City of Sioux Falls

Standard Specifications

for

Fiber Optics

Section 635C

Adopted: September 3, 2008

City of Sioux Falls
Public Works/Engineering
224 West Ninth Street
P.O. Box 7402
Sioux Falls, SD 57117-7402

635C.1 DESCRIPTION

This work consists of furnishing, installing, and testing the materials and equipment necessary for the operation of a fiber optic system.

635C.2 MATERIALS

A. Fiber Optic Cable

1. **General Requirements:** Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of the products. All materials and equipment furnished shall be new, unused, and completely free from defects and poor workmanship. All fibers shall be glass and be manufactured by Lucent, Corning, or approved equal. All fiber shall be loose tube construction for outdoor installation.

2. **Fiber Characteristics:** All fibers in the cable must be usable fibers and meet required specifications.

    a. Multi-Mode Fiber <GB Rated bandwidth>
    Core diameter: 62.5 +3.0um
    Cladding diameter: 125.0 +2.0um
    Core-to-cladding offset: <3.0um
    Coating diameter 250 +15um
    Graded Index
    Attenuation uniformity: No point discontinuity shall be greater than 0.25 dB at either 850nm or 1300nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.
    Uniform dB loss less than 3.4 dB per Km.

    b. Single-Mode Fiber <GB Rated Bandwidth>
    Typical core diameter: 8.3um
    Cladding diameter: 125 +1.0um by fiber end measurement
    Core-to-cladding offset: <1.0um
    Coating diameter: 250 +15um
    Attenuation uniformity: No point discontinuity shall be greater than 0.1 dB at either 1310nm or 1550nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

3. **Fiber Specification Parameters**

    a. All fibers in the cable shall meet the requirements of this specification. Multimode fibers shall have attenuation of 3.40 db/km or less at 850 Nm and 1.0 db/km or less at 1300 Nm.

b. The attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable.

c. The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km at 1550 nm, with 80 percent of the measured values no greater than 0.10 dB/km at 1550 Nm. Attenuation of single mode fiber shall be less than 0.50 db/km at 1310 Nm.

d. Optical fibers shall be placed inside a loose buffer tube, minimum twelve (12) fibers per tube.

e. The buffer tubes will meet EIA/TIA-598, “Color coding of fiber optic cables.”

f. Single-mode fibers are to be placed in the first buffer tubes. Multimode fibers shall be in the remaining buffer tubes. Fiber count shall be as specified on the plans.

g. Fillers shall be included in the cable core to lend symmetry to the cable cross section where needed.

h. 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.

i. Buffer tubes shall be stranded around a central member. Acceptable techniques include the use of the reverse oscillation, or “SZ,” stranding process.

j. The cable shall be of gel-free design fully water blocked using water-swellable yarns and tapes that are nonhygroscopic, nonnutritive to fungus, electrically nonconductive, and homogeneous material. The material shall be free from dirt and foreign matters.

k. All dielectric cables (with no armoring) 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 flooding compound. Cable jacketing shall utilize the newer designs to provide maximum flexibility without loss or appreciable dB attenuation.

l. The jacket or sheath shall be marked with the manufacturer’s name, the words “optical cable,” the year of manufacture, number of fibers, type of fiber <SM and/or MM>, and sequential feet. The markings shall be repeated every 2 feet. The actual length of the cable shall be within

–0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

m. The maximum pulling tension shall be 600 pounds (2700 N) during installation. The Contractor shall discard the first 10 feet of pulled fiber as it may be damaged during pulling.

4. **Manufacturer's Quality Assurance Provisions**

a. All optical fibers shall be proof tested by the fiber's manufacturer at a minimum load of 100 KPSI.

b. All optical fibers shall be 100 percent attenuation tested at the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for each frequency, both sets, 850 and 1300 for multimode and 1310 and 1550 for single mode. The documentation provided with each spool shall be provided to the Engineer. The Contractor shall designate, on a copy of each print of this documentation, the location where each spool has been installed and provide this data to the Engineer.

5. **Breakout/Fanout Kits:** The breakout kit, used to terminate the individual fiber, shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials to facilitate direct connection to equipment. The breakout kit shall be housed in a termination enclosure.

The fanout kits used to terminate fibers within a buffer tube shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials. The fanout kit shall match the number of fibers within the buffer tube and be color coded to match the TIA/EIA 598 B fiber optic color code standard. The fanout kit shall be housed in a termination enclosure.

The breakout/fanout kits will be considered incidental to the termination of the fiber.

6. **Connectors:** Connectors for multi-mode fibers shall be mechanical ST (ceramic Ferrule) compatible, field installable, and self-aligning and centering unless otherwise specified. Fiber optic equipment, used for terminating fibers, shall be rated for the type of connectors used. Connectors shall be Siecor CamLite or Corning Unicam nonepoxy mechanical type or Engineer approved equal.

Connectors for single-mode fibers shall be SC unless otherwise specified. Any connector for single-mode fiber shall be factory-manufactured assembly with a six-foot (6') pigtail to be fusion spliced to the fiber cable. SC and ST connectors will be considered incidental to the termination of the fiber.

7. **Termination Enclosures:** Termination enclosures shall be of either Corning WIC-04P wall mount or Panduit FAP6WBUDSCZ rack mount, or equal, to include all couplers to facilitate the fiber installation.

8. **Patch Cords:** Patch cords and pigtails shall be factory-manufactured assemblies and shall be fully compatible with the fiber interconnect cable and connecting modems and modules. The patch cords and pigtails shall be equipped with connectors as described herein and shall be either three feet (3') or six feet (6'), or as required to fit in length. The length shall be sized to preclude possible damage in the installation and of moving of equipment.

   One (1) duplex type patch cord with matching connectors shall be supplied for every fiber optic cable entering and exiting each termination location, unless otherwise specified.

9. **Trace Wire:** Along with the fiber optic cable, a 1c- #12 AWG THHN, 600-volt single conductor trace wire (identifier conductor) shall be pulled with ten feet (10') slack in each junction box. The tracer wire shall be continuous from junction box to junction box. The tracer wire shall be spliced using a Buchanon crimp sleeve and left bare (insinuated). The cost for the trace wire shall be incidental to the contract price for the fiber optic cable.

   Tracer wire installation will not be required when fiber optic cable is being pulled into an existing conduit already containing tracer wire meeting the above requirements.

B. Conduit: All conduits for fiber optic cable installation shall meet the requirements for innerduct in Section 635A.2.D.3.

635C.3 CONSTRUCTION REQUIREMENTS

A. General: Installations shall comply with applicable sections of the NEC, state regulations, and local ordinances. Licenses or permits required shall be obtained by and at the expense of the Contractor.

The Contractor shall be responsible for the locating of all fiber optic infrastructure from the start of the project until the fiber optic work has been accepted and the as-built information has been provided to the City Engineer’s office.

Contractor Qualifications: Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. The Contractor upon request of the Engineer shall provide documentation of qualifications and experience for fiber optic equipment installations. The Engineer shall determine if the Contractor is qualified to perform this work. The Contractor shall have attended a certified fiber optic training class mandated by these specifications prior to starting work.

Warranties and guarantees offered by electrical and mechanical equipment manufacturers shall be turned over to the maintaining authority at the time of acceptance of the project. The maintaining authority shall be named as the obligee on all manufacturer warranties and guarantees.

All fiber cables shall be identified as shown on the field wiring diagram in hand holes, junction boxes, pedestal bases, electrical service cabinets, and controller cabinets. Labels to identify cables shall be plastic or cloth adhesive tape which is embossed or printed with numerals and letters and wrapped around the cable.

Miscellaneous Equipment: The Contractor shall furnish and install all necessary miscellaneous connectors and equipment to make a complete and operating installation in accordance with the contract documents and accepted good practice of the industry. Miscellaneous equipment will be considered incidental to other fiber optic bid items.

B. Fiber Optic Cable: Fiber optic cable for traffic signal use shall be continuous from traffic signal controller cabinet to traffic signal controller cabinet unless otherwise specified on plans. Fiber optic cable for Information Technology use shall be continuous except for locations specified on plans. No splices shall be allowed, unless shown on the plans.

A suitable cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct off the reel. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified. Precautions shall be taken during installation to prevent the cable from being “kinked” or “crushed.” A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or breakaway pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked, or forced around a sharp corner. If a lubricant is used, it shall be of water based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination, minimum of 30 feet. This slack shall be in addition to installation slack as hereinafter specified. Additional slack cable shall be left in each controller cabinet, junction box, at the top of each conduit riser, and at each wood support pole. Excess slack at controller cabinets shall be repulled into the nearest junction box to provide a neat and orderly installation. The minimum slack amounts shall be as follows:

i. Controller cabinet—30 feet

ii. Pull box (junction box)—15 feet

iii. Double pull box—15 feet

iv. Conduit riser—30 feet

v. Support poles—30 feet

Storage of minimum slack cable in controller cabinets and additional slack at pull boxes shall be coiled. The slack coils shall be bound at a minimum of three points around the coil parameter and supported in their static storage positions. The binding material and installation shall not bind or kink the cable. Storage of additional slack cable adjacent to conduit risers and support poles shall be as visibly marked/tagged as "CAUTION—FIBER OPTIC CABLE." Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations.

For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the diameter of the cable outside diameter or as recommended by the manufacturer.

C. Testing: The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform the following tests of the fiber optic cables. All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the Engineer as hereinbefore specified. Each of the following tests shall be performed on all sections of fiber optic cable installed:

1. OTDR Testing: All fibers, including terminated and nonterminated fibers, shall be tested using an optical time domain reflectometer (OTDR) to locate points of localized loss caused by bends or kinks. All fibers in each section of the cable shall be tested separately. Each fiber strand shall be tested bi-directionally. When a section of fiber is found to be out of specification, the Contractor shall replace the damaged section of cable with no additional payment. Splices will not be allowed to repair the damaged section. After all fiber cable is installed between traffic controller cabinets and fiber links between fiber distribution points (FDP) are fusion spliced, complete links shall be tested with an OTDR. Multimode fiber shall be tested using 850 and 1300 Nm and single mode shall be tested at 1310 and 1550 Nm.

A launch attenuator shall be used when testing with an OTDR. The launch attenuator shall be of the same fiber core size and type as the fiber under test. The attenuator shall emulate a 350-foot fiber length, minimum.

2. Transmitter/Receiver Power Level Test: All fibers, including terminated and nonterminated fibers, shall undergo a power level test. The detector in the

power meter shall have an effective numerical aperture and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 DBMS to -40 DBMS. The power meter shall have an accuracy of +/-0.5 dB through the operating temperature and minimum resolution of 0.1 dB.

The output power levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation.

The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read, recorded, and then zeroed. The transmitter is then reconnected to the cable link and the power meter connected to the receiver side of the equipment. The receive power level shall then be read and recorded. Recordings shall not include connecting cables.

3. **Continuity Test:** All fibers, including terminated and nonterminated fibers, shall be tested for continuity. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receiver fiber.

   An LED light source with a wavelength that is the system wavelength shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical apertures (NA) and core diameter. To perform a continuity test, a high-intensity LED shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

4. **Documentation:** The result of all testing shall be recorded along with date of test, name of person performing test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data.

   a. **OTDR Testing:** The results of each OTDR test shall be provided to the Engineer by the Contractor on electronic media such as CDs, DVDs, or memory stick as well as a paper printout. This documentation shall include:

      i. The OTDR pictorial diagram of the trace for the total length of fiber segment shall be shown. The pictorial diagram shall be scaled so it displays the total trace in > 50% of the viewable area.

      ii. Measured point loss values.

      iii. Frequency used during the test

iv. Distance to each splice

v. dB loss of each section as measured in the final test for each fiber.

vi. Footage markings from the jacket of each section of fiber cable at access points (FDPs, JBs, and cabinets) shall be recorded and displayed.

vii. The Contractor shall provide the Engineer with a written report showing all the values measured compared to the calculated values for length and coupler/connector losses at the completion of these tests.

b. Power Level Test Documentation: Data documentation shall include for the power level test the output power levels at the transmitter and receiver sites for all fibers in the cable. This documentation shall be provided to the Engineer on electronic media such as CDs, DVDs, or memory stick as well as a paper printout.

c. Continuity Test Documentation: Data documentation shall include for the continuity test between cabinets or between FDP sites, whether it passed or failed, and shall be provided to the Engineer on electronic media such as CDs, DVDs, or memory stick as well as a paper printout

D. Terminations: Terminations shall be made using the method recommended by the connector manufacturer. All cables shall terminate in controller cabinets or FDP. All fibers shall utilize a fan-out kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube. All fibers terminated shall utilize a ceramic ferrule, ST, or SC connectors. ST connectors shall be a mechanical termination equal to Siecor CamLite connectors. ST terminations shall not exceed 0.5 dB per coupled set. SC connectors shall be factory-manufactured assemblies.

E. Splicing: All splices shall be fusion method. Individual splices shall be protected by heat shrink tubing rated for fiber optic fusion splices and all splices shall be housed in a spice tray. The splice tray will be considered incidental to the fusion splices.

F. Conduit: All conduit installation shall meet the requirements for innerduct in Section 635A.3.G.

G. Salvage Fiber Optic Cable: The Contractor will be responsible to remove, salvage, and transport the existing fiber optic cable to the City Traffic Shop. The Contractor shall take care to avoid any damage to the fiber optic cable during removal and transportation.

635C.4 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

A. Salvage Fiber Optic Cable: The plan shown quantity of cable to the nearest foot will be the measured quantity unless changes are ordered by the Engineer. Payment will be at the contract unit price per foot and will be full compensation for all labor, equipment, materials, and incidentals necessary to salvage and transport the fiber optic cable.

B. Fiber Optic Cable: Fiber optic cable will be measured to the nearest foot of each type of fiber optic cable installed. Plans quantity will be the measured quantity unless changes are ordered by the Engineer. The fiber optic cable shall be paid for by the lineal foot and will be full compensation for all materials including tracer wire, labor, equipment, and incidentals necessary to furnish and install the fiber optic cable.

C. Terminate Fiber Optic Cable: The termination of the multi-mode and single-mode fibers shall be measured per each individual fiber terminated. Payment will be at the contract unit bid price per each and shall be full compensation for all labor, equipment, materials, and incidentals necessary for the termination of the multi-mode fibers.

D. Fiber Optic Testing: Measurement and payment for testing shall be on a lump sum basis. Payment will be full compensation for all labor, materials, and incidentals necessary to complete the testing including test equipment, temporary mechanical splice units, consumables, fiber optic patch cords, etc.

E. Termination Enclosures: The measurement of termination enclosures shall be per each termination enclosures installed. Payment will at the contract unit price per each and will be full compensation for all labor, equipment, materials, and incidentals necessary to install the termination enclosure.

F. Patch Cords: The measurement of patch cords shall be per each patch cord installed. Payment will at the contract unit price per each and will be full compensation for all labor, equipment, materials, and incidentals necessary to install the patch cords.

G. Fusion Splices: The measurement of fusion splices shall be per each fiber spliced. Payment will at the contract unit price per each and will be full compensation for all labor, equipment, materials, and incidentals necessary to splice each fiber.

H. Conduit: The measurement and payment for fiber optic cable conduit shall conform to Section 635A.4.