

TECHNICAL SPECIFICATIONS

DIVISION 2950 TRAFFIC SIGNAL INTERCONNECT:

2951 GENERAL: This work shall consist of furnishing and installing all necessary equipment and materials to complete a traffic signal interconnect system in accordance with these Specifications and as shown on the plans or established by the Engineer.

The scope of this work shall include furnishing, installing and testing portions of an interconnected arterial master closed loop system at locations shown in the plans. The system shall include all equipment as listed in the traffic signal interconnect summary of quantities and as shown in the plans and shall include any incidental items necessary for the satisfactory operation of the system.

The Engineer's approval or acceptance of materials or work performed shall in no way lessen the Contractor's responsibility to provide a fully functioning system.

2952 MATERIALS AND EQUIPMENT: All materials shall conform to the requirements herein. All materials shall be as specified in the traffic signal interconnect summary of quantities in the plans and shall be new or of an unused quality.

.1 Modem: The signal system modem shall be a fiber optic modulator/demodulator capable of operating in a master or local mode of communications to control traffic in a Type 170E closed loop traffic control system, utilizing Type 170E Controllers meeting City specifications.

The signal system modem shall be capable of operating in a full duplex mode of operation, employing asynchronous RS-232 data link protocol. The modem shall be capable of operating at standard communications rates up to and including 9600 baud. There are two types of modems that the City uses and are described below:

A. The signal system modem shall be a printed circuit board assembly 9.375 inches (238mm) long by 6.25 inches (159 mm) high and shall fit in the 400-modem slot of the controller. On the assembly, there shall be an edge connector, which shall mate with the internal connector on the controller motherboard.

On this assembly, there shall be two pairs of optical emitters and optical detectors labeled pair "1" and pair "2", designed to attach to standard ST connectors. There shall be two LEDs provided, one labeled "T" for transmit and one labeled "R" for receive. These LEDs shall illuminate when the modem is either receiving or transmitting at the local controller. There shall be a slide switch labeled "M" for master operation and "L" for local operation. In the master position, the electrical data entering the modem via the edge connector shall be transmitted as optical signals in a parallel mode from each of the two emitters. The optical signals received by the two detectors shall be converted to electrical signals and sent in parallel to the controller via the edge connector.

In the local mode of operation, optical signals received by detector 1 shall be converted to electrical signals and sent to the 170 controller via the edge connector. These same signals shall be regenerated and transmitted by emitter 2 to the next adjacent modem downstream in the daisy chain. Optical signals received by detector 2 shall be regenerated and transmitted by emitter 1 to the next adjacent modem upstream. Electrical signals received by emitter 1 from the controller shall be transmitted to the next adjacent modem upstream. Regeneration shall maintain pulse fidelity within ± 0.1 percent for each modem.

- B. The signal system modem shall be approximately 3 inches (75 mm) wide, 2 inches (50 mm) high and 6 inches (150 mm) deep. There shall be an integral electrical cable attached to the rear side of the modem with a connector attached thereto. This connector shall be a 14 position "M" series connector with male pins designed to positively intermate with a Type 170E Controller's C2 connector. The signal system modem shall be self-contained and be capable of reliable operation from -31°F. to 167° F. (-35° C. to 75° C).

On the front panel there shall be two pairs of optical emitter and optical detector sockets, labeled pair "1" and pair "2" designed to accept standard ST connectors. There shall be at least two light emitting diodes (LED's) provided on the front panel. One shall be marked "Transmit" or "Emitter" and the other shall be marked "Receive" or "Detector". These LEDs shall illuminate when the signal system modem is either receiving or transmitting (as appropriate) at the local site.

There shall be a toggle switch labeled "M" for Master and "L" for Local operation. In the Master position, the electrical data signals entering into the signal system modem via the electrical cable, shall be transmitted as optical signals in a parallel fashion to each of the two emitters. Optical signals received by either or both optical detectors shall be converted to electrical data signals and transferred to the 170E Controller through the electrical cable.

In the Local mode of operation, optical signals received by Detector 1 shall be converted to electrical signals and transmitted to the attached 170E Controller. These same optical signals shall be regenerated and transmitted to Emitter 2. Optical signals received by Detector 2 shall be regenerated and transmitted back upstream via Emitter 1. Additionally, electrical signals from the attached 170E Controller shall be transmitted back to the next upstream signal system modem via Emitter 1.

The signal system modem shall derive its power from the 170E Controller through the integral cable attached to the rear of the modem. Connection of signal grounds shall be allowed only through this cable and connection to the C2 connector on the 170E Controller. No other signal ground connections shall be allowed.

The signal system modem shall have a backup power source that allows for continued daisy chain operation when the 170E Controller that normally provides power to the modem is incapable of doing so. This backup power source shall provide uninterrupted operation of the daisy chain interconnect system, both upstream and downstream from the affected modem for a minimum period of 24 hours based on a 50% duty cycle.

The modem shall be delivered with dust caps on all four ports. One signal system modem shall be provided for each Type 170E Controller provided unless otherwise specified.

Suitable 0.125-inch (3.2 mm) aluminum shelves shall be provided by the Contractor in each of the local controllers for racking the signal system modem. Shelf design and installation methods shall be approved by the Engineer.

.2 Interconnect Cable: The signal interconnect cable shall be a 12-fiber cable assembly consisting of loose buffer tubes identified using EIA / TIA color-code standards. There shall be 6 single-mode and 6 multimode-graded index fibers. Each color-coded buffer tube shall be filled with a gel to prevent moisture penetration. Each individual fiber within each buffer tube shall be individually color-coded using EIA / TIA color-code standards. All other areas around the buffer tubes and cable core components shall be filled with water-blocking compounds or swellable dry-flex tape for added moisture blocking penetration. A glass reinforced S-glass plastic shall be used for the central member. High tensile aramid and/or Kevlar yarn shall be utilized over the cable core for additional tensile strength. A medium or high density polyethylene outer jacket shall be applied overall and shall be permanently labeled in consecutively numbered 3-foot (1-meter) increments so that cable lengths between any two points can be readily determined.

The signal interconnect cable shall conform to the following specifications as a minimum:

1. Indoor/Outdoor Multiple Loose Tube Fiber
2. U.L. Rating – OFNR, Compliant with TIA/EIA Standards
3. Fiber Count: 6 single mode and 6 multimode
4. Normal Diameter .51
5. Normal Weight 102
6. Maximum Tensile Loading
 - Installation 600 lbs.
 - Long Term 200 lbs.
7. Minimum Bending Radius
 - Installation 10.2 inches
 - Long Term 5.1 inches
8. GR-409, GR-20 & GR-2961 Qualified Design

- 9. Multimode and single mode under one jacket
- 10. Riser and Plenum rated design. OSP armored indoor / outdoor
- 11. Operating Temperature -50 Deg. to 70 Deg. Celsius
- 12. Storage Temperature -40 Deg. to 70 Deg. Celsius
- 13. Installation Temperature -10 Deg. to 65 Deg. Celsius

The Contractor shall deliver to the Engineer a copy of the cable manufacturer's test results attesting to the proof of performance of the fiber product used by the manufacturer, if requested by the Project Engineer.

- .3 Conduit:** Conduit shall be as specified in the section of this specification entitled 4203 Traffic Signal Construction Requirements - .9 Conduit with the following additions. The conduit shall be orange in color and equipped with a No. 10 AWG stranded USE copper locating cable located inside the conduit. The locating cable insulation shall be green in color. All connections and/or splices below ground level shall be waterproofed.
- .4 Bulkhead Assembly:** One or two bulkhead assemblies shall be provided for each controller cabinet. Cabinets with one signal interconnect cable shall be provided with one 12-position or two 6-position bulkhead assembly(ies). These will generally be cabinets located at the terminus of the cable runs. Cabinets located at midpoints will be provided with two 12-position or four 6-position bulkhead assemblies; one set for the inbound cable and one set for the outbound cable.

The 12/6-position bulkhead assemblies shall consist of a series of 12/6 ST mating adapters. The adapters shall be constructed with a nickel-plated die cast zinc alloy body and a split Beryllium copper or zirconia alignment sleeve. The 12/6 adapters shall be mounted on the proper bulkhead adapter plate to mate with the termination cabinet being installed inside the controller cabinet.

Each bulkhead assembly shall be provided with dust caps; one installed on each bulkhead. A 2m/3m duplex jumper shall be provided with each modem for each cable direction terminated in the cabinet as a minimum.

Standard breakout kit(s) shall be used to terminate all signal interconnect cable(s). Breakout kits(s) shall be a minimum of 15 inches (380 mm) / maximum of 30 inches (760 mm) in length and be configured for the signal interconnect cable specified.

All fiber optic cable end connectors shall be industry standard ST style connectors designed for field installation and to operate within a temperature range of -31°F. to 167° F. (-35° C. to 75° C.). The connector shall be a low-loss type comprised of a ferrule, crimp sleeve (where required) and a 2-inch (50mm) strain relief boot. The nominal loss per connector shall be less than 0.5 dB. The ferrule shall have either a zirconia or a ceramic tip material and shall have a keyed, bayonet coupling mechanism for secure repeatable matings. Each connector shall be provided with a

dust cap if not plugged into a bulkhead. The ST connector used shall be designed for the type of fiber to which it is attached.

- .5 Fiber Optic Jumpers:** Multi-mode duplex fiber optic jumpers shall be provided to interconnect the bulkhead assembly where the signal interconnect cable is terminated with the signal system modem. The duplex jumper shall be heavy duty and shall consist of two individually tight-tube buffered, graded index 62.5uM compatible fibers with a 2.8/3.0 mm jacket encapsulating both fibers, terminated with ST connectors. The jumper cable shall be 2 to 3 meters long, and positively identify each of the two fibers (i.e. 1 & 2 or Tx & Rx). The cable shall be the most pliable, allowing the tightest bending radius available from the manufacturer (<5.0 cm) without compromising system operation. Each jumper assembly shall be supplied with optical performance test data indicating insertion loss for that jumper assembly.

Single-mode duplex fiber optic jumpers shall be provided to interconnect the bulkhead assembly where the signal interconnect cable is terminated with the signal system modem. The duplex jumper shall be heavy duty and shall consist of two individually tight-tube buffered, graded index 8.2 uM compatible fibers with a 2.8/3.0 mm jacket encapsulating both fibers, terminated with ST connectors. The jumper cable shall be 2 to 3 meters long, and positively identify each of the two fibers (i.e. 1 & 2 or Tx & Rx). The cable shall be the most pliable, allowing the tightest bending radius available from the manufacturer (<5.0 cm) without compromising system operation. Each jumper assembly shall be supplied with optical performance test data indicating insertion loss for that jumper assembly.

- .6 Dial-Up Modem:** A Dial-Up Modem unit shall be provided. The unit shall be an auto-dial, auto-answer modem to be installed at the specified Master location. The model shall be Hayes-compatible, capable of responding to the standard "Hayes command set". The modem shall be self-contained and be capable of reliable operation from -37° C. to +74° C. The unit shall be powered by a nominal 120 VAC from a duplex receptacle in the cabinet. Alternatively, the modem may be designed to fit into the internal modem slot in the Master 170E Controller and draw its power from the back panel. The modem shall be capable of operating at 300, 1200 or 2400 baud over a standard dial-up unconditioned voice-grade line and shall be provided with the appropriate interface cables to connect to: 1) an RJ11 telephone jack mounted on the Telephone Interface Panel, and 2) the C20 connector on the Master 170E Controller. This connector shall be a 14-position "M" series connector with male pins designed to positively intermate with a Type 170E Controller's C20 connector.

- .7 Conduit:** Unless otherwise specified, all signal interconnect cable shall be installed in smooth, continuous, pre-lubricated 2-inch (50 mm) conduit as shown in the plans and as approved by the Engineer. Conduit shall be orange in color, as approved by the Engineer.

Each trench installed that accommodates conduit containing signal interconnect cable shall have a tracing wire installed on the inside of the conduit to facilitate locating the buried conduit in the future. The wire shall be a No. 10 AWG stranded copper Type USE cable. The wire shall be connected with a connector at each end to a lightning, gas-protecting arrestor mounted in the controller which is attached to a ½-inch x 8-foot (12.5 mm x 2.4 meter) long ground rod.

Underground warning tape shall be installed in all trenches where conduit is installed. The warning tape shall be installed approximately 12 inches (0.3 meters) above the conduit. The tape shall be 4-inch (100 mm) wide polyethylene material, at least 0.004 inches (0.10 mm) thick. The tape shall be orange with black letters that say "Caution - Buried Fiber Optic Cable". The message shall be repeated continuously along the length of the tape. Other legends may be tendered for approval.

- .8 Telephone Interface Panel:** A Telephone Interface Panel (TIP) shall be installed in each Master location, as indicated on the plans. The TIP shall consist of an RJ11 jack for the interface cable to the Dial-Up modem, a lightning arrestor, a 6-position barrier strip and a chassis ground point. The panel shall be connected to the RJ11 jack with a pigtail that terminates on the 6-position barrier strip. The Tip and Ring (Green and Red) conductors are then routed through the lightning arrestor and back to two other terminals on the 6-position barrier strip. These two positions will interconnect to the RJ11 jack to interface to the modem. The ground wire from the lightning arrestor shall connect to a lug that will also accommodate a green No. 12 AWG wire connected to the cabinet chassis ground.

The lightning arrestor shall be able to withstand a peak surge current of 10,000 amps (8 x 20 μs wave shape). The response time shall be less than 5 nanoseconds. The clamp voltage shall be 150 volts. Series resistance shall not exceed 25 ohms total. The unit shall operate over the full temperature range of -40° to +85° Celsius. Primary protection shall be afforded by a three element gas tube. Secondary protection shall be solid state clamps. All shunts will be to ground. The arrestor shall be a plug replaceable unit mounted in a permanently attached socket. Electrical mating surfaces shall be gold-plated.

2953 CONSTRUCTION REQUIREMENTS: Unless otherwise described herein, all construction requirements shall conform to the sections of this specification titled "Traffic Signal Installation" and "Conduit".

Before commencing work, a complete schedule of materials and equipment proposed for installation shall be submitted to the Engineer for approval. This schedule shall include catalog cuts, diagrams, drawings, and other such descriptive data that may be required by the Engineer.

All submittals shall include the manufacturer brand name and part number where applicable. Where more than one item is present on a submittal sheet, the appropriate item or items shall be circled, not highlighted. All submittals shall be organized as much as practical in order with the summary of quantities sheet in the plans. In the event that any materials or equipment contained in the schedule fail to comply with specification requirements, are not circled, or submittals are not packaged, such items may be rejected. New submittals on rejected items shall be supplied to the Engineer for approval.

When it is required by these specifications that a test be made of the material to be used on the project, the Contractor shall furnish the Engineer a certified copy of such test prior to the installation of such material. When any reference is made in these specifications to any specification such as ASTM, IPCEA, AIEE, etc., or a related specification referred to by reference therein, or revision thereof which states that a certain test, or tests are to be made only at the request of the purchaser, it shall be considered that the Engineer does request such test or tests to be made at the Contractor's expense.

- .1 Signal System:** One signal system modem is to be installed on an approved, suitable 0.125-inch aluminum shelf provided by the Contractor in each of the local 170E Controller cabinets. Modems shall be connected to the 170E Controllers' C2 connector via the integral modem cable. The local modems shall also be connected to the fiber optic jumper cables. Installation of the modems shall include connection of all cabling, testing, and system integration and installation of all shelves and any other necessary appurtenances.
- .2 Interconnect Cable:** The signal interconnect cable hereinafter called fiber optic cable or cable shall be installed in continuous runs, in conduit, between traffic signal controller cabinets as shown on the plans. No splices will be allowed, unless otherwise noted on the plans. The cable shall be terminated at each controller utilizing breakout kits and ST connectors to mate with the bulkhead assembly. All fibers (including dark fibers) in each signal interconnect cable shall be terminated and identified in each cabinet.

The fiber optic cable installation shall be supervised by trained and experienced personnel. Installation of the fiber optic cable shall be by a Contractor having

proven installation experience in fiber optic systems in the past twelve (12) months. Written proof of experience shall be supplied to the Engineer for approval of the Contractor. The Contractor shall notify the Engineer one (1) working day in advance of whenever any fiber optic cable work is to be performed.

Proof of experience shall include:

1. Name of the client
2. Name and phone number of client's representative who monitored the project
3. Description of project, specifically Contractor's involvement in project
4. Key Contractor personnel involved, who would also be involved in this project

This information need be supplied for no more than three (3) projects in the last twelve (12) months. Each end of the interconnect cable shall be sealed with a manufacturer approved end cap or pulling grip for use during installation. These caps or grips will be removed only after complete installation of the cable and for cable acceptance testing. End caps shall be installed to remain in place where fibers are not to be terminated.

The minimum bend radius of the interconnect cable during installation shall be 9 inches (230mm). The pulling of the cable shall be hand assisted at each junction or service box and controller locations. The cable shall not be kinked, crushed or forced around a sharp corner. Pulling equipment may be used, however, all pulling equipment and hardware must maintain the cable's minimum bend radius. Such equipment that may contact the cable includes sheaves, capstans, bending shoes, and quadrant blocks designed for use with fiber optics. Where pulling equipment such as a winch is used, cable tension must be continuously monitored. This may include use of a winch with a calibrated maximum tension or a dynamometer or in-line tensiometer. A ball or roller-bearing swivel shall be used to prevent twist. A breakaway coupler with a 600psi (42 kg/cm²) or less shear bolt shall be incorporated in the pulling rig for all fiberoptic cable pulls.

If a lubricant is used, it shall be of the water-based type as approved by the cable manufacturer and shall be compatible with the pre-lubricated PVC conduit. If used, lubricant type and manufacturer shall be supplied to the Engineer for approval.

Installation of the fiber optic cable shall also be in accordance with the manufacturer's specifications. Should the manufacturer's specifications appear to conflict with any portion of these Specifications, the matter shall be brought to the attention of the Engineer for resolution.

Sufficient slack shall be left at each end of the cable to allow proper cable termination. Each controller cabinet shall have a minimum of 30 feet (9.1 meters) of cable left available on each run. Unless otherwise noted in the plans, additional slack of two turns of cable (min. 10 feet (3.0 meters)) shall be left at each junction box or service box, neatly coiled and racked as per the manufacturer's minimum bending radius specifications. At each junction or service box and at the controller

cabinets, the cable shall be visibly marked "Caution - Fiber Optic Cable" by self adhesive, weatherproof tags.

After the fiber optic cable installation, each section of the cable shall be tested with an Optical Time Domain Reflectometer (OTDR) as a minimum. The tests shall be conducted at 1310 nm for multimode fiber and at both 1310 nm and 1550 nm for single-mode fiber. If excess attenuation and/or problems are found, the Contractor shall use an OTDR to locate points of localized loss caused by bends, kinks or fractures. The Contractor will then try to relax any identified bends or kinks. If this is not successful, the Contractor shall replace the damaged section of cable at his own expense and retest the section. The Contractor shall provide the Engineer with a written report showing all the values measured during these tests, as well as calculated and allowable values, and any corrective actions taken to attain satisfactory results. OTDR measurements shall be made of all fiber lengths and a printout of the traces for each fiber shall be provided to the Engineer. Insertion loss testing and documentation of results may be required if data from OTDR is suspect or test results do not resolve system performance problems. All installed connectors shall be examined with a fiber optic microscope (100x min.) to verify quality of end face polish. Chips, scratches, and any damaged connector deemed unacceptable by industry standards will be rejected and replaced by the Contractor at their expense prior to final approval.

When the Contractor is working inside the cabinet of an existing closed loop system, it is the Contractor's responsibility to restore the system and to verify that the system is operating properly once construction is complete.

- .3 **Dial-Up Modem:** A Dial-Up Modem shall be installed in the designated Master control location. Installation shall include furnishing all cabling, connectors, lightning suppression and incidental items necessary for system operation.
- .4 **Conduit:** Fiber optic cable shall be installed in conduit, as specified on the plans. Any open trench containing conduit, including those sections between service boxes where conduit is installed by both open trenching and boring, shall have a No. 10 AWG stranded copper Type USE cable installed inside the conduit before backfilling. This trace wire shall be installed with no splices. Each end of the trace wire will be connected to a lightning, gas- protecting arrestor mounted in the controller which is attached to a ground rod driven for this purpose exclusively and no other connections shall be made to this ground rod, with the exception that another trace wire may be connected to the same rod. The rod shall be driven through the bottom of the service box where excess fiber optic cable is stored.

The conduit shall be installed in a 36-inch (0.9 meters) deep trench with a 24-inch (500 mm) to 30-inch (760 mm)) cover. The trace wire shall be installed on top of (or as near as practical to) the conduit. Consecutive six-inch (150 mm) layers of approved backfill soil or backfill material (free of any rocks or debris) shall be compacted in the trench in accordance with the Specifications. A 4-inch (100mm)

wide underground warning tape shall be laid in the trench, in a continuous run from one service box to the next, approximately 12 to 18 inches (0.3 to 0.45 meters) above the conduit. Aboveground fiber optic conduit markers shall be installed to indicate fiber optic cable routing. The markers shall be placed midpoint between adjacent fiber optic service/junction boxes and/or such that the spacings are approximately 500 feet (150 meters) between markers.

All fiber optic splicing shall be fusion spliced. Mechanical splices will not be permitted. The enclosure shall be installed according to the manufacturer's recommended guidelines. For the mainline splice, the cables shall be end-to-end fusion spliced. End-to-End splicing shall be performed as per manufacturer instructions for the supplied splice Enclosure units.

Mid-span splicing (drop splice) shall be performed for each device location at locations shown on the plans. Splicing shall be performed as per Siecor Recommended Procedure SRP-004-013, "Mid-span access of Fiber Optic Cable (Cable slack present)", or appropriate manufacturer instructions. All mid-span splices shall be contained within enclosures.

2954 MEASUREMENTS AND PAYMENTS:

- .1 Method of Measurement:** Traffic signal interconnect shall be measured by the lump sum complete in place.
- .2 Basis of Payment:** The amount of completed and accepted work measured as stated above, shall be paid for at the contract lump sum price bid for "Traffic Signal Interconnect"; which price shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the work.