

SECTION 680

FIBER OPTIC CABLE

DESCRIPTION

680.01.01 GENERAL

- A. The work under this section shall consist of furnishing, installing, and testing all underground and outdoor fiber optic cables.
- B. All equipment and cable selection, mounting, and installation, as well as the cable management plan must be approved by the Freeway & Arterial System of Transportation (FAST) Director or designee, prior to installation.

MATERIALS/EQUIPMENT

680.02.01 FIBER OPTIC CABLE

- A. All fiber optic cable shall be Single Mode Fiber Optic (SMFO) cable that is of loose tube construction, filled with a water-blocking material, and constructed by a certified International Organization for Standardization (ISO) 9001 or 9002 manufacturer.
- B. Fiber optic cable shall be dielectric and comply with the requirements of Rural Utilities Service Standards 1755.900 except as modified by these specifications.
- C. Fiber optic cable shall comply with the following requirements:
 - 1. Number of fibers: Minimum 72 strands, 6 tubes of 12 fibers each.
 - 2. Cladding diameter: $125 \pm 1.0 \mu\text{m}$.
 - 3. Core-to-cladding offset: $\leq 0.8 \mu\text{m}$.
 - 4. Cladding non-circularity: $\leq 1.0\%$.
 - 5. Maximum attenuation: $\leq 0.40 \text{ dB/km}$ at 1310 nm; $\leq 0.30 \text{ dB/km}$ at 1550 nm.
 - 6. Microbend attenuation (1 turn, 32 mm diameter): $\leq 0.05 \text{ dB}$ at 1550 nm.
 - 7. Microbend attenuation (100 turns, 75 mm diameter): $\leq 0.05 \text{ dB}$ at 1310 nm.
 - 8. Mode-field diameter (matched cladding): $9.3 \pm 0.5 \mu\text{m}$ at 1310 nm; $10.5 \pm 1.0 \mu\text{m}$ at 1550 nm.
 - 9. Maximum chromatic dispersion: $\leq 3.2 \text{ ps}/(\text{nm} \times \text{km})$ from 1285 nm to 1330 nm and $< 18 \text{ ps}/(\text{nm} \times \text{km})$ at 1550 nm.
 - 10. Fiber polarization mode dispersion: $0.5 \text{ ps}/(\text{km})^{1/2}$.
 - 11. Fiber coating: Dual layered, UV cured acrylate.
 - 12. Coating diameter: $245 \mu\text{m} \pm 10 \mu\text{m}$.
 - 13. Min storage temperature range: -40°F to 158°F .
 - 14. Min operating temperature range: -4°F to 158°F .
 - 15. Rated life: Certify a 20-year life expectancy when installed to manufacturer's specifications.
- D. Buffer Tubes:

1. Each buffer tube shall be filled with a non-nutritive to fungus, electrically non-conductive, water-blocking material that is free from dirt and foreign matter.
 2. The water-blocking material shall allow free movement of the fibers, without loss of performance, during installation and normal operation including expansion and contraction of the buffer tubes.
 3. The water-blocking material shall be readily removable with conventional nontoxic solvents.
 4. Buffer tubes shall be stranded around a central member using the reverse oscillation or "S-Z" stranding process.
 5. The use of filler rods in the fiber optic cable when required to lend symmetry to the cable section is mandatory.
- E. Central Strength Member: The fiber optic cable shall have a central strength member designed to prevent buckling of the cable.
- F. Cable Core: The fiber optic cable shall utilize a dry water-blocking material to block the migration of moisture inside the cables.
- G. Tensile Strength Members:
1. The fiber optic cable shall have tensile strength members designed to minimize cable elongation due to installation forces and temperature variation.
 2. Underground fiber optic cable shall withstand a 2700N (600 lbf) tensile load where the change in attenuation does not exceed 0.2 dB during loading and 0.1 dB after loading.
 3. The cable shall be rated for an installed tensile service load of 890N (200 lbf) or more.
- H. Cable Jacket:
1. The fiber optic cable jacket shall be constructed of a high or medium density polyethylene (HDPE/MDPE) jacket that has been applied directly over the tensile strength members and water-blocking material.
 2. The jacket shall have at least 1 ripcord designed for easy sheath removal.
 3. This cable will be rated for use in both underground and overhead installations.
- I. Conductive Line Locating Material:
1. A 6-pair polyethylene (PE) 39, 22 AWG (American Wire Gauge) interconnect cable shall be directly adjacent to the cable in every conduit containing fiber optic cables to aid in locating of the conduit once it is in place.
 2. This is not required if an existing interconnect cable is in place.
 3. Any other method of providing a conductive tracer wire must be approved by the FAST Director or designee prior to installation.
- J. Environmental: The cable shall be capable of withstanding the following conditions without damage or decrease in function:
1. Total immersion in water with natural mineral and salt contents.
 2. Salt spray or salt-water immersion for extended periods.
 3. Wasp and hornet spray.

CONSTRUCTION

680.03.01 INSTALLATION – GENERAL

- A. The cable shall not be installed in any pull box until the pull box has been approved for pulling by the Contracting Agency.
- B. Cabinets shall be installed prior to cable installation.
- C. Installation of fiber optic cable shall be performed by individuals who are experienced and certified by a nationally recognized fiber optic installation certification organization.
 - 1. Certifications shall be approved by the FAST Director or designee prior to construction.
 - 2. Installation of fiber optic cable shall be continuous and without splices unless approved by the FAST Director or designee.
 - 3. The Contractor shall perform all final length measurements and order cable accordingly.
- D. The Contractor shall handle fiber optic cable carefully taking care not to pull cable along the ground, over or around obstructions, or through unnecessary curves or bends.
 - 1. The Contractor shall not exceed fiber optic cable bend radius at any time.
 - 2. Manufacturer approved pulling grips, cable guides, feeders, shoes, blowing devices, pulleys, and bushings shall be used to prevent damage to the cable during installation.
- E. Prior to installing any fiber optic cable, the Contractor shall furnish recommended procedures, maximum pulling tension, a list of the cable manufacturer's approved pulling lubricants, and the lubricant manufacturer's procedures for use. The Contractor shall adhere to the cable and lubricant manufacturer's installation procedures.
- F. The Contractor shall ensure that the tensile load on the cable does not exceed the allowed maximum manufacturer's specification by using a pulling load/tension system, approved by the cable manufacturer, that alerts the installer when the pulling or blowing tension approaches the limit and/or that displays the actual tension on the cable.
 - 1. Contractor may supplement this procedure with a breakaway tension limiter set below the recommended tensile limit of the cable being pulled or blown.
 - 2. A device known as a mechanical cable tugger may be used with appropriate tension limiter, and at no time shall any type of vehicle be used for pulling the fiber optic cable.
- G. When removing cable from the reel prior to installation, place it in a figure-8 configuration to prevent kinking or twisting. Take care to relieve pressure on the cable at crossovers by placing cardboard shims (or equivalent method) or by creating additional figure-8s.
- H. If cables are installed in conduit with existing cables or wires that shall remain, the Contractor shall not damage the existing cables or wires.
 - 1. The Contractor shall disconnect, remove, reinstall, and reconnect the existing cables and wires if necessary to facilitate the installation of the new cable at no additional cost to the Contracting Agency.
 - 2. The Contractor shall be responsible for any damage to the existing cables or wires caused by this operation.

3. New and existing conductors shall be terminated and the labeling shall be reconciled as part of this process.
 4. Two weeks prior to disconnecting any existing cables, the Contractor shall submit a schedule, for approval by the FAST Director or designee, with the accurate time frames of when the existing cables are to be disconnected.
- I. In all locations where fiber enters a pull box, for each cable entering the pull box or vault, cable slack shall be loosely looped through in a figure-8 or a loose loop with a minimum of 30 feet of slack in all pull boxes smaller than a Type 200 vault, unless approved by the FAST Director or designee, prior to installation. The Contractor shall leave a minimum of 60 feet of slack per conduit entrance in all Type 200 vaults or other pull boxes where fiber optic cable is to be spliced, allowing the splicing activities to take place outside the pull box above ground in a controlled environment.
 - J. If the pull box has racks and hooks, the Contractor shall attach the cables to racks or hooks with industry standard cable ties immediately upon entering the box.
 1. In all cases each cable shall be labeled, looped, and tied independently.
 2. The labeling on the fiber optic cable shall be approximately 2 feet from the entry point, and shall note the direction of the cable along with its next point of entry (i.e., FAST FIBER North to XYZ St. or FAST FIBER West to ABC Blvd.).
 3. Cable ties shall be tightened to prevent cable slippage, but the cable sheath shall not be deformed or damaged.
 - K. The Contractor shall follow local building codes and the National Electrical Code, Article 770, inclusive of the Fine Print Notes (FPN), when installing indoor fiber optic cable.
 - L. The Contractor shall furnish attachment hardware, installation guides, and other necessary equipment, not specifically listed herein, as necessary to install the fiber optic cable.

680.03.02 TESTING

- A. Fiber optic cable shall meet the test requirements specified below. All testing shall be performed by an experienced and certified tester of a nationally recognized certification organization.
 1. Factory Testing:
 - a. The Contractor shall submit factory test data and related documentation from the manufacturer to the Engineer and the FAST Director or designee, prior to installing the cable.
 - b. This includes the index of refraction of the cable to be installed.
 - c. This test shall demonstrate that the attenuation for each fiber string complies with the loss budgets required by these specifications.
 - d. Test blue and slate fibers at 1,310 nm and 1,550 nm.
 - e. Submit factory results for approval by the FAST Director or designee, prior to installing the cable.
 2. Pre-Installation Testing:
 - a. The Contractor shall test all cable prior to installation.
 - b. Any cable that is found to have visual cladding damage shall be rejected.

- c. Test fibers at 1,310 nm and 1,550 nm.
 - d. Submit Optical Time Domain Reflectometer (OTDR) trace results for approval by the FAST Director or designee, prior to installing the cable.
 - e. OTDR results shall be approved by the FAST Director or designee, prior to installation.
3. Post-Installation Testing:
- a. Testing shall conform to the American National Standards for "Measurement of Optical Fiber Cabling Components Standard," latest revision.
 - b. After installation, the Contractor shall perform the following tests using the procedures of "Measurement of Optical Power Loss on Installed Single-Mode Fiber Cable Plant," latest revision, and all standards and procedures invoked therein, subject to the following clarification:
 - 1) OTDR Tests:
 - a) Conduct tests using an OTDR for each fiber.
 - b) Demonstrate that the attenuation for each fiber string comply with the loss budgets required by these Standards.
 - c) Test fibers at 1,310 nm and 1,550 nm.
 - d) Submit OTDR trace results for approval and acceptance by the FAST Director, or designee.
 - 2) Power meter readings are required from all fibers. Submit power meter results for approval and acceptance by the FAST Director, or designee.
- B. The Contractor shall test all fibers on the cables, identify any unacceptable losses, and make corrective actions at no additional cost. The Contractor shall replace any cable in its entirety that is not compliant with these specifications at no additional cost.
- C. Following completion of all testing, and approval by the FAST Director or designee, the Contractor shall compile and submit 1 one organized test notebook in hard copy format, as well as a single electronic copy in Microsoft® Excel that includes all required test results, summary tables, splice details, circuit diagrams, and OTDR traces and power meter results of each fiber by each cable tested. The test notebook and electronic copy shall also include the following:
1. Identification number and name as appropriate.
 2. A summary sheet that clearly illustrates length and measured loss versus budgeted loss for each fiber or connected fiber string as appropriate; and
 3. Calculations and notations for each fiber and wavelength that include total loss, measured dB/km loss, and any anomalies over 0.1 dB.
- D. FAST shall have in its possession all pre- and post-testing data prior to final approval and acceptance.

METHOD OF MEASUREMENT

680.04.01 MEASUREMENT

- A. The quantity of Fiber Optic Cable (72-strand) will be measured per linear foot installed, in place, complete and operational, and successfully tested.

1. The cable shall be measured by the marking on the exterior cable sheath.
2. No separate measurement will be made for lubricant in this item.

BASIS OF PAYMENT

680.05.01 PAYMENT

- A. The accepted quantity of Fiber Optic Cable (72-strand) will be paid for at the contract unit price bid per linear foot, which shall be full compensation for installing the cable and appurtenances, complete in place, and for providing labor, hardware, cable ties, single mode fiber optic cable, lubricant, conductive line locating material, water blocking material, and labeling, all as specified, as shown on the drawings, and as required by the Engineer.
 1. All materials required to complete the system shall be incidental to the cable including the approval, furnishing, and installation of racks and hooks in pull boxes, for each type installed.
 2. Payment for the fiber optic cable installation shall also include the cost of all fiber optic termination strips, terminations, and labeling as incidental to the item requiring the work.
 3. Testing, warranty, documentation, and spare parts are considered incidental to the item requiring the work.
- B. All other components of the approved Communications Distribution Cable Assembly shall be specified and paid for under **Section 681, "Fiber Optic Splice and Distribution Equipment."** Testing, temporary connectors for testing, warranty, documentation, training, and spare parts are considered incidental to the item requiring the work.
- C. Payment will be made under:

PAY ITEM	PAY UNIT
Fiber Optic Cable (72-strand)	Linear Foot