

FIBER OPTIC CABLE

****From Hartford-Sharon FITS(503)**

xx. DESCRIPTION. This work shall consist of furnishing and installing Fiber Optic Cable (FOC) into innerducts by means of pulling or blowing; documenting installed fiber optic cable throughout the project limits; and installing one (1) 3-Cell Maxcell fabric innerducts within each of the 4" galvanized Black Steel Pipe (BSP) carriers on the Bridge 11 crossing, as shown in the Plans and as directed by the Engineer.

xx. GENERAL REQUIREMENTS. This item of work shall conform to the applicable Sections of the Standard Specifications and with IMSA General Specification 70 for Single and Multi-Mode Fiber Optic Cable. The FOC shall consist of 144 strands as indicated on the Plans.

Either pulling or blowing of the fiber optic cable installation is acceptable, however at no time shall the maximum dynamic pulling tension or the minimum dynamic bend radius of the cable be exceeded. At no time shall the cable be cut during the installation process. The entire length of cable on the reels shall be installed in one piece. No cable shall be installed until it has passed the on-reel acceptance testing.

xx. MATERIALS. The Contractor is required to submit material specification sheets for all materials used, for approval by the Engineer.

The FOC shall be shipped in reels that meet the following requirements:

- (a) The reels shall be designed to prevent damage to the cable during shipment and installation.
 - (1) Each reel shall contain an identification tag with the following minimum information:
 - a. Date of Manufacture.
 - b. Manufacturer's Cable Code.
 - c. Fiber Count.
 - d. Length of Cable.
 - e. Beginning and End length markings.
 - (2) Both ends of the cable shall be accessible to provide access for testing.
 - (3) The cable ends shall be securely fastened and shall not protrude beyond any portion of the reel in an unprotected manner to prevent the cable from becoming loose in transport.
 - (4) Cables ends shall be sealed to prevent the escape of the water blocking material and entry of moisture during shipping, handling, storage, and installation.

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The FOC must meet or exceed the following requirements:

- (a) The FOC shall operate over a temperature range of -40 to 74°C at a relative humidity of 10% to 90% condensing.
- (b) All fiber optic strand materials shall be non-conductive to electricity.
- (c) The FOC shall meet or exceed the following performance characteristics when tested in accordance with the following fiber optic test procedures (FOTP) and EIA/TIA-455-B Series Standards:
 - (1) When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the change in attenuation at extreme operational temperatures (-400°C and +700°C) shall not exceed 0.2 dB/km at 1550 nm.
 - (2) 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 change in attenuation shall not exceed 0.2 dB at 1550 nm.
 - (3) 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 lbs). The change in attenuation shall not exceed 0.2 dB during loading and 0.1 dB after loading at 1550 nm.
 - (4) When tested in accordance with FOTP-37, "Low or High Temperature Bend Test for Fiber Optic Cable", the cable shall withstand four full turns around a mandrel of <10 times the cable diameter for non-armored cables and <20 times the cable diameter for armored cables after conditioning for four hours at test temperatures of -300°C and +600°C. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears, or other openings. Optical continuity shall be maintained throughout the test.
 - (5) When tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," 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 sample. The load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for ten minutes. The change in attenuation shall not exceed 0.4 dB during loading and 0.2 dB after loading at 1550 nm.
 - (6) When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable", the cable shall exhibit no flow (drip or leak) of filling and/or flooding material at 80°C.

- (7) When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test", a length of cable no greater than 4 meters shall withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.1 dB at 1550 nm.
- (8) When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test", the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.1 dB at 1550 nm.

The cable shall be composed of the following elements:

- (a) Anti-buckling central member which shall prevent the cable from buckling and stretching. The central member shall consist of a dielectric glass reinforced plastic rod. The central member expansion and contraction characteristics shall be similar to the optical fibers and the fiber tubes.
- (b) Loose buffered tubes in which multiple fibers strands are placed inside. Each buffer tube shall meet the following requirements:
 - (1) Allowed buffered tube diameters shall be 3.0 mm or 1.9 mm.
 - (2) The number of fibers inside a buffer tube shall not exceed 12 strands.
 - (3) Buffer tube material shall prevent the fiber from adhering to the inside of the tube.
 - (4) Buffer tubes shall be colored in accordance with TIA/EIA-598-A, "Color Coding of Optical Fiber Cables".
 - (5) Fiber optic strands shall be placed loosely inside the buffer tube to allow for fiber expansion and contraction due to temperature changes.
 - (6) Buffer tube shall be filled with a water blocking gel meeting the following requirements:
 - a. Filling compound in the buffer tubes shall be a homogeneous hydrocarbon based gel with anti-oxidant additives.
 - b. The filling shall prevent water intrusion, be non-toxic, and non-irritant to skin contact.
 - c. The filling shall be non-nutritive to fungus.
 - d. The filling shall be electrically non-conductive and readily removable with conventional non-toxic solvents.
- (c) Fiber optic strands, which shall consist of a doped-glass cylindrical core surrounded by a concentric cladding. An acrylic

coating shall cover the fiber to add protection and color. Each fiber optic strand shall meet the following requirements:

- (1) Core diameter shall be $8.3 \mu\text{m} \pm 0.5\mu\text{m}$.
 - (2) Cladding diameter shall be $125 \mu\text{m} \pm 1.0 \mu\text{m}$.
 - (3) Core to cladding offset shall be less than $0.8 \mu\text{m}$.
 - (4) Cladding non-circularity shall be less than 1.0%.
 - (5) Total coating diameter shall be $245 \pm 10\mu\text{m}$ and shall be mechanically strippable.
 - (6) Coating color shall be in accordance with TIA/EIA-598-A, "Optical Cable Color Coding".
 - (7) No point discontinuity along the fiber shall have attenuation greater than 0.10 dB at either 1310 or 1550 nm.
 - (8) Zero water peak.
 - (9) Mode-field diameter shall be $9.30 \pm 0.50 \mu\text{m}$ at 1310 nm, and $10.5 \pm 1.0 \mu\text{m}$ at 1550 nm.
 - (10) Zero dispersion wavelength shall be between 1301.5 nm and 1321.5 nm.
 - (11) Zero dispersion slope shall be less than $0.092 \text{ ps}/(\text{nm}^2 \cdot \text{km})$.
 - (12) Cable loss shall not exceed 0.4 dB/Km when measured at a light wavelength of 1310 nm.
 - (13) Cable loss shall not exceed 0.3 dB/Km when measured at light wavelength of 1550 nm.
- (a) The cable casing shall be composed of a minimum of two protective layers. Layer requirements are as follows:
- (1) The first casing layer shall be composed of high tensile strength dielectric yarns helically stranded evenly around the cable core.
 - (2) The second and outermost layer shall be a polyethylene jacket. The jacket shall meet the following requirements:
 - a. The jacket shall be black medium or high density polyethylene in accordance with ASTM D 1248, Type II or Type III, Class C, Category 3, 4, or 5 and contain a suitable antioxidant.
 - b. The jacket shall contain carbon black to provide ultraviolet light protection.
 - c. The jacket shall have a minimum thickness of 1.4 mm.

- d. The jacket shall have permanent affixed markings every two feet or every one meter along the cable. These markings shall contain at a minimum the cable length (in feet if markings appear every two feet or in meters if markings appear every one meter), manufacturer's name, date of manufacturer, and the fiber count.
 - (3) A ripcord shall be provided between the first and second layer.
 - (4) All casing layers shall be non-nutritive to fungus.
- (e) The Maxcell fabric innerduct shall be 3-cell, designed for use in 3" or larger conduits, and have a maximum cable diameter per cell of 1.03".

xx. CONSTRUCTION REQUIREMENTS. The installation of FOC shall meet the following requirements:

- (a) Unless otherwise specified in the Plans, the following coil requirements are included:
 - (1) A minimum 50' coil of slack FOC in all intermediate handholes for use during installation.
 - (2) A minimum 50' coil of slack FOC from the end of each cable at a splice point location handhole.
 - (3) A minimum 100' coil of slack FOC in all splice vault locations for future ring cuts into the network infrastructure.
- (b) All FOC to be installed in a conduit or duct facility shall be pulled or blown as a unit. The Contractor shall ensure the cable is not damaged during storage, delivery, and installation.
- (c) The cable shall not be pulled along the ground or over or around obstructions. The cable shall not be stepped on by workmen, nor run over by vehicles or equipment. All cable shall be inspected and approved by the Engineer prior to installation.
- (d) All cable pulled shall use a cable grip designed to provide a firm hold on the exterior covering of the cable, with heat shrinkable end caps placed on the cable ends.
- (e) The maximum pulling tensions and minimum bending radius shall not be violated at any time during installation, and shall be monitored at all times during installation.
- (f) Prior to any installation of cable, the Contractor shall clean existing conduit and aerial messengers (if applicable) per industry standards.
- (g) The Contractor shall establish adequate voice communications between the cable feeding location and the cable pulling

equipment prior to commencing any pulling operation. The cable reels shall be placed on the same side of the pull box with the conduit where the cable is being installed. The reel shall be made level and brought into proper alignment with the conduit section, such that the cable will pass from the top of the reel. The cable shall be fed by manually rotating the reel.

- (h) An approved cable feeder guide shall be used between the cable reel or the storage stack and the face of the conduit to protect the cable, and to guide the cable installation. The dimensions and set-up of the feeder guide shall be such that the cable does not bend at any location to a radius less than the cable's minimum allowable bending radius. The cable shall not be pulled over edges or corners, over or around obstructions, or through unnecessary curves or bends. The cable shall be looped in and out to cabinets and pull boxes to provide adequate slack and the least amount of stress on the fibers. The Contractor shall ensure that the cable is not damaged during storage or installation.
- (i) FOC ends shall be kept sealed at all times during installation using an approved cable end cap. Tape shall not be permitted to seal the cable end. The cable end shall remain sealed until the Contractor terminates the fiber cables. Cables that are not immediately terminated shall have a minimum of six feet of slack.
- (j) The allowable pulling tension shall be the lesser of either of the two values below:
 - (1) The cable manufacturer's recommended pulling tension from the outer jacket for the cable.
 - (2) Eighty percent of the cable manufacturer's maximum pulling tension from the other jacket.
- (k) The Contractor shall monitor the tension on the FOC with the use of an approved tension gauge. The gauge shall be placed a sufficient distance from the take up reel, such that the tension can be read throughout the entire pulling operation.
- (l) When using lubricants, the Contractor shall adhere to the cable manufacturer's requirements for the proper amount, application tools and method, and removal of the lubricant from the exposed cable.
- (m) All cable shall run continuously from termination point to termination point as indicated on the Plans or as directed by the Engineer. The Contractor shall carefully determine the length of cable to reach from termination point to termination point. Splicing of FOC at any location other than those shown on the Plans will not be permitted without prior approval from the Engineer.

The Contractor shall document the installation of FOC as follows:

- (a) The Contractor shall document the locations of all splices and connections for each strand of FOC.

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- (b) This documentation shall show the distance in feet of FOC from the end of the cable for every splice and connection, and shall also show the cable length marking as marked on the cable for every splice and connection.
- (c) Four copies of the documentation shall be furnished to the Engineer prior to testing.
- (d) Documenting of the fiber optic cable installation point shall incorporate the following information:
 - (1) Location, handhole no., splice vault no., splice enclosure, or any other descriptive correspondence.
 - (2) Cable serial number.
 - (3) Sequential marking into the above referenced location.
 - (4) Sequential footage marking out of the above referenced location.
 - (5) Cable start sequential marking.
 - (6) Cable end sequential marking.

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (Fiber Optic Cable) to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (Fiber Optic Cable) will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for performing the work specified and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
900.640 Special Provision (Fiber Optic Cable)	Meter (Linear Foot)