ORIGINATION FORM

Date: November 8, 2012
Originator: Jeff Morgan
Contact Information:
Traffic Engineering and Operations, Traffic Systems Section
850-410-5600

Specification Title:
COMMUNICATION CABLE
Specification Section, Article, or Subarticle Number: 633

Why does the existing language need to be changed? The specification must be updated to consolidate material requirements from the Minimum Specifications for Traffic Control Signals and Devices (MSTCSD) and the Standard Specifications for Road and Bridge Construction (SSRBC). This new section combines content formerly contained in Section 632 and Section 783. This activity is a planned part of an ongoing specification consolidation effort.

Summary of the changes: The changes merge various similar content from the MSTCSD and SSRBC.

Are these changes applicable to all Department jobs? If not, what are the restrictions? This requirement is typically applicable to all jobs, but specifically those using communication cable.

Will these changes result in an increase or decrease in project costs? If yes, what is the estimated change in costs? No increase or decrease in project costs is expected.

With who have you discussed these changes? In-house stakeholders (Traffic Engineering and Operations Office staff, Specifications Office staff, C-team).

What other offices will be impacted by these changes? Specifications and Estimates, Construction, Maintenance, and Roadway Design.

Are changes needed to the PPM, Design Standards, SDG, CPAM or other manual? Yes. Coordination of changes is an ongoing effort of the Consolidation of Products and Specifications (COPS) working group in conjunction with the C-team.

Is a Design Bulletin, Construction Memo, or Estimates Bulletin needed? Yes.

Contact the State Specifications Office for assistance in completing this form.
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ANANTH PRASAD, P.E.
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M E M O R A N D U M

DATE: December 10, 2012

TO: Specification Review Distribution List

FROM: Trey Tillander, State Specifications Engineer

SUBJECT: Proposed Specification: **6330000 Communication Cable.**

In accordance with Specification Development Procedures, we are sending you a copy of a proposed specification change.

The changes are proposed by Jeff Morgan of the Traffic Engineering Operations Office to consolidate material requirements from the Minimum Specifications for Traffic "Control Signals and Devices (MSTCSD) and the Standard Specifications for Road and Bridge Construction (SSRBC). This new section combines content formerly contained in Section 632 and Section 783.

Please share this proposal with others within your responsibility. Review comments are due within four weeks and should be sent to Mail Station 75 or to my attention via e-mail at SP965TT or trey.tillander@dot.state.fl.us. Comments received after **January 8, 2013,** may not be considered. Your input is encouraged.

TT/ft
Attachment

COMMUNICATION CABLE.
(REV 11-20-12)

PAGE 787. The following new Section is added after Section 632:

SECTION 633
COMMUNICATION CABLE

633-1 Description.

Furnish and Install underground and aerial communication cable as shown in the Plans and Design Standards.

633-2 Materials.

633-2.1 Fiber Optic Cable and Connections.

633-2.1.1 Single Mode Fiber Optic Cable: *Provide all-dielectric, dry-filled, loose-tube, dispersion-unshifted, single-mode fiber (SMF) with low water peak, gel free, and suitable for underground (i.e., in conduit) and aerial outside plant installation. All fiber optic cable shall be splice-compatible with the Department's existing dispersion-unshifted SMF and require no electronic equipment for dispersion compensation between new and existing fiber. Ensure that all components that comprise a single length of cable are continuous and of the same material. Furnish only commercial off-the-shelf materials, equipment, and components.*

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: 125µm, ±0.7 µm
Core-to-Cladding Concentricity: ≤0.5 µm
Cladding Noncircularity: ≤0.7%
Mode Field Diameter: 1,550 nm; 10.4 µm, ±0.5 µm
Coating Diameter: 245 µm, ±5 µm
Colored Fiber Nominal Diameter: 250 ±15 µm
Optical
Cabled Fiber Attenuation: 1,310 nm, ≤0.4 dB/km; 1,550 nm, ≤0.3 dB/km
Point Discontinuity: 1,310 nm, ≤0.05 dB/km; 1,550 nm, ≤0.05 dB/km
Cable Cutoff Wavelength (λ_{ccf}): ≤1,260 nm.
Total Dispersion: 1,625 nm ≤23.0 ps/(nm•km)
Macrobend Attenuation: Turns – 100; Outer diameter (OD) of the mandrel – 60 mm, ±2 mm; ≤0.05 dB at 1,550 nm
Cabled Polarization Mode Dispersion: ≤0.5 $\text{ps}/\sqrt{\text{km}}$

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.

633-2.1.1.2 Buffer Tubes: *Ensure that the fiber optic cable includes loose buffer tubes that isolate internal optical fibers from outside forces and provide protection from physical damage as well as water ingress and migration. Ensure that buffer tubes provide freedom of movement for internal optical fibers. Ensure buffer tubes allow for expansion and contraction of the cable without damage to internal optical fiber. Ensure that fiber does not adhere to the inside of the tube. Ensure that buffer tubes permit intentional scoring and breakout without damage to the fiber. Ensure that each fiber optic cable buffer tube contains 12 fibers per tube unless otherwise shown in the Plans.*

633-2.1.1.3 Color Code: *Ensure that the marking and color--coding of the fibers and buffer tubes conforms to the TIA/EIA-598-B standard.*

Ensure that colors are permanent and stable during temperature cycling, and not subject to fading or smearing onto each other or into the water-blocking material. Ensure that fibers are colored with UV curable inks that remain clearly distinguishable as the intended color.

633-2.1.1.4 Strength Member: *Ensure that the fiber optic cable contains a dielectric central 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.*

633-2.1.1.5 Water Blocking Compound: *Ensure that the fiber optic cable contains a dry water-blocking material to prevent the ingress of water within the outer cable jacket. Ensure that water-blocking materials are non-nutritive, dielectric, and homogeneous, and free from dirt and foreign matter. Use dry water-blocking material for fiber optic cables used for either aerial or underground installations. Apply dry water-blocking compound longitudinally around the outside of the central buffer tubes. Construct all cables with water-blocking material that complies with the requirements of the EIA/TIA-455-81B standard and is subjected to water penetration tests as defined in the EIA/TIA-455-82B standard.*

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

633-2.1.1.7 Filler: *Fillers or rods may be included in the cable core to lend symmetry to the cable cross section if required.*

633-2.1.1.8 Outer Jacket: *Ensure that the fiber optic cable is jacketed with medium density polyethylene (MDPE) that is free of blisters, cracks, holes, and other deformities. Ensure that the nominal jacket thickness is a minimum of 0.03 inches. Ensure the outer jacket provides UV protection and does not promote the growth of fungus.*

Mark the jacket with the cable manufacturer's name, fiber type, fiber count, date of manufacture, the words "FDOT FIBER OPTIC CABLE" (unless otherwise shown in the Plans), and the sequential cable lengths marked in feet. Ensure that the actual length of the cable is within 1% of the length indicated by the marking. Provide legible marking with contrasting color to that of the cable jacket.

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 30º to 158º F. Ensure that the installation temperature range of fiber optic cable meets or exceeds minus 22º to 140º F.*

633-2.1.1.9.2 Bend radius: *Ensure that the fiber optic cable is capable of withstanding a minimum unloaded bend radius of 10 times the cable diameter and a minimum loaded bend radius of 20 times the cable diameter when loaded to pulling tension of 600 pounds. Test the cable as required in the EIA-455-33A standard. Ensure that bending the fiber optic cable up to the minimum bend radius does not affect the optical characteristics of the fiber.*

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/EIA-455-25B 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.*

633-2.1.1.9.4 Water Penetration: *Ensure that the fiber optic cable is capable of withstanding the tests for water penetration defined in the TIA/EIA-455-82 standard. Ensure that a one-meter length of cable is able to withstand a one-meter static head of water applied at one end for 24 hours without water leaking through the other open cable end.*

633-2.1.2 ~~Splicing~~ ~~Materials~~Fiber Optic Connection Hardware: *Ensure that all splice enclosures, organizers, cable end preparation tools, and procedures are compatible with the fiber optic cable, and are approved by the Engineer.*

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-711-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 0.55 inches, plus 10%, without jeopardizing the waterproof characteristics of the enclosure.

Provide fiber optic splice enclosures meeting the following requirements:

Mechanical
Resist compression deformation to a maximum of 400 pounds.
Withstand an impact energy to a maximum of 40 foot-pounds at 0° F.
Axial Tension: 100 pounds for 30 minutes.
Cable Torsion: ten 90-degree rotations.
Cable Flexing: ten 90-degree bends.
Environmental
Hydrostatic Pressure Head: Up to 20 foot-pounds (-9 pounds per square inch).
Withstand 40 freeze/thaw temperature cycles.
Ultraviolet resistant during a maximum 30-day exposure in compliance with the requirements detailed in the ASTM B117 standard.
Chemical
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.

633-2.1.2.2 Splice Trays: *Ensure that splice trays are securely attached and accessible, and provide sufficient storage for the fiber cable. Ensure splice trays provide access to individual fibers without disrupting other fibers in the tray. Ensure that splice trays hold the buffer tubes rigidly in place and provide protection for fusion splices. Ensure that the raceway accommodates the minimum bend radius of the fiber. Ensure that splice trays allow visible inspection of the fiber. Ensure that splice trays include a cover with a locking mechanism to hold it in place.*

633-2.1.3 Cable Terminations: *Use Type ST, SC, LC, or FC connectors only, 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 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 connector provides a minimum 50 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), ensure that the connectors test to an average insertion loss of

less than or equal to 0.4 decibel and a maximum loss of less than or equal to 0.75 decibel. Test the connectors as detailed in FOTP-107 (TIA/EIA-455-107) to reflectance values of less than or equal to minus 50 decibels.

633-2.1.3.1 Pre-terminated Connector Assemblies (Pigtails): *Ensure that pre-terminated cable assemblies consist of fiber optic cables with factory-installed connectors on one end of the cable and an un-terminated optical fiber on the other. Ensure that the pre-terminated connector assemblies are installed with fusion splices. Ensure that all buffer tubes and fibers are protected once the attachment of pre-terminated connector assemblies is complete.*

633-2.1.3.2 Buffer Tube Fan-out Kits: *Ensure that a buffer tube fan-out kit is installed when fiber optic cables are terminated. Use a kit compatible with the fiber optic cable being terminated and that is color-coded to match the optical fiber color scheme. Ensure that the buffer tube fan-out kit supports 12 fiber strands. Ensure that output tubing and the fiber strands contained therein are of sufficient length for routing and attachment of fiber optic cable to connected electronics or as directed by the Engineer. Ensure that the kit and the connectors are supplied by the same manufacturer.*

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 ST-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.*

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 ST-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.*

633-2.1.4.2 Field Assembled and Terminated Patch Panels: *Ensure that the field-assembled patch panel is a termination panel that includes a connector panel and the hardware required to mount the patch panel within an approved cabinet at the field device location and connect the panel to the backbone fiber cable.*

633-2.1.4.2.1 Connector Panel: *Ensure that the connector panel provides 12 ST-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.

633-2.1.5 Handling:

633-2.1.5.1 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.*

633-2.1.5.2 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.

633-2.1.5.3 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. Ensure that all cable delivered has been manufactured within 6 months of the delivery date.*~~

6~~7~~. Provide a copy of the transmission loss test results as required by the EIA/TIA-455-61 standard, as well as results from factory tests performed prior to shipping.

7~~8~~. Ensure that the manufacturer provides 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.

633-2.1.6 Manufacturer Testing and Certification: *Provide documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.*

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

633-2.3 Communication Cable Support Wire: *Provide support wire, whether separate from or integral to aerial interconnect cable, having a minimum diameter of 6.35 mm and meeting the requirements in Section A634.*

633-2.4 Aerial Cable Attachment Hardware: *Use attachment hardware with sufficient tensile strength for the application. Ensure that all bolts and nuts less than 5/8 inch in diameter are passivated stainless steel, Type 316 or Type 304 and meet the requirements of ASTM F593 and ASTM F594 for corrosion resistance. Ensure that all bolts and nuts 5/8 inch and over in diameter are galvanized and meet the requirements of ASTM A307. Use stainless steel lashing wire, galvanized or stainless steel lashing rod, cable rings or self-locking cable ties of U.V. stabilized black plastic having a minimum tensile strength of 100 pounds.*

633-3 Installation Requirements.

633-3.1 Fiber Optic Cable Installation: *Install all materials and equipment according to the latest version of the manufacturer's installation procedures. Ensure that all materials and installation practices are in accordance with the applicable OSHA requirements as found in*

29 Code of Federal Regulations (CFR) Part 1926, Safety and Health Standards for Construction. In addition, perform the following:

1. Ensure conduit and inner-duct is clean and free from damage prior to installing fiber optic cable.

2. Document the sequential cable length markings at each splice box and pull box wall that the cable passes through, and include the information with the as-built documentation.

Provide all incidental parts needed to complete the installation, but not specified in the Plans, as necessary for a complete and properly operating system.

633-3.1.1 Cable Identification: *Develop a nomenclature plan for identification of fiber optic cable. Submit the nomenclature plan to the Engineer for approval. Use approved cable nomenclature to create cable tags for the identification of fiber optic cable. Provide cable tag identification on all test results or fiber related documents provided to the Engineer.*

Install cable tags within 1 foot of each splice and/or termination point indicating the cable type, fiber count, and each fiber optic cable's origination and termination points. Ensure that the cable tags are permanent labels suitable for outside plant applications and are affixed to all fiber optic cables. Ensure that lettering is in permanent ink and displays the phrase "FDOT FIBER OPTIC CABLE".

633-3.1.2 Pulling: *Install the fiber optic cable by hand or by using a mechanical pulling machine. If a mechanical pulling machine is used, equip the machine with a monitored or recording tension meter. Ensure that at no time the manufacturer's recommended maximum pulling tension is exceeded. Ensure that the central strength member and aramid yarn are attached directly to the pulling eye during cable pulling. Use pulling attachments, such as "basket grip" or "Chinese finger" type, to ensure that the optical and mechanical characteristics are not degraded during the fiber optic cable installation.*

Ensure that excess cable is coiled in a figure eight and fed manually when pulling through pull boxes and splice boxes by hand. If pulleys and sheaves will be used to mechanically pull through pull boxes and splice boxes, provide a drawing of the proposed layout showing that the cable will never be pulled through a radius less than the manufacturer's minimum bend radius. Use large diameter wheels, pulling sheaves, and cable guides to maintain the appropriate bend radius. Provide tension monitoring at all times during the pulling operation. Ensure that cable pulling lubricant used during installation is recommended by the optical fiber cable manufacturer.

633-3.1.3 Blowing: *Use either the high- airspeed blowing (HASB) method or the piston method. When using the HASB method, ensure that the volume of air passing through the conduit does not exceed 600 cubic feet per minute or the conduit manufacturer's recommended air volume, whichever is more restrictive. When using the piston method, ensure that the volume of air passing through the conduit does not exceed 300 cubic feet per minute or the conduit manufacturer's recommended air volume, whichever is more restrictive.*

633-3.1.4 Slack Cable Storage: *Provide and store fiber optic cable at each pull box and splice box to allow for future splices, additions, or repairs to the fiber network. Store the fiber optic cable without twisting or bending the cable below the minimum bend radius.*

Store a total of 200 feet of fiber optic cable in splice boxes, with 100 feet of cable on each side of the cable splice point or as shown in the Plans.

Store 50 feet of spare fiber optic cable in pull boxes.

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. 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.

633-3.1.5.1 Splice Plan: *Provide a splice plan showing the location and configuration of splices in the system for approval by the Engineer. Perform all splicing according to the plan. Document each splice location and identify the source and destination of each fiber in each splice tray. Document all fiber colors and buffer jacket colors used during installation, and develop a sequential fiber numbering plan as required in the TIA/EIA-598-A standard for color-coding in the documentation.*

633-3.1.5.2 Splice Equipment: *Use a fusion splice machine to splice all optical fiber. Ensure that splice equipment is new from the factory, or serviced and certified by the factory or its authorized representative within the previous 6 months from the commencement of its use. Provide the Engineer with a letter from the manufacturer or his authorized representative certifying compliance. Clean all splicing equipment and calibrate according to the manufacturer's recommendations prior to each splicing session at each location.*

633-3.1.6 Cable Termination Installation: *Ensure that cables, buffer tubes, or strands are neatly routed, secured and terminated in a patch panel. Ensure all cable termination points include documentation regarding the identification, route, and function of each fiber installed at that location. Ensure that at least one copy of this information is placed alongside the installed equipment (for instance, in a document pouch or drawer within a field cabinet).*

633-3.1.7 Patch Panel Installation: *Ensure that patch panels are neatly installed and secured in a weather proof enclosure. Ensure all patch panel connectors are clearly and permanently labeled. Ensure all installed patch panels include documentation regarding the identification, route, and function of each patch panel connector at that location. Ensure that at least one copy of this information is placed alongside the installed equipment.*

633-3.1.8 Installation Testing: *Notify the Engineer of cable testing at least 14 calendar days in advance. Provide the testing procedures to the Engineer for approval prior to commencement of testing. Perform all tests at 1,310/1,550 nanometer wavelengths, and include the last calibration date of all test equipment with the test parameters set on the equipment in the test documentation. Test all installed fibers (terminated and un-terminated) using methods approved by the Engineer.*

633-3.1.8.1 End to End Attenuation Testing: *Perform testing on all fibers to ensure that end to end attenuation does not exceed allowable loss (0.4 db/km for 1310 ~~nm~~nanometer wavelength, 0.3 db/km for 1550 ~~nm~~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.*

633-3.1.8.2 OTDR Tracing: *Test all fibers from both cable end points with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 ~~nm~~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.

633-3.1.8.3 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. Repair or replace splices that exceed allowable attenuation at no cost to the Department.*

633-3.1.8.4 Connector Loss Testing: *Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed 0.5 decibel. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.*

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.

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: *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.*

633-4 Warranty.

Ensure that the fiber optic cable, the splice enclosures, and terminations have a manufacturer's warranty covering defects for a minimum of two 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.

632~~2~~3-5 Method of Measurement.

632~~2~~3-5.1 General: *The quantities to be paid will be: (1) the length, in feet, of fiber optic cable; (2) the number, per each, of fiber optic connections; (3) the number, per each, of fiber optic connection hardware; and (4) the length, per foot, of twisted pair cable, accepted by the Engineer.*

~~*Measurement for payment will be in accordance with the following work tasks. Payment shall be per foot of cable furnished, installed, warranted, tested, and deemed fully operational.*~~

633-5.2 Furnish and Install: *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.

6323-5.3 Furnish: *The Contract unit price for communication cable, furnished, will include the cost of the required cable as specified in the Contract Documents, plus all shipping and handling costs involved in delivery as specified in the Contract Documents.*

6323-5.4 Install: *The Contract unit for communication cable, installed, will include 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, warranted, tested, and accepted installation. The Engineer will supply all cable.*

633-6 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.*