

**STATE OF OHIO
DEPARTMENT OF TRANSPORTATION

SUPPLEMENTAL SPECIFICATION 804
FIBER OPTIC CABLE
FOR TRAFFIC SIGNAL INTERCONNECT**

JANUARY 19, 2007

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804.01 Description. This work consists of furnishing and installing fiber optic cable for traffic signal interconnect complete and ready for service.

804.02 General. Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of products used for outdoor fiber optic system installations. All materials and equipment furnished shall be new, of first quality, of latest design and be completely free from defects in material and poor workmanship. All like pieces of equipment shall be of the same type and manufacturer to assure uniformity, interchangeability of components, single responsibility, and most satisfactory service.

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number and catalog number on a plate secured to the equipment.

The fiber optic installation shall be in accordance with or exceed all minimal requirements of State and National codes as applicable. Construction techniques shall conform to the following in order of precedence: (1) These standards and specifications; (2) Cable manufacturer; (3) Accepted industry practices.

Furnish and install all necessary miscellaneous equipment to make a complete and operating system. The cost for all materials and labor not specifically itemized shall be considered incidental to the various items of work.

A. Applicable Standards. Materials and equipment supplied as part of the fiber optic system shall comply with the latest issue of the following documents:

RUS Rural Utility Service Material Acceptance List

REA Specifications for Filled Fiber Optic Cables (RUS Bulletin 1753F-601)

EIA-STD-RS-455 Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

MIL-STD-454 Standard General Requirements for Electronic Equipment

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

EIA/TIA-598 Tube and Fiber Color Code

EIA-568-A Fiber Optic Cable Testing Procedures

NFPA-70-2005 National Electrical Code Article 770, Optical Fiber Cable

B. Contractor Qualifications. In addition to the pre-qualification requirements set forth in the Section 102.01 of the Construction and Material Specifications, the following requirements shall apply to the fiber optic contract work. Provide proof of meeting the personnel requirements by the technicians performing the work prior to the beginning of any fiber optic related interconnect work. Failure to provide this proof to the Engineer will result in a halt being placed upon interconnection work until such a time that proof of meeting technician personnel requirements is met.

1. Fiber Optic Contractor Qualifications Any project requiring the opening of the fiber optic cable jacket, installation of fiber optic connectors, splicing fibers or the testing of any fiber optic cable, drop cable or patch cords shall have at least one Supervising Fiber Optic Technician (SFOT) assigned to it. SFOTs shall meet the following minimum requirements:

a. SFOTs shall have attended and successfully completed at least one comprehensive "installation of fiber optic products school". This school will be conducted by a major manufacturer of fiber optic products or an approved independent school that encompasses all aspects of fiber optic technician certification.

b. SFOTs shall be able to document a minimum of twelve months of work experience where the splicing, termination and testing of fiber optic cable with an optical time domain reflectometer (OTDR) was a primary job responsibility.

c. The SFOT shall be on the job site supervising other technicians at least the first three days of each of the following activities: cable pulling, removal of cable jackets, cable splicing, installation of fan-out kits and

connectors. The SFOT shall supervise a minimum of the first three days activities of each of the above listed activities to make sure the other technicians are performing their work assignments correctly.

The SFOT shall also be present to review the entire installation before completion.

Technicians, other than the SFOT, performing fiber optic work such as cable cleaning, splicing, connectorizing and terminations shall have successfully completed a minimum of one 16 hour fiber optic cable installation course from a major cable manufacturer or approved independent school.

All fiber optic technicians shall carry evidence of their qualifications on their person at all times when working on the project.

C. General System Construction. Entry into controller cabinets from the trunk cable shall be made via the specified drop cable. The drop cable inside of the cabinet shall be fitted with a fan-out kit and connectorized. Connectors shall be terminated in the specified termination panel. Patch cords shall connect the drop cable fibers in the termination panel to the fiber optic transceiver, hub/switch, multiplexer, etc. Place connectors on all fibers unless directed otherwise.

1. Cable Installation. Both aerial and conduit installations shall comply with no load and applied load bend radii specified below:

10X cable diameter under no load (0-180 lbs) (0-82 kgs)

20X cable diameter under applied load (181 lbs - 400 lbs)(83 kgs-182 kgs)

Minimum bend diameter is 2X minimum bend radius

No fiber optic cable shall be installed prior to the Engineer acknowledging the cable delivered to the project is acceptable based upon the Contractor completing the pre-installation testing given in these specifications.

Fiber optic cable installed in conduit shall be in accordance with the following:

- a. No more than two 90 degree changes in direction per cable pull.
- b. Circuitous pulls and pulls exceeding 1000 feet (300 meters) shall be made by back feeding or center feeding of cable.
- c. After installation there shall be no tension except due to cable weight.
- d. Tension of cable shall be monitored with a tensiometer during installation.

e. The applied tension during installation shall not exceed cable manufacturer recommendations. In no case shall tension exceed 400 pounds (182 kgs). A breakaway swivel shall be used on all pulls and its break tension set as close as possible to 90% of the rated load. Any broken tension bolts or pins shall be given to the Engineer before the pull is resumed.

f. The central strength member and the Aramid yarn shall be directly attached to the pulling eye. "Basket grip" or "Chinese finger" type attachments to the outer jacket of the cable will not be permitted.

Fiber optic cable installed aerially shall be provided with a sag of 3% to 5% unless existing cables will be sharing the pole in which case a sag matching the existing cables shall be provided.

The method of joining two reels of fiber optic cable shall be fusion splicing all of the trunk cable fibers of one reel to the corresponding fibers on the second reel. All splices for joining two fiber reels of trunk cable together shall be made in the last splice enclosure the fiber optic cable passed through. In other words, when a reel runs out of cable, any excess beyond the splice point shall be cut off and disposed of by the Contractor. The splice joining the two cable reels together shall be made in the splice enclosure that contains the drop cable to trunk cable splice. Cost for the quantity of cut off fiber optic cable and for the additional splices beyond the splices shown on the plans shall be incidental to the cost of the fiber optic cable. It shall be the Contractor's responsibility to calculate his cost to join fiber optic reels on the project based upon the reel lengths that he orders. Where cable length permits, the Contractor can avoid the cost of joining cable reels together by ordering a single reel of sufficient length.

The only place where fibers can be cut is where it is necessary to splice two reels of cable together or at locations shown on the plans. This practice of splicing reels together shall be kept to a minimum and shall not occur more than once per every mile (1600 meters).

2. Cable Cleaning. Loose tube cable will require the Contractor to use a De-Gel solvent to remove water blocking gel from exposed fibers prior to placement of fan-out kits, splicing or termination of each fiber. The solvent chosen for this task shall dissolve the gel and allow for a complete removal of all solvent residue. The solvent shall not remove any of the color from individual fiber or buffer tubes and shall not prove harmful to the outer PE jacket of the cable itself. Cost for De-Gel solvent and cleaning of fibers shall be incidental to the cost of the cable.

804.03 Materials. Furnish materials conforming to:

Fiber Optic Cable.....	904.01
Fan-Out Kit.....	904.02
Drop Cable.....	904.03

Fiber Optic Patch Cord.....	904.04
Fiber Optic Connector.....	904.05
Splice Enclosure.....	904.06
Fiber Optic Modem.....	904.07

804.04 Fan-Out Kit. Since only 4 drop cable fibers are required for daisy chain communication, all extra drop cable fibers at the cabinet end shall be inserted into the fan-out kit, connectorized and terminated in the termination panel for future use. Cost for the connectors used with the fan-out kit will be itemized separately.

804.05 Drop Cable. Unused drop cable fibers shall be left for future use. Spare drop cable fibers at the splice enclosure end shall be placed inside of the enclosure with sufficient excess to provide two service loops. Spare drop cable fibers at the device end shall be inserted into the fan-out kit, connectorized and terminated in the termination panel.

Drop cables routed down through a pole from aerial interconnect shall be provided with strain relief (cable support assembly). Cost of the cable support assembly shall be incidental to the bid item price of the drop cable. A minimum of 10 feet (3 meters) slack drop cable shall be provided in each device cabinet or termination panel location. Slack drop cable shall be coiled and bound to the cabinet or wall via tie wrap or other approved means. Any means of securing the slack cable shall NOT apply stress to the drop cable. Tie wraps shall be loosely wrapped around the cable.

804.06 Fiber Optic Patch Cord. The Contractor, at his option, may supply separate one fiber patch cords; however, only one fiber patch cord quantity will be provided at each controller.

804.07 Termination Panel. The NEMA cabinet termination panel shall be attached to the side of the cabinet in a place that provides the most room for making connections. After attaching the termination panel on the wall of the cabinet or support member, no sharp objects, such as screws, shall protrude outside of the cabinet that might cause injury to pedestrians. Termination panels used in 170/2070 cabinets shall be mounted within the 19" (475 mm) cage.

804.08 Fusion Splice. The only place splices will be permitted is to connect the loose tube drop cable to the loose tube trunk cable unless noted in the plan.

Fusion splice shall conform to the following:

A. Splice Loss (Fusion Splicing). The average splice loss shall not exceed 0.1 dB (per EIA-568-A) for single mode fibers. The average splice loss is defined as the summation of the loss as measured in both directions using an optical time domain reflectometer (OTDR) through the fusion splice, divided by two. No single direction shall exceed 0.15 dB (per EIA-568-A) for single mode fibers.

B. Splice Protection. Fusion splices require adequate splice protection. When splicing outdoors, the spliced and stripped cable shall be protected by a splice closure. All fiber splices are housed in splice trays or organizers inside a closure. The proper splice tray shall be selected based on the type of protection required by the splice. Fusion splices require additional protection and strain relief which can be provided by glass capillaries, heat shrink tubing or silicone sealant (commonly referred to as RTV).

A quantity of one splice will be provided for each pair of fibers that require splicing.

804.09 Fiber Optic Connector. The procedure for the termination of connectors used shall meet that process set out in the connector manufacturer's Standard Operating Procedure (SOP) for field installation. This SOP shall be submitted, in written or file format. Unless recommended otherwise by the connector manufacturer, each fiber shall be cleaved, cleaned and receive multiple polishings with increasingly fine grit polishing pads. The approved SOP will be the basis for inspection.

The average loss for mated pairs of connectors shall not exceed 0.4 db for single mode fibers.

804.10 Splice Enclosure. At splice locations, a ring cut methodology shall be used. Trunk cable jacketing shall be cut back a sufficient distance to allow unused trunk fiber tubes to be stored uncut/unopened with two service loops inside the enclosure. The trunk cable tube that contains the interconnect fibers shall be opened to expose the inner fibers. Only the trunk cable fibers that will be spliced may be cut. The remaining trunk cable fibers in the opened tube shall remain uncut and stored in the splice tray with a minimum of two service loops. The only trunk cable fibers that are to be cut are the trunk cable fibers being spliced into the drop cable.

Cost for the splices will be itemized separately.

804.11 Slack Installation. Where a splice enclosure is not designated, provide a 100 feet (30 meters) in-line aerial mounted slack cable installation . Where an aerial splice enclosure is shown, provide 50 feet (15 meters) of aerial mounted slack for each cable entering the splice enclosure. Where an underground installation is required, provide 40 feet (12 meters) of slack for each cable run entering the designated pull box.

Proper storage of slack cable, both long term and short term, will be required. Do not leave slack cable lying free on the ground, bottom of a pull box or floor of a building except during the actual pulling process. At all other times, the cable shall be neatly mounted, adhering to the bend radius requirements, on racks or bays. Submit to the Engineer certified shop drawings of the materials and installation of the anchored mounting channels to be installed in pull boxes and aerial hardware according to 625.06.

The cost for the fiber optic cable used in the slack installation (both aerial and underground) and mounting hardware shall be included in this pay item. The quantity of fiber optic cable necessary for the slack installation is not separately itemized.

804.12 Fiber Optic Modem. The controllers are to be equipped with modems capable of communications with the signal system controllers. Install and activate each modem in the controller housing and contact the manufacturer for replacement panels if necessary.

804.13 Testing. OTDRs used as part of these testing specifications shall be calibrated to sheath (jacket) length, not optical length by adjusting the unit's index of refraction.

All OTDR traces shall maximize both the vertical and horizontal scales to the greatest extent possible and still fit the entire trace on the screen.

Testing shall be performed in accordance with the following requirements. Failure of a link at any part of the testing shall result in the Contractor having to repair the problem and retest the installation. Cost for any required repairs and retesting shall be borne solely by the Contractor.

A. Pre-Installation Cable Acceptance (Tested with OTDR in one direction).

Utilize bare fiber adaptors to test all fibers for attenuation loss using an OTDR set to 2-Point loss measurement parameters prior to installation (on the reel). Marker points shall be placed at the beginning and end of each backscatter signature recorded by the OTDR. The manufacturer instructional guide can determine proper placement of these markers. The OTDR display shall be recorded on CD or DVD with identification and numbering sequences to be pre-approved by the Engineer. Each trace must contain as a minimum: cable/sheath length (not optical fiber length), 2-Point db loss, attenuation in db/mile (db/km), fiber type, wavelength used, pulse width selection and fiber/cable identification. The stored trace shall allow full manipulation of the trace when viewed with the PC emulation software.

Worst case wavelength testing will be applied to all fibers. Proper pulse width selection is required to minimize attenuation dead zone effect (10ns pulse: SM dead zone = 33 feet (10 m))

Fiber lengths in excess of 3280 feet (1000 m) worst case wavelength is: SM=1550nm

Fiber lengths less than 3280 feet (1000 m) worst case wavelength is: SM=1310nm

There shall be no attenuated anomalies in the backscatter trace as viewed by the OTDR.

Any attenuated anomaly shall be considered a fiber defect and will be grounds for rejecting the cables.

Pre-installation Maximum Acceptable Attenuation Loss:

SM @ 1310nm = 0.64 db/mile (0.4 db/km)

SM @ 1550nm = 0.48 db/mile (0.3 db/km)

Worst case wavelengths are defined as:

SM = 1310 nm (link length less than 3280 ft (1 km))
SM = 1550 nm (link length greater than 3280 ft(1km))

Maximum acceptable link attenuation shall be calculated as follows:

Maximum Acceptable Link Attenuation = Splice Loss + Connector Loss + Cable Attenuation

Maximum Acceptable Link Attenuation = 0.2 db + 0.2 db + (Link Length x Attenuation*)

* Attenuation for SM is:

SM @ 1310nm = 0.64 db/mile (0.4 db/km)

SM @ 1550nm = 0.48 db/mile (0.3 db/km)

The link attenuation as calculated above is a not to exceed the maximum value. Link measurements, which exceed this budget, will not be accepted and shall be brought to within accepted maximum values at the Contractor's expense. This may require the Contractor to replace connectors, splices or the entire link.

B. Link Testing with OTDR after Splicing and Terminating. All links without splices shall be tested in one direction. All links with splices shall be tested bi-directionally.

Any link which is longer than 1000 feet (300 m) and has splice points or interconnect points in said link shall be tested bi-directionally using worst case wavelengths. Links that are longer than 3280 feet (1 km) shall include 1550nm testing on SM fibers.

All fiber shall be tested for attenuation loss using an OTDR set to 2-Point loss measurement parameters. Marker points shall be placed at the beginning and end of each backscatter signature recorded by the OTDR. The manufacturer's instructional guide can be used to determine proper placement of these markers. The OTDR display shall be recorded on CD or DVD with identification and numbering sequences to be pre-approved by the Engineer. Each trace must contain as a minimum: cable/sheath length (not optical fiber length), 2-point db loss, attenuation in db/mile (db/km), fiber type, wavelength used, pulse width selection and fiber/cable identification. The stored fiber trace shall allow full manipulation of the trace when viewed with the PC emulation software. Both a hard copy print out and CD or DVD copy of each trace shall be submitted to the Engineer for approval.

Links that contain splice points or interconnect points shall also contain an additional "Events Display Table" to accompany the OTDR trace. This display shall show the distance to the events, distance between multiple events, each events loss in db and a

description of the event (reflective event, non-reflective event, gains and cable end). All attenuation event loss readings shall be in the LSA (Least Square Average) mode of the OTDR. 2-Point attenuation measurements at events are not acceptable. Proper pulse width selection is required to minimize attenuation dead zone effect (10ns pulse: SM dead zone = 33 feet (10 m)).

Any link that fails the above tests shall be replaced and retested at the Contractor's expense.

804.14 Method of Measurement. The Department will measure Fiber Optic Cable by the number of feet (meters), and will include the costs for equipment, labor and miscellaneous materials.

The Department will measure Fan-Out Kit by the number of each, and will include all costs for material, equipment, tools and labor to provide and install the fan-out kit.

The Department will measure Drop Cable by the number of each, and will include all costs for material, equipment, tools and labor to provide and install the drop cable.

The Department will measure Patch Cord by the number of each, and will include supplying and installing connectors on all ends of the patch cord.

The Department will measure Termination Panel by the number of each, and will include all materials, tools and labor to provide and install a termination panel.

The Department will measure Fusion Splice by the number of each, and will include all costs for equipment, material and labor to provide a permanent fused splice including splice protection.

The Department will measure Fiber Optic Connector by the number of each.

The Department will measure Splice Enclosure by the number of each, and will include aerial or pull box wall mounting brackets as required.

The Department will measure Slack Installation by the number of each, and will include all materials, equipment and labor to provide a slack installation.

The Department will measure Fiber Optic Modem by the number of each.

804.15 Basis of Payment. The Department will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
804	Foot (Meter)	Fiber Optic Cable, (Armored) (Integral Messenger Wire), _____ Fiber

804	Each	Fan-Out Kit, _____ Fiber
804	Each	Drop Cable, _____ Fiber
804	Each	Fiber Optic Patch Cord, _____ Fiber
804	Each	Termination Panel, _____ Fiber
804	Each	Fusion Splice
804	Each	Fiber Optic Connector
804	Each	Splice Enclosure
804	Each	Slack Installation
804	Lump	Fiber Optic Cable Testing
804	Each	Fiber Optic Modem