

SECTION 684

FIBER OPTIC CABLE FURNISH ONLY Pay Item 684-X24

684-1 Description

This Section shall cover the work of furnishing 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, test, and maintenance equipment 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 single mode fibers in conformance with this technical 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 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): $\leq 0.092 \text{ psl}(\text{nm}^2\text{km})$.

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 $\leq 3.2 \text{ ps}/(\text{nm km})$ for 1285 nm through 1330 nm and shall be $(18 \text{ ps}/(\text{nm km}))$ 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 three 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 three 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.

684-2.1.5 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 weatherproof 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. 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 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 two 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 Engineer prior to the delivery of the cable to the job site.

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 that meet the defined attenuation requirements, and shall be sufficiently free of surface imperfections and occlusions to satisfy the optical, mechanical, and environmental requirements of this Technical Special Provision.

684-5 Method of Measurement

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 this Technical Special Provision. The number of fibers will be specified in the plans. If none are specified, 36 count is assumed.

684-7 Basis of Payment

UNIT PRICE COVERAGE

The accepted work of furnishing Fiber Optic Cable, measured as noted in the plans as Pay Item 684-X24, 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.