

## SECTION 3000 – FIBER OPTICS

### 3001 SCOPE OF PROJECT

The communications subsystems to be furnished and installed by the Contractor shall include all field electronic elements; lightning and surge protection elements; user-owned fiber optic cable as defined in the plans; and all auxiliary cabinets, hardware, and wiring incidental to the transmission of data between the traffic control computers and the field locations.

The Contractor shall assume full responsibility for ensuring the successful construction and proper operation of the system components. The Contractor shall be fully responsible for all hardware design, testing, training, and documentation as detailed in this Technical Special Provision. This Technical Special Provision provides detailed operational and technical requirements for specific elements of the signal system necessary to satisfy the objective of this project.

#### A. General

To assure full and complete utilization and compliance of all equipment furnished, the Contractor shall provide support services and materials at various points in the construction, including:

- Documentation as specified in **Section 3002 C.** of this Technical Special Provision.
- Testing as specified in **Section 3006** of this Technical Special Provision.

The Contractor shall be fully responsible for the maintenance and care of all equipment furnished and installed or modified by the Contractor until the time of final acceptance by the Engineer.

The equipment and materials installation shall conform to the Plans and this Technical Special Provision, the City of Lawrence standard specifications included in the project manual, and the latest edition of the National Electric Code. The intent of this Technical Special Provision is that the work to be completed under this Contract shall be neat, finished, full, and complete in every detail and ready for use and operation for the purpose for which it is intended. The Contractor shall furnish all labor, tools, materials, machinery, test equipment, and any other equipment necessary to complete the installation and operational tests for the system. The cost of all incidentals, minor and miscellaneous items, work, and materials for which no payment is specifically provided, and any items, work, and materials not specified or shown which are necessary to complete and maintain the work shall be included in the price bid for other items in the Contract, and no other compensation will be allowed. The Contractor shall pay all shipping costs for the equipment furnished and installed under this Contract.

B. Scheduling of Work

In no case shall the Contractor install any equipment at a location until the equipment location has been flagged, staked, or marked by the Contractor and approved by the Engineer. All materials for that location must be on-hand and ready for installation unless the Engineer gives approval. Once installation of this equipment commences, the Contractor shall complete this work in a most expeditious manner. The following items shall be considered equipment:

- Communications equipment, including fiber, accessories, etc.
- Any and all electrical connections, accessories, etc., required to ensure the operation of the proposed system.

3002 GENERAL REQUIREMENTS FOR EQUIPMENT, MATERIALS AND EVALUATION

A. General

Throughout the entire project, all units of any one item shall be made by the same manufacturer unless otherwise approved by the City of Lawrence, or the local jurisdiction's designated representative (the Engineer). The equipment, including all parts and accessories, shall be constructed in a thoroughly competent manner and in accordance with best commercial practices. Particular attention shall be given to neatness and thoroughness of soldering, wiring, welding and brazing, plating, riveting, finishes, and machine operations. The equipment shall be free from burrs and sharp edges or any other defects that could make the equipment unsatisfactory for the operation intended. Electrical materials shall conform to the applicable standards of the City of Lawrence, latest edition, the National Electrical Code (NEC), the International Municipal Signal Association (IMSA), the National Electrical Manufacturer's Association (NEMA), the National Safety Code (NSC), the Electronic Industry Alliance (EIA), the National Transportation Communications for ITS Protocol (NTCIP), and the American National Standards Institute (ANSI) in every case where a standard has been established for the particular article, material or equipment. Where specific standards and serial numbers are stipulated, the reference shall be construed to be the most recent standard specifications in force and in existence on the date of advertisement.

B. Submittals

All Contractor submittals shall be directed to the designated representative (Engineer). If necessary, the Engineer may direct the submittals to other parties for review. However, the Contractor must obtain written approval of the submittal from the Engineer prior to using the equipment being reviewed. All submittals must be in both hard copy and electronic format. For all submittals, the Engineer's review of the material will be completed within 21 calendar days from the date of receipt of the submission unless otherwise specified. The Engineer will advise the Contractor, in writing, as to the acceptability of the material submitted. The Engineer may determine that the item is approved, in which case no further action is required by the Contractor; or the item may be partially or

totally rejected, in which case the Contractor shall be required to modify the submittal as required by the Engineer and resubmit the item within 14 calendar days. At this time, the review and approval cycle described above shall begin again. The costs associated for the submittals from the Contractor shall be included within the price for the individual items and no additional compensation will be made.

#### 1. Materials and Equipment List

Prior to the approval of any components or material related to the project items listed in **Section 3008**, and no more than 30 calendar days after contract award, the Contractor shall submit to the Engineer eight (8) hard copies and an electronic version of a Materials and Equipment List. The Materials and Equipment List shall identify the quantity, manufacturer, description, catalog number, or other identification, options and/or special features for each item furnished. A unique identification number shall be indicated for each item on the Materials and Equipment List.

### **FIBER OPTIC INFRASTRUCTURE RELATED COMPONENTS**

Including, but not limited to:

- Conduit
- Pull boxes
- Communications cable
- Splice enclosures
- **MISCELLANEOUS** Including, but not limited to:
- Grounding material
- Construction material
- Surge protection devices
- Lightning protection devices
- Concrete
- Architectural elements

#### 2. Catalog Cuts

Four (4) hard copies and an electronic version of catalog cuts and manufacturers' descriptive literature shall be submitted with each copy of the Materials and Equipment List for all manufactured items. Submittal data shall be adequate to determine if the equipment and material meet the requirements of the Plans and this Technical Special Provision. Catalog cuts shall have highlighted the submittal data to be reviewed. If the catalog cuts are not highlighted, the submittal will be automatically rejected. The Contractor shall clearly note any deviations, changes, additions, or other modifications to the submittal data, which are appropriate to reflect the exact equipment, and/or material intended for use. Approval by the Engineer of the Materials and Equipment List and

submittal data shall not relieve the Contractor of any of their responsibility under the Contract for the successful completion of the work in conformity with the requirements of the Plans and this Technical Special Provision.

C. Documentation

1. Wiring Diagrams

Documentation is not required for fiber (wiring diagrams including end terminations and splicing) if the wiring is completed as specified in the Plans. If installation differs from the plans documentation shall be provided which includes:

The contractor shall provide final as-built drawings of the fiber cable and splicing connectivity to the City. Coordinate for a City approved computer generated fiber splicing matrix to be provided by the contractor for the project. As-built drawings of the fiber itself should be provided with the footages of fiber denoted between all pull box, cabinet, and splice points (points A to B to C, Etc.).

3003 CONDUIT

A. General

The Contractor shall furnish and install underground conduit as specified in the Plans. Quantities shown in the Plans for conduit installation include all quantities of each installation type (Trenched/Bored), as determined by the Contractor, necessary to install the conduit as shown in the Plans. The Contractor may choose to trench or bore conduit. Contractor shall be paid for conduit installation based on the unit cost of trenched or bored conduit.

The contractor shall provide as-built drawings denoting the depth of all new conduit installed at a maximum interval of 100'. The conduit shall be installed at a minimum depth of 36 inches below finished grade. The Contractor may reroute proposed conduit and/or adjust proposed conduit depth to a minimum of 24 inches from grade when proposed conduit installation is near and/or in conflict with an existing underground utility line unless otherwise directed or approved by the Engineer. The conduit depth shall be adjusted and documented only in the area of the conflict.

All new conduit installed, and all existing conduit used under this Contract shall be blown and/or rodded clean to the satisfaction of the Engineer prior to the installation of any cable or wire in that conduit.

Disruption to sidewalks due to the Contractor installation of conduit shall be repaired or replaced by the Contractor. Costs associated with sidewalk repair or replacement due to conduit installation shall be subsidiary to conduit costs.

Sidewalk restoration shall be full width by section for all sidewalks five feet wide or narrower. For sidewalks seven feet or wider, the restoration may be in half-width sections or to the nearest existing seam or joint as approved by the Engineer. Sidewalks between five feet and seven feet wide may be replaced to the nearest seam or joint only if existing and approved by the Engineer. Aesthetic sidewalk and/or pavement (brick, brick paver, paver block, colored concrete, granite, slate, etc.) shall be replaced entirely and the Contractor shall match color and texture in accordance with the owner's requirements.

Underground conduit shall generally be installed in non-pavement areas if possible. The Contractor shall install underground conduit in the grass utility strip if such a strip is available. The Contractor is responsible for sizing the conduit to be used on all installations in accordance with the minimum conduit size requirements in the Plans and this Technical Special Provision. The conduit shall be of sufficient size to allow the cables/conductors to be installed without any damage. The conduit sizes and fill requirements shall conform to the requirements of the National Electric Code.

Standard "runs" of conduit for the installation of City of Lawrence fiber, shall consist of conduits of 1 1/4" SDR-11 with orange as the primary color or a multi-duct conduit with up to 7 interior conduits with sizes to be determined by project and interior conduit colors specified per project using orange, red, white, gray, brown, green, or blue. When a single conduit is used as a separate pathway to service a building, that conduit shall be 1 1/4" SDR-11 solid orange. All new conduits shall be installed with pull tape.

The grounding/tracer wire shall be a continuous line with no splices between handholes. The grounding/tracer wire shall be installed in the solid orange conduit but not in the multi-duct conduit.

Pull boxes installed along new conduit runs should be spaced between 500-800 feet apart. The contractor should place pull boxes at road intersections whenever possible. The Contractor shall notify the Engineer of deviations and request approval for exceptions.

**B. Conduit Installation into Existing Pull Boxes**

All conduits shown in the Plans to be installed into existing pull boxes shall be installed in accordance with the requirements for conduit installation into new pull boxes. The Contractor shall maintain the existing pull box, provide general maintenance and cleaning out as required, and shall restore the surrounding area to a condition equivalent to that prior to when work began. The Contractor shall immediately notify the Engineer if the Contractor determines that the existing pull box is unacceptable for reuse. If the existing pull box needs to be temporarily removed or otherwise disturbed for the new conduit installation, new gravel shall be installed in the base of the reinstalled existing pull box as required for new pull boxes. The costs of all labor, materials, and equipment necessary to

complete the installation of new conduit into existing pull boxes or foundations as required in this Technical Special Provision shall be included in the quantities shown in the Plans for conduit installation. The cost of payment for base, sub-base, restoration of sidewalk, driveway, and curb restoration shall be included in the quantities shown in the Plans for conduit installation.

### 3004 FIBER OPTIC CABLE

Fiber optic cable will be installed in both new and existing conduit. The existing system consists of multiple 1 1/4" conduits or a multi-duct conduit with interior conduits sizes determined per project or application, owned by the City or other entities that enter into separate pull boxes. The contractor shall have access to only City of Lawrence property. Care should be taken to not disrupt or damage the remaining infrastructure within the duct bank.

#### A. General Requirements

The Contractor shall furnish and install fiber optic cable as shown on the Plans and in accordance with the requirements specified herein. All fibers in cable must be in working order. All fiber shall be shipped on reels of marked contiguous length. No splices shall be permitted within the fiber jacket. No point discontinuities of greater than 0.10dB shall be permitted. All fiber shall be labeled with the length at a minimum of every three feet. Fiber shall be imprinted with the following based on the owning agency:

- "Lawrence, Traffic Engineering Division, 913.832.3035"

After installation, the distance markings at each end of each run shall be logged and provided to the Engineer in a form acceptable to the Engineer. After installation, each run of fiber optic cable shall be marked within one foot of each splice and/or termination with the location that the cable goes to. This nomenclature shall be submitted to the Engineer for approval prior to its use. The nomenclature shall be used on the OTDR sweep test results specified separately. The following standards are applicable to this item and are hereby incorporated by reference:

#### B. Fiber Optic Cable

Unless otherwise noted on the plans, the single mode cable shall consist of up to 432 fibers determined by project or application, arranged in color-coded buffer tubes of 12 individually color-coded fibers. Cable shall be loose-tube and consist of steel tape armoring under the outer jacket or cable will be a micro-fiber cable. Each buffer tube shall be filled with a non-hygroscopic gel for protection of the fibers from impact and moisture ingress. Aramid strength members shall be bundled with the buffer tubes and the filler rods, and the jacket shall also contain non-hygroscopic gel. Alternatively, the cable may be provided with a dry water blocking material installed inside the cable jacket. The entire cable shall conform to Rural Utilities Service (RUS) Specification PE-90, unless the cable manufacturer's recommendation is more stringent. The minimum bend radius of

the cable shall be 20 times the cable diameter when under load and 10 times the diameter when under no load. The maximum tensile strength shall be at least 2700 Newtons (600 pound force) short-term and 601 Newtons (135 pound force) long-term.

The single mode fiber cable shall meet the following optical specifications:

1. The fibers shall be designed for dual wavelength operation at both 1310 and 1550 nm.
2. Each fiber shall have a mechanically strippable color-coated acrylic protective coating. The color of the inks applied to the fibers shall be clearly distinguishable from one another (EIA/TIA Standard) and remain so after cleaning and end preparation for splicing.
3. Each fiber shall have been subjected to and passed a tensile proof stress test equivalent to 100 kpsi for 1.0 second dwell time without damage of any kind.
4. The induced attenuation due to fiber wrapped around a mandrel of 75 mm diameter for 100 turns at 1310 nm shall not be greater than 0.05 db
5. Optical fiber parameters – The fiber shall meet the following specifications:
  - a. Core Diameter: 8.3  $\mu$ m
  - b. Cladding Diameter: 125  $\pm$  0.7 $\mu$ m
  - c. Coating Diameter: (uncolored) 245  $\pm$  5  $\mu$ m (colored) 245  $\pm$  7  $\mu$ m
  - d. Mode-field Diameter at 1310 nm: 9.2  $\pm$  0.3  $\mu$ m 1385 nm: 9.6  $\pm$  0.6  $\mu$ m 1550 nm: 10.4  $\pm$  0.5  $\mu$ m
  - e. Core to Cladding Offset:  $\leq$  0.5  $\mu$ m
  - f. Max Attenuation at 1310 nm: 0.34 dB/km 1385 nm: 0.31 dB/km 1550 nm: 0.22 dB/km

All fiber optic glass shall meet or exceed TIA/EIA-492CAAA, International Electrotechnical Commission (IEC) Publication 60793-2, and Telcordia GR-20CORE. The operating, shipping, and storage range of the cable shall be -40°F to +158°F. The installation temperature range of the cable shall be -22°F to +140°F.

<u>ORGANIZATION</u>	<u>STANDARD</u>	<u>APPLICABILITY</u>
RUS	PE-90	Cable Construction
TIA/EIA	598B-01	Color Coding
TIA/EIA	472D0000	Fiber Optic Cable
TELCORDIA	GR-20	Optical characteristics

### C. Installation

All fiber shall be installed in underground conduit. Air assisted is the preferred method however pulling the fiber in place shall be by hand or by an approved

mechanical pulling machine. If a mechanical pulling machine is used, it must be equipped with a monitored or recording tension-meter. At no time shall the manufacturer's recommended maximum pulling tension be exceeded. Where pulling through pull boxes, approved pulleys and sheaves shall be used or the excess cable must be coiled in a figure eight and fed by hand. If sheaves are to be used, the contractor shall provide the Engineer with a drawing of the proposed layout showing that the cable will never be pulled through a radius less than the manufacturer's minimum bending radius

Fifty (50) feet of fiber optic cable shall be looped neatly in all fiber optic pull boxes unless noted differently in the plan set. Fifty (50) feet of fiber optic cable shall be looped neatly at all pull boxes located at signal intersections unless noted differently in the plan set. This fiber is for future additions or repairs to the fiber network. All conduit installed shall meet the requirements of **Section 3003** of these Technical Special Provisions as well as applicable City of Lawrence specifications.

#### D. Fiber Optic Cable Splicing

##### 1. General Requirements

The Contractor shall complete all final end terminations and connections for the fiber network. When designated in the Plans, the Contractor shall terminate the fibers into a fiber distribution unit. All fibers shall be spliced by the fusion method. The Contractor shall provide and use a fusion splice machine for this purpose. The splice machine shall be equipped with a method for estimating the achieved splice loss. Either the "Local Injection Detection" or "Core Alignment Loss Estimation" system is acceptable. The machine used shall be new from the factory or serviced and certified by the factory or its authorized representative within the previous six months from the commencement of its use on the project. The Contractor shall provide to the Engineer a letter from the manufacturer or their authorized agency certifying that this requirement is met. Splice loss shall not exceed a bi-directional average of **0.10 dB** per splice for a complete fiber run or a maximum of **0.15 dB** bi-directional averages for any single splice at 1310 and 1550 nanometers. All fiber cable sizes called out in the Plans must be continuous for the entire length of the run unless otherwise noted in the plans. Where a fiber cable is to be accessed for signal insertion or drop, only the buffer tube containing the fiber(s) to be accessed shall be opened. For a continuous cable run, only the actual fiber to be accessed shall be cut. For a drop fiber cable, all fibers shall be cut to a length equal to that of the fiber to be used and the spare neatly laid into the splice tray. At least one and one-half revolutions of the splice tray of fiber shall be left on each end of fiber after splicing.

##### 2. Splice Materials

At each splice point splice organizer trays shall be provided to contain and protect the bare fibers and splices. Splice trays shall be subsidiary to splice



enclosures. Splice trays shall be easily attachable and accessible. Splice tray raceways shall include a raceway for excess fiber storage that shall accommodate the minimum bend radius of the fiber without causing excessive signal losses due to bending or fiber damage. The splice trays shall have a means to affix the buffer rigidly in place, and space and guides to allow "race tracking" of the fiber and guides to locate the splice protectors. The splice trays shall be layered above the transition/storage compartment and shall be easily slipped into place on two studs and secured with a hold down strap. Splice trays shall have fixed rigid slots for fiber placement. Each tray shall be made of injection-molded plastic and have a hinged clear plastic cover for maximum fiber protection that allows for visible inspection of the fibers. The covers shall have a lock mechanism to hold them in place. All splices shall be protected with a heat-shrink sleeve containing a stainless steel strength rod or protective sleeve and housing. Completed splice protectors shall be held in place with RTV silicone or adhesive tape. No more than 12 splices shall be placed in one tray unless the engineer approves any changes.

#### E. Fiber Optic Terminations

##### 1. General Requirements

Terminations to fiber optic cable shall be made with SC (or LC where applicable) connectors. All single-mode single break-out cable shall be yellow in color. Terminations at traffic signal cabinets shall be made via the fiber optic interface panel ITS drop cable as described in **Section 3005**. The Contractor shall utilize the color codes and splice diagrams shown in the Plans for the termination of all cables.

##### 2. Fiber Optic Connectors

All SC and LC type connectors shall conform to the NTT-SC and Telcordia 326 specifications for SC and LC connectors. The completed termination shall exhibit a loss of no more than 0.25 dB per mated pair when tested with an OTDR and a standard test cable. This requirement applies equally to field terminations and factory terminated pigtails.

#### F. Underground Splice Enclosures

##### 1. Location

The cost of the enclosure used for this purpose shall be considered incidental to the installation of the communications cable network and included in the cost for fiber. Underground splice enclosures shall meet the requirements of this Technical Special Provision.

##### 2. Underground Splice Enclosures

Underground splice enclosures will be used for cable splicing. Splice

enclosures shall be designed to be easily accessible for testing and maintenance with the necessary vehicles and equipment to perform the task. The fiber optic splice enclosures shall be capable of accommodating splice organizers to facilitate fiber management and accept fiber fusion splices. The splice enclosure shall provide fiber optic cable penetration end caps on one end, to accommodate at least two trunk fiber optic cables and two branch fiber optic cables. Water-blocking techniques shall be used to ensure that the splice enclosure and cable entry locations do not leak when immersed in 19 feet of water for 30 days. The enclosure end caps should be factory drilled to the proper diameter to accept and seal the fiber optic cable entry (ies). Cable entry locations shall accommodate an assortment of fiber optic cable outer diameters ranging from 0.45 inches to 0.55 inches ( $\pm$  10 percent) without jeopardizing its waterproof characteristics. All fiber optic splice enclosures shall meet the requirements of Telcordia Technologies (formerly Bellcore) GR-771-CORE and shall comply with all applicable NEC requirements.

Splice enclosures may encounter high water table conditions. Splice enclosures shall be non-filled (no encapsulate), airtight and prevent water intrusion, able to accommodate pressurization, pressurized to 4.0 psi, and have the capability to be re-entered without requiring specialized tools or equipment. Splice enclosures shall also be supplied with all hardware necessary to provide solid mounting to wall structures. All enclosures and associated facilities provided under this Contract shall include a quality assurance/quality control inspection for materials, workmanship, and compliance of the product to meet these specifications. The Contractor shall provide to the Engineer an executed Certificate of Compliance from the manufacturer indicating that the splice enclosures meet the requirements included herein. All splice enclosures must employ a complete fiber management system consisting of splice trays and a stress relief system. Each enclosure shall be designed to accommodate future expansion and contain modular splice organizers/trays capable of handling splices in a neat and distinguishable fashion. Spare splicing trays shall be provided to allow for future splices equal to the number of fibers in the cable. Trays shall be easily attachable and accessible.

## 3005 SYSTEM AUXILIARIES

### A. Fiber Optic Communications Network

This Technical Special Provision establishes the requirements for the fiber optic network installation. Fiber requirements and termination connections are referenced in **Section 3004**.

## 3006 CONSTRUCTION REQUIREMENTS

### A. Acceptance Procedures

#### 1. Test Procedure and Documentation

The Contractor shall demonstrate in the presence of the Engineer, and/or the Engineer's representative if the Engineer so desires that the equipment supplied and installed as part of this project functions in full compliance with this Technical Special Provision. For this purpose, a program of testing is defined. The tests can be separated into pre-installation tests, system component tests, and a burn-in period followed by final inspection and acceptance. All test procedures and equipment shall be furnished and maintained by the Contractor. For these tests, the Contractor shall submit four copies of documentation containing proposed test procedures, test equipment, report forms, and expected results to the Engineer for review and approval at least 45 day prior to performing any test. The test plan will be reviewed by the Engineer, who shall either approve or indicate changes that are required for approval within 30 days of receipt. The Contractor shall submit the revised test to the Engineer within 15 days following the receipt of the review of the initial test plan. This process shall be repeated until the Engineer approves the test plan. Tests shall not be conducted without prior approval. Tests shall be performed on approved equipment using approved test procedures. The Contractor shall notify the Engineer at least 15 days in advance of the times and places which the tests will take place to enable the Engineer to witness them. The Contractor shall perform the tests and document the test results. When the tests are completed, whether successful or not, four copies of the test results shall be furnished to the Engineer for evaluation. The documented test results shall be self-explanatory, clearly stating how the results were obtained along with an explanation where the test results deviated from the expected results. The Engineer will notify the Contractor whether the test was successfully completed within 24 hours of receipt of the test results.

#### 2. Inspection

All equipment and material furnished and all work performed in connection with the project shall be subject to inspection by the Engineer. The Engineer, or their authorized representative, shall have free access during normal working hours to any local facility or area in which work associated with the project is occurring. The Contractor shall ensure that full and sufficient information concerning the character of materials and workmanship is made available to the Engineer or their representatives.

Inspection by the Engineer or their representative shall not relieve the Contractor of their obligation to comply with the requirements of the Plans and this Technical Special Provision. Any equipment or labor, which is found by the Engineer to be defective or unsuitable prior to Final Acceptance, shall be replaced or corrected at the Contractor's expense.

3. Pre-installation Testing

The equipment for this project is subject to pre-installation tests by the City Lawrence Staff at a location designated by the City.

The Engineer reserves the right to withhold any payment related to the provision or installation of any piece of equipment that fails to meet the requirements of this Technical Special Provision.

The Contractor shall coordinate with the City to conduct pre-installation tests for the equipment. In the event a pre-installation test is failed, the Contractor shall schedule a retest no sooner than 15 days following the completion of the pre-installation test for that particular equipment item. The equipment item shall not be installed without successful completion of pre-installation tests and written approval of the Engineer.

4. System Component Tests

System component tests shall be performed on all system hardware. These tests shall be successfully completed prior to the start of the control section tests. Failure to successfully complete any system component test will require the Contractor to re-run the test, in part or in whole, at no expense to the City. The Contractor shall schedule a re-test no sooner than three days following notification by the Engineer of a system component test failure.

a. Fiber Optic Communications Cable Tests

i. Pre-installation Test

The Contractor shall test all fiber optic cable prior to installation. Cable delivered to the job site shall be tested on the reels prior to installation. This test shall consist of a single direction sweep of each individual fiber with an Optical Time Domain Reflectometer (OTDR) that has been calibrated for the index of refraction of the fiber to be tested. Verification of the fiber length and attenuation shall be made. Attenuation shall not exceed 0.56dB/mile at 1310nm and 0.40dB/mile at 1550nm and no discontinuities greater than 0.1dB over a distance of less than 300 feet shall be allowed. If the cable fails to meet these requirements, the Contractor shall replace the entire reel at no additional cost. Printouts of the OTDR trace with the identification of the fiber and the attenuation and length noted on the printout shall be provided. This test may be eliminated at the Contractor's option if the manufacturer has done these tests at the factory and after the cable is placed on the reel and provides a typical OTDR trace together with a table of all attenuations and lengths of each fiber on a reel. If the Contractor elects to forgo this test, it shall in no way relieve him of the obligation to replace any cable that, after installation and testing, proves not to meet the specifications. Cable

replacement shall be done at no additional cost to the City.

ii. Post-installation Test

After all the splices and terminations have been completed, test each fiber, including spares, with a power meter and OTDR as follows:

(1) Power Meter Tests: Install feed through connectors at all locations where an optical device is to be connected. Conduct power meter tests for each fiber to demonstrate connectivity and attenuation from origin to destination. Demonstrate that the attenuation for each fiber path including connectors, and splices as a whole, comply with the loss budgets required by these Specifications and the optical equipment being installed. Submit a test result summary sheet of each fiber to the Engineer for review and approval.

(2) OTDR Tests: Conduct bi-directional tests using an OTDR for each fiber. Demonstrate that the attenuation for each fiber and splice, individually and as a whole comply with the loss budgets required by these Specifications. Test fibers at 1310 nm and 1550 nm, using a launch cable no less than three times the pulse width used to shoot the cable. Submit OTDR traces to the Engineer for review and approval. Clearly annotate each splice and identify the measured loss. The Contractor shall investigate any discontinuities greater than those specified for the fiber and repair them or replace the cable section at no additional cost to the City. Failed splices may be remade and re-tested for compliance

Following completion of all testing, and approval by the Engineer, the Contractor shall compile and submit two (2) organized test notebooks and electronic files. These notebooks/files shall include a test summary that includes the OTDR traces of each fiber strand, and the power meter test results. An example cable verification worksheet is included in these specifications. The worksheet can be modified if approved by the Engineer.

b. Grounding System Protection Test

The Contractor shall test the grounding of each communications termination panel. Written test results shall be provided to the Engineer prior to acceptance of the controller assembly installation. The test shall be performed from the communications termination panel surface to the cabinet grounding electrode/wire in the cabinet. Maximum allowable resistance to cabinet grounding electrode/wire shall be 2 ohms.

## 5. Burn-in Period

The burn-in period shall commence upon written authorization by the Engineer and will terminate 7 consecutive days thereafter for each intersection, unless an equipment malfunction occurs. The burn-in period will be stopped for the length of time the equipment is defective. When the equipment is repaired and functions properly, the burn-in period will begin again.

Successful completion and acceptance of the burn-in period will be granted on the 7 day unless any equipment has malfunctioned, in which event Final Acceptance will be withheld until all the equipment is functioning properly for 7 days after repair.

When a specific piece of equipment has malfunctioned more than twice during the 7day burn-in period, the Contractor shall replace that equipment with a new unit at their cost. The Engineer will maintain records of equipment malfunctions.

## 6. Final Inspection

Upon completion of the burn-in period, the Engineer will make a final inspection. If all construction and all other aspects of the Plans and this Technical Special Provision are found complete, the Engineer may declare this project complete and inform the Contractor in writing of the Final Acceptance as of the date of final inspection.

If during the final inspection the Engineer deems any work unsatisfactory or not conforming with the Plans and this Technical Special Provision, the Engineer shall notify the Contractor in writing of any deficiencies. The Contractor shall correct these conditions within five working days, unless the Engineer grants additional time in writing. Upon completion of the Contractor's corrections, the Engineer shall conduct another final inspection. When the Engineer approves the final inspection, the Engineer shall send written notice to the Contractor of the Final Acceptance of the project.

## 3007 GUARANTEES

The Contractor shall be responsible for repairing and/or replacing all equipment and material, including software, supplied under this Technical Special Provision. The Contractor shall also bear the total cost of delivery and transportation related to the repair and replacement of equipment and material throughout the Contract.

In the event of failure on the part of the Contractor to replace or repair to original condition any such articles of equipment or material within one week (seven calendar days) from the date of notice, the Engineer may have the work done by others and charge the cost to money due to the Contractor. Final Acceptance will not be given and the Contractor will not be released from the Contract until payment for such work is received.

The Engineer shall reserve the sole right to determine unsuitability of the supplied equipment and material. The Contractor shall transfer to the City of Lawrence, Kansas any manufacturers warranties and guarantees remaining on all items after Final Acceptance. This will occur at 12:01 A.M. of the day following Final Acceptance.

### 3008 APPROVED MATERIALS LIST FOR FIBER OPTICS

#### **CABLES**

Ethernet Cables	Quiktron, 541-110-006	(CAT 6, boot ends, 6' long)
Fiber Optic Patch Cable	Major Custom Cables	(LC-SC-S-D-2M)
Micro Fiber	RaDD	(10-21002.01A 12F)
	RaDD	(10-21008.02A 24F)
	RaDD	(10-21017.02A 48F)
	RaDD	(10-21022.02A 72F)
	RaDD	(10-21027.02A 96F)
	RaDD	(10-21031.02A 144F)
	RaDD	(10-21036.02A 288F)
	RaDD	(10-21046.02A 432F)
#10 AWG Tracer Wire	United Copper Ind.	(stranded, red jacket)

#### **CONDUIT & COUPLINGS**

HDPE Conduit	RaDD	(20-10031Or.03As)
		2.00" SDR-11 Conduit
	RaDD	(20-10016Or.03As)
		1¼", SDR 11 Conduit
Micro-Duct	RaDD	(20-12065Or.03L-18awg)
		07-Way Multi-Duct, 18x14mm
	RaDD	(20-12062Or.03L-18awg)
		04-Way Multi-Duct, 18x14mm
	RaDD	(20-11031Or.01L) Multi colors
		Single Micro-Duct 12.7x10mm
	RaDD	(20-11041Or.04L) Multi colors
		Single Micro-Duct, 16x12mm
	RaDD	(20-11051Or.03L) Multi colors
		Single Micro-Duct, 18x14mm
	RaDD	(20-14066.D - 2.00")
		Plastic Duct Coupler
	RaDD	(20-14073.D - 1.25")
		Plastic Duct Coupler, 1.25" SDR
	RaDD	(20-14051.Y - 18x14mm)
		Micro-Duct Coupler
	RaDD	(20-14041.Y - 16x12mm)
		Micro-Duct Coupler
	RaDD	(20-14021.Y - 12.7x10mm)
		Micro-Duct Coupler

**ETHERNET SWITCHES**

1G Switch	Cisco	(IE-3300-8T2S-E)
10G Switch	Cisco	(IE-3300-8T2X-E)
Power Supply	Cisco	(PWR-IE65W-PC-AC)
SFP	Approved Optics	(GLC-LX-SM-RGD-A)

**LOCATING MATERIALS**

Tracer Cable	United Copper Industries	(stranded, red jacket)
Ground Rods	Hubbell Power Systems	(C611380, 8'L, ½"D)
Ground Rod Clamps	Galvan Industries	(SRC-1/2")
Ground Test Wells	Copperhead Industries	CD14*2T-SW Snakepit
Detectable Pull Tape	Erin Rope Corporation	WPD18003000 5/8" 3,000lb
Detectable Pull Tape	Erin Rope Corporation	WPD18005000 5/8" 5,000LB

**SERVICE BOXES** (note: Quazite)

AXS-900R900-CO Tier 22	RaDD	(25-10024.00L) Heavy Duty Straight Wall Round Vault w/o Base, External Dimensions (39.00"D x 41.00"H)
AXS-900R450-CO Tier 22	RaDD	(25-10022.00L) Heavy Duty Straight Wall Round Vault without Base, External Dimensions (39.00"D x 23.00"H)
AXS-500R670-S Tier 15	RaDD	(25-10013.01L) Medium Duty Straight Wall Round Vault without Base, External Dimensions (29.50"D x 26.30"H)
RFW 24x36x30-T22	RaDD	(25-10032.01L) Heavy Duty Flared Wall Rectangular Vault, External Dimensions (38.00"W x 45.00"L x 31.00"H)

**SPLICE ENCLOSURES**

Opticonn 500 Dome Fiber Closure	RaDD	(30-10055.04Ac) Micro
Opticonn 500 Dome Fiber Closure	RaDD	(30-10058.02Ac) Armor
Opticonn 500 Short Splice Tray		(30-11011.Ac )

**TERMINATION DROP CABLES**

Gator Patches	Fiber Connections, Inc.	(G320J006FRB-LENGTH)
---------------	-------------------------	----------------------

**CONDUIT PLUGS**

Cal Am Manufacturing	(Kwikie Plug w/loop nut)
----------------------	--------------------------