheath by hand or with pliers. ~~Ensure that the ripcord permits the removal of the sheath by hand or with pliers.~~

SUBARTICLE 633-2.1.1.9.1 is deleted and the following substituted:

**633-2.1.1.9 Performance Requirements:**

**633-2.1.1.9.1 Operating Temperature:** Ensure that the shipping and the operating temperature range of fiber optic cable meets or exceeds minus ~~43~~<sup>40</sup>° to 158° F. Ensure that the installation temperature range of fiber optic cable meets or exceeds minus 22° to ~~158~~<sup>140</sup>°F.

SUBARTICLE 633-2.1.3 is deleted and the following substituted:

**633-2.1.3 Cable Terminations:** Use Type LC connectors for all new network installations. Use Type ST, SC, ~~LC~~, or FC connectors only; for connections to existing equipment or as specified in the Plans or by the Engineer. ~~Ensure that all ST-type fiber optic connectors, whether factory pre-terminated or field installed, are 0.1 inch physical contact with preradiused tips.~~ Ensure that all connectors include a ceramic ferrule and provide a strain relief mechanism when installed on a single fiber cable that contains strength elements. Ensure that ST and FC connectors include a ~~ceramic ferrule and a~~ metallic body, ~~and provide a strain relief mechanism when installed on a single fiber cable that contains strength elements.~~ Ensure that ~~the ST-type all~~ connectors provides a minimum ~~1150~~ pound pullout strength. Ensure that the optical fiber within the body of all connectors is mechanically isolated from cable tension, bending, and twisting.

Ensure that all connectors are compliant with the ~~TIA/EIA-568-A and~~ TIA/EIA-604 standards, as applicable, and are tested according to the Telcordia/Bellcore GR-326-CORE standard. When tested according to the TIA and EIA's Fiber Optic Test Procedure (FOTP)-171 (TIA/EIA-455-171~~B~~) at the manufacturer, ensure that the connectors ~~have test to~~ an average insertion loss, as reflected on the manufacturer data sheet, of less than or equal to ~~0.154~~ decibel and a maximum loss of less than or equal to ~~0.2075~~ decibel. Test the connectors as detailed in FOTP-107 (TIA -455-107A) to reflectance values of less than or equal to minus 50 decibels.

SUBARTICLE 633-2.1.4 is deleted and the following substituted:

**633-2.1.4 Patch Panels:** Ensure that the patch panel is compatible with the fiber optic cable being terminated and color coded to match the optical fiber color scheme. Ensure that the patch panel has a minimum of 12 ~~LCST~~-type panel connectors unless otherwise shown in the Plans. Ensure that the patch panel dimensions do not exceed 14 inches x 6 inches x 4 inches for fiber counts of twelve or less. Ensure the patch panel is suitable for mounting within an approved cabinet at the field device location. Ensure patch panels are sized to accommodate specified

coupler housings and maintain sufficient bend radius for cables. Ensure the patch panel is sized to occupy the minimum space required for capacity.

SUBARTICLE 633-2.1.4.1 is deleted and the following substituted:

**633-2.1.4.1 Pre-terminated Patch Panels:** Ensure that the pre-terminated patch panel includes a factory installed all-dielectric SMF cable stub. Ensure that the panel includes factory installed and terminated LCST-type panel connectors unless otherwise shown in the Plans. Ensure that the cable stub is of sufficient length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or as directed by the Engineer.

SUBARTICLE 633-2.1.4.2.1 is deleted and the following substituted:

**633-2.1.4.2.1 Connector Panel:** Ensure that the connector panel provides 12 LCST-type, bulkhead-mount coupling connectors unless otherwise shown in the Plans. Ensure that each coupling connector allows connection of a cable terminated on one side of the panel to a cable on the opposite side.

Ensure that each bulkhead-mount coupling connector includes a locknut for mounting the connector in predrilled or punched holes in the connector panel.

ARTICLE 633-2 is expanded by the following new Subarticle:

**633-2.1.5 Fiber Optic Jumper Cables:** Ensure that the fiber optic jumper cables include a factory installed all-dielectric SMF. Ensure that the fiber optic jumper cables include factory installed and terminated LC-type connectors or as shown in the plans, as directed, or as required to complete the connection.

SUBARTICLE 633-2.1.5 is deleted and the following substituted:

**633-2.1.6~~5~~ Handling:**

**633-2.1.6~~5~~.1 Cable End Sealing:** Ensure that fiber optic cable ends are capped or sealed to prevent the entry of moisture during shipping, handling, storage, and installation. Equip one end of the fiber optic cable with flexible pulling eyes.

**633-2.1.6~~5~~.2 Protective Wrap:** Ensure that the fiber optic cable is shipped and stored with a protective wrap or other approved mechanical reel protection device over the outer turns of the fiber optic cable on each reel. Ensure that the wrap is weather resistant and protects the cable reel from environmental hazards. Ensure that the cable reel remains wrapped until cable is to be installed.

**633-2.1.6~~5~~.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-A 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.

**633-2.1.7~~6~~ Manufacturer Testing and Certification:** Submit documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.

SUBARTICLE 633-3.1.5 is deleted and the following substituted:

**633-3.1.5 Fiber Optic Connection - Splicing:** Perform all optical fiber splicing using the fusion splicing technique, and according to the latest version of the manufacturer's cable installation procedures; industry accepted installation standards, codes, and practices; or as directed by the Engineer. Ensure that all splices match fiber and buffer tube colors unless shown otherwise in the Plans. Ensure that splice loss does not exceed a maximum of 0.05 db per splice as measured on the fusion splice machine when splicing newly installed fibers together. Ensure that splice loss does not exceed a maximum of 0.1 db per splice as measured on the fusion splice machine when splicing newly installed fibers to existing fibers. Where a fiber cable is to be accessed for lateral or drop signal insertion, only open the buffer tube containing the fiber to be accessed and only cut the actual fiber to be accessed. If a fiber end is not intended for use, cut the fiber to a length equal to that of the fiber to be used and neatly lay it into the splice tray. Treat any fibers exposed during splicing with a protective coating and place in a protective sleeve or housing to protect the fiber from damage or contaminants. Neatly store all splice enclosures within a splice box. Attach the splice enclosure to the splice box interior wall to prevent the enclosure from lying on the bottom of the splice box. Splices shall be made only at locations as shown in the plans, or as approved by the Engineer.

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 or termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-61 standard.

SUBARTICLE 633-3.1.8.1 is deleted and the following substituted:

#### **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~~<sup>4</sup> db/km for 1310 nanometer wavelength, 0.~~25~~<sup>3</sup> 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.

SUBARTICLE 633-3.1.8.2 is deleted and the following substituted:

~~633-3.1.8.1.12~~ OTDR Tracing: Test all fibers ~~from both cable end points~~ with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 nanometer. ~~Test the fibers that are not terminated at the time of installation using a bare fiber adapter. Present the results of the OTDR testing (i.e., traces for each fiber) and a loss table showing details for each splice or termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-61 standard.~~

SUBARTICLE 633-3.1.8.3 is deleted and the following substituted:

~~633-3.1.8.1.23~~ 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.

SUBARTICLE 633-3.1.8.4 is deleted and the following substituted:

~~633-3.1.8.1.34~~ Connector Loss Testing: Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed

0.65 decibel when measured using an OTDR. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.

SECTION 633 is expanded by the following new Article:

**633-5 Fiber Optic Cable Locator.**

Locate and mark all existing Department owned or maintained fiber optic facilities within project limits prior to performing any subsurface work.

Locate and mark as necessary to ensure that all fiber optic facilities are located and visibly marked at all times.

ARTICLE 633-5 is deleted and the following substituted:

**633-65 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, per day, of fiber optic cable locator; and the length, per foot, of twisted pair 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 633-6 is deleted and the following substituted:

**633-76 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 Cable - per foot.          |
| <u>Item No. 633- 6</u> | <u>Fiber Optic Locator - per day.</u>   |

**COMMUNICATION CABLE****(REV 2-11-21)**

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
Cladding Diameter: 125 $\mu$ m, $\pm$ 0.7 $\mu$ m
Core-to-Cladding Concentricity: $\leq$ 0.5 $\mu$ m
Cladding Noncircularity: $\leq$ 0.7%
Mode Field Diameter: 1,550 nm; 10.4 $\mu$ m, $\pm$ 0.5 $\mu$ m
Coating Diameter: 245 $\mu$ m, $\pm$ 5 $\mu$ m
Colored Fiber Nominal Diameter: 250 $\mu$ m $\pm$ 15 $\mu$ m
Optical
Cabled Fiber Attenuation: 1,310 nm, $\leq$ 0.35 dB/km; 1,550 nm, $\leq$ 0.25 dB/km
Point Discontinuity: 1,310 nm, $\leq$ 0.05 dB/km; 1,550 nm, $\leq$ 0.05 dB/km
Cable Cutoff Wavelength ( $\lambda_{\text{cef}}$ ): $\leq$ 1,260 nm.
Dispersion: 1,550 nm $\leq$ 18.0 ps/(nm•km)
Macrobend Attenuation: Turns – 100; Outer diameter (OD) of the mandrel – 50 mm, $\pm$ 2 mm; $\leq$ 0.03 dB at 1,550 nm
Polarization Mode Dispersion (PMD <sub>Q</sub> ): $\leq$ 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 633-2.1.1.4 is deleted and the following substituted:

**633-2.1.1.4 Strength Member:** Ensure that the fiber optic cable contains a dielectric central and outside elements that prevent buckling of the cable and provide tensile strength. Ensure that the fiber optic cable can withstand a pulling tension of 600 lbs. without damage to any components of the fiber optic cable.

SUBARTICLE 633-2.1.1.6 is deleted and the following substituted:

**633-2.1.1.6 Ripcord:** Ensure that the cable contains at least one ripcord under the sheath or alternate method that allows the removal of the sheath by hand or with pliers.

SUBARTICLE 633-2.1.1.9.1 is deleted and the following substituted:

**633-2.1.1.9 Performance Requirements:**

**633-2.1.1.9.1 Operating Temperature:** Ensure that the shipping and the operating temperature range of fiber optic cable meets or exceeds minus 40° to 158° F. Ensure that the installation temperature range of fiber optic cable meets or exceeds minus 22° to 158°F.

SUBARTICLE 633-2.1.3 is deleted and the following substituted:

**633-2.1.3 Cable Terminations:** Use Type LC connectors for all new network installations. Use Type ST, SC, or FC connectors only for connections to existing equipment or as specified in the Plans or by the Engineer. Ensure that all connectors include a ceramic ferrule and provide a strain relief mechanism when installed on a single fiber cable that contains strength elements. Ensure that ST and FC connectors include a metallic body. Ensure that all connectors provide a minimum 11 pound pullout strength. Ensure that the optical fiber within the body of all connectors is mechanically isolated from cable tension, bending, and twisting.

Ensure that all connectors are compliant with the TIA/EIA-604 standards, as applicable, and are tested according to the Telcordia/Bellcore GR-326-CORE standard. When tested according to the TIA and EIA's Fiber Optic Test Procedure (FOTP)-171 (TIA/EIA-455-171B) at the manufacturer, ensure that the connectors have an average insertion loss, as reflected on the manufacturer data sheet, of less than or equal to 0.15 decibel and a maximum loss of less than or equal to 0.20 decibel. Test the connectors as detailed in FOTP-107 (TIA -455-107A) to reflectance values of less than or equal to minus 50 decibels.

SUBARTICLE 633-2.1.4 is deleted and the following substituted:

**633-2.1.4 Patch Panels:** Ensure that the patch panel is compatible with the fiber optic cable being terminated and color coded to match the optical fiber color scheme. Ensure that the patch panel has a minimum of 12 LC-type panel connectors unless otherwise shown in the Plans. Ensure that the patch panel dimensions do not exceed 14 inches x 6 inches x 4 inches for fiber counts of twelve or less. Ensure the patch panel is suitable for mounting within an approved cabinet at the field device location. Ensure patch panels are sized to accommodate specified coupler housings and maintain sufficient bend radius for cables. Ensure the patch panel is sized to occupy the minimum space required for capacity.

SUBARTICLE 633-2.1.4.1 is deleted and the following substituted:

**633-2.1.4.1 Pre-terminated Patch Panels:** Ensure that the pre-terminated patch panel includes a factory installed all-dielectric SMF cable stub. Ensure that the panel includes factory installed and terminated LC-type panel connectors unless otherwise shown in the Plans. Ensure that the cable stub is of sufficient length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or as directed by the Engineer.

SUBARTICLE 633-2.1.4.2.1 is deleted and the following substituted:

**633-2.1.4.2.1 Connector Panel:** Ensure that the connector panel provides 12 LC-type, bulkhead-mount coupling connectors unless otherwise shown in the Plans. Ensure that each coupling connector allows connection of a cable terminated on one side of the panel to a cable on the opposite side.

Ensure that each bulkhead-mount coupling connector includes a locknut for mounting the connector in predrilled or punched holes in the connector panel.

ARTICLE 633-2 is expanded by the following new Subarticle:

**633-2.1.5 Fiber Optic Jumper Cables:** Ensure that the fiber optic jumper cables include a factory installed all-dielectric SMF. Ensure that the fiber optic jumper cables include factory installed and terminated LC-type connectors or as shown in the plans, as directed, or as required to complete the connection.

SUBARTICLE 633-2.1.5 is deleted and the following substituted:

**633-2.1.6 Handling:**

**633-2.1.6.1 Cable End Sealing:** Ensure that fiber optic cable ends are capped or sealed to prevent the entry of moisture during shipping, handling, storage, and installation. Equip one end of the fiber optic cable with flexible pulling eyes.

**633-2.1.6.2 Protective Wrap:** Ensure that the fiber optic cable is shipped and stored with a protective wrap or other approved mechanical reel protection device over the outer turns of the fiber optic cable on each reel. Ensure that the wrap is weather resistant and protects the cable reel from environmental hazards. Ensure that the cable reel remains wrapped until cable is to be installed.

**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-A 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.

**633-2.1.7 Manufacturer Testing and Certification:** Submit documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.

SUBARTICLE 633-3.1.5 is deleted and the following substituted:

**633-3.1.5 Fiber Optic Connection - Splicing:** Perform all optical fiber splicing using the fusion splicing technique, and according to the latest version of the manufacturer's cable installation procedures; industry accepted installation standards, codes, and practices; or as directed by the Engineer. Ensure that all splices match fiber and buffer tube colors unless shown otherwise in the Plans. Ensure that splice loss does not exceed a maximum of 0.05 db per splice as measured on the fusion splice machine when splicing newly installed fibers together. Ensure that splice loss does not exceed a maximum of 0.1 db per splice as measured on the fusion splice machine when splicing newly installed fibers to existing fibers. Where a fiber cable is to be accessed for lateral or drop signal insertion, only open the buffer tube containing the fiber to be accessed and only cut the actual fiber to be accessed. If a fiber end is not intended for use, cut the fiber to a length equal to that of the fiber to be used and neatly lay it into the splice tray. Treat any fibers exposed during splicing with a protective coating and place in a protective sleeve or housing to protect the fiber from damage or contaminants. Neatly store all splice enclosures within a splice box. Attach the splice enclosure to the splice box interior wall to prevent the enclosure from lying on the bottom of the splice box. Splices shall be made only at locations as shown in the plans, or as approved by the Engineer.

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 or termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-61 standard.

SUBARTICLE 633-3.1.8.1 is deleted and the following substituted:

**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.

SUBARTICLE 633-3.1.8.2 is deleted and the following substituted:

**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.

SUBARTICLE 633-3.1.8.3 is deleted and the following substituted:

**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.

SUBARTICLE 633-3.1.8.4 is deleted and the following substituted:

**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.

SECTION 633 is expanded by the following new Article:

**633-5 Fiber Optic Cable Locator.**

Locate and mark all existing Department owned or maintained fiber optic facilities within project limits prior to performing any subsurface work.

Locate and mark as necessary to ensure that all fiber optic facilities are located and visibly marked at all times.

ARTICLE 633-5 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, per day, of fiber optic cable locator; and the length, per foot, of twisted pair 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 633-6 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 Cable - per foot.
Item No. 633- 6	Fiber Optic Locator - per day.