ORIGINATION FORM

Date: November 9, 2012
Originator: Gene Glotzbach
Contact Information:
Traffic Engineering and Operations, ITS Section
850-410-5600

Specification Title:
FIBER OPTIC CABLE AND INTERCONNECT
Specification Section, Article, or Subarticle Number: 783

Why does the existing language need to be changed? The content in this section has been moved to other Specification Sections (630, 635, 633) as part of the Department's ongoing Specification Consolidation effort. Section 783 must be deleted in its entirety in conjunction with the content moves, updates, etc. pending for Sections 630, 635, and the new Section 633.

Summary of the changes: The changes delete content that is being moved into other sections.

Are these changes applicable to all Department jobs? If not, what are the restrictions?
This change is applicable to all jobs, but specifically those using fiber optic cable and interconnect.

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? No.

Is a Design Bulletin, Construction Memo, or Estimates Bulletin needed? Yes. Coordination of changes is an ongoing effort of the Consolidation of Products and Specifications (COPS) working group in conjunction with the C-team.

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: **7830000 ITS – Fiber Optic Cable and Interconnect.**

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 delete Section 783. The content has been rolled into Sections 630, 635 and 633.

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

INTELLIGENT TRANSPORTATION SYSTEMS – FIBER OPTIC CABLE AND INTERCONNECT.
(REV 11-20-12)

SECTION 783 (Pages 897 – 913) is deleted.

~~SECTION 783~~
~~INTELLIGENT TRANSPORTATION SYSTEMS~~
~~FIBER OPTIC CABLE AND INTERCONNECT~~

~~783-1 Fiber Optic Cable System.~~

~~**783-1.1 Description.** Furnish and install a fiber optic cable system as shown in the Plans.~~

~~**783-1.2 Materials:**~~

~~**783-1.2.1 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.~~

~~**783-1.2.1.1 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 $ps/\sqrt{km}$~~

~~Ensure that each optical fiber is glass and consists of a germania-doped silica core surrounded by concentric silica cladding. 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.~~

~~**783-1.2.1.2 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 noted in the Plans.~~

~~**783-1.2.1.3 Color Code:** Ensure that the marking and color-coding of the fibers and buffer tubes conforms to telecommunication industry requirements as detailed in 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.~~

~~**783-1.2.1.4 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.~~

~~**783-1.2.1.5 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.~~

~~**783-1.2.1.6 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.~~

~~**783-1.2.1.7 Filler:** Fillers or rods may be included in the cable core to lend symmetry to the cable cross section if required.~~

~~**783-1.2.1.8 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. Apply the jacketing material directly over the tensile strength members and water-blocking material. Ensure that the MDPE contains carbon black to provide 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," 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.

783-1.2.1.9 Performance Requirements:

783-1.2.1.9.1 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.

783-1.2.1.9.2 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.

783-1.2.1.9.3 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.

783-1.2.1.9.4 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.

783-1.2.2 Splicing Materials: 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.

783-1.2.2.1 Splice Enclosures: Contain all optical fiber splices within a splice enclosure. Ensure that the enclosures provide storage for fiber splices, nonspliced 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 allow re-entry and 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.

783-1.2.2.2 Splice Trays: Ensure that the splice trays are securely attached and accessible, and provide adequate storage for the fiber cable. Ensure the splice trays provide access to individual fibers without disrupting other fibers in the tray. Ensure that the 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 the splice tray includes a cover with a locking mechanism to hold it in place.

783-1.2.3 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.

Ensure that the ST-type connectors have an operating and storage temperate range of minus 30° to 165°F as per the NEMA TS 2 standard.

783-1.2.3.1 Pre-terminated Connector Assemblies (Pigtails): Ensure that pre-terminated connector assemblies are used for fiber termination. Ensure that the pre-terminated cable assemblies consist of fiber optic cables with factory-installed ST-type 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.

783-1.2.3.2 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.

783-1.2.4 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. 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 to maintain their specified optical performance. Ensure the patch panel is sized to occupy the minimum space required to adequately accommodate fiber capacity.

783-1.2.4.1 Pre-terminated Patch Panels: Ensure that the pre-terminated patch panel is a termination panel that includes a factory installed all-dielectric SMF cable stub. Ensure that the panel includes factory installed and terminated ST-type panel connectors. Ensure that the cable stub is of adequate length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or as directed by the Engineer.

783-1.2.4.2 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.

783-1.2.4.2.1 Connector Panel: Ensure that the connector panel provides 12 ST-type, bulkhead-mount coupling connectors. 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.

783-1.2.5 Handling:

783-1.2.5.1 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.

783-1.2.5.2 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.

783-1.2.5.3 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.
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.
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.

783-1.3 Installation: Install all equipment according to the latest version of the manufacturer's installation procedures and the industry-accepted installation standards, codes, and practices, or as directed by the Engineer. 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.

783-1.3.1 Fiber Optic Cable Installation: 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".~~

~~**783-1.3.1.1 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.~~

~~**783-1.3.1.2 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.~~

~~**783-1.3.1.3 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.~~

~~**783-1.3.2 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.~~

~~**783-1.3.2.1 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.

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.

783-1.3.2.2 Splice Equipment Specifications: Use a fusion splice machine to splice all optical fiber. Ensure that the unit is portable, and capable of 120 V_{AC} and internal battery-powered operation. Ensure that the unit is able to splice fibers with a 250 micrometer coating. The fusion splice machine shall have the following capabilities:

1. Splice loss measurement.
2. Splice protection sleeve heater.
3. Battery with charging unit and power cable.
4. Spare electrodes, fuses, and lamps.
5. Power meter/light source with carrying case.

Ensure that the power meter/light source is a calibrated pair that is portable and battery operated. Ensure that the power meter/light source operates at selectable wavelengths of 850/1,300/1,550 nanometers. Ensure that the power meter has a decibel milliwatt measurement scale with a range of plus 3 to minus 45 decibel milliwatts for SMF operation and an accuracy of 0.5 decibel or better.

Ensure that the splice machine 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.

783-1.3.3 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).

783-1.3.4 Patch Panel Installation: Ensure that patch panels 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.

783-1.4 Testing and Certification:

783-1.4.1 Manufacturer's Testing: Provide documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.

783-1.4.2 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.

783-1.4.2.1 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

1310nm wavelength, 0.3 db/km for 1550nm 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.

783-1.4.2.2 OTDR Tracing: Test all fibers from both cable end points with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550nm. 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.

783-1.4.2.3 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.

783-1.4.2.4 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.

783-2 Conduit and Locate System.

783-2.1 General: Furnish and install conduit and a locate system for fiber optic cable. Ensure that the conduit complies with the requirements of Section 630.

Place the locate system along any underground conduit installation. Ensure that the locate system includes aboveground route markers, warning tape, tone wire, and electronics that allow detection of buried conduit and other related underground facilities.

Furnish and install a system as shown in the Plans and as directed by the Engineer. Ensure that the locate system provides:

1. An end-to-end electrical conductor, such as a locate wire, buried along the conduit system for conductive facility locating.
2. Visual notification of the presence of conduit installed on Department projects.
3. Public notification of potential hazards and contact information for public or private inquiries regarding the conduit system.
4. A means of locating any conduit system pull box or splice box that is buried.
5. Surge protection and dissipation of transient voltages that may be induced into the route marker system.

783-2.2 Materials:

783-2.2.1 Route Markers: Mark the location of the conduit system with rigid sign posts known as route markers. Use route markers of the type shown in the Plans and approved by the Engineer. Route markers may be either a Standard Route Marker (SRM) type or an Electronic Route Marker (ERM) type. The SRM is a rigid, tubular, driven post used for location and notification purposes only. The ERM should be physically identical to the SRM, but also include a termination board to provide aboveground access to locate wire buried alongside conduit and cable runs.

Ensure that each SRM is labeled and identified as an FDOT fiber optic cable marker as shown in the Plans and approved by the Engineer. Ensure that labels include the Department's logo, contact information for the local FDOT District, and a telephone number to call prior to any excavation in the area. Ensure that the identification information is permanently imprinted on the top fitting, and will not peel, fade, or deteriorate with prolonged exposure to the

typical roadside environmental hazards. Ensure that all route markers used on the project are new and consistent in appearance.

783-2.2.1.1 Standard Route Marker: Ensure that the SRM post is white with a top fitting cover that is orange with white lettering and graphics. Ensure that the SRM is a tubular configuration, and both the marker post and the top fitting are made from virgin Type 111 high-density polyethylene (HDPE). Ensure that any fasteners used with the SRM are constructed of stainless steel.

Ensure that all SRMs have a minimum outside diameter of 3.5 inches with a minimum 0.125 inch wall thickness. Ensure that the top fitting cover is a minimum of 1.5 feet long and has an outside diameter of 3.75 inches with a 0.125 inch wall thickness. Ensure that each SRM provides a tensile strength of 4,200 pounds per square inch as required in the ASTM D638 standard. Ensure that each SRM is manufactured for use in temperatures range of minus 30° to 165°F as per the NEMA TS 2 standard.

Ensure that each SRM can withstand 70 foot-pounds of impact force at 32°F as required in the ASTM D2444 standard before and after UV conditioning for 2,000 hours as required in the ASTM G53-88 standard. Ensure that the control sample of any material employed maintains a minimum of 70% of its original tensile strength as required by the ASTM D638 standard.

Ensure that an SRM installed at the minimum 2 foot depth withstands at least one vehicle impact at 45 miles per hour by a car or truck weighing no less than 3,500 pounds. After impact, ensure that the post returns to an upright position within 10 degrees of vertical alignment within 30 seconds from the time of impact. Ensure that all SRMs withstand a 12-gauge shotgun blast without penetration by any pellets when fired from a 50 foot distance.

783-2.2.1.2 Electronic Route Marker: Ensure that the ERMs meet the same material and performance requirements as the SRMs with the following exceptions. Equip each ERM with a removable, top-fitting cover that is black with white lettering. Ensure that each ERM contains a terminal board equipped with locate wire and ground connectors.

Ensure that the terminal board is made from corrosion-resistant materials and includes terminal facilities labeled according to function. Ensure the terminal board includes uniform spacing between connection points.

783-2.2.2 Warning Tape: Ensure that the buried cable warning tape is flexible, elastic material 3 inches wide and 6 mil thick, intended for burial and use as an underground utility warning notice. Ensure that the surface of the warning tape is coated and sealed to prevent deterioration caused by harsh soil elements. Ensure that the tape material and ink colors do not change when exposed to acids, alkalis, and other destructive chemical variances commonly found in Florida soils. Ensure that the warning tape color is orange as required by the American Public Works Association (APWA) Uniform Color Code, and has “CAUTION: FDOT FIBER OPTIC CABLE BURIED BELOW,” or other wording approved by the Engineer, permanently printed on its surface.

Include buried cable warning tape with all conduit.

783-2.2.3 Locate Wire: Ensure that the locate wire and locate wire splices comply with Section 630.

783-2.2.3.1 Locate Wire Surge Protection: Furnish and install a locate wire surge protection system as shown in the Plans or directed by the Engineer. Ensure that locate wires are attached to a surge protection system dedicated to safely dissipating high

transient voltages or other foreign electrical surges induced into the designating system. Provide this grounding through a stand-alone system that does not include electric power or ITS device grounding. Ensure that the surge protection system allows signals generated by locate system transmitters to pass through the protection system without going to ground. Ensure that the protection system automatically resets and passes locate system transmitter signals after the unit has grounded to dissipate over-voltages. Ensure that the locate wire surge protection is intended for below- or above-grade applications. Ensure that the locate wire surge protection system is grounded to a driven rod within 10 feet of the system using a AWG #6 single conductor wire with green insulation. Ensure that the locate wire surge protection is enclosed for protection from environmental hazards and accessible for connection of portable locate system transmitters.

Ensure that the locate wire surge protection system meets the following minimum standards for surge protection:

Surge Element	3-element maximum duty fail-safe gas tube.
Rating	40,000 A surge capacity (single-cycle, 8 by 20 microsecond waveform).
Life	Minimum 1,000 surges (1000 A to ground).
Fail-Safe	Integral fail-shorted device.
Insulation Resistance	1,000 megohm minimum at 100 volts of direct current (V_{DC}).
Clamp Voltages	a. Impulse at 100 Volts per Microsecond: Typically 500 volts. b. Direct Current: 300 to 500 volts.

783-2.2.4 Locate System Electronic Equipment: Provide locate system electronic equipment that is designed specifically for locating buried pipes and cables. Ensure that the locate system electronic equipment is able to detect the location and depth of the locate wire buried alongside conduit and cable runs. Ensure that the locate system electronic equipment is capable of locating faults in the sheath of a buried locate wire. Ensure that locate system electronic equipment is provided with protective cases suitable for daily transport and storage of transmitters and receivers. Ensure that the locate system electronic equipment includes a transmitter, receiver, and electronic box markers as shown in the Plans and approved by the Engineer.

783-2.2.4.1 Transmitter: Ensure that the transmitter is a portable unit designed to create and apply an identifiable signal onto a locate wire so that it can be located and traced with a receiver. Ensure the transmitter is capable of applying a trace signal using direct connection and inductive methods. Ensure that the transmitter output circuitry is protected against inadvertent connection to conductors carrying voltages up to 250V at 50/60Hz.

Deliver the transmitter to the Engineer upon completion of the installation and acceptance of the work.

783-2.2.4.1.1 Electrical Specifications: Ensure that the system operates using 120 V_{AC} input power as well as self-contained, rechargeable battery power. Ensure that the transmitter can operate from battery power for a minimum of 10 hours per charge. Ensure that the transmitter is supplied with all chargers, cords, cables, and accessories required for standard operation.

~~**783-2.2.4.1.2 Mechanical Specifications:** Ensure that the transmitter's physical dimensions allow portability and storage in a case no larger than 16 inches x 12 inches x 5 inches. Ensure that the transmitter weight does not exceed 10 pounds.~~

~~**783-2.2.4.1.3 Environmental Specifications:** Ensure that the transmitter is constructed with impact-resistant materials, is weather resistant, and designed to operate unattended in all weather and climates found in the outdoor roadside environment. Ensure that operating temperature meets or exceeds minus 4º to 122º F.~~

~~**783-2.2.4.1.4 Operation and Display:** Ensure that the transmitter includes programming buttons and visual indicators or displays for self-contained setup and operation. Ensure that all transmitter functions and operational parameters are programmable using an onboard, man-machine interface. Ensure that the operational status, including battery strength and current device settings, are displayed on the transmitter.~~

~~**783-2.2.4.1.4.1 Transmitter Output:** Ensure that the transmitter is capable of generating radio frequency (RF) signals and audio tones. Ensure that RF and audio output levels are user selectable.~~

~~**783-2.2.4.1.4.2 Output Frequency Requirements:** Ensure that RF frequencies produced for locate operations are user-selectable. Ensure that the transmitter produces consistent, stable, and defined frequencies normally associated with locating and marking equipment. Ensure that the transmitter can transmit at least three different user-selectable frequencies, with at least one frequency in each of three general ranges, defined here as low (0-1 kHz), mid-range (1 kHz – 40kHz), and high (40 kHz – 85 kHz) bands.~~

~~**783-2.2.4.2 Receiver:** Ensure that the receiver is a portable hand-held unit ergonomically designed and intended for the purpose of locating underground utilities, conduit, cable, and pull and splice boxes. Ensure the receiver is capable of receiving all of the signals generated by the transmitter as well as those associated with electronic box markers. Ensure that the receiver can serve as a marker locator by energizing and detecting electronic box markers. Ensure that the receiver can passively locate cables transmitting power and RF signals.~~

~~Deliver the receiver to the Engineer upon completion of the installation and acceptance of the work.~~

~~**783-2.2.4.2.1 Electrical Specifications:** Ensure that the system operates using self-contained, rechargeable battery power. Ensure that the receiver can operate from battery power for a minimum of 10 hours per charge. Ensure that the receiver is supplied with all chargers, cords, cables, and accessories required for standard operation.~~

~~**783-2.2.4.2.2 Mechanical Specifications:** Ensure that the receiver's physical dimensions allow portability and storage in a case no larger than 30 inches x 12 inches x 9 inches. Ensure that the receiver weight does not exceed 6 pounds.~~

~~**783-2.2.4.2.3 Environmental Specifications:** Ensure that the receiver is constructed with impact-resistant materials, is weather resistant, and designed to operate in all weather and climates found in the outdoor roadside environment. Ensure that operating temperature meets or exceeds minus 4º to 122º F.~~

~~**783-2.2.4.2.4 Operation and Display:** Ensure that the receiver includes programming buttons and a graphical display for self-contained setup and operation. Ensure that all receiver functions and operational parameters are programmable using an on-board man-machine interface. Ensure that current operational status, including battery strength and current device settings, and current signal strength from targets are displayed on the receiver. Ensure that receiver sensitivity is adjustable. Ensure that the receiver includes an internal speaker and~~

headphone output that is able to provide audible tones that indicate received signal strength. Ensure audible outputs include on/off and volume control.

Ensure that the receiver is capable of locating buried locate wire and electronic box markers within plus or minus 5% of actual depth. Ensure that the receiver can detect the center line of a target locate wire within 3 inches of its actual location.

783-2.2.4.3 Electronic Box Marker: Equip all pull boxes and splice boxes buried below finish grade with an electronic box marker inside the pull box or splice box to mark the location. Ensure that the electronic box marker is a device specifically manufactured to electronically mark and locate underground facilities. Ensure that the electronic box marker includes circuitry and an antenna encased in a waterproof polyethylene shell. Ensure that the outer shell is impervious to minerals, chemicals, and temperature extremes normally found in underground plant environments. Ensure that the electronic box marker does not require any batteries or active components to operate. Ensure that electronic box markers used to mark fiber optic cable and general telecom applications are orange in color and operate at 101.4 kHz. When excited by a marker locator, ensure that the electronic box marker's passive circuits produce an RF field to direct the marker locator to its position. Ensure that the electronic box marker has a minimum operating range of 5 feet from the marker locator.

783-2.3 Installation Requirements:

783-2.3.1 Route Markers: Install route markers as shown in the Plans and as directed by the Engineer. Ensure that route markers are plumb and level with the notification information clearly visible when viewed from the side facing the roadway. Place route markers at a 1 foot offset from the conduit system or as shown in the Plans. Ensure that markers are set within the right-of-way.

Set the route markers concurrently with the conduit system installation and prior to the fiber cable installation. Install route markers of the type as shown in the Plans and as follows:

1. 1. So that a clear line of sight is maintained from one marker to the next.

2. A maximum distance apart of 500 feet.

3. On both sides of the road at any crossing point where the conduit system changes to the opposite side of the road.

4. At the center point of any conduit run between two pull or splice boxes.

5. At gate locations when the conduit system is adjacent to a fence line.

6. On both sides of a stream, river, or other water crossing.

7. On both sides of aboveground attachments, such as bridges and walls.

Remove and replace all marker posts damaged during installation at no additional cost. Ensure that the top of the marker post is a minimum of 5 feet and no more than 6 feet above the finish grade.

Ensure that route marker signs are labeled with a unique identification number, as detailed in the Plans or as approved by the Engineer. Provide as-built documentation at the completion of installation that includes identification number and location of all installed route markers and correlates the marker to the fiber optic infrastructure that it signifies.

Ensure that installation of ERMs includes connection of the route marker to the locate wire associated with the conduit run that the markers identify. Install locate wire through the base of the marker and terminate the locate wires to connectors mounted on the terminal board inside the marker. Install an underground magnesium anode at a minimum of 10 feet away from the marker and perpendicular to the conduit system. Terminate the anode lead on the connector mounted on the terminal board inside the marker. Install the bond straps between the anode connector and all locate wire connectors to provide cathodic protection for the locate wire conductor.

783-2.3.2 Warning Tape: Install buried cable warning tape 1 foot below the finish grade, directly over any installed conduit and cable run.

783-2.3.3 Locate Wire: Ensure that the installation of locate wire and locate wire splices are compatible with Section 630.

783-2.3.4 Locate Wire Grounding Units: Install locate wire grounding units (WGUs) in pull boxes and splice boxes as shown in the Plans or directed by the Engineer. Mount the device in a location high enough from the bottom of the box to allow access to terminal facilities without disturbing cables present within the box. Terminate the locate wires and connect the surge protection device to ground per the manufacturer's instructions. Do not use power utility grounds or any ITS device grounding system as the grounding point for WGUs.

783-2.3.5 Locate System Electronic Box Marker: Install an electronic box marker inside all pull boxes and splice boxes buried below finish grade at the time of installation. Place the electronic box marker on the floor or wall of the box. Ensure that the electronic box marker is installed less than 5 feet below finish grade.

783-2.4 Testing and Certification. Inspect all conduit route marker system components and approve prior to installation. Fully test the locate wire system after installation to ensure that it functions and can be used to accurately locate the conduit system.

Ensure that the conduit route marker system is fully functional prior to installing the fiber optic cable.

783-3 Pull Boxes and Splice Boxes for Fiber Optic Cable.

783-3.1 Description: Furnish and install pull boxes and splice boxes of the type, size, and quantity as shown in the Plans. Ensure that pull boxes and splice boxes meet the requirements of Section 635. Use only equipment and components that are listed on the Department's Approved Product List (APL).

Use pull boxes and splice boxes that provide:

1. At-grade access to fiber optic cables housed within conduit systems used for Department ITS communications.
2. At-grade access to aid in the installation of fiber optic cable.
3. Protection for installed fiber optic cable.
4. Adequate space for cable storage and splice enclosures.

Ensure that pull boxes and splice boxes containing fiber optic cable do not contain power cables for ITS devices or other equipment.

783-3.2 Materials:

783-3.2.1 General Requirements: Ensure that all pull boxes and splice boxes are compatible with the fiber optic cable and are approved by the Engineer.

783-3.2.2 Pull Box: Ensure that all pull boxes have an open bottom. Ensure that the pull box is equipped with a nonskid cover secured by bolts and any other miscellaneous hardware required for installation or as shown in the in the Plans.

~~Ensure that the minimum pull box size is approximately 2 feet wide by 3 feet long by 3 feet deep, or as required in the Plans. Ensure that the pull box is large enough to house fiber optic cable without subjecting the cable to a bend radius less than 14 times the diameter of the cable.~~

~~**783-3.2.3 Splice Box:** Use splice boxes at all fiber optic splice locations, as shown in the Plans, and at other locations as approved by the Engineer. Ensure that all splice boxes have an open bottom. Ensure that the splice box is equipped with a nonskid cover secured by bolts; cable racks and hooks; pulling eyes; and any other miscellaneous hardware required for installation or as shown in the in the Plans.~~

~~Ensure that the splice box size is approximately 2.5 feet wide by 5 feet long by 4 feet deep or as shown in the Plans. Ensure that the splice box is large enough to house fiber optic cable without subjecting the cable to a bend radius less than 14 times the diameter of the cable.~~

~~**783-3.2.4 Marking:** Ensure that all pull box and splice box covers include the words "FDOT FIBER OPTIC CABLE" or text shown in Plans permanently cast into their top surface. Ensure that markings are permanently affixed and clearly visible after installation.~~

~~**783-3.3 Installation Requirements.** Install all pull boxes and splice boxes according to the manufacturer's recommendations; as shown in the Plans; and in compliance with Section 635 and Design Standards, Index No. 17700. Complete the installation of pull boxes, splice boxes, and conduit prior to cable installation. Provide all pull boxes and splice boxes a final finish grade elevation as shown in the Plans. Excavate pull box and splice box installation sites to a depth of 1 foot below the bottom of the box, and replace with a 1 foot bed of pearock or crushed stone at the excavation base prior to installing the box.~~

~~Ensure that the box cover is flush with the existing finish grade after installation. Taper the finish grade contour to provide drainage from the splice box.~~

~~**783-3.3.1 General Placement and Spacing:** Place pull boxes and splice boxes as detailed in the Plans, and at the following locations, unless directed otherwise by the Engineer:~~

~~1. At all major fiber optic cable and conduit junctions.~~

~~2. Approximately every 2,500 feet in rural areas with any continuous section of straight conduit if no fiber optic cable splice is required.~~

~~3. At a maximum of 1,760 feet in metropolitan areas.~~

~~4. At each end of a tunnel, and on each side of a river or lake crossing.~~

~~5. On each side of an aboveground conduit installation, such as an attachment to a bridge or wall.~~

~~6. At all 90 degree turns in the conduit system.~~

~~Ensure that all pull boxes and splice boxes are flush mounted at grade level, and are located near the base of a service pole or near the communication equipment cabinet serving the ITS field device to provide:~~

~~1. A transition point between the fiber optic conduits extending from the fiber backbone and the conduit feeding the communication cabinet.~~

~~2. An assist point for the installation of fiber optic drop cable.~~

~~3. Storage of slack fiber optic drop cable.~~

~~Do not place the pull boxes in roadways, driveways, parking areas, ditches, or public sidewalk curb ramps. Avoid placing pull boxes and splice boxes on steep slopes where the cover cannot be leveled within a tolerance of 1 inch of drop to 1 foot of grade or in low-lying locations with poor drainage.~~

783-3.3.2 Bonding and Grounding: Ensure that pull box and splice box installation includes a bonding and grounding system including a driven rod that is a minimum of 10 feet in length and 5/8 inches in diameter. Ensure that grounding rod is constructed of copper clad steel and complies with the UL 467 standard. Ensure that bonding conductors are bare solid AWG #6 copper wire as required in the ASTM B1 standard. Ensure that splice and termination components meet or exceed the UL 467 requirements, and are clearly marked with the manufacturer, catalog number, and conductor size. Ensure that grounding system complies with the NEC.

783-3.3.3 Material Removal and Restoration Specifications: Provide all material, equipment and labor for the removal of turf, earth, concrete/asphalt pavement or other site specific material to be removed for box installation. Ensure that original turf, earth, concrete/asphalt pavement or other site specific material is restored to its original condition once box installation is complete.

783-3.4 Testing and Certification:

783-3.4.1 Material Inspection: Inspect all pull boxes and splice boxes and approve prior to installation, and again prior to installation of the fiber optic cable.

783-3.4.2 Compaction and Density Testing: Perform compaction tests for each soil type encountered. Provide sufficient in-place density tests to confirm the adequacy and uniformity of the compaction procedures as required by the governing authorities or right of way owners, or as shown in the Plans.

783-4 Guaranty Provisions.

Ensure that the fiber optic cable, the splice enclosures, termination points, conduit, locate system, pull boxes and splice boxes have a two year manufacturer's warranty from the date of final acceptance by the Engineer in accordance with 5-11 of all the work to be performed under the Contract. If the manufacturer's warranties for the components are for a longer period, those longer period warranties will apply.

Ensure that the manufacturer's warranties on the fiber optic cable, the splice enclosures, termination points, conduit, locate system, pull boxes and splice boxes are fully transferable from the Contractor to the Department. Ensure that these warranties require the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department within 10 calendar days of notification by the Department.

783-5 Method of Measurement.

783-5.1 Furnish and Install: Fiber optic cable shall be measured per foot of cable furnished, installed, warranted, tested and deemed fully operational.

Splices and terminations as shown in the Plans shall be measured per each fiber connection furnished and installed.

The conduit and locate system shall be measured for payment per foot of conduit, buried cable warning tape and locate wire furnished, installed; designated with standard or electronic route markers (SRM or ERM), grounded, and protected. The conduit and locate system shall be warranted, made fully operational, and tested according to this specification.

The locate system electronic equipment (transmitters and receivers) shall be measured as each is delivered to the Engineer upon completion of the installation and acceptance of the work. Electronic box markers shall be measured as each is furnished, installed, and tested. The locate system electronic equipment shall be warranted, made fully operational, and tested according to this specification.

The fiber optic pull boxes and splice boxes shall be measured as each is furnished and installed, with grounding and associated hardware as detailed in the Plans.

The Contract unit price, furnished and installed, will include furnishing, placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages and firmwares, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

783-5.2 Furnish: The Contract unit price per foot of fiber optic cable, conduit, or locate wire and route markers (SRM or ERM); each locate system transmitter, receiver, or electronic box marker; and each pull box or splice box, furnished, will include all equipment specified in the Contract Documents, plus all shipping and handling costs involved in delivery as specified in the Contract Documents.

783-5.3 Install: The Contract unit price per foot of fiber optic cable, conduit, or locate wire and route markers (SRM or ERM); each electronic box marker; and each pull box or splice box, installed, will include placement and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages and firmwares, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The Engineer will supply the equipment specified in the Contract Documents.

783-6 Basis of Payment.

Prices and payments will be full compensation for all work described herein or shown in the Plans.

Payment will be made under:

Item No. 783- 1- ITS Fiber Optic Cable-per foot.
Item No. 783- 2- ITS Fiber Optic Connection-each.
Item No. 783- 3- ITS Fiber Optic Connection Hardware.
Item No. 783- 4- ITS Conduit-per foot.
Item No. 783- 5- ITS Pull Box for Fiber Optic - each.
Item No. 783- 6- ITS Splice Box for Fiber Optic - each.
Item No. 783- 9- ITS Locate System Electronic Equipment - each.