

DESIGNER COMMENTS FOR VARIOUS PAY ITEMS ARE GIVEN THROUGHOUT THESE SPECIFICATIONS. THESE DESIGNER NOTES ARE IN ITALICIZED PRINT AND SHOULD NOT BE INCLUDED IN PLAN NOTES.

PLEASE ADDRESS ANY COMMENTS OR QUESTIONS TO DAVID HOLSTEIN, ODOT OFFICE OF TRAFFIC ENGINEERING, PHONE 614-644-8137, EMAIL DHOLSTEI@DOT.STATE.OH.US

GENERAL REQUIREMENTS

The following provides the minimum standards and qualifications necessary to provide a fiber optic communication link between intersections in an interconnected traffic signal system.

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 codes, National codes and manufacturer 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.

The contractor shall 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.

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
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-70-1993	National Electrical Code Article 770, Optical Fiber Cable

DOCUMENTATION REQUIREMENTS FOR SUPERVISING FIBER OPTIC TECHNICIAN

In addition to the pre-qualification requirements set forth in the State of Ohio Construction and Material Specifications (CMS), section 102.01, the following requirements shall apply to the fiber optic contract work. Following the opening of bids and prior to the pre-construction meeting, the awarded contractor shall submit documentation showing their ability to comply with the following Supervising Fiber Optic Technician (SFOT) requirements. Failure to submit this documentation may be grounds for the low bidder being disqualified at the discretion of the Department.

Technicians other than the SFOT shall show proof of meeting their personnel requirements prior to the beginning of any fiber optic related interconnection work. Failure to provide this proof to the Engineer will result in the cessation of interconnection work until such a time that proof of meeting technician requirements is met.

Fiber Optic Technician Requirements

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 SFOT assigned to it. SFOT 's shall meet the following minimum requirements.

- (1) SFOT 's 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.
- (2) SFOT 's shall document a minimum of 6 months work experience where the splicing, termination, and testing of fiber optic cable with an optical time domain reflectometer (OTDR) and power meter was a primary job responsibility.
- (3) 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; each phase of the cable testing procedure. 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.

- (4) Technicians, other than the SFOT performing fiber optic work such as cable cleaning, cable pulling, 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.

General System Construction

Entry into controller cabinets from the trunk cable shall be made via the specified drop cable. The drop cable will be spliced to the trunk cable in a specified splice enclosure. 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. A four (4) fiber patch cord shall connect the drop cable fibers in the termination panel to the fiber optic transceiver. See "Typical System Construction" details.

CABLE INSTALLATION

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

MINIMUM BEND RADIUS

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

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

Minimum bend diameter is 2 X minimum bend radius

2. 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.
3. 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 meter) 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 shall not exceed cable manufacturer recommendations. In no case shall tension exceed 400 pounds (182 kgs).
 - 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. A breakaway swivel shall be used on all pulls.
4. 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.

5. Splicing Reels of Cable - 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 splice enclosure at the last intersection the interconnect cable passed through. In other words, when a reel runs out of cable, any excess beyond the last traffic signal intersection 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 intersection 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 16 splices beyond the four splices required to install the drop cable 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 interconnect system length permits, the Contractor can avoid the cost of joining cable reels together by ordering a single reel of sufficient length to extend from one end of project to the other.

The only place where fibers that are not used for interconnection can be cut is where it is necessary to splice two reels of cable together. This practice of splicing reels together shall be kept to a minimum and shall not occur more than once per every mile (1600 meters).

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 be harmful to the outer PE jacket of the cable itself. 3M's part number 4414 "filled cable cleaning kit" or approved equal shall be utilized at every opening of the cable. Cost for De-Gel solvent and cleaning of fibers shall be incidental to the cost of the cable.

632 Interconnect Misc.: 18 Fiber, Loose Tube, By Type

(By Type refers to : Single Mode, Multi-mode or Hybrid; Armored if required; Integral Messenger Wire if required. NOTE: the 18 fiber count is not intended to be the only acceptable standard. Fiber count, along with associated items such as the number of splices and connectors can be changed on a project by project basis depending on the needs of a particular system. Different cable constructions such as tight buffered cables may also be specified depending on maintaining agency choice, however, this would require additional specification modifications other than just this pay item.)

1. The fiber optic cable supplied shall be an 18 fiber single mode (SM), multi-mode (MM), or a hybrid cable containing both as specified. Multi-mode cable shall have a 62.5 μm nominal core diameter. Single-mode cable shall have a 8.3 μm nominal core diameter. Hybrid cables, when specified, shall be comprised of 12 multi-mode fibers and 6 single mode fibers.
2. All fiber optic cable supplied shall utilize water blocking tape technology inside the outer cable jacket and shall be an accepted cable with the Rural Utility Service (RUS). A list of

acceptable cables can be found on the RUS web site:
 (www.usda.gov/rus/telephone/1stmat/sec-1.htm)

3. All fiber optic cable glass shall be supplied by the same manufacturer and shall be part of a fiber optic cable utilizing loose tube construction with the following properties:

	<u>Multi-mode</u>	<u>Single Mode</u>
Cladding Dia.	125+/-1.0 μm	125+/-1.0 μm
Coating Dia.	245+/-10 μm	245+/-10 μm
Numerical Aperture	0.275+/-0.015	N/A
Max. Attenuation	3.5/1.0 db/km@850/1300nm	0.4/0.3 db/km@1310/1550nm
Min. Bandwidth	160/500 Mhz-km@850/1300nm	N/A
Proof Tensile Test	0.7 GPA	0.7 GPA

4. Where armored cable is specified it shall be on the RUS acceptable material list.
5. Where self supporting cable is specified the messenger cable shall 0.25 inch (6 mm) and shall be on the RUS acceptable material list.
6. Documentation shall be provided showing RUS acceptance.
7. Cables shall be packaged wound on wood spools or reels. All reels shall be the property of the contractor and he is solely responsible for the return or disposal of the reels that the cable is shipped on. The diameter of the drum shall be a minimum of 20 times the diameter of the cable. Each reel shall contain only one continuous length of cable. Labels shall be attached to the reel showing length, cable identification name and number, and date of manufacture.

The outer ends of the cable shall be securely fastened to the reel head so as to prevent the cable from becoming loose during transit. Both ends of the cable shall extend a minimum of 10 feet (3m) into the inside of the cable reel to provide access for testing. Test tails shall be secured to the inside of the reel in such a manner that they will not become loose during transportation. End seals shall be applied to each end of the cable to prevent the intrusion of moisture into the cable.

Documentation shall accompany each reel documenting the attenuation of each cable fiber in db/km.

8. All fiber optic cable to be used as part of the traffic signal system shall be rated for outdoor use unless specifically noted in the plans.
9. Fiber optic cable rip cords shall be provided and made from either standard telco nylon material or from braided kevlar. No un-braided kevlar will be accepted.
10. Cable Jacketing shall be permanently labeled approximately every two feet (0.6 m) with the cable manufacturer's name, cable type, fiber count, manufacturing date, and incremental

cable length. Cable length shall refer to the cable sheath length.

All costs to install fiber optic cable, either aerially or underground, shall include the costs for equipment, labor, and miscellaneous materials in the bid item price per linear measurement of Item 632 Interconnect Misc.: 18 Fiber, Loose Tube, By Type unless itemized separately.

632 Interconnect Misc.: Fan-out Kit, 6 Fiber

(6 fiber drop cables are not meant to be the only acceptable standard. Fiber count in drop cables can be modified on a project by project basis to accommodate the needs of a particular system. If the drop cable fiber count is increased a 12 fiber or larger fan-out kit can be specified as needed. Additional modifications would also have to be made to the connector quantities.)

Fan-out kits shall be provided for loose tube drop cable terminal ends that need to be fitted with connectors. The fan-out kit can be an individual buffer tube kit, multiple buffer tube kit or spider design kit. All fan-out kits shall have a minimum of 24" (600 mm) of tubing covering each fiber when installation is complete. Prior to any work the contractor shall submit for approval; catalog cut sheets, general specifications, and standard operating procedures for the kit that is to be utilized on the project. Only one type of fan-out kit may be used throughout the project. Fan-out kits shall be rated for outdoor use (-40°C to 70 °C). 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. Cost for loose tube fan-out kits shall be paid at the bid item price for each Item 632 Interconnect Misc.: Fan-out Kit, 6 Fiber and shall include all costs for material, equipment, tools and labor to provide and install the fan-out kit.

632 Interconnect Cable Misc.: Drop Cable, 6 Fiber

(6 fiber drop cables are not meant to be the only acceptable standard. Fiber count in drop cables can be modified on a project by project basis to accommodate the needs of a particular system.)

Drop cables for loose tube fiber optic cables shall be paid on a linear measurement basis and shall be made from the same glass and cable manufacturer that provides the trunk cable. Since only 4 fibers are required for daisy chain communication, 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 2 service loops. Spare drop cable fibers at the controller end shall be inserted into the fan-out kit, connectorized and terminated in the cabinet termination panel. Cost for fiber optic drop cables shall be paid at the bid item price of Item 632 Interconnect Cable Misc.: Drop Cable, 6 Fiber and shall include all costs for material, equipment, tools and labor to provide and install the drop cable. Note: Drop cables routed down through a pole from aerial interconnect shall be provided with strain relief (cable support assembly) per the installation details. 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 the each controller cabinet. Slack drop cable shall be coiled and bound to the cabinet 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.

632 Interconnect Misc.: Fiber Optic Patch Cord, 4 Fiber

A four fiber patch cord shall be provided between each fiber optic transceiver and each termination

panel. The fibers shall be either multi-mode or single mode as required to match the trunk cable and transceiver. Patch cords shall be fitted with SC/PC type connectors unless the proposed/existing equipment requires a different connector. Connectors shall be attached to the patch cords using an epoxy crimped methodology where the kevlar is crimped to the connector. Cost for supplying and installing connectors on all ends of the patch cord shall be incidental to the bid item price of the Patch Cord. The contractor at his option may supply four separate one fiber patch cords or two duplex patch cords, however, only one 4 fiber patch cord quantity will be provided at each controller. Cost for the patch cord shall be at the bid item price for each Item 632 Interconnect Misc.: Fiber Optic Patch Cord, 4 Fiber.

632 Interconnect Misc.: Termination Panel

(Modification to drop cable fiber count or a different system construction (such as terminating the entire trunk cable in each cabinet) may require a larger termination panel being specified)

Termination panels used in NEMA cabinets shall be a model WCH-02P as manufactured by Siecor. 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/ITS cabinets shall be mounted within the 19" (483 mm) cage and shall be model CCH02U as manufactured by Siecor. All costs including materials, tools and labor to provide and install a termination panel shall be included in the bid item price for each Item 632 Interconnect Misc.: Termination Panel. The bid item price for the termination panel shall include the cost of the required termination bulkhead. Bulk heads shall be appropriate for the supplied type of connector.

625 Trench for Fiber Optic Cable

In addition to Item 625.12, the Contractor shall place warning tape directly above all new conduit containing fiber optic cable. The warning tape shall be placed between 6" (150 mm) and 12" (300 mm) below finished grade with a tape length equal to the length of the conduit or cable. The tape shall be dielectric polyolefin film tape, 0.1 mm thick, 3" (76 mm) wide, orange in color. Materials and ink colors shall be used that will not change when exposed to acids and other destructive substances commonly found in soil.

Payment shall be made at the contract linear unit price of Item 625, Trench For Fiber Optic Cable and shall include all costs for trenching, the warning tape, backfilling and restoration.

625 Pullbox Misc.: Pullbox, 713.081, 24" (610mm) X 35" (890mm) X 26" (660mm)

(Any pullbox where a splice is required or change in cable direction is made should use this larger pullbox. The plastic pullboxes cited in this note are bell shaped at the bottom to help maintain cable minimum bend radii.)

Pullboxes shall have nominal opening dimensions of 24 inches (610mm) x 35 inches (890mm) as manufactured by: Carson Model 2436 (box) and model 2436-2R (cover); Associated Plastics model FCB243624C02 (box) and model PCC243600A02 (cover); PenCell Plastics model PEM-2436 (box) with a steel lid. The word "Traffic" shall be integrally cast as part of the cover or securely fastened with corrosion resistant hardware. The supplied pullboxes shall be able to support a 10,000 lb. minimum vertical loading without permanent damage or deflection to the unit. This item shall

include but is not limited to the disposal of surplus material and the restoration of disturbed facilities and surfaces.

The largest bend radius possible shall be maintained for the fiber optic cable as specified by this specification. All costs resulting from the above requirement shall be included in the unit price bid per each of Item 625 Pullbox, 713.081, 24" (610mm) X 35" (890mm) X 26" (660mm)

632 Interconnect Misc.: Fusion Splicer

(This fusion splicer note is required if the plan requires fusion splicing in lieu of mechanical splicing and the maintaining agency wishes to be supplied with a fusion splicer for future maintenance work at project cost .)

The fusion splicer used as part of this project shall be purchased new by the Contractor and turned over to the maintaining agency in good working order at the conclusion of the project. The fusion splicer shall provide a video display of the fibers and shall utilize a direct core light injection system (LID), profile alignment, 3 axis fiber alignment or V-block and shall be capable of automatically cleaning, positioning (gap) and fusing fibers at the touch of a button. The splice unit shall be capable of splicing either multi-mode or single mode fibers and shall be able to instantly calculate splice loss and display the results in an easily understood manner. The fusion splice unit shall include an attachable heat shrink oven and crimp & go type splice protection crimping device. It shall be able to operate on battery, AC or external DC power. The estimator should be accurate to ± 0.05 db 100% of the time. Certification and testing papers for the fusion splicer shall be submitted with the unit when it is turned over to the maintaining agency. If the unit certification expires before the project completion or if the unit is used by the Contractor during construction, the unit shall be re-certified at the Contractor's expense before it is turned over to the maintaining agency. All costs to purchase and turn over in good working order a fusion splicer conforming to these specifications shall be included in the bid item price for each Item 632 Interconnect Misc.: Fusion Splicer.

632 Interconnect Misc.: Fusion Splice

(Project designer will have to decide if fusion splices or mechanical splices will be used in the project. Only the relevant note for chosen splice technic should be included in the plan. Maximum allowable db loss can be modified on a project by project basis to accommodate the loss budget needs of a particular system.)

Typically 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 of each multi-mode fiber shall not exceed 0.2 dB (per EIA-568-A) for both single and multi-mode fibers. The average splice loss is defined as the summation of the loss as measured in both directions using an OTDR through the fusion splice, divided by two.
- (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).

Fusion splices shall be paid at the bid item price for each Item 632 Interconnect Misc.: Fusion Splice and shall include all costs for equipment, material and labor to provide a permanent fused splice including splice protection. A quantity of one splice will be provided for each pair of fibers that require splicing.

632 Interconnect Misc.: Mechanical Splice

(Project designer will have to decide if fusion splices or mechanical splices will be used in the project. Only the relevant note for chosen splice technic should be included in the plan. Maximum allowable db loss can be modified on a project by project basis to accommodate the loss budget needs of a particular system.)

Typically the only place splices will be permitted is to connect the loose tube drop cable to the loose tube trunk cable unless specifically noted in the plan.

Mechanical splices shall conform to the following:

- (a) Splice Loss (Mechanical Splicing). A maximum splice loss of 0.20 dB is allowed for single-mode and multi-mode fiber connections.
- (b) Splice Protection. When mechanical splices require storing, a mechanical splice tray organizer shall be used.

Mechanical splices shall be made using 3M Fibriok splicing kits.

Mechanical splices shall be paid at the bid item price for each Item 632 Interconnect Misc.: Mechanical Splice and shall include all costs for equipment, material and labor to provide a permanent splice including splice protection. A quantity of one splice will be provided for each pair of fibers that require splicing.

632 Interconnect, Misc.: Fiber Optic Connector

Unless a different connector is required for compatibility with existing or proposed active components, fiber optic connectors shall be field installable SC/PC compatible, ceramic ferrule, with the fiber permanently secured within the ferrule by epoxy (heat set), chemically cured or a hot melt adhesive in accordance with the connector and/or the epoxy manufacturer. When connectors are installed outside of a controlled environmental location, the connector operating temperature shall be minimum (-40 C to +70 C). For those applications within a controlled environmental location, the operating temperature shall be minimum (-20 C to +60 C).

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 for approval to the Engineer. 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 both single and multi-mode fibers.

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Fiber Optic Connector.

632 Interconnect, Misc.: Cleave Tool

(Optional Note)

Cleave tools are used during splicing to cut the individual SM or MM fibers as close to a perfect 90 degree angle as possible, thus allowing the highest core to core alignment and therefore the lowest dB splice loss. The manufacturers of cleave tools have established "end angle" cleave averages that are based on a minimum of 150 cuts utilizing a minimum of 10 cutters. Based on these test results cleave tools shall have minimum end angle averages as follows: <0.70 degree average with no cut of the 150 cleaves exceeding 1.5 degree will be allowed. Prior to the splicing of any fiber cable, the Contractor shall submit the part number and manufacturer of the cleave tool along with an "end angle" distribution chart which demonstrates the actual 150 cut end angles, such as Siecor part number FBC-005 or Alcoa Fujikura CO12 or equal. The Contractor shall purchase a cleave tool that meets this specification to be left in good working condition with the maintaining agency for maintenance of the fiber system.

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Cleave Tool.

632 Interconnect, Misc.: Mechanical Splice Tool Kit

(Optional Note)

A mechanical splice tool kit shall include all the tools necessary for the assembly of a mechanical splice. The tools shall allow for easy completion of cable preparation, removal of fiber coating, cleaning and cleaving, prior to completing the splice. Mechanical splice kits typically include a connector assembly tool, cleave tool, No-Nik fiber stripper, micro-strip precision stripper, cable stripper, telecommunication snips, 20X magnifier, lint-free cloth, protective carrying case and manual.

A cleave tool shall be included in the mechanical splice kit. The Contractor shall purchase a pre-assembled mechanical splice kit that meets this specification, similar to 3M 2530 Fiber Splice Preparation Kit, Siecor TKT-100-02 or approved equal, to be left in good working condition with the maintaining agency for maintenance of the fiber system.

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Mechanical Splice Tool Kit.

632 Interconnect, Misc.: Fiber Optic Termination Tool Kit

(Optional Note)

A termination tool kit shall include all tools and materials listed below necessary to terminate the connectors used as part of this project. Termination kits shall include a hot melt oven, crimp tool, one-step lap film, polishing jig, polishing pad, cooling stand, connector holder, stripping collar, scribe

carbide, bottle of 99% isopropyl alcohol, snips, cable stripper, No-Nik stripper, view scope, lint-free cloth and pipe cleaners, jewelers loupe, pocket ruler and instruction manuals. The Contractor shall purchase a pre-assembled termination tool kit that meets this specification, similar to 3M 6150-A Termination Kit, Siecor TKT-025 or approved equal, to be left in good working condition with the maintaining agency for maintenance of the fiber system. The entire kit shall come in a hard side carrying case.

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Fiber Optic Termination Tool Kit.

Item 632 Interconnect, Misc.: Optical Time Domain Reflectometer (OTDR)

(This OTDR note is required if the plan requires the contractor to provide the maintaining agency with an OTDR for future maintenance work at project cost.)

The contractor shall purchase an OTDR that meets the following requirements and turn it over to the maintaining agency for their use at the conclusion of the project.

The OTDR shall be supplied with the following features as a minimum:

1. Field interchangeable source modules for single and multi-mode fiber analysis of optical links from 300 feet (100 m) to 15,000 feet (5 km) in length.
2. Minimum of 3 user selectable pulse widths per wavelength
3. Auto mode button for one button testing
4. Auto mode or simplified mode for trace naming and storing
5. Dual trace analysis mode
6. Event table display
7. Internal hard drive for trace storage
8. 3.5" floppy disk drive (1.44 meg)
9. Peripheral support for keyboard, mouse, VGA monitor and printer
10. Individual and batch printing modes
11. PC based emulation software for Windows 95 or DOS (to be included with OTDR)
12. System shall be software upgradeable
13. Internal Battery with AC adapter/battery charger
14. Internal or external printer
15. Bi-directional analysis through emulation software or internal to OTDR

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Optical Time Domain Reflectometer (OTDR).

632 Interconnect, Misc.: Splice Enclosure (Under Grade or Aerial)

Splice enclosures shall be water proof and shall be a Siecor model UCA0, 3M 2178 or approved equal. Included with each enclosure shall be aerial or pull box wall mounting brackets as required by the particular splice location. Where armored cable is specified, the armor shall be grounded in the grounding system provided with the enclosure. As a minimum, a 12 fiber splice tray shall be provided with the enclosure. Where more than 12 fibers are specified, additional splice trays shall be included as necessary to accommodate the fiber count. The splice enclosure shall feature a moisture tight sealing arrangement which is re-enterable for system expansion and repair. No stress shall be placed on

finished splices within the 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 2 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 2 trunk cable fibers being spliced into the drop cable. (To drop cable fibers R1, T1, R2, T2) Note: See "Typical System Construction" details.

Payment shall be made at the contract unit price bid per each of Item 632, Interconnect, Misc.: Splice Enclosure (Under Grade & Aerial) and shall include all costs including materials, equipment and labor to provide a complete installed fiber optic splice enclosure. Cost for the splices will be itemized separately.

632 Interconnect Misc.: Slack Installation

Where designated in the plans, the contractor shall provide an aerial mounted slack cable installation conforming to the plan details. Where an underground installation is required, the contractor shall provide 50 feet (15 m) of slack cable inside of the designated pull box.

All costs including materials, equipment and labor to provide a slack installation shall be at the bid item price for each Item 632 Interconnect Misc.: Slack Installation. Note the cost for the fiber optic cable used in the slack installation (both aerial and underground) shall be included in this pay item. The linear quantity of fiber optic cable necessary for the slack installation shall be included in this pay item and is not itemized in the linear bid item price of the fiber optic back bone cable.

632 Interconnect Misc.: Pole Entrance Fitting

(The maintaining agency may opt to have the Contractor route drop cables down the outside of strain poles. This alternate method of installation is shown in the construction details. Should the alternate method be desired, this note should be deleted and a note should be provided requiring the alternate construction method. Additional methods of transitioning from overhead to underground may be specified by the designer.)

A pole entrance fitting shall be provided in accordance with the enclosed details to allow fiber optic cable entrance into both existing and proposed steel poles. In proposed poles, the contractor shall have the 2" (51 mm) entrance holes shown in the details pre-manufactured. Blind half couplings shall be welded into any new strain poles supplied as part of the project.

Existing strain poles will require the contractor to field locate the pole entrance hole and drill two pilot holes and use a hole saw to cut the 2" (51 mm) hole. All non-galvanized pole surfaces exposed after cutting the hole shall have 3 coats of zinc enriched paint applied. See construction details

No pole entrance fitting holes shall be located vertically within 24" (600 mm) of any other holes or blind half couplings.

All costs to provide a pole entrance including material, equipment and labor shall be included in the bid item price for each Item 632 Interconnect Misc.: Pole Entrance Fitting.

632 Signalization, Misc.: Fiber Optic Cable Testing

General

1. OTDR 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.
2. 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.
3. 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.

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

The contractor shall utilize bare fiber adaptors or other approved means 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 computer diskettes 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/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 : MM dead zone=23 feet (7 m), SM dead zone = 33 feet (10 m))

Fiber lengths in excess of 3280 feet (1000 m) worst case wavelength is: MM=850nm/SM=1550nm
Fiber lengths less than 3280 feet (1000 m) worst case wavelength is: MM=850nm/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 use on the project.

Pre-installation Maximum Acceptable Attenuation Loss: MM @ 850nm = 5.6 db/mile (3.5 db/km)
MM @ 1300nm = 0.625 db/mile(1.0 db/km)
SM @ 1310nm = 0.64 db/mile (0.4 db/km)
SM @ 1550nm = 0.48 db/mile (0.3 db/km)

Link Testing with OLTS (Power Meter) and OTDR (After Splicing and Terminating)

OLTS (Power Meter)

All links shall be tested with the OLTS after splicing and termination work is completed. Link testing will be bi-directional for attenuation loss with worst case wavelengths. Test procedure shall comply with EIA-568-A requirements.

Worst case wavelengths are defined as:

- MM = 850 nm
- MM = 1300 nm (link length greater than 4 km)
- 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*)
Note: Any additional splices such as splicing reels together must also be included.

* Attenuation for SM and MM are:

- Attenuation: MM @ 850nm = 5.6 db/mile (3.5 db/km)
- MM @ 1300nm = 0.625 db/mile(1.0 db/km)
- SM @ 1310nm = 0.64 db/mile (0.4 db/km)
- SM @ 1550nm = 0.48 db/mile (0.3 db/km)

Optical fiber test results submitted shall show the loss measured on each individual fiber as compared to the reference launch power. The link attenuation as calculated above is a not to exceed 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.

OTDR

All links shall be tested with an OTDR that are 1000 feet (300 m) or longer for the 850nm and 1310nm wavelengths. Links which are in excess of 3280 feet (1 km) shall include 1550nm testing on SM fibers. OTDR testing shall be in one direction following worst case wavelength selection when there are no splice points or interconnect points in the link.

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 testing at the 1550nm wavelength for 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 computer diskettes 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 diskette copy of each trace shall be submitted to the Engineer for his 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. Poper pulse width selection is required to minimize attenuation dead zone effect (10ns pulse : MM dead zone=23 feet (7 m), SM dead zone = 33 feet (10 m)).

All costs to perform the above testing shall be included in the bid lump sum price for Item 632 Signalization Misc.: Fiber Optic Cable Testing. Any link that fails the above tests shall be replaced and retested at the contractor's expense.

633 Controller Item, Misc.: Fiber Optic Transceiver (MM or SM)

Communications on the fiber optic cable shall require fiber optic transceivers. The controllers are to be equipped with transceivers capable of communications with the signal system controllers. It is the Contractors responsibility to install and activate each of these modems in the controller housing and contact the manufacturer for replacement panels if necessary. Price for the controllers is itemized separately.

Payment shall be made at the contract unit price bid per each of Item 633, Controller Item, Misc.: Fiber Optic Transceiver (MM or SM)

632 Signalization Misc.: Fiber Optic Training Plan

The Contractor shall submit a comprehensive fiber optic training plan for approval within 15 days of notice of signed contract. The training course shall take place prior to installation and may be attended by personnel from the maintaining agency or their designees. This training shall be for up to twelve (12) personnel to be determined by the Engineer.

The training shall be conducted by an approved instructor who can demonstrate a minimum of 2 years experience in fiber optics and fiber optic training. The instructor(s) shall be familiar with the cable types and equipment being installed on this project. The plan shall be for a minimum three (3) day fiber optic training course, including lecture, classroom "hands-on", and project field training. One half of the total training course shall be dedicated to various cable splicing and testing equipment workshops.

The course shall teach personnel from the maintaining agency the processes, fine tune techniques and verify a craftsman's abilities to install and inspect cable , fan-out, terminate, splice (both mechanical & fusion), and test (hand held, mini-OTDR and full size OTDR) fiber optic cable. Specific focus will be on the traffic interconnect systems, with emphasis on "drop and insert" (closed loop) installations.

The following subjects shall be covered at minimum. Course content is not limited to this list.

- Safety
- Fiber Optic Theory
- Cable Types & Applications, Cable Manufacturer's Overview
- Cable Placement
- Sheath Removal
- Armor Grounding Methods
- Duct Pulling Options
- Aerial Pulling Options
- Testing Processes Overview (Hand Held Process, Mini-OTDR, OTDR)
- Cable Splicing (Mechanical & Fusion, Splice Enclosure)
- Splice Enclosure Installation & Splicing Discussion And Workshop
- Cable Fan-Out W/Kits
- Cable Placement (Distribution Box)
- Termination (Field) Discussion And Workshop
- Testing The System
- Closure & Slack Management
- Trouble Shooting
- System Restoration

The training site shall be provided by the Contractor at a mutually agreed upon location with the maintaining agency. All costs associated for providing the above training shall be included in the lump sum price bid for Item 632 Signalization Misc.: Fiber Optic Training Plan