

SECTION 684

FIBER OPTIC CABLE FURNISH AND INSTALL Pay Item 684-X14

684-1 Description

This Section shall cover the work of furnishing and installing Fiber Optic Cable for traffic signal control systems in accordance with the provisions of this Section and the details shown in the Plans.

684-2 Materials

This section defines the material requirements for fiber optic cable, splices and splice enclosures, test and maintenance equipment, and training courses for fiber optic maintenance for this project.

684-2.1 Fiber Optic Cable

The following requirements for materials will govern the furnishing of Fiber Optic Cable unless otherwise specified by plan details.

The Fiber Optic Cable shall consist of an all dielectric, loose tube buffer, cable containing the number of single mode fibers shown in the Plans. The cable shall be installed as shown on the Plans, in conformance with these Special Provisions.

All fiber optic cable to be installed on this project shall be manufactured by the same manufacturer and shall be Corning Cable Systems or approved equal, Altos Single mode Fiber Optic Cable . The manufacturer shall be ISO 9001 certified. The construction and testing of the fiber optic cable shall comply with all applicable Electronic Industry Standards (EIA / TIA), International Telegraph and Telephone Consultative Committee (CCITT), ANSI, and ASTM standards, and FDDI and SONET specifications.

The cable shall meet all requirements stated in this specification. The cable shall be an accepted product of the United States Department of Agriculture Rural Utilities Service (RUS) as meeting the requirements of 7 CFR1755.900.

The cable shall be new, unused, and of current design and manufacture. All fibers in the cable must be usable fibers and meet required specifications. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

684-2.1.1 Optical Fibers

Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. Fibers shall be graded for maximum individual fiber attenuation, and shall be a matched clad design. The single-mode fibers utilized in the cables specified herein shall conform to the following specifications:

Typical Core Diameter 8.3 μm .

Cladding Diameter $125.0 \pm 1.0 \mu\text{m}$.

Core-to-Cladding Offset: $\leq 0.8 \mu\text{m}$.

Cladding Non-Circularity: $\leq 1.0\%$.

Defined as: $(1 - (\text{min. cladding dia.} / \text{max. cladding dia.})) \times 100$

Coating Diameter $245 \pm 10 \mu\text{m}$.

Colored Fiber Diameter nominal 250 μm .

Attenuation Uniformity- No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm.

Attenuation at the Water Peak- The attenuation at $1383 \pm 3 \text{ nm}$ shall not exceed 2.1 dB/km.

Cutoff Wavelength- The cabled fiber cutoff wavelength shall be $<1260 \text{ nm}$.

Mode-Field Diameter (Petermann II) -

$9.30 \pm 0.50 \mu\text{m}$ at 1310 nm

$10.50 \pm 1.00 \mu\text{m}$ at 1550 nm

Zero Dispersion Wavelength: $1301.5 \text{ nm} \leq \lambda_0 \leq 1321.5 \text{ nm}$.

Zero Dispersion Slope (S_0): $\leq 0.092 \text{ ps/(nm}^2\text{km)}$.

Polarization Mode Dispersion $\leq 0.5 \text{ ps/sq.rt. km}$

When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber Optic Components," the average change in attenuation at extreme operational temperatures (-40°C to $+70^\circ\text{C}$) shall not exceed 0.05 dB/km at 1550 nm. The magnitude of the maximum attenuation change of each individual fiber shall not be greater than 0.15 dB/km at 1550 nm.

The maximum dispersion shall be $\leq 3.2 \text{ ps/(nm km)}$ for 1285 nm through 1330 nm and shall be (18 ps/(nm km)) at 1550 nm.

The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer.

The coating shall be mechanically strippable without damaging the fiber.

684-2.1.2 Cable Construction

Optical fibers shall be placed inside a loose buffer tube containing up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube.

Each fiber and each buffer tube shall be distinguishable from others by means of color coding according to the following:

- | | |
|-----------|------------|
| 1. Blue | 7. Red |
| 2. Orange | 8. Black |
| 3. Green | 9. Yellow |
| 4. Brown | 10. Violet |
| 5. Slate | 11. Rose |
| 6. White | 12. Aqua |

These colors shall meet EIA/TIA-598-A₁ "Optical Fiber Cable Color Coding" Fiber colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

Buffer tubes shall be of a dual-layer construction with the inner layer made of polycarbonate and the outer layer made of polyester. Buffer tubes shall be kink resistant within the specified minimum bend radius.

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

Buffer tubes shall be stranded around a central member using the reverse oscillation, or "SZ", stranding process. Water blocking yarns shall be applied longitudinally along the central member during stranding.

Two polyester yarn binders shall be applied contra helically with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.

A water blocking tape shall be applied longitudinally around the outside of the stranded tubes / fillers. The tape shall be held in place by a single polyester binder yam. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free of dirt and foreign matter.

The cable shall contain at least one ripcord under the sheath for easy sheath removal.

Tensile strength shall be provided by high tensile strength dielectric yams. The high tensile strength yams shall be helically stranded evenly around the cable core.

The cable shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness.

The cable jacket shall be marked with the manufacturer's name, the words "Optical Cable," sequential foot markings, the year of manufacture, and a telecommunication handset symbol, as required by Section 350G of the National Electrical Safety Code (NESC). The actual length of the cable shall be within -0+1% of the length markings. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

The maximum pulling tension shall be 2700 N (608 lbf) during installation (short term) and 890 N (200 lbf) long term installed.

The shipping, storage, and operating temperature range of the cable shall be -40°C to +70°C. The installation temperature range of the cable shall be -30°C to +70°C.

684-2.1.3 Cable Performance

The unaged cable shall withstand water penetration when tested with a one meter static head or equivalent continuous pressure applied at one end of a one meter length of filled cable for 24 hours. No water shall leak through the open cable end. When a one meter static head or equivalent continuous pressure is applied at one end of a one meter length of aged cable for one hour, no water shall leak through the open cable end. Testing shall be done in accordance with FOTP-82, "Fluid Penetration Test for Filled Fiber Optic Cable."

When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable;" Method A. The cable shall exhibit no flow (drip or leak) of filling or flooding compound at 65°C.

The cable shall withstand a minimum compressive load of 440 N/cm (250 lbf/in) for armored cables and 220 N/cm (125 lbf/in) for non-armored cables applied uniformly over the length of the compression plate. The cable shall be tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (single-mode). The average increase in attenuation for the fibers shall be ≤ 0.20 dB at 1300 nm (multimode). The repeatability of the measurement system is typically ± 0.05 dB or less. No fibers shall exhibit a measurable change in attenuation after load removal.

When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 ± 1 cycles per minute, with a sheave diameter not greater than 20 times the cable diameter. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. The average increase in attenuation for the fibers shall be ≤ 0.20 dB at 1300 nm (multi-mode). The cable jacket shall exhibit no cracking or splitting when observed under 5X magnification.

When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand 25 impact cycles. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. The average increase in attenuation for the fibers shall be ≤ 0.40 dB at 1300 nm (multi-mode). The cable jacket shall not exhibit evidence of cracking or splitting at the completion of the test.

When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a tensile load of 2700 N (608 lbf) applied for one hour (using "Test Condition II" of the procedure). In addition, the cable sample, while subjected to a minimum load of 2660 N (600 lbf), shall be able to withstand a twist of 360 degrees in a length of less than 3 meters (9.9 feet). The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (single-mode). The repeatability of the measurement system is typically ± 0.05 dB or less. The average increase in attenuation for the fibers shall be ≤ 0.40 dB at 1300 nm (multimode). The cable shall not experience a measurable increase in attenuation when subjected to the rated residual tensile load, 890 N (200 lbf).

When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters will withstand 10 cycles of mechanical twisting. The magnitude of the attenuation change will be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers will not experience an attenuation change greater than 0.1 dB at 1550 nm. The repeatability of the measurement system is typically ± 0.05 dB or less. The average increase in attenuation for the fibers shall be ≤ 0.40 dB at 1300 nm (multi-mode). The cable jacket will exhibit no cracking or splitting when observed under 5X magnification after completion of the test.

When tested in accordance with the proposed FOTP-181, "Lightning Damage Susceptibility Test for Optic Cables with Metallic Components," the cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA. The test current used shall be damped oscillatory with a maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to half-value of the waveform envelope shall be from 40 - 70 μ s. In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e. core tube) and strength members must be intact after removal of the cable specimens from the test box.

684-2.1.4 Fiber Optic Drop Cable Terminations

Where six fiber cables are used to service local intersection controllers, each fiber shall be terminated on the cabinet end with a male FC-PC optical connector; a 2.5 mm ceramic ferrule connector designed for single mode applications, with Zirconia Ceramic material and a PC (Physical Contact) pre-radiused tip. The connector shall have a yellow color on the body or boot to designate the presence of a single mode fiber.

The FC-PC connector operating temperature range shall be -40°C to $+80^{\circ}\text{C}$ and shall have a mean attenuation of 0.3 dB and a maximum attenuation of 0.5 dB.

Insertion loss shall not exceed 0.5 dB and connectors shall be at least 40 dB and a connection durability shall be less than a 0.2 dB change per 500 mating cycles.

All terminations shall provide a minimum 35 lb. pull out strength. Terminations may be either factory terminated or field terminated.

684-2.1.5 Preparation of Cable for Shipping

The fiber optic cable shall be shipped on reels designed to prevent damage to the fiber optic cable during shipment and installation. Each reel shall have a weather proof reel tag attached identifying the reel and cable. Each cable shall be accompanied by a cable data sheet that contains significant information on the cable and installation procedures.

Adequate protection for the fiber optic cable ends shall be provided in order to seal the cable ends to prevent the escape of the filling compound and the entry of moisture. Top and bottom ends of the cable shall be available for testing. Unconnectorized fiber optic cable ends shall be equipped with flexible pulling eyes.

684-2.1.6 Pre-installation Cable Testing

All fiber optic cable provided for this project shall be tested, on the reel, prior to shipment from the factory, and again at the Contractor's Tallahassee area facility prior to installation. The factory test shall include verification of the fiber specifications as listed in the Fiber Characteristics Table, which shall be supplied by the manufacturer with the appropriate documentation. The Engineer or representative shall be present during the testing process in Tallahassee, and may elect to be present to observe testing at the factory.

The testing shall provide attenuation values, for the entire cable length, for each fiber, which shall be provided to the Engineer in a floppy disk form. In addition, the Engineer shall be provided with a PC compatible software package, so that the Engineer can use the software to inspect and review the loss figures of the cable trunk line and interconnect fiber optic cables. Documentation of all test results shall be provided to the Engineer within 2 working days after the test involved

Copies of the results shall be maintained on file at the manufacturer's facility for a minimum of 10 years, and shall also be attached to the cable reel in a waterproof pouch, and also submitted to the Contractor and to the Engineer prior to the delivery of the cable to the job site.

The Contractor shall submit a test procedure and proposed data forms for the pre-installation tests to the Engineer for approval prior to testing. The Contractor or manufacturer shall provide all personnel, equipment, instrumentation and materials necessary to perform all testing. The Engineer shall be notified 10 working days prior to all field tests.

Attenuation tests shall be performed on the cable with an Optical Time Domain Reflectometer (OTDR) conforming to the requirements of 684-4.1 High Resolution Optical Time Domain Reflectometer.

All single mode fibers shall be tested at 1310 nm and 1550 nm. All fibers in the cable shall be usable fibers which meet the defined attenuation requirements, and shall be sufficiently free of surface imperfections and occlusions to satisfy the optical, mechanical, and environmental requirements of these specifications.

684-2.2 Fiber Optic Splices

Select fibers in a fiber optic cable shall be spliced to another cable as required for the connection of system components at locations as shown in the Plans, and shall conform to these Technical Special Provisions.

The splices shall only be of the fusion type; mechanical splices shall not be permitted.

The construction and testing of the fiber optic splices and splice enclosures shall comply with all applicable Electronic Industry Standards (EIA/TIA), International Telegraph and Telephone Consultative Committee (CCITT), ANSI, ASTM standards and FDDI specifications.

684-2.2.1 Splice Enclosures

The splices shall be encased in a splice enclosure at all splice locations identified in the Plans. If the Contractor requires additional splice enclosures to support the pulling plan, and only if the Engineer approves such splices, these enclosures shall be provided and installed at no additional cost. The splice enclosure shall be Performed Line Products Coyote Enclosure or approved equal.

The splice enclosure shall be air tight, water tight, corrosion resistant, rodent proof, and re-enterable; the shell shall be constructed from a durable thermoplastic material. As appropriate by installation, the splice enclosure shall be manufacturer certified for below ground, junction box (pull box) installation or for aerial installation and shall match existing units currently used by the City of Tallahassee.

The below ground splice enclosure shall be no larger than approximately 22 inches long and 8.5 inches in diameter. The splice case shall be designed and equipped with the necessary mounting hardware to be attached to the side of the junction box, with sufficient clearance at each end for acceptable cable bends.

Aerial splice enclosures shall be designed for secure attachment to the messenger, as shown in the Plans.

The splice enclosure shall be a complete kit including the following, all of which shall be compatible with the specified cable:

- 1) Connection brackets and/or mounting hardware
- 2) Fan Out Kits
- 3) Grounding clamps
- 4) Thermoplastic outer shell
- 5) Splice trays with all required retainers and supports
- 6) Cable restraints
- 7) End plates (caps) as required
- 8) Shell supports
- 9) Shell clamp assemblies
- 10) Insulation/sealing tape

The enclosure shall utilize a double rubber tape sealing system on the end plates, and shall utilize captive stainless steel hardware. The enclosure shall be hermetically sealed and pressurized. The enclosure shall not require a reentry kit for access to the enclosure.

The splice enclosure shall be designed so that the fiber optic cable shall enter the splice enclosure through the end plates. The end plates (or caps) of the splice enclosure shall be air and water tight, and shall form an air and water tight seal with the splice case body. Each end plate shall have factory installed cable entry inserts for two cables for securing the entering cables in an air and water tight seal. Fiber optic cables shall be restrained within the splice enclosure such that there is no discernable tensile force on the optical fiber.

The splice enclosures shall have sufficient capacity to splice up to 144 optical fiber splices.

Splice trays shall be provided in each enclosure for holding, protecting and organizing the optical fibers. Splice trays shall be all dielectric, provide sufficient space for coiling of optical fibers to prevent micro bending, and have capability to pass uncut/unaffected fibers through the enclosure. The placement of the bare optical fibers in the splice tray shall be such that there is no disenable tensile force on the optical fiber.

A single splice tray shall be used for no more than the maximum number of optical fiber optical splices, depending on the manufacturer's specification. Sufficient splice trays shall be provided with each splice enclosure to accommodate the splices required at each location.

684-2.3 Fan Out Kits

The Contractor shall furnish and utilize a fan-out kit at each cable end to be connectorized. Fan out kits can be an individual buffer tube kit, a multiple buffer tube kit, or spider design kit. All fan out kits shall have a minimum of 24 inches of tubing, measured from cable end to the back of the connector body, covering each fiber when installation is complete.

684-2.4 Central Site Termination

All fiber optic cables shall be terminated at the Transportation Management Center located on the first floor of City Hall. Termination / patch panels shall be designed for the termination of 72 single mode fibers with FC type connectors; a sufficient number of panels to terminate all fibers shall be provided. Termination / patch panels shall be designed to install in a standard EIA 19-inch rack, and each panel shall not exceed 11 inches in height and shall match all existing units currently in use by the City of Tallahassee.

Termination panels shall include a front cover that can be easily be removed or opened to provide easy access for cable installation. The bottom or back of the panel shall include openings for cable entrances and shall provide for strain relief. The panel shall include drawers and other fixtures as required to maintain the cable fibers at more than the minimum bending radius without strain being placed on the cable.

The termination panels shall be mounted in an attractively designed 19-inch EIA rack cabinet designed to accommodate multiple fiber termination assemblies. An attractive door with plexiglass viewing panel shall be included.

684-3 Construction Requirements

WARNING: Laser light can damage your eyes. Laser light is invisible. Viewing it directly does cause pain. The Iris of the eye will not close involuntarily as when viewing a bright light. Consequently, serious damage to the retina of the eye is possible. Never look into a fiber which MAY have a laser coupled to it. Should accidental eye exposure to laser light be suspected, arrange for an eye examination immediately.

The fiber optic cable shall be installed using due care to prevent damage to the fibers or the cable. The installation of this fiber optic cable plant shall be installed such that the optical characteristics are not degraded in any manner. Cable shall be installed in accordance with current practices used in the fiber optic telecommunications industry, and in accordance with the cable manufacturer's recommendations. The Contractor shall provide to the Engineer, for review and approval, a detailed description of his proposed cable installation procedures seven (7) days prior to the initiation of construction. Such approved procedures shall be utilized by the Contractor during all subsequent installation processes.

Cable tensile loading during cable pulling shall not exceed 80% of the maximum installation cable rating, or 480 pounds, whichever is lower. The bending radius shall be not less than 20 times the cable cross section radius during the installation, and not less than 10 times the cable cross section radius after installation, i.e. during operation. The cable installation and bend radius configuration shall not change the optical characteristics of the fiber.

The Contractor shall splice fiber optic cable only where designated by the plans or approved by the Engineer.

Each cable shall be labeled with permanent plastic labels, (type and color as approved by the Engineer) suitable for outside cable plant applications. Lettering shall be permanent or indelible ink. These labels shall be affixed to the cable, using tie wraps, at each pole, pull box, manhole, vault, and cabinet, indicating **FIBER OPTIC TRAFFIC CONTROL CABLE**, and showing cable origin and destination. In addition, at each pull box, manhole, cabinet, and vault, and on each splice enclosure, a warning label advising of the hazards of laser light shall be permanently affixed to the cable or innerduct. All labeling shall be installed in compliance with the National Electrical Safety Code.

The security of the on-reel fiber cable shall be maintained at all times. The Contractor shall be responsible for any damage to, or theft or loss of the cable.

684-3.1 Aerial Installations

Aerial sections of the fiber optic cable shall be lashed to the messenger wire using stainless steel lashing wire. The lashing wire shall be continuous along the span; splicing of the lashing wire shall not be permitted. The lashing wire shall be clamped to the messenger at each end of the span, as shown in the Plans. Lashing wire shall be installed with a minimum of one wrap per linear foot.

Short aerial sections of cable (less than 50 feet) shall be attached to the messenger using preformed lashing rod.

At splices and at locations shown in the Plans, slack cable shall be provided for splice maintenance or for future splices using the "bow tie" slack mounting attachments as shown in the Plans. A short slack section shall also be provided in each span and at each pole, as shown in the Plans.

When installing fiber optic cable into conduit risers and other conduit sections, the cable pulling operations shall be performed such that the minimum-bending radius of the cable is not exceeded in the unreeling and pulling operations. Entry guide chutes shall be used to guide the cable into the junction box conduit ports. Lubricating compound shall be used to minimize the cable to conduit friction. In addition, corner rollers, if used, shall not have radii less than the minimum installation bending radius of the cable.

A series array of smaller wheels can be used for accomplishing the bend if the array is specifically approved by the cable manufacturer. The pulling tension shall be continuously measured and shall not be allowed to exceed the maximum tension specified by the cable manufacturer. Fuse links and breaks shall be used to insure the cabling tensile strength is not being exceeded. Fuse links shall not exceed 2700 Newtons pulling tension.

Conduits shall be sealed with a two-part urethane compound after the cable installation in any of the local cabinets. The urethane compound will be contained within two inches of end of the conduit so that it may be removed and the conduit re-used if necessary.

684-3.2 Duct System Installation

Within the downtown area of the City of Tallahassee, the fiber optic network will utilize the City of Tallahassee Electric Department's underground duct, manhole, and vault system. The Contractor is advised that the duct system carries high voltage cables and that working within the duct system will require extreme care and close coordination with the City of Tallahassee Electric Department.

In addition, these ducts, vaults, and manholes are known to contain Asbestos Containing Materials (e.g., fireproofing material, fireproof cable wrap tape, and transite pipe). Contractor personnel working in the proximity of the Asbestos Materials shall comply with all applicable Federal, State, and Local laws, ordinances, or regulations.

684-3.2.1 Electrical Safety Procedures

The Contractor shall conform to all applicable City of Tallahassee Electric Department Safety Procedures when working within the duct, manhole, and vault system. These procedures shall include the applicable Maintenance of Traffic setups, venting of the vaults or manholes, pumping out of the manholes or vaults, and the personnel safety, equipment safety, and other requirements put forth by the Electric Department. In addition, the Contractor shall work in conformance with all applicable OSHA requirements and general good practice techniques for underground cable installation.

684-3.2.2 Identification of Proposed Ducts and Laterals

The Electric Department will advise the designer of the proposed ducts to be used for the installation of the fiber optic cable; these proposed ducts, in turn, will be shown within the plans. The Contractor shall confirm the location of the proposed duct with the Electric Department prior to the initiation of work affecting that duct. Electric Operations will identify or provide locations of assigned ducts as required.

The Contractor shall notify City Electric Operations a minimum of 48 hours prior to the commencement of work on or within the downtown underground duct, manhole, and vault system, so that appropriate City personnel can be scheduled to observe and monitor the work. Under no circumstances shall Contractor personnel enter and work in City Electric manholes, vaults, etc., without obtaining a Confined Space Entry Permit from Electric Operations.

In addition, the cable routing uses lateral conduits from the manhole or vault to a new or existing junction box located on one quadrant of the intersection, and from the manhole or vault to an existing controller cabinet on another quadrant. The Contractor shall confirm the utilization of this conduit with the Electric Department before starting any work on that conduit and, if required, the replacement of the junction box related to that lateral conduit.

684-3.2.3 Preparation of Proposed Duct

After the Contractor has identified the appropriate duct for installation of the new fiber optic cable, the duct shall be prepared to receive the new cable.

The proposed duct shall be thoroughly cleaned and rodded using industry - common practices and procedures, as approved by the City of Tallahassee Electric Department. Non-destructive techniques, subject to the approval of the Electric Department, shall be used in this process. High pressure water or air is not acceptable as a method of non-destructive duct cleaning.

After the cleaning and rodding of the duct, the flexible innerduct (defined elsewhere within these Technical Special Provisions) shall be installed in accordance with the manufacturer's recommendations. The innerduct shall provide for the protective installation of the fiber optic cable within the duct, and shall be continuous through manholes or vaults where no splices or drop cables will be placed.

The Contractor shall also install a # 12 AWG insulated copper pull wire within the duct, external to the innerduct, to allow for the pulling of future cables or innerducts within the same duct. The pull wire shall be terminated at each end of the duct within the manhole or vault.

684-3.2.4 Preparation of Lateral Conduit

The lateral conduit for servicing splices and controller cabinets shall be thoroughly cleaned and rodded in a manner similar to that used for cleaning and rodding the ducts. This work shall be initiated only after the installation (if required) of the fiber optic junction box on the lateral's splice enclosure quadrant. Non-destructive techniques, subject to the approval of the Electric Department, shall be used in this process. High pressure water or air is not acceptable as a method of nondestructive duct cleaning.

After the cleaning process has been completed, a flexible innerduct and # 12 AWG insulated copper pull wire shall be installed within the conduit, ready for the installation of fiber optic cable or for other signal cables as required in the future.

684-3.2.5 Preparation of Manhole or Vault

The manhole or vault shall be prepared for the installation of the fiber optic cable and innerduct system. The innerduct shall be securely attached to the racking system within the manhole or vault in a manner not to interfere with the existing cables within the vault. The Contractor shall avoid any adjustment, moving, or displacement of the existing electrical cables.

Any additional cable racks and support arms that may be needed for the placement of the fiber optic cable in City Electric manholes or vaults shall be installed on an as-needed basis, by City Electric personnel, at the convenience of City Electric Operations.

684-3.2.6 Installation of Fiber Optic Cable

After the ducts and laterals have been cleaned and the innerduct has been installed, the fiber optic cable shall be installed utilizing the recommended practices of the cable manufacturers. Seven (7) days prior to the initiation of the cable installation, the Contractor shall develop, and submit to the Engineer for approval, a cable pulling plan, designed to identify the appropriate reel and winch locations.

Cable lubricants, pulling grips, tension monitoring equipment¹ and the appropriate pulling equipment shall be used in accordance with industry guidelines and the cable manufacturer's recommendations.

All installation and construction work within City Electric's manholes and vaults shall be in compliance with the National Electric Safety Code.

All fiber optic cables shall be installed in designated underground City Electric ducts as shown within the Plans and physically identified in manholes, vaults, etc.

At splices and at locations shown in the Plans, slack cable shall be provided for splice maintenance or for future splices as shown in the Plans.

Fiber optic cables entering City Hall from the City Electric manhole shall be installed in existing ductwork to the Transportation Management Center.

684-3.3 Splicing

All splices shall connect the fibers of two or more fiber optic trunk cables together or shall connect termination cable fibers to trunk cable fibers as indicated on the plans and conductor schedules. All remaining fibers shall be passed through the splice enclosure without damage.

All fusion splices shall be made with a fusion splicer.

All water blocking gel shall be completely removed from each exposed fiber and / or buffer tube, prior to the splicing or the termination of that fiber. A solvent shall be utilized to dissolve the gel, then allow for a complete removal of all solvent residue. The solvent shall not remove any of the color from the individual fiber or buffer tubes and shall not prove harmful to the outer jacket of the cable.

684-3.4 Post-Installation Cable Testing

All fiber optic cable provided for this project shall be thoroughly tested after the completion, including splicing and terminating, of the field installation to verify the integrity of the fiber optic cable plant and its performance.

The Contractor shall perform an insertion loss test on each optical fiber using the Attenuation Test Sets in accordance with the EIA FOTP-171 and EIA OFSTP-14 test procedures. These tests shall be performed after a complete run of cable has been installed and/or a splice has been made. Splices testing -0.10dB or greater shall be remade.

The testing shall provide attenuation values, for the entire cable length, for each fiber, which shall be provided to the Engineer in a floppy disk form compatible with the software provided during the Pre-Installation Cable Testing. Documentation of all test results shall be provided to the Engineer within 2 working days after the test involved is completed.

The Contractor shall submit a test procedure and proposed data forms for the post-installation tests to the Engineer for approval prior to testing. The Contractor or manufacturer shall provide all personnel, equipment, instrumentation and materials necessary to perform all testing. The Engineer shall be notified 10 working days prior to all field tests and may choose to be present.

Attenuation tests shall be performed on the cable with an Optical Time Domain Reflectometer (OTDR) as defined earlier in these specifications. All single mode fibers shall be tested at 1310 nm and 1550 nm. All fibers in the cable shall be usable fibers which meet the defined attenuation requirements, and shall be sufficiently free of surface imperfections and occlusions to satisfy the optical, mechanical and environmental requirements of these specifications.

684-3.5 As Built Plans

The Contractor shall provide to the Engineer four complete sets of as-built plans and to City Electric Operations one complete set of as-built plans. The plans and drawings shall show the fiber cable routing, including pole attachments and underground duct usage. As-built plans shall also show or identify poles and ducts where old traffic cables have been removed. The plans shall also include a complete measurement of Fiber Optic cable installed including all slack portions on a per link basis. To be included in the as-built plans will be the cable identification scheme used for each link. Also to be included are the fiber optic cable test results, both pre-installation and post installation test results.

684-4 Fiber Optic Test Equipment - Deleted

684-5 Method of Measurement

The Furnishing and Installation of Fiber Optic Cable shall be measured in complete units consisting of the furnishing; installation, and testing of fiber optic cable and all related hardware as defined in these Technical Special Provisions.

The Furnishing of Fiber Optic Cable shall be measured in complete units consisting of the furnishing, and on-reel testing of fiber optic cable as defined in these Technical Special Provisions.

The Furnishing and Installation of a Fiber Optic Splice shall be measured in complete units consisting of the furnishing, installation, and labor of splicing of the necessary fibers within fiber optic cable as defined in these Technical Special Provisions.

The Furnishing of a Fiber Optic Splice Enclosure shall be measured in complete units consisting of the furnishing of a Splice Enclosure as defined in these Technical Special Provisions.

The Furnishing of a Fiber Optic Splice Kit shall be measured in complete units consisting of the furnishing of a Splice Kit defined in these Technical Special Provisions.

The Furnishing and Installation of a Fiber Optic Termination Panel Assembly shall be measured in complete units consisting of the furnishing, installation, and labor of installing the assembly, connectorizing of all fibers within the fiber optic cables being terminated at the Transportation Management Center, as defined in these Technical Special Provisions.

The Furnishing of Fiber Optic Testing shall be measured in complete units consisting of the performing of the defined Tests with documentation as defined in these Technical Special Provisions.

684-7 Basis of Payment

UNIT PRICE COVERAGE

The accepted work of furnishing and installing Fiber Optic Cable, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and installation of the cable in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.

The accepted work of furnishing Fiber Optic Cable, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and delivery of the cable in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.

The accepted work of furnishing and installing a Fiber Optic Splice, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and installation of the splice enclosure and other splice components in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.

The accepted work of furnishing a Fiber Optic Splice enclosure, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and delivery of the splice enclosure in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.

The accepted work of furnishing a Fiber Optic Splice Kit, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and delivery of the splice kit in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.

The accepted work of furnishing and installing a Fiber Optic Termination Panel Assembly, measured as noted above, shall be paid for at the contract unit price bid, which shall be full compensation for the satisfactory furnishing and installation of the assembly and other components in accordance with these Technical Special Provisions, and for all equipment, tools, labor, services, insurance, permits, and incidentals necessary to complete the work.