1040 - FIBER OPTIC COMMUNICATION SYSTEM INSTALLATION

1040.1 DESCRIPTION

a. Work

This specification covers the furnishing and installation of fiber optic communication system infrastructure as shown on the plans. Work under this item shall consist of furnishing and installing fiber optic conduit and cable, removal and reinstallation of existing fiber optic cable, furnishing and installing fiber optic Ethernet switches, performing fiber optic terminations, and communication system testing.

The work provided for in these Specifications shall consist of furnishing all labor, materials, appliances, and equipment, and performing all work and operations in connection with the construction of fiber optic communication system items and all other incidental and related work as set forth in these Specifications and as directed by the Engineer to make a complete and finished job

b. Plans

The plans that accompany these specifications shall be considered a part thereof. Whenever any part of the plans shall be in conflict with any other part or parts of the plans, or any part of these specifications shall be in conflict with any other part or parts of these specifications or any of the items proposed to be constructed shall appear to be impracticable, or impossible to construct, then the matter shall be immediately brought to the attention of the Engineer or their agent. The Engineer's decision in the matter shall be final, and the Contractor shall follow their directions to avoid any such conflict in the plans or specifications.

All incidental parts which are not shown on the plans or specified herein and which are necessary to complete the fiber optic system shall be furnished and installed as though such parts were shown on the plans or specified herein. All systems shall be complete and in operation to the satisfaction of the Engineer at the time of acceptance of the work.

All appurtenances shall be located as shown on the plans. Any deviations must be established by the Engineer in the field. The Contractor shall have a copy of the plans and specifications at the job location at all times and accessible to the Engineer or their authorized representative.

Prior to the acceptance of the work, the Contractor shall submit an "As Built" or corrected plan showing in detail all construction changes, especially location and depth of conduit.

c. Grades

All work shall conform to line, elevation and grades as shown on the plans.

d. Qualifications of Installers

For the actual fabrication, installation, and testing of the work of this Section, use only thoroughly trained and experienced personnel who are completely familiar with the requirements for this work and with the installation recommendations of the manufacturers of the specified items. In acceptance or rejection of installed fiber optic system, no allowance will be made for lack of skill on the part of installers.

e. Preliminary Schedule of Equipment and Material

Prior to commencement of construction activities, the Contractor shall submit a complete schedule of materials and equipment proposed for installation for the approval by the Engineer. This schedule shall include catalog cuts, diagrams, drawings, and other such descriptive data as may be required by the Engineer. Any item not listed on the Approved Manufacturer’s List shall also require the submittal of catalog cuts, diagrams, drawings, technical specifications, and a physical sample of the item for evaluation by the Engineer. In the event any items of material or equipment contained in the schedule fail to comply with specification requirements, such items may be rejected.

f. Rejected Materials

Rejected materials shall be immediately removed from the project site by the Contractor and shall not again be brought upon the project site. Work shall be commenced and continued at such points as may be approved by the Engineer and shall be carried on diligently and without unnecessary or unreasonable delay.

g. Coordination with Existing Utilities

All existing conduit/conductor runs and other utility information were obtained from existing office records. It shall be the Contractor's responsibility to locate all utilities, whether above, on, or below the ground, and to protect the City against any and all damages arising from work under this project.

No new infrastructure shall be constructed as part of this contract which is in conflict with any existing utilities' facility or the code required thereby, unless approved by the Engineer

h. Notification

The Contractor shall notify the Engineer before beginning work on the project. The Contractor shall keep the Engineer advised as to the progress of the project and the Contractor's proposed schedule. The Engineer may, at their option, require any work completed without their knowledge or inspection to be dismantled and inspected to their satisfaction. The contractor shall notify each property owner at least one day in advance of construction activity being started in front of the respective property.

i. Protection of Work and Cleanup

The Contractor shall care for all work until final completion and acceptance by the City. All damage done to existing improvements by the Contractor shall be repaired by the Contractor. The Contractor shall remove all surplus material and rubbish from the work as it accumulates and before the Contractor makes application for the acceptance of the work.

j. Replacing Damaged Improvements

Improvements such as sidewalks, curbs, driveways, roadway pavements and any other improvements removed, broken or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials found on the work or with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed.

1040.2 MATERIALS

Unless specifically noted otherwise, all fiber optic materials and equipment shall be new and similar to the best grade of this type of equipment, and shall be approved by the Traffic Engineer. The Contractor shall install all of the equipment and cabling necessary for the communication system as indicated on the plan and in accordance with this specification. The fiber optic communication system shall be complete, and the Contractor shall furnish and install all equipment necessary for the satisfactory operation of the system whether specifically mentioned or not.

a. Approved Materials List

All material for fiber optic communication systems used by the Contractor shall be from the City's approved list of vendors. It is important that users be completely knowledgeable of all application requirements and procedures prior to product application. It is the responsibility of the installer to contact the supplier of all materials if questions regarding application procedures or conditions arise.

Manufacturers interested in pre-qualifying material under this specification shall submit a sample of the material along with a complete materials specification for each item to be considered. The sample will be reviewed for compliance with all requirements of this specification. No material shall be used unless the material has been pre-qualified. A complete list of pre-qualified materials is maintained by the Traffic Services Engineering Division of the Department of Public Works.

b. Conduit

(1) PVC Conduit Material

Rigid nonmetallic conduit shall be polyvinyl chloride (PVC) conduit manufactured from PVC compounds complying with the UL651 standards (latest version) and sized according to the plans. The conduit shall bear an Underwriters' Laboratories label. It shall also meet NEMA TC2, National Electric Code (NEC) for nonmetallic raceway for wires and cables, and rated for use with 90 degree C conductors or cable. Schedule 40 PVC conduit shall be used underground and schedule 80 PVC conduit shall be used above ground or exposed on the underside of bridge decks.

(2) HDPE Conduit Material

The conduit shall exhibit good workmanship and be free from holes, blisters, inclusions, cracks, and homogenous throughout. There should not be any foreign particles embedded in the plastic as a result of the extrusion process. There should not be any surface distortions that penetrate either internally or externally into the conduit wall greater than 10% of the minimum wall thickness. The conduit shall be constructed of polymeric materials which are lightweight, flexible, corrosion resistant and nonconductive. The base material shall be clean, virgin grade high-density polyethylene (HDPE) which conforms to ASTM D3350, most recent edition, Type III. Any regrind material shall be non-wide specification, reworked from the same virgin material from the same manufacturer as the original conduit. The conduit shall have a controlled outside diameter with the cross-sectional dimensions meeting SDR 13.5 manufactured to ASTM D3035 specifications and having a minimum ASTM cell classification 334480E. The conduit shall be smooth walled inside and out with a minimum coefficient of friction of 0.35. The conduit shall meet the following minimum requirements:

Density	> 0.940 g/cc	ASTM D-1505
Melt Index	< 0.4 gm/10 min.	ASTM D-1238(E)
Flexural Modulus	> 80,000 psi	ASTMD-790
Tensile Strength	> 3,000 psi	ASTM D-638
Slow Crack Growth		
ESCR (Bell Test)	10% Igepal	ASTM D-1693
Test Duration	192 hours min.	ASTM D-1693
Failure	10% max	ASTM D-1693
Molded Plaque	3	ASTM D-1693
Hydrostatic Strength Class	NPR	ASTM D-2837
Color and UV Stabilizer	E > 2%	ASTM D-3350
Ultimate Elongation	>400 %	ASTM D-638

Minimum wall thickness shall be in accordance with the following table:

Diameter	Wall Thickness
2” SDR 13.5	0.176”
3” SDR 13.5	0.259”

Fiber optic conduit shall be sized according to the plans for 2” or 3” diameter. The conduit shall be pigmented throughout the entire cross-section so as to produce a uniform orange color, forming an integral part of the product. All colors shall be produced from light stabilized pigments, which are further protected from ultra-violet (UV) degradation by the incorporation of Hindered Amine Light Stabilizers (HALS) allowing protection for up to two years of outside storage. The conduit shall be sequentially marked and identified along its outer length in contrasting color and with a print of at least 0.125” height. The print interval shall not exceed five feet and shall include: 1) Manufacturer’s name, 2) Product name/number, 3) Production code and 4) Length of Conduit (in feet).

The conduit coming off the reel shall return to a circular shape upon the release of tension when it is unreeled. The conduit ovality as defined in ASTM D-2122 shall not exceed the percentage listed in the following table per ASTM F-2160:

Diameter	% Ovality
2”	7%
3”	10%

When conduit 3" or above in diameter exceeds 10% ovality, it may be used if the contractor uses re-rounding equipment until 10% ovality or less is achieved. The mean elongation defined as the change in length divided by the original length, multiplied by 100 at a given load shall not be more than 10%. The conduit shall recover to a minimum of 95% of its original outer diameter upon release of a 200 pound load or shall not deflect to more than 5% of its original inside diameter within 10 minutes after removal of the compressive load.

c. Conduit Couplings, Elbows and Fittings

Couplings for conduit shall be used to connect two runs of conduit, whether PVC to PVC, PVC to HDPE, HDPE to HDPE, PVC to RGC or HDPE to RGC as appropriate for field conditions and as outlined in the standard details and Approved Equipment List.

(1) PVC Conduit Couplings, Elbows and Fittings

Polyvinyl chloride (PVC) couplings, elbows and fittings shall be schedule 40 or schedule 80 for use with schedule 40 and 80 PVC conduit, respectively and shall be listed to UL-651 (latest revision). Standard PVC to PVC couplings shall have a center stop. Standard and special radius elbows shall either have a plain end or bell end.

(2) HDPE Conduit Fittings

An approved factory coupling or adhesive, as listed in the Overland Park Approved Equipment List shall be used for connection of the HDPE conduit to PVC conduit or between two HDPE conduits.

(a) Conduit Adhesive

The adhesive shall be capable of joining HDPE conduit to PVC, fiberglass and metal conduit using standard PVC couplings. It shall be a rapid cure, two-part resin adhesive supplied in a side-by-side mixing cartridge to form a durable, strong and watertight joint. The adhesive shall have the following minimum properties:

Color	Grey	
Peak Exotherm @ 70º F	< 200º F	
Hardness	70-80	Shore D Durometer
Flexibility	>2%	ASTM D-790
Dielectric Strength	450 Volts/Mil (Nonconductive)	ASTM D-149
Airtight (continuous)	120 psi	
Specific Gravity Part A	1.2	
Specific Gravity Part B	1.2	
VOC	0 g/L	ASTM D-1693
Operating Temperature	-60º F to 250º F	ASTM D-2837

(b) Mechanical Coupling

Couplings shall be able to join HDPE conduit to HDPE or PVC conduit. Couplings can be fabricated from either aluminum or high-density polyethylene and shall be able to mechanically connect to the conduits.

Aluminum body couplings for use on HDPE conduit shall contain a center stop and reverse threads to draw two conduits together and shall be able to be installed by hand. The sharp threads shall be able to withstand high pulling loads that meet or exceed the Bellcore tensile standard of 1,000 lbs. The coupling shall be machined with one degree of taper and have a long chamfered lead-in for straight, easy starting. They shall incorporate a wide, six pitch thread angle which greatly reduces the number of revolutions necessary to install the coupling.

Aluminum body couplings for use between HDPE and PVC conduit shall contain left hand threads on the HDPE end of the coupling that will cause, when installing the female pipe thread, them to tighten further on the conduit. The other end of the conduit shall be machined with regular IPS female pipe threads to accept a male to female PVC pipe adapter while gluing the PVC pipe into the female end of the adapter.

Polyethylene body couplings for use between HDPE conduits or between HDPE and PVC conduits shall have locking rings and external band clamps and 5/16" hex head tightening bolts that are all made from corrosion-resistant stainless steel. They shall be able to be re-entered without any special tools and shall be air and water tight by use of internal o-rings on each end. They shall meet UL-514B standards.

(c) Fusion Couplings

Electrofusion couplings shall be manufactured in accordance with ASTM F-1055 for use with pipe conforming to ASTM D2513/3035, F-714 and with Butt fittings conforming to ASTM D3261 as applicable. They shall be produced from a pre-blended virgin resin that has a PPI listing of PE3408 rating and Hydrostatic Design Basis of 1600 psi @ 73º F. The resin shall have a cell classification of 445574C which complies with ASTM D3350. The heating wire shall be copper, or nickel alloy. The terminal pins shall be machined or die swaged 70/30 brass or nickel-plated carbon steel.

(d) Conduit Expansion Fittings

Conduit expansion fittings shall be two-piece PVC. One piece shall telescope the other to accommodate thermal expansion and contraction along the conduit run. The spigot part of the joint shall slide through an internal o-ring to keep moisture and debris out of the fitting. Couplings for conduits sized through 2" in diameter shall expand up to 4". Couplings for conduits sized 2" through 6" shall expand up to 8".

d. Cable

(1) Tracer Wire

The locating cable shall be single conductor cable with minimum 600 volt rating and shall be and a #10 AWG THHN/THWN stranded annealed copper. The locating cable insulation shall be colored red. The polyethylene insulation shall meet the requirements of paragraph 3.9 of I.P.C.E.A. standard S-61-402 before application to the conductor, and paragraph 3.9.1 after application to the conductor. The locating cable shall be pulled through the installed conduit by use of a polyester/polypropylene pull rope. Caution should be taken as to not burn or tear the conduit ends or conduit body.

(2) Fiber Optic Cable

Work under this item shall consist of furnishing and installing 6, 12, 36, and 72 Count Fiber Optic Communications Cable as shown on the Plans, and as hereinafter provided. Fiber Optic Cable shall meet the following minimum requirements:

(a) Fiber Characteristics

All fibers in the cable must be usable fibers and meet required specifications. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

Core Diameter	8.3 micron.
Cladding Diameter	125.0 +/- 1.0 micron.
Core-to-Cladding Offset	< 0.8 micron.
Cladding Non-Circularity	< 1.0%.
Coating Diameter	245 +/- micron.
Colored Fiber Diameter	Nominal 250 micron.
Attenuation Uniformity	No point discontinuity > 0.10 dB at either 1310 or 1550 nm.
Attenuation at the Water Peak	The attenuation at 1383 nm shall not exceed 2.1 dB/km.
Cutoff Wavelength	< 1260 nm
Mode-Field Diameter	9.30 +/- micron at 1310 mm, 10.50 +/- 1.00 micron at 1550 nm

The coating shall be a dual layered, UV-cured acrylate applied by the fiber manufacturer, and shall be mechanically strippable.

(b) Fiber Parameters

All fibers in the cable must meet the following required parameters:

Fiber Type	Single Mode
Required Fiber Grade- Maximum Individual Fiber Attenuation	The maximum dispersion shall be < 3.2 ps/(nm * km) from 1285 nm to 1330 nm and < 18 ps/(nm * km) at 1550 nm
Required Minimum Load	100 kpsi

The fiber manufacturer shall proof-test 100% of the optical fiber to verify that the cable is capable of sustaining a minimum load of 100 kpsi.

(c) Fiber Construction

Optical fibers shall be placed inside a loose buffer tube. The fibers shall not adhere to the inside of the buffer tube. Each buffer tube and fiber shall be distinguishable by means of color coding according to the TIA/EIA-598 Specifications, "Optical Fiber Cable Color Coding." Buffer tubes containing fibers shall be color-coded with distinct and recognizable colors according to the above references specification.

In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the ~~gel filling~~water blocking material. Colors shall not cause fibers to stick together.

Buffer tubes shall be kink resistant within the specified minimum bend radius.

Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a dielectric glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

Each buffer tube shall be ~~filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents. Buffer tubes shall be~~ stranded around a central member using the reverse oscillation, or "S-Z", stranding process.

The cable core shall contain a craft-friendly, gel-free, water-swellable tape which make cable access simple and require no clean up. ~~water blocking material.~~ The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional (nontoxic) solvents.

Formatted: Not Highlight

Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage. The cable shall contain at least one ripcord under the sheath for easy sheath removal. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.

All-dielectric cables ~~(with no armoring)~~ shall be sheathed with medium density polyethylene (MDPE) over a single corrugated steel armor that provides additional crush and rodent protection with a high-strength ripcord under the armor for easy stripping. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

The jacket or sheath shall be free of holes, splits, and blisters. ~~The cable jacket shall contain no metal elements and shall be of a consistent thickness.~~ Cable jackets shall be marked with the Manufacturer's Name, Optical Cable-Year, Telephone Handset Symbol, (as required by Section 350G of the National Electrical Safety Code).

The cable length shall also be marked every meter. The actual length of the cable shall be within –0/+1% of the length markings. Cable marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

The maximum pulling tension shall be 600 lbf during installation (short term) and 200 lbf long term installed

The shipping, storage, and operating temperature range of the cable shall be -40 degrees C to +70 degrees C. The installation temperature range of the cable shall be -30 degrees C to +70 degrees C.

When tested in accordance with FOTP-3, "Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components," the average change in attenuation at extreme operational temperatures (-40 degrees C to +70 degrees C) shall not exceed 0.05 dB/km at 1550 nm for single-mode fiber. The magnitude of the maximum attenuation change of each individual fiber shall not be greater than 0.15 dB/km at 1550 nm.

(d) General Cable Performance Specifications

When a one-meter static head or equivalent continuous pressure is applied at one end of a one-meter length of unaged cable for 24 hours, no water shall leak through the open cable end. When a one-meter static head or equivalent continuous pressure is applied at one end of a one-meter length of aged cable for one hour, no water shall leak through the open cable end. The aging cycle is defined as exposing the cable to +85E " 2E C for 168 hours and two cycles of -40 degrees C to +70 degrees C with cable held at these temperatures for 24 hours. At the end of this cycle, the cable will be decreased to +23 degrees C and held for 24 hours. The water penetration test is completed at the end of the 24-hour hold. Testing shall be performed in accordance with the industry standard test, FOTP-82, "Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable."

When tested in accordance with FOTP-81, "Compound Flow (Drip) Test for Filled Fiber Optic Cable", the cable shall exhibit no flow (drip or leak) of filling and/or flooding material at +65 degrees C.

The cable shall withstand a minimum compressive load of 250 lbf/in for armored cables and 125 lbf/in for non-armored cables applied uniformly over the length of the compression plate. The cable shall be tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables," except that the load shall be applied at the rate of 1/8” to 3/4” per minute and maintained for ten minutes. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (SM). The repeatability of the measurement system is typically 0.05 dB or less. No fibers shall exhibit a measurable change in attenuation after load removal.

When tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test," the cable shall withstand 25 mechanical flexing cycles at a rate of 30 cycles per minute around a sheave diameter not greater than 20 times the cable diameter. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (SM). The repeatability of the measurement system is typically 0.05 dB or less. For armored cables, the inside or outside of the armor surface shall be inspected for fractures. Any visible cracks causing separation of the armor shall not have propagated more than 3/16”. The outer cable jacket shall not exhibit evidence of cracking or splitting when observed under 5x magnification.

When tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies," the cable shall withstand 25 impact cycles. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (SM). The repeatability of the measurement system is typically 0.05 dB or less. The cable jacket shall not exhibit evidence of cracking or splitting at the completion of the test.

When tested in accordance with FOTP-33, "Fiber Optic Cable Tensile Loading and Bending Test," using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a tensile load of 600 lbf applied for one hour (using "Test Condition II" of the procedure). In addition, the cable sample, while subjected to a minimum load of 600 lbf, shall be able to withstand a twist of 360 degrees in a length of less than 10 feet. The magnitude of the attenuation change shall be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers shall not experience an attenuation change greater than 0.1 dB at 1550 nm (SM). The repeatability of the measurement system is typically 0.05 dB or less. The cable shall not experience a measurable increase in attenuation when subjected to the rated residual tensile load, 200 lbf.

When tested in accordance with FOTP-85, "Fiber Optic Cable Twist Test," a length of cable no greater than 2 meters will withstand 10 cycles of mechanical twisting. The magnitude of the attenuation change will be within the repeatability of the measurement system for 90% of the test fibers. The remaining 10% of the fibers will not experience an attenuation change greater than 0.1 dB at 1550 nm. The repeatability of the measurement system is typically 0.05 dB or less. The average increase in attenuation for the fibers shall be < 0.40 dB at 1300 nm. The cable jacket will exhibit no cracking or splitting when observed under 5X magnification after completion of the test.

When tested in accordance with FOTP-181, "Lightning Damage Susceptibility Test for Optic Cables with Metallic Components," the cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA. A damped oscillatory test current shall be used with a maximum time-to-peak value of 15 Fs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to half-value of the waveform envelope shall be from 40 - 70 Fs.

(e) Certification

It is the responsibility if the Contractor to insure that all of the above tests have been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the Engineer. Manufacturer certification is necessary for the model of closure to the actual tests described herein.

(f) Quality Assurance Provision

All cabled optical fibers greater than 3,300 feet in length shall be 100% attenuation tested. The attenuation of each fiber shall be provided with each cable reel. The Contractor shall provide all attenuation test results by each reel prior to installation of any cable from said reel. The cable manufacturer shall be ISO 9001 registered. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification. The Manufacturer shall certify that the supplied cable meets all requirements of these specifications.

(g) Packaging

The completed cable shall be packaged for shipment on non-returnable wooden reels. Top and bottom ends of the cable shall be available for testing. Both ends of the cable shall be sealed to prevent the ingress of moisture. Each reel shall have a weatherproof reel tag attached identifying the reel and cable.

A cable data sheet shall accompany each cable. The following information shall be included:
CABLE NUMBER
FACTORY ORDER NUMBER
CUSTOMER PURCHASE ORDER NUMBER
MEASURED ATTENUATION OF EACH FIBER (FOR LENGTHS > 3,300 Ft)
ORDERED LENGTH
ACTUAL SHIPPED LENGTH

(3) ITS Termination Drop Cable

The ITS termination drop cable shall be a factory terminated patch panel that is compact, durable and secure as detailed in the standard details and as specified herein.

(a) ITS Patch Panel Design

The ITS termination patch panel shall be a factory terminated design with a plug-in feature eliminating the need for on site terminations. It shall be pre-terminated and pre-tested. It shall be available as single-mode fiber in either a 6-count or 12-count as specified in the plans with ST-LC connectors that are factory tested and labeled to insure proper installation. The termination panel shall have a stair-step design with mounting holes for rack mounting and shall include stainless steel hardware. The housing shall be ABS plastic and potted with epoxy with a strain relief grommet at the housing exit. All terminations shall come equipped with removable dust caps.

(b) Distribution Lead-in Cable

The distribution lead-in cable shall be an OFNR-rated, all-dielectric cable that is UV-resistant and is fully water-blocked for both indoor and outdoor use. It shall have a 3.0 mm buffer-tube containing six to twelve color-coded fibers as indicated in the plans for a minimum installed bend radius of 2.8". The patch panel shall be equipped with a pigtail length of cable long enough to run from the splice enclosure continuous to the traffic signal controller cabinet, including slack coil length, with the required length as specified in the plans.

(c) Technical Specifications

Test:	Characteristics
Insertion Loss	0.15 typical
Reflectance	< -40 dB SPC
Durability	1000 rematings <0.20 dB change
Tensile Strength	50 lbs (220 N) < 0.20 dB change
Temperature Cycling	-40 degrees C + 70 degrees C, 40 cycles <0.20 dB change
Inside Polishing	Super Physical Contact (SPC)
Ferrule Material	Ceramic
Housing Material	ABS Plastic

(4) Fiber Optic Patch Cables

Fiber patch cords shall meet or exceed the following specifications:

(a) General

6 Feet long

Single Mode Duplex Fiber

(b) Connectors

ST–LC connectors for patch cables interconnecting termination panels to fiber optic Ethernet switches.

(c) Environmental

Temperature: 32 F to 113 F

Storage Temperature: - 25 F to +165 F

Relative Humidity: Up to 90%, non-condensing

e. Fiber Optic Ethernet Switch

The fiber optic Ethernet switch shall consist of a switch, a power supply, two small form-factor pluggable transceivers (SFP) and an expansion module if specified.

(1) General Characteristics

DIN-Rail Mount

5-year limited warranty

(2) Connectors

8 - Ethernet 10/100 copper ports (RJ45)

2 - dual-purpose uplink ports (dual purpose ports supports one active copper 10/100/1000 or SFP Fiber)

(3) Power Supply

Support 110/220VAC and 88-300VDC input

24VDC/2.1 Amp Output

DIN-Rail Mount

(4) Small Form-Factor Pluggable Tranceivers (SFP)

Operating temperatures -40 to 185° F

1310 Wavelength

Single Mode Fiber

10 km cable distance

LC connectors

(5) Electrical & Environmental Characteristics
Operating Temperature of –34 to +60 degrees C
120VAC External Universal Power Supply (2A, 15W)
MTBF > 300,000 hours
(6) Network Management
Console port access via RS-232 cable
Telnet Remote Access
Web browser support (HTTP)
SNMP v2 (RFC 1157)
MIB I (RFC 1757)
MIB II (RFC 2918)
Bridge MIB (RFC 1493)
IGMP MIB (RFC 2933)
RMON 1 MIB (RFC 2918)
Java applet-based MIB browser
TFTP software-upgrade capability
(7) LED Indication
Per Unit - Power status
Per Port - 100/TX, 10/RX, FDX/COL (3 LEDs)
(8) Functional / Miscellaneous Characteristics
Layer 2 switching required but shall be capable of layer 3 switching
256 VLANs
8000 MAC Addresses
2 MB buffer memory
Forwarding rates wire speed of 14,880 pps @ 10Mbps
Forwarding rates wire speed of 148,800 pps @ 100Mbps
Minimum rerouting time of 500 milliseconds when configured in a ring installation

f. Fiber Optic Splice Enclosures

The fiber optic splice enclosures shall be designed for use under the most severe conditions such as moisture, vibration, impact, cable stress and flex temperature extremes as demonstrated by successfully passing the factory test procedures and minimum specifications listed below:

(1) Physical Requirements

The splice enclosure shall be a “bell” type enclosure to ensure that it shall prevent the intrusion of water without the use of encapsulates. No “clam” type enclosures shall be allowed. The enclosure must handle up to four cables in a butt configuration. A butt adapter may be used to increase capacity to six cables.

The enclosure shall prevent the intrusion of water without the use of encapsulates and be capable of accommodating splice organizer trays that accept mechanical, fusion, or multi-fiber array splices. The splice enclosure shall have provisions for storing fiber splices in an orderly manner, mountings for splice organizer assemblies, and space for excess or unspliced fiber. Splice organizers shall be re-enterable. Splice cases shall hold a sufficient number of splice trays to hold up to 96 splices. The splice case shall be UL rated.

Enclosure re-entry and subsequent reassemble shall not require specialized tools or equipment. Further, these operations shall not require the use of additional parts.

The splice enclosure shall have provisions for controlling the fiber bend radius to a minimum of 38 mm.

(2) Factory Testing

The enclosure shall be able to meet the following testing requirements:

(a) Compression Test

The enclosure shall not deform more than 10% in its largest cross-sectional dimension when subjected to a uniformly distributed load of 300 lbf at a temperature of 0ºF and 100ºF. The test shall be

performed after stabilizing at the required temperature for a minimum of two hours. It shall consist of placing an assembled enclosure between two flat paralleled surfaces, with the longest enclosure dimension parallel to the surfaces. The weight shall be placed on the upper surface for a minimum of 15 minutes. The measurement shall then be taken with weight in place.

(b) Impact Test

The assembled enclosure shall be capable of withstanding an impact of 20 ft-lbf at temperatures of 0 ºF and 100 ºF. The test shall be performed after stabilizing the enclosure at the required temperature for a minimum of 2 hours. The test fixture shall consist of 20 lb cylindrical steel impacting head with a 2 inch spherical radius at the point where it contacts the enclosure. It shall be dropped from a height of 12 inches. The enclosure shall not exhibit any cracks or fractures to the housing that would preclude it from passing the water immersion test. There shall be no permanent deformation to the original diameter or characteristic vertical dimension by more than 5%.

(c) Cable Gripping and Sealing Testing

The cable gripping and sealing hardware shall not cause an increase in fiber attenuation in excess of 0.05 dB/fiber @ 1550 nm when attached to the cables and the enclosure assembly. The test shall consist of measurements from six fibers, one from each buffer tube or channel, or randomly selected in the case of a single fiber bundle. The measurements shall be taken from the test fibers, before and after assembly to determine the effects of the cable gripping and sealing hardware on the optical transmission of the fibers.

(d) Vibration Test

The splice organizers shall securely hold the fiber splices and store the excess fiber. The fiber splice organizers and splice retaining hardware shall be tested per EIA Standard FOP-II, Test Condition I. The individual fibers shall not show an increase in attenuation in excess of 0.1 dB/fiber.

(e) Water Immersion Test

The enclosure shall be capable of preventing a 10 foot waterhead from intruding into the splice compartment for a period of 7 days. Testing of splice enclosure is to be accomplished by the placing of the enclosure into a pressure vessel and filling the vessel with tap water to cover the enclosure. Apply continuous pressure to the vessel to maintain a hydrostatic head equivalent to 3 meters on the enclosure and cable. This process shall be continued for 30 days. Remove the enclosure and open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure.

(f) Certification

It is the responsibility of the Contractor to insure that all of the above tests have been performed by either the manufacturer, or an independent testing laboratory, and the appropriate documentation has been submitted to the Department. Manufacturer certification is necessary for the model of enclosure supplied. It is not necessary to subject each supplied enclosure to the actual tests described herein.

g. Service Boxes

Material for service boxes shall be a polymer concrete of select-grade aggregate consisting of sand and gravel bound together with a polymer resin system and reinforced with continuous woven glass strands. It shall have the following minimum properties:

Compressive Strength: 11,000 psi per ASTM C-109/D-3410
Tensile Strength: 1,700 psi per ASTM C-496/D-638/D-2343
Flexural Strength: 7,500 psi per ASTM C-580/D-790

All service boxes, and covers shall be rated at no less than 22,500 lbs. test load (Tier 15) per ANSI/SCTE-77. All boxes shall be stackable for extra depth. The box shall consist of straight sides and open on the bottom. The various types of junction and service boxes shall be sized according to the standard details.

The cover shall have a non-skid textured surface having a minimum coefficient of friction of 0.50 under wet or dry conditions. It shall have a slot with a lift pin for inserting a lift hook. There shall be two stainless steel hex head bolts and washers in opposite corners for bolting down the cover to the box. There shall be a cleanout hole in the box below the bolt to aid cleaning out debris. A logo with the words “Fiber

Optic" shall be either embossed or molded into the cover or on a name plate that can be permanently affixed to the recessed area in the box lid.

h. Ground Rods and Clamps

Ground rods located in service boxes shall be 5/8" in diameter x 8' long, fabricated from a rigid, high carbon steel core and tip with a heavy, 99.95% pure, 10 mil minimum uniform coating of copper, metallurgically bonded to the core. They shall be UL-467 rated. The name, length, diameter, part number and UL logo shall be roll-stamped onto the ground rod.

Ground rod clamps shall be fabricated from high strength copper or bronze alloy meeting UL-467 standards with a hex head clamping bolt. It shall be able to accommodate a bare, #10 AWG THHN/THWN copper locating/tracer cable.

1040.3 CONSTRUCTION REQUIREMENTS

a. Excavation

The Contractor shall perform all excavations for installing underground conduits, cable and boxes in whatever substances encountered, to the depths indicated on the drawings or as otherwise approved. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the excavation to avoid slides. All excavated materials not required or unsuitable for backfill shall be removed and wasted at location obtained by the Contractor.

(1) Rock Excavation and Blasting

Where solid rock, shale, or similar material is found, the excavation shall be as shown in the plans or as directed by the Engineer. The areas shall be excavated in accordance with "Rock Excavation and Blasting". ABSOLUTELY NO BLASTING OF ANY KIND WILL BE ALLOWED.

(2) Backfilling

All areas excavated shall be backfilled and compacted. In no instance shall any lift or layer exceed six inches of compacted thickness. Compaction using the bucket of an excavator is not sufficient and shall not be allowed. Small areas shall require compaction with a pneumatic compactor or rabbit's foot tamper. After backfilling, all disturbed areas shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made or surface restoration is completed..

b. Replacing Damaged Improvements

Improvements such as sidewalks, curbs, gutters, Portland Cement concrete and asphaltic concrete pavement, bituminous surfacing base material and any other improvements removed, broken or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as above specified.

c. Conduit

Conduit installation shall conform to the appropriate articles of the National Electrical Safety Code. The location of conduit runs shown on the plans are for bidding purposes only and may be changed with permission of the Engineer in charge of construction to avoid underground obstructions.

When trenching multiple conduits, a minimum of 12" horizontal or vertical separation shall be maintained between nearest edges of conduits. Any conduit installed in a trench that will be below any paved surface shall be backfilled with AB-3 or crushed rock to a depth of 6" above the top of the conduit and then low strength flowable fill to below the proposed paved surface. When directional boring, only one conduit shall be pulled back at a time. Multiple conduits shall not be pulled through the same bore hole. As much as physically possible, a minimum of 12" horizontal and vertical separation shall be maintained between bored conduits. Boring pits shall be kept 24 inches clear of the edge of any type of pavement wherever possible. Excessive use of water such that pavement might be undermined, or subgrade softened, will not be permitted.

The conduit installed under all roadway surfaces shall be placed a minimum of forty-eight (48) inches below the bottom of pavement elevation to the top of conduit; under drives at a depth of between

twenty-four (24) and thirty-six (36) inches below top of pavement; and within park areas at a depth of between twenty-four (24) and thirty-six (36) inches below finished grade. Any conduit installed under existing pavement shall be bored.

Conduit entering equipment shall be continuous into the service box, type FO service box and control center or as otherwise shown on the plans. No couplings or joints will be allowed at intermediate points unless approved by the Engineer in charge of construction. At a traffic signal service box or type FO service box, the conduit shall enter and exit the sides of the service box tangentially such that the cable can enter, be coiled, and exit without exceeding an 8 inch bending radius. For straight through connections, the conduit shall enter and exit the same side of the service box. For changes in direction, the conduit shall enter tangentially and exit tangentially at a 90° angle to the entrance.

Conduit bends or sweeps shall have a radius of not less than six (6) times the inside diameter of the conduit. Conduit bends shall be made without crimping or flattening, using the longest radius practicable. The ends of all conduits shall be well reamed to remove burrs and rough edges. Conduit in the bottom of the fiber optic service box shall extend approximately 3 inches vertically above the aggregate backfill. Conduit shall enter from the direction of the run.

It shall be the privilege of the Contractor at his own expense to use larger size conduit if desired; and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted.

Existing underground conduit to be incorporated into a new system or newly installed conduit which will be left empty shall be cleaned with a mandrel and blown out with compressed air. A locating wire shall be placed in any conduit that would otherwise be empty. Expanding foam sealant shall be installed in the end of all conduits in service boxes and at the control center.

The location of all conduits installed or used in this project shall be marked by aluminum markers placed in the top of curb, gutter, or wall, directly above the conduit. The markers shall either be embedded in fresh conduit or they shall be drilled with a recess such that the top of the marker is flush with the finished surface. When markers are installed in a drilled hole, they shall be set with epoxy. The City will provide the markers.

Snaking the conduit under the road will not be permitted. Continuous conduit shall be installed under all pavement crossings between appurtenances. The number of bends in any run of conduit shall not exceed 360 degrees.

It shall be the privilege of the Contractor at their own expense to use larger size conduit if desired; and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted.

d. Coundit Couplings

Conduit couplings between appurtenances shall not be allowed unless approved by the Engineer. If approved, fusion couplings or other fusion methods shall be used as specified herein. No matter what coupling is used for the specific application, the end(s) of the conduit shall be round and shall be cut square using an appropriate tube cutters. The contractor shall measure the “stab” depth of the coupler and transfer this measurement on each conduit end with a permanent marker to ensure both conduit ends are fully inserted into the coupling when complete. The coupling shall be centered over the contact points of the two conduits.

(1) Fusion Couplings

Fusion couplings shall require installation by a skilled and certified installer. Proof of certification shall be made prior to installing the coupling. Installation of one test coupling shall be required before this method of coupling HDPE conduit is approved. The certified installer shall be present for every coupling. All heat fusion joining methods require that there is no water flowing or standing in or below the conduit that can reach the fusion surfaces. Conduit surfaces shall be dry prior to and during fusion and should be protected from moisture during rain or snow events. Electrofusion couplings can be installed at ambient temperatures ranging from -10 degrees F to 120 degrees F. Follow the recommendations of the manufacturer. The fusion surface of the coupling shall be clean and free from body oils or other substances that will prevent proper fusing. The ends of the conduit shall be cleaned with 90% or greater

concentration of isopropyl alcohol, wiping in only one direction. The area to be cleaned shall be at least two times the full length of the coupling on each end of the conduit. Measure and mark the conduit slightly longer than ½ the length of the coupling to indicate the scrape/peel length needed. Scribe "witness marks" on the conduit surface. Each end of the conduits shall be scraped or peeled to remove the oxidation and contamination layer with a "peeler" type tool that removes a continuous and measureable ribbon of conduit surface. A minimum of 0.007" of material (thickness of two sheets of paper) shall be removed from each end. None of the "witness marks" shall be visible after scraping. Sandpaper, utility/emory cloth, wood rasps, metal files and abrasives/grinders shall never be used to scrape the conduit ends. Insert the conduit ends into the coupling to the stab depth (½ the length of the coupling). After the conduit has been inserted into the coupling, assembly clamps shall be used to align the ends. The electrical source shall be connected to the electrofusion control box. The contractor shall verify the control box inputs based on the model used. The control box shall acclimate to the jobsite weather conditions for a minimum period of 15 minutes prior to using. The power should be of sufficient output for the size and type of fitting being used. See the power requirements of the manufacturer of the coupling. If an extension cord is used, it should be of sufficient gauge and not more than the specified maximum length according to manufacturer's instructions. Connect the control box leads to the fitting and verify proper fusion time and voltage. Fusion time is different depending on the size of the coupling. After the fusion process is complete, allow proper cooling time while the conduit is still being held by clamps and additional cooling time before rough handling of conduit according to the manufacturer's instructions.

(2) Butt Fusion Plates

Commercial fusion plate machines shall be used in this process. All points on both heating tool surfaces, where the heating tool surfaces will contact the conduit ends, shall be within the prescribed minimum and maximum temperatures. The temperature differentials between any two points on the heating tool fusion surfaces shall not exceed 20 degree F. Clean the inside and outside of the conduit ends by wiping with a clean, dry, lint free cloth or paper towel. Remove all foreign matter. Align the conduits in the machine by placing them in the clamps and tightening. Conduit ends should protrude past the clamps enough so that facing will be complete. Bring the ends together and check high-low alignment. Adjust the alignment as necessary by tightening the high side down. Place the facing tool between the component ends, and face them to establish smooth, clean, parallel mating surfaces. A complete facing will produce continuous circumferential shavings from both ends. Face until there is minimal distance between the fixed and moveable clamps. Stop the facer before moving the pipe ends away from the facer. Remove the facing tool, and clear all shavings and pipe chips from the component ends. Do not touch the component ends with your hands after facing. Bring the component ends together, check alignment and check for slippage. Look for complete contact all around both ends with no detectable gaps. Verify that the contact surface of the heating tool is maintaining the correct temperature. Place the heating tool between the conduit ends, and move the ends against the heating tool. Bring the conduit ends together under pressure to ensure full contact. The initial contact pressure should be held very briefly and released without breaking contact. Pressure should be reduced when evidence of melt appears on the circumference of the conduit. Hold the ends against the heating tool without force. Beads of melted conduit will form against the heating tool at the component ends. When the proper melt bead size is formed, quickly separate the ends and remove the heating tool. The proper bead size is dependent upon the size of the conduit. During heating, the melt bead will expand out flush to the heating tool surface, or may curl slightly away from the surface. Immediately after the heating tool is removed, quickly inspect the melted ends, which should be flat, smooth and completely melted. If the melt surfaces are acceptable, immediately and in a continuous motion, bring the ends together and apply the correct joining force (or fusion pressure). The correct fusion pressure will form a double bead that is rolled over and contacts the conduit surface. Maintain fusion pressure until the joint is cool to the touch.

(3) Glued Couplings

Install glued couplings within the working temperature as specified by the manufacturer. For conduit over 3" in diameter, taper the end at 45 degrees with a rasp or knife. Abrade and clean both

adhesion surfaces and wipe with a clean rag to remove dirt and grime. Sand the outside of the conduit ½" beyond the depth of insertion into the coupling with 80-grit sandpaper as well as the inside of the coupling. All polish shall be removed. Clean the adhesion surfaces with recommended cleaner. Dispense the adhesive material through the mixing tubes in a 1/8" to ¼" bead using a zigzag pattern the depth of the coupling insert. Squeeze out a small sample prior to applying to the conduit to ensure the product is properly mixed in the mixing tube. The pattern should be about 3/8" in width and extend to the outer edge of the conduit. The coupling shall immediately be twisted onto the conduit and held in place. The joint shall not be moved until the recommended working time is achieved based on the ambient air temperature according to the manufacturer's instructions.

e. Service Boxes

Service boxes shall be installed at the locations shown on the plans. The Contractor may install, at their own expense, such additional boxes as may be desired to facilitate the work upon approval of the Engineer. Service boxes shall be installed on eighteen (18) and eight (8) inches of crushed rock, respectively, as shown on the plans or as directed by the Engineer. Additional rock shall be installed around the base of the box such that the rock extends 2" above the bottom of the box. The excavated opening outside the pull box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches deep and each layer shall be thoroughly compacted before the next layer is placed. Boxes shall be installed so that the covers are level with the curb or sidewalk grade or approximately 1 inch above the surrounding earth or sod to match the slope of the existing ground line. Service boxes placed in a paver median or island shall have a concrete border placed around them as indicated in the standard details.

f. Cable

(1) Tracer Wire

The tracer/locating wire shall be pulled through the installed conduit by use of a polyester/polypropylene pull rope. Caution should be taken as to not burn or tear the conduit ends or conduit body. The cable shall be terminated in each service box to the ground rod and a ground rod clamp.

(2) Fiber Optic Cable

All cables installed shall be pulled into the conduit, multi-cell or otherwise, using a flat woven pull tape. The Contractor shall not use a single of pull tape for more than a single cable pull. The Contractor shall install the pull tape and fiber optic cables in accordance with the testing procedures completed for this project and the pull tape and cable manufacturer's recommendations.

All cable shall be installed as per Siecor Recommended Procedure 005-011 "Fiber Optic Cable Placing B Duct". These general procedures will be followed regardless of the manufacturer of the cable. If the cable manufacturer recommends an operation in conflict with these procedures, a request for installation procedure change shall be submitted for approval to the Department. The maximum pulling tension shall be 600 lbs during installation (short term) and 200 lbs long term installed.

If the total loss exceeds the specifications as documented under the item "Communication System Testing", the Contractor shall replace or repair that cable run at the Contractor's expense, both labor and materials. Elevated attenuation due to exceeding the pulling tension during installation will require the replacement of the cable run at the Contractor's expense, both labor and materials.

(3) ITS Termination Drop Cable

Cable shall be carefully pulled through conduit without chafing the insulation jacket on the edge of the conduit. The distribution lead-in cable shall be spliced to the trunk fiber in the specified splice enclosure. Sufficient slack shall be coiled in the fiber optic service boxes as indicated on the plans. The patch panel shall be installed in the traffic signal cabinet with the appropriate hardware. The cable shall be tied with plastic cable ties to hold it out of the way of door hinges, etc. and other devices that may cause damage to the cable. All dust covers shall be installed on all terminals that are not being utilized.

(4) Fiber Optic Patch Cables

The Contractor shall install the fiber optic patch cords between fiber optic termination panels and equipment at locations as shown on the plans.

g. Compaction

Compaction shall be accomplished using rollers meeting the requirements of paragraph "Compaction Equipment" and operating at a rolling speed of no greater than 1.5 miles per hour. Each lift of material, including shoulders, shall be compacted with the number of passes of the roller as specified by the City Engineer. In addition, a minimum field dry density, as specified by the City Engineer, shall be maintained. If the required field dry density is not obtained, the number of roller passes shall be adjusted. Excessive rolling resulting in crushing of aggregate particles shall be avoided. In all places not accessible to the rollers, the material shall be compacted with mechanical hand operated tampers.

h. Grounding

A ground rod with clamp shall be installed in each fiber optic service box for the attachment of the #10 AWG THHN/THWN stranded copper locating cable. See the standard details for additional information. The locating cable shall be bonded to the ground rod so as to provide a continuous locating system throughout the limits of the project. The tightening bolt on the clamp shall never be installed such that it crimps the grounding conductor against the ground rod.

i. Fiber Optic Termination Panel

The contractor shall securely install the termination panel in existing traffic signal cabinets by securing the panel to the existing 19-inch rack, and in a manner as approved by the City.

j. Fiber Optic Fusion Splices

All fiber optic splicing shall be fusion spliced, unless otherwise indicated in the plans and bill of materials. Mechanical splices will not be permitted.

The splice enclosure shall be installed according to the manufacturer's recommended guidelines. For the mainline splice, the cables shall be end-to-end fusion spliced. If the plans indicate the contractor will not splice the fiber cable, the splice enclosure shall be provided to the City. 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 Corning 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.

In the event that the Contractor is performing fiber optic fusion splices in existing splice enclosures where an insufficient number of splice trays are present, the Contractor shall provide splice trays for installation in the existing splice enclosure. Splice organizer trays shall accept mechanical, fusion, or multi-fiber array splices, and shall be re-enterable.

k. Testing of Fiber Optic Cable

If the plans call out for testing the fiber optic cable, these specifications shall be followed:

(1) Certification

Certified Technicians" shall perform all testing under this item. Certified Technicians are considered telecommunications professionals who meet the following requirements:

1 YEAR OF DOCUMENTED EXPERIENCE WITHIN THE LAST 3 YEARS IN THE INSTALLATION AND TESTING OF FIBER OPTIC COMMUNICATION SYSTEMS

THE TECHNICIAN SHALL HAVE ATTENDED AND SUCCESSFULLY COMPLETED AT LEAST ONE FOUR-DAY "INSTALLATION OF FIBER OPTIC PRODUCTS" COURSE. A MAJOR MANUFACTURER OF FIBER OPTIC PRODUCTS, SUCH AS AT&T OR SIECOR, SHALL HAVE CONDUCTED THE COURSE.

The Contractor shall provide the date, time and location of any tests required by this specification to the Engineer at least 3 working days prior to performing the test.

(2) Pre-Construction Testing Requirements

The Contractor shall test all fiber cable that is to be removed and reinstalled under this contract to form a baseline of fiber optic system performance prior to the removal / reinstallation of fiber optic cable.

A Certified Technician utilizing an Optical Time Domain Reflectometer (OTDR) and Optical Source/Power Meter must conduct the installation test. The Technician is directed to conduct the test using the Standard Operating Procedure as defined by the manufacturer of the test equipment.

The method of connectivity between the OTDR and the cable shall be a factory patch cord of a length equal to the "dead zone" of the OTDR. Optionally, the Technician can use a factory "fiber box" of 100 meters minimum with no splices within the box. The test shall adhere to the following:

TESTS SHALL BE CONDUCTED AT BOTH 1310 NM AND 1550 NM FOR ALL CABLE AND SHALL BE BI-DIRECTIONAL

At the completion of the test, the Contractor shall provide two copies of documentation of the test results to the Project Engineer. The test documentation shall be bound and include the following:

(a) CABLE & FIBER IDENTIFICATION
(b) CABLE ID
(c) CABLE LOCATION - BEGIN AND END POINT
(d) FIBER ID, INCLUDING TUBE AND FIBER COLOR
(e) OPERATOR NAME
(f) DATE & TIME
(g) SETUP PARAMETERS
(h) WAVELENGTH
(i) PULSE WIDTH (OTDR)
(j) REFRACTORY INDEX (OTDR)
(k) RANGE (OTDR)
(l) SCALE (OTDR)
(m) TEST RESULTS

(3) Testing Locations:

The testing points shall be as follows:

(a) At Sanders Justice Center:

Test fibers 1 through 36 to the south at the Sanders Justice Center
Fibers 1 to 18 transmit to the Fire Training Center (1-18).
Fibers 19 to 36 transmit to the South Maintenance Facility (1-18).

(b) At Fire Training Center:

Test fibers 1 through 36 to the south at the Fire Training Center.
Fibers 1 to 18 transmit to the Sanders Justice Center (1-18).
Fibers 19 to 36 transmit to the intersection of 135th/Antioch (1-18)

(c) At South Maintenance Facility:

Test fibers 1 through 36 to the south at the South Maintenance Facility.
Fibers 1 to 18 transmit to the Sanders Justice Center (19-36).
Fibers 19 to 36 transmit to the intersection of 135th/Antioch (19-36).

(4) Post-Installation Testing Requirements

Upon notification of the test date, the City shall provide the contractor with test points where existing termination panels (or panels installed by the Contractor) are present. In the event that one end of the cable is not terminated (due to either an existing condition or a contractual requirement), the bi-directional testing requirement stated herein shall be waived.

Upon completion of the cable installation, splicing, and termination, the Contractor shall test all fibers for continuity, events losses, and total attenuation of the cable. The test procedure is as follows:

A Certified Technician utilizing an Optical Time Domain Reflectometer (OTDR) and Optical Source/Power Meter must conduct the installation test. The Technician is directed to conduct the test using the Standard Operating Procedure as defined by the manufacturer of the test equipment.

The method of connectivity between the OTDR and the cable shall be a factory patch cord of a length equal to the "dead zone" of the OTDR. Optionally, the Technician can use a factory "fiber box" of 100 meters minimum with no splices within the box. The test shall adhere to the following:

TESTS SHALL BE CONDUCTED AT BOTH 1310 NM AND 1550 NM FOR ALL CABLE AND SHALL BE BI-DIRECTIONAL

At the completion of the test, the Contractor shall provide two copies of documentation of the test results to the Project Engineer. The test documentation shall be bound and include the following:

(a) CABLE & FIBER IDENTIFICATION
(b) CABLE ID
(c) CABLE LOCATION - BEGIN AND END POINT
(d) FIBER ID, INCLUDING TUBE AND FIBER COLOR
(e) OPERATOR NAME
(f) DATE & TIME
(g) SETUP PARAMETERS
(h) WAVELENGTH
(i) PULSE WIDTH (OTDR)
(j) REFRACTORY INDEX (OTDR)
(k) RANGE (OTDR)
(l) SCALE (OTDR)
(m) TEST RESULTS

(5) OTDR Test

The following is a list of information that shall be measured during the OTDR test and prior to fiber optic cable acceptance:

TOTAL FIBER TRACE
SPLICE LOSS/GAIN
EVENT LOSS
MEASURED LENGTH (CABLE MARKING)
TOTAL LENGTH (OTDR)

The Contractor shall provide copies of the fiber cable traces taken during the OTDR test to the City Engineer on diskette for review.

(6) Optical Source Power Meter

The following is a list of additional test measurements that shall be performed prior to fiber optic cable acceptance:

TOTAL ATTENUATION
ATTENUATION (DB/KM)

The Contractor shall provide copies of these results in tabular form for review to the City Engineer.

(7) Fiber Optic Cable Acceptance

The following shall be the criteria for the acceptance of the cable:

The test results shall demonstrate that the dB/km loss does not to exceed +3% of the factory test or 1% of the cable's published production loss. The error rate for the test equipment will be considered.

Event losses shall be considered an average of each direction of test, and shall be limited to the following:

Event Type	Allowable Loss
Fusion Splicing	0.05 dB
ST-Connector (factory assembled)	0.50 dB
ST-Connector (field installed)	0.70 dB

The total dB loss of the cable, less events, shall not exceed the manufacturer's production specifications as follows: .40 dB/km at 1310 and 0.30 at 1550 nm.

If the total loss exceeds these specifications, the Contractor shall replace or repair that cable run at the Contractor's expense, both labor and materials. Elevated attenuation due to exceeding the pulling

tension during installation will require the replacement of the cable run at the Contractor's expense, both labor and materials.

(8) System Corrections

In the event that any component is found to be defective or below the standards of these specifications, the Contractor shall repair and/or replace the defective components at no cost to the City. Upon completion of the repair and/or equipment replacement, the Contractor shall conduct a new system test and provide the appropriate documentation to the City.

(9) Test Documentation

The Contractor shall provide test documentation for all test functions described under this item. The test documentation shall adequately address each test function.

1040.4 MEASUREMENT AND PAYMENT

a. Lump Sum

The Engineer will measure the "Fiber Optic Communication System Installation" as indicated on the plans, complete-in-place and accepted, as a unit lump sum quantity for all work necessary.

Payment for "Fiber Optic Communication System Installation" at the contract lump sum price bid is full compensation for the specified work.

b. Unit Bid Prices

(1) The "Fiber Optic Communication System Installation", as indicated on the plans or as directed by the Engineer will be measured by the units indicated herein, and shall include all items necessary to complete the work of a fully functional system. The Engineer will measure all work related to furnishing and installing conduit of specified type and size by the linear foot.

(2) The Engineer will measure all work related to furnishing and installing fiber optic cable of specified type by the linear foot, including slack in service boxes and appurtenances as specified in the plans. For the purpose of measuring slack cable, all slack cable included in the splice enclosures is considered subsidiary to the "fiber optic splice enclosure" and is not counted toward the slack in service boxes as called out in the plans.

(3) The Engineer will measure each ITS termination drop cable, including the specified length of the fiber optic lead in cable associated with it as specified in the plans.

(4) The Engineer will measure all work related to furnishing and installing service boxes of specified size and type, including one 5/8" ground rod and the aggregate rock base per each.

(5) The Engineer will measure locating/tracer cable by the linear foot, including slack in service boxes.

(6) The Engineer will measure each fiber optic fusion splice, fiber optic splice enclosure, and fiber optic termination as listed in the proposal.

(7) The Engineer will measure each fiber optic patch cable for the length as specified including ST-LC connectors.

(8) The Engineer will measure each fiber optic Ethernet switch as listed in the proposal including the power converter, rack mount kit, and miscellaneous equipment.

Payment for the above listed items at the contract unit prices bid is full compensation for the specified work.