CITY OF COLUMBUS, OHIO
DEPARTMENT OF PUBLIC SERVICE
DIVISION OF DESIGN AND CONSTRUCTION

SUPPLEMENTAL SPECIFICATION 1620
FIBER OPTIC CABLE MATERIAL, INSTALLATION, AND TESTING REQUIREMENTS

September 10, 2018

1620.01 Description. This supplemental specification describes the requirements for the materials, installation, and testing of fiber optic cable for use in City of Columbus traffic signal system interconnect and communications.

1620.02 Contractor Qualifications. The Contractor and all Contractor employees including subcontractors hired by the Contractor and supervisors conducting the work shall satisfy all pre-qualification requirements set forth in ODOT Work Type 56 and shall present these qualifications at the time of pre-construction meeting, unless they are listed on the ODOT pre-qualified vendors list for ODOT Work Type 56.

In addition, the Contractor and all Contractor employees including subcontractors hired by the Contractor and supervisors conducting the work shall be registered and approved through the City of Columbus Vendor Services and be approved through Vendor Services by the Department of Technology to complete fiber optic cable work.

The Contractor and all Contractor employees including subcontractors hired by the Contractor and supervisors conducting the work shall provide documentation of having been directly and actively involved in the installation of fiber optic cabling (including, but not limited to pulling, testing, and end connectorization) for a minimum of five (5) years.

Prior to the start of any fiber splicing or fiber connectorization, each installer conducting the work shall supply a photocopy of their certificate of completion from an accredited fiber optic installation school along with a list of hands-on work experience splicing fiber optic cable.

Proof of these qualifications shall be presented to the City of Columbus Fiber Construction Coordinator prior to the commencement of any fiber optic-related work.

All Contractor employees including subcontractors hired by the Contractor and supervisors conducting the work shall maintain any and all current licenses and certifications that may be necessary for the work that person will be performing. Failure to do so will result in the employee being prohibited from completing any further work until the Contractor provides evidence that the employee has restored their credentials. Any work previously performed by that employee shall be rejected and re-performed by the Contractor at the Contractor's expense.

1620.03 Notification of Work and Downtime Disincentive. The following specifies the permitted duration of ITS system device disruption due to actions performed by the Contractor (includes all subcontractors) as part of this project.

The Contractor shall abide by the following maximum downtimes for specified devices. Additionally, the Contractor shall be capable of taking the appropriate actions necessary to maintain functionality of system devices, including but not limited to the installation of temporary communications and power services.

Multiple agencies utilize the communication infrastructure of the Columbus Traffic Signal System (CTSS). Disruption of normal CTSS operations may cause downtime to CTSS system devices.

The City of Columbus, Department of Public Service, Division of Design and Construction requires notification of any anticipated system disruption a minimum of forty-five (45) calendar days in advance of work at the site. The requested month from the Contractor will be reviewed and dependent on previously scheduled workload of the fiber network for the month, it may not be available. The Contractor will coordinate their project schedule and work with the available downtimes.

Notification:

City of Columbus
Department of Public Service
Division of Design and Construction
Fiber Construction Coordinator
614-645-0444
fibercoordinator@columbus.gov

The City of Columbus, Department of Public Service and Department of Technology, as well as the Ohio Department of Transportation, and Franklin County Engineer's Office shall be the determining parties in deeming if a circumstance is unusual enough to warrant additional downtime.

All work that will disrupt system devices or infrastructure shall be limited to the third weekend of each month, unless it has been specifically permitted in the plans or otherwise directed by City Fiber Construction Coordinator. The third weekend of the month includes the hours of 9 PM Friday through 5 AM Monday.

Special circumstances may allow for the blue buffer tube or certain other buffer tubes utilized by City of Columbus Traffic exclusively to be down between the hours of 10 AM and 2 PM on a weekday with total downtime not exceeding 24 hours, excluding the third weekend of the month, for the entire duration of the project. Such circumstances shall be clearly stated in the plans or directed by the City Fiber Construction Coordinator.

The Contractor shall make arrangements so that these devices have new (temporary or permanent) infrastructure in place before taking actions that result in the existing site equipment going offline longer than the allowable downtime as specified below. In the event that downtime of a specific site exceeds the allowable limit, a disincentive penalty may be charged to the Contractor.

CCTV Camera disruption shall be limited to a downtime of 72 hours.

Disincentive: $400/day or $17/hour – beginning after the allowable downtime.

All temporary or permanent fiber optic cable shall be installed and ready for splicing prior to any work on existing fiber optic cables. The Contractor shall furnish a temporary fiber optic cable meeting or exceeding the capacity of the installed cable. All fibers of the temporary cable shall be core-aligned fusion spliced to the like fiber (buffer-tube to buffer-tube, color to color).

Disincentive: $400/hour – beginning after the allowable downtime.

Unscheduled downtime resulting from damage to fiber optic cable or CCTV camera facilities shall be measured from the beginning of service disruption until the repairs, compliant with requirements of this specification, have been completed and accepted by the Fiber Construction Coordinator and connectivity has been fully restored.

If repairs cannot be made within a reasonable amount of time, the Columbus Department of Technology will restore connectivity and all associated expenses will be paid by the Contractor which caused the damage to the Department of Technology.

Disincentive: $400/hour - beginning at service disruption.

1620.04 Applicable Documents. All work described in this specification shall meet or exceed the applicable provisions of the following documents:

1. U.S. Department of Agriculture, Rural Electrification Administration specification for totally filled optical fiber cable, pe-90

2. EIA/TIA 455-A, standard test procedure for fiber optic fibers, cables, transducers, sensors, connecting and terminating devices, and other fiber optic components

3. EIA/TIA-455-25A, repeated impact testing of fiber optic cables and cable assemblies

4. EIA-455 28B, method for measuring dynamic tensile strength of optical fibers

5. EIA-455-33A, fiber optic cable tensile loading and bending test

6. EIA-455 34, interconnection device insertion loss test

7. EIA-455-41, compressive loading resistance of fiber optic cables

8. EIA/TIA-455-81A, compound flow (drip) test for filled fiber optic cable

9. EIA/TIA-455-82B, fluid penetration test for fluid-blocked fiber optic cable

10. ELA 455 89A, fiber optic cable jacket elongation and tensile strength

11. EIA-455 95, absolute optical power test for optical fibers and cables

12. EIA-455-104, fiber optic cable cyclic flexing test

13. EIA/TIA-598, color coding of fiber optic cables

14. EIA/ANSI-472 generic requirement for optical fiber and optical fiber cables

15. ANSI/ICEA S-87-640

16. ANSI/TIA/EIA-526-7: OFSTP-7 measurement of optical power loss of installed single-mode fiber cable plant.

1620.05 Materials. The Contractor shall provide all materials required for the installation, connecting, and splicing of the specified fiber optic cables. All materials, cables, fiber, and hardware shall be fabricated from the same manufacturer and be included in the current version of the City of Columbus Qualified Products List (QPL) at time of bid advertisement or at the time a repair is made.

All supplied materials shall be fully compatible with existing materials and equipment.

All replacement material, for projects and repairs shall match the material being replaced including but not limited to the cable, splice enclosures, termination panel assemblies, and cabinet materials. When splicing to an existing cable, the proposed cable shall be of the same manufacturer and product number as the existing. In the event that a product or material is no longer available or has been replaced with a more current model or part, the material installed shall be included in the current version of the City of Columbus QPL. It shall be the responsibility of the Contractor to ensure that all replacement materials are compatible with the existing facilities.

1620.06 Fiber Optic Cable Material. Fiber optic cable shall be loose tube, single mode dielectric cable. The cable shall be listed in the latest edition of the Rural Utilities Service (RUS) list of materials acceptable for use on telecommunications systems of RUS borrowers, category OC-D-F and shall be 8.2/125 µm, single–mode, loose buffer optical fiber cables, Corning SMF-28e+, type II, that meets the following specifications:

- ITU-T G.652 (CATEGORIES A, B, C & D)
- IEC SPECIFICATION 60793-2-50 TYPE B1.3
- TIA/EIA 492-CAAB
- TELECORDIA'S GR-20

The cable manufacturer shall be TL 9000 registered.

The Contractor shall provide manufacturer's certification that the offered cable shall comply with all optical and/or electrical, and mechanical requirements set forth in this specification. Any deviation of the offered cable from the requirements set forth herein shall be conspicuously noted in the Contractor's material submittal.

The Contractor shall provide a warranty on all installed cable for a period of one (1) year following final project acceptance.

All fibers in the cable shall be usable fibers and shall be free of surface imperfections material and inclusions in order to meet or exceed one hundred percent (100%) of the optical, mechanical, and environmental requirements contained in this specification. If 100% useable fibers are not achievable, the cable shall be replaced by the Contractor at the Contractor's expense.

All cables shall be free of material or manufacturing defects and dimensional non uniformity that would:

1. Interfere with the cable installation using accepted cable installation practices.
2. Degrade the transmission performance and environmental resistance after installation.
3. Inhibit proper connection to interfacing elements.
4. Otherwise yield an inferior product.

A. Mechanical and Performance Requirements. The cable shall be a rugged all dielectric outdoor cable containing color coded buffer tubes with 12 single mode color-coded fibers per-buffer tube, dual window (1310 nm and 1550 nm) fibers with UV acrylate coating in color coded, gel-free, loose buffer tubes with the maximum outer diameter as shown in the chart below based on cable strand count.

Strand Count	Maximum Outside Diameter (Inches)	Minimum Allowable Bending Radius (in) Loaded/Installed	Maximum Weight (lbs./1000')
12-72	0.45	6.2/4.1	49
144	0.65	9.5/6.5	110
288	0.75	11/7.5	135

The loose buffer tubes shall be stranded around an all-dielectric center strength element using a reverse oscillation lay, wrapped by water blocking core separator or functional equivalent. The maximum allowable attenuation of the fiber is .35dB/km for 1310 nm and .25dB/km for 1550 nm.

Each buffer tube shall contain a water blocking element for water blocking protection. No water blocking yarns are permitted to avoid accidentally cutting fibers. The water blocking elements shall be non-nutritive to fungus, electrically non-conductive, and homogeneous. It shall also be free from dirt or foreign matter. This water blocking element will preclude the need for other water blocking material; the buffer tube shall be gel free.

Water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.

All optical fiber cable on this project shall be from a manufacturer who is regularly engaged in the production of fiber optic cables and all optical fiber cable of the same type shall be from the same manufacturer.

The optical fiber cable shall withstand water penetration when tested with a one-meter static head or equivalent continuous pressure applied at one end of a one-meter length of filled cable for one hour. No water shall leak through the open cable end. Testing shall be done in accordance with EIA 455 82B.

B. Outer Jacket. Cables shall be all dielectric cable (with no armoring) and shall be jacketed (sheathed) with medium density polyethylene as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8. Jacketing material shall be applied directly over the tensile strength members to provide mechanical protection, and to serve as the primary moisture barrier. This cable sheath shall be designed to meet or exceed the tensile criteria defined in EIA 455-89A. Each jacketed fiber shall have a tensile strength in excess of 50 lbs. The polyethylene shall contain carbon black to provide ultra-violet light protection, and it shall not promote the growth of fungus.

The jacket or sheath shall be free of any holes, splits, or blisters.

The cable jacket shall contain no metal elements and shall be of a consistent thickness.

The cable shall have scored outer jacket or contain at least one ripcord under the sheath for easy sheath removal.

C. Crush Resistance. The non-armored optical fiber cables shall withstand a compressive load of 220 n/cm applied uniformly over the length of the cable. The average increase in attenuation for the fibers shall be 0.10dB at 1550 nm for a cable subjected to this load. The cable shall not exhibit any measurable increase in attenuation after load removal. Testing shall be in accordance with EIA-455-41, "compressive loading resistance of fiber optic

cable," except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes.

The Contractor shall submit manufacturer's certification for approval of Engineer.

D. Cyclical Flexing. The cable shall be capable of withstanding 25 cycles of mechanical flexing at a rate of 30 +/- 1 cycles/minute. The average increase in attenuation for the fibers shall be ≤ 0.10dB at 1550 nm at the completion of the test. Outer cable jacket cracking or splitting observed under 10x magnification shall constitute failure. The test shall be conducted in accordance with EIA-455-104, except that the sheave diameter shall be a maximum diameter of 20 times the cable outer diameter (O.D.). The cable shall be tested in accordance with test conditions I and III of EIA-455-104.

The cable shall withstand 25 impact cycles. The average increase in attenuation for the fibers shall be≤0.20dB at 1550 nm (single-mode). The cable jacket shall not exhibit evidence of cracking or splitting. The test shall be conducted in accordance with EIA/TIA-455-25A.

The Contractor shall submit the manufacturer's certification of the testing for approval.

E. Cable Marking. The optical fiber cable outer jacket shall be marked with manufacturer's name and indicate the year of manufacture, strand count, optical fiber type, and sequential linear foot marks. The markings shall be repeated and a minimum of every 3 ft. The marking shall be in a contrasting color to the cable jacket. The marking shall be 2.5 mm in height and must be permanent weatherproof and rugged enough as to not wear off during the installation in the underground conduit system.

F. Tensile Strength. Tensile strength shall be provided by high tensile strength aramid yarns and fiberglass, which shall be helically stranded evenly around the cable core.

The cable shall withstand a tensile load of 2700 Newtons (N) [600 lbs.] without exhibiting an average increase in attenuation of greater than 0.10dB. The test shall be conducted in accordance with EIA-455-33A, using a maximum mandrel and sheave diameter of 560 mm. The load shall be applied for one hour in test condition ii of EIA-455-33A.

The optical fiber cable shall withstand a maximum pulling tension of 2700 N (600 lbs.) during installation (short term) with no damage and 845N (190lbs.) installed (long term).

The Contractor shall submit the manufacturer's certification that the cable meets the tensile strength requirements.

G. Temperature. The storage and operating temperature range of the cable shall meet or exceed min. -20 °F to max. +155 °F (-29 °C to +68 °C). Installation temperature range of the cable shall meet or exceed min. 15 °F to 138 °F (-8 °C to 58 °C).

H. Loose Buffer Tube. Single-mode fibers shall be contained in a loose buffer tube. The configuration shall be dimensionally sized to minimize local stresses and microbend losses. Buffer tubes shall be 2.5 mm in outer diameter. The optical fiber cable shall be an approved product of the Department of Agriculture, Rural Electrification Administration in accordance with the requirements of REA-PE-90, or as otherwise indicated, and shall conform to EIA/TIA-598. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.

Buffer tubes shall be constructed of polypropylene.

Fillers shall 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 glass reinforced plastic rod. This and other items necessary to comply with the maximum flexibility requirements may be omitted, if pre-approved by the Engineer.

I. Colors. All optical fibers shall be identifiable by standard color codes as defined in EIA/TIA-598. Each fiber shall be distinguishable, as determined by the owning agency, from others by means of color coding and shall conform to the following EIA/TIA sequence of colors:

Fiber	Color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White

Fiber	Color
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

The colors shall be in accordance with the Munsell color shades.

The fiber coloring shall be an ultraviolet (UV) curable ink which is applied to the outside of the optical fiber protective coating layer and shall not be an integral component of the coating layer itself in order to produce more distinguishable colored fiber.

Buffer tubes containing fibers shall also be color-coded with distinct and recognizable colors according to the following sequence of colors:

Tube	Color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

Tube	Color
13	Blue w/ Black Tracer
14	Orange w/ Black Tracer
15	Green w/ Black Tracer
16	Brown w/ Black Tracer
17	Slate w/ Black Tracer
18	White w/ Black Tracer
19	Red w/ Black Tracer
20	Black w/Yellow or White Tracer
21	Yellow w/ Black Tracer
22	Violet w/ Black Tracer
23	Rose w/ Black Tracer
24	Aqua w/ Black Tracer

The color formulation shall be compatible with the fiber coating and be heat stable. It shall not fade or smear or be susceptible to migration and it shall not affect the transmission characteristics of the optical fibers and shall not cause fibers to stick together.

J. Quality Assurance Provision. The optical fiber cable shall meet or exceed the requirements of this specification when measured in accordance with the methods of the individual requirements or the following methods as defined in EIA-455-A:

1. Fiber dimensions
2. Attenuation
3. Numerical aperture
4. Fiber proof test
5. Crush resistance
6. Cable bending
7. Tensile load
8. Impact resistance
9. Attenuation vs. Temperature

K. Packing and Shipping. The completed cable shall be packaged for shipment on non-returnable wooden reels. The cable and reel shall be wrapped in a water resistant covering.

Each end of the cable shall be securely fastened to the reel to prevent the cable from coming loose during transit. At least six feet of cable length on each end of the cable shall be accessible for testing. Both ends of the cable shall be sealed to prevent the ingress of moisture.

Each cable reel shall have a durable weatherproof label or tag showing the manufacturer's name, the cable type, and the actual length of cable on the reel, the Contractor's name, the contract number, and the reel number. A shipping record shall also be included in a weatherproof envelope showing the above information and also include the date of manufacture, cable characteristics (size, attenuation, etc.), cable identification number and any other pertinent information.

The minimum diameter of the reel shall be at least thirty times (30x) the diameter of the cable. The optical fiber cable shall be in one continuous length per reel with no factory splices in the fiber. Each reel shall be marked to indicate the direction the reel shall be rolled to prevent loosening of the cable.

Installation procedures and technical support information shall be furnished by the manufacturer and submitted to the Fiber Construction Coordinator for record and review at the time of delivery.

1620.07 Fiber Optic Cable Installation.

When ordering optical fiber cable the Contractor shall exercise extreme caution so as to ensure that no additional splicing, beyond that indicated in the Plans, permitted in this pay item, or from points as determined by the Engineer shall be required. Should the Contractor believe additional splices are required beyond what is permitted; this matter shall be immediately brought to the attention the Engineer for resolution.

Should any locations contain additional splice enclosures or splices not shown in the plans or approved in advance by the Fiber Construction Coordinator, the Contractor shall be required to replace the entire run of fiber from splice enclosure to splice enclosure or device to device at the discretion of the Fiber Construction Coordinator where the cable installed can match the splicing details as shown on the Plans. The Contractor will not be compensated to and additional time will not be allotted to perform this corrective work.

The Contractor shall be certified to perform installation using the cable manufacturer's recommended procedures regarding, but not limited to the following:

1. Proper attachment to the cable strength elements for pulling during installation.

2. Cable tensile limitations and the tension monitoring procedures.

3. Cable bending radius limitations.

The Contractor shall comply with the cable manufacturer's specifications at all times.

To accommodate long continuous installation lengths, bi-directional pulling of the optical fiber cable is permissible and shall be implemented as follows:

1. From the midpoint of a pull station, pull the optical fiber cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.

2. When this portion of the pull is complete, the remainder of the cable must be removed from the reel to make the inside end available for pulling in the opposite direction.

3. This is accomplished by hand pulling the cable from the reel and laying it into large "figure eight" loops on the ground, or truck/trailer rack designed for this purpose. The purpose of the figure eight pattern is to avoid cable tangling and kinking.

4. The figure eight loops shall be laid carefully one upon the other (to prevent subsequent tangling) and shall be in a protected area.

5. The inside reel end of the cable shall be available for installation.

6. Should it be necessary to set up a winch at an intermediate manhole or pull box, the required length of cable shall be pulled to that point and brought out of the manhole and coiled into a figure eight.

7. The figure eight is then turned over to gain access to the free cable end. This can then be reinserted into the duct system for installation into the next section.

The Contractor shall ensure that the minimum bending radius of the optical fiber cable is not compromised when preparing this stored cable slack.

Installation shall involve the placement of optical fiber cables in an inner duct, conduit, overlashed to existing interconnect, or attached to messenger wire. The Contractor shall ensure that inner ducts are secured to prevent movement during the cable installation process.

The pulling eye/sheath termination hardware on the optical fiber cables shall not be pulled over any sheave blocks.

When power equipment is used to install optical fiber cabling, the pulling speed shall not exceed 100 ft per minute. The pulling tension and bending radii limitation for optical fiber cables shall not be exceeded under any circumstances. The Contractor shall adhere to the bending radii limitation for the specified optical fiber cable as stated within.

Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be provided at all times during installation.

The pulling operation and shall be accomplished using commercial dynamometers, load cell instruments, or shearing pins (2700 N Max.).

The Contractor shall coil 75 ft of fiber optic cable slack per cable entering/exiting a (overhead or underground) splice enclosure. Additional slack locations are identified in the plans. For instances where a pull box does not contain adequate space to neatly coil the required fiber optic cable slack, as much slack as possible shall be installed at the box and the remaining slack shall be installed at an adjacent pull box so that the proper cable slack length amount is installed for the cable run and may be made available to perform future maintenance of the cable.

A. For aerial installation, cable guard shall be installed and secured on cable and messenger wire where limbs or other obstacles are within 12 inches of any cable, or at the direction of the Engineer. The cost of cable guard shall be considered incidental to fiber optic cable bid items. The work as described will be measured as the length of cable installed in linear feet.

1620.08 Fiber Optic Cable Splicing. All permanent optical splices shall be of the core alignment fusion type method. Temporary splices may utilize mechanical or other forms of temporary splices with the approval of the Fiber Construction Coordinator. All temporary splices shall be removed and replaced with permanent splices before acceptance.

Splicing shall occur only at locations identified in the Plans or approved by the Fiber Construction Coordinator. In the event that an error is discovered in the splicing details in the Plans, the Contractor shall immediately notify the Fiber Construction Coordinator. Depending on the nature of the error, the Fiber Construction Coordinator will give direction on the remedy or may provide updated splicing drawings. The Contractor shall not complete any work known to contain substantial errors in the splicing detail.

In the event that a repair is required, the entire fiber optic cable shall be replaced between splice enclosures where all fibers of the cable contain splices or device to device at the discretion of the Fiber Construction Coordinator. No repair shall introduce new splices that the cable originally did not have without written consent of the Fiber Construction Coordinator. Full cable cut splices within 1,200 feet of the next full cable cut splice are not permitted under any circumstance.

All splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Cable preparation, closure installation, and splicing shall be accomplished in accordance with accepted and approved industry standards. All splicing work shall be completed in a controlled environment.

Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job site, and disposed of in an environmentally acceptable manner.

The average splice loss of each fiber shall be 0.05 dB or less per splice. The average splice loss is defined as the summation of the attenuation as measured in both directions through the splice, divided in half.

No individual splice loss measured in a single direction shall exceed 0.05 dB.

The work as described will be measured as the number of fiber optic fusion splices completed.

1620.09 Fiber Optic Cable Testing

A. Optical Cable Fiber Reel and Factory Test. The Contractor shall obtain factory test data sheets for each reel of optical fiber cable delivered. The tests shall be performed by the factory at 1310 nm and 1550 nm and shall include directional OTDR traces and test data for each fiber in the cable. The Contractor shall test each reel at 1550 nm prior to installation to ensure no damage occurs to the fiber in transit and that the length of cable is correct. The Contractor shall provide the OTDR manufacturer, model number, and serial number of each unit used during the test along with the name of the person(s) performing the test. These two test results shall be provided to the City of Columbus prior to installation as part of final acceptance of the section of cable for payment.
All cabled optical fibers longer than 3500 ft (1000 m) in length shall be attenuation tested. The attenuation of each fiber shall be provided with each cable reel.

The Contractor shall supply the City of Columbus with the factory, and pre-installation test results documenting that the cables meet all relevant EIA specifications as stipulated in these supplemental specifications.

Single-mode fibers utilized in the cables specified herein shall be subjected to and successfully pass a tensile proof stress test equivalent to 100 kpsi (0.70 gn/m2) for 1.0 second.

Fibers shall contain no factory splices.

B. Post-installation Testing. The Contractor shall test all continuous fiber with a light source utilizing procedures as stated in ANSI/TIA/EIA-526-7: OFSTP-7 measurement of optical power loss of installed single-mode fiber cable plant. Testing procedures shall utilize one jumper reference. Bi-directional testing of optical fibers will be required.

The Contractor shall coordinate with the City of Columbus for specific locations for the testing. The Contractor shall provide the City of Columbus written notification a minimum 14 calendar days before testing the fiber optic cable. Testing shall not begin unless receiving written authorization and fiber locations and test points from the City of Columbus.

The Contractor shall provide the OTDR manufacturer, model number, and serial number of each unit used during the test along with the name of the person(s) performing the test.

The Fiber Construction Coordinator shall have the final authority in deciding the testing parameters to be used including pulse width.

Prior to the testing of a segment of installed fiber optic cable, all terminations and patch panels connected to that specific cable segment must be installed in their final position within the controller cabinet and/or equipment rack as indicated in the plans. Failure to test

the cable system and its components in their final installed placement will result in nullification of test results and will require the retesting of those cable segments.

All single mode fiber cables shall be tested at both 1310 nm and 1550 nm after installation. Fibers will be considered acceptable if the OTDR trace for that fiber shows an end to end loss of less than (xx)dB + yy(0.05)dB + zz(0.2)dB (where yy is the number of splices (a number to be provided by the Engineer), zz is the number of connector pairs and xx is calculated using the following formula: xx = distance x fiber attenuation/unit distance @ lambda). In addition, no splice may show a loss of greater than 0.05dB and no connector pairs may show a loss of greater than 0.2dB, regardless of the total accumulated end-to-end loss. Any additional tests required by the ANSI/TIA/EIA standard shall also be performed and also included in the written test report.

The Contractor shall test each fiber strand from both ends of the fiber utilizing an OTDR at the wavelengths specified above. Overall, the OTDR test results shall be made up of the wavelength of the conducted test, the link length, attenuation, cable identification, and the locations of the near end, the far end and each splice point or points of discontinuity.

Electronic format results for each fiber strand shall be submitted as part of “as-built” documentation. All test results shall be turned over to the Engineer and the City of Columbus in electronic format provided by the manufacturer of the test equipment used by the Contractor to perform the tests. Those results must be provided such that they can be viewable by and the City of Columbus without the use of special software or additional equipment. If the test results cannot be view on a standard PC without requiring the need for additional software or equipment, that software or equipment must also be delivered to the City of Columbus. If software is provided a separate document showing all fiber test results must be submitted to the City of Columbus to be placed in the project file. Any software or equipment so delivered will become the permanent property of and the City of Columbus and will not be returned.

If the cable fails to meet the above requirements, it shall be replaced by the Contractor at the Contractor’s expense.

Test results shall include a record of wavelength, fiber type, fiber and bundle number, test equipment and model number, date, reference setup, and operator (crew members). The Contractor shall document the start/end locations of all fibers.

The Contractor shall provide hard copy and electronic format reports of all test data to the Engineer. In the event that test results are not satisfactory, the Contractor shall make adjustments, replacements, and changes as necessary and shall then repeat the test or tests that disclosed faulty or defective material, equipment, or installation method, and shall perform additional tests as the engineer deems necessary.

Tests related to connected equipment of others shall only be done with the permission and presence of the agency representative involved. The Contractor shall perform only that testing as required to prove the fiber connections are correct.

Fiber connection as-built diagrams and documentation shall be placed in sealed plastic pouches in each cabinet.

Fiber optic cable testing shall be considered incidental to the cable and fusion splices.

1620.10 Cable Identification.

A. Wraps. The Contractor is required to place a UV-resistant cable owner identification wrap on every installed cable, at every pole, pull box, median junction box, and cabinet location. These pre-coiled, snap -on wrap-around markers will be four (4) inches in horizontal length for underground installations and eight (8) inches in horizontal length for aerial installations. The Engineer will direct the Contractor on the locations of each type of cable marker dependent on maintaining agency. They shall be made of 0.015 mil solid color throughout vinyl with black heat-sealed ink printing. The wording shall include no advertising logo or message. Color and text shall be as follows:

Agency	Text/Wrap Color	Text
City of Columbus Traffic	Black on pink	TRAFFIC CITY OF COLUMBUS 614-645-7393
City of Columbus, Department of Technology	Black on yellow	CABLE INTERCONNECT SECTION CITY OF COLUMBUS 614-645-7756
Franklin County Engineer's Office	Black on yellow	TRAFFIC, FCEO 614-525-6158
ODOT	Black on yellow	ODOT FIBER OPTIC CABLE - I.T.S. 614-387-4113

The manufacturer and specified product shall be approved by the Fiber Construction Coordinator before any markers are ordered.

B. Fiber Optic Cable Marker. Fiber optic cable markers shall be installed as directed by the Engineer and/or at every pull box within ODOT Limited Access Right-of-Way containing fiber optic cable and shall be one (1) of two (2) types:

TYPE 1 – COTTMARK 511, FRICK FLEXPOST, or CARSONITE CURV-FLEX MARKER, or approved equal

TYPE 2 – COTT BIGFINK, FRICK TESTPOST, or RHINODOME TEST STATION, or approved equal

The fiber optic cable markers shall be 6 ft. in length and shall be securely placed in the ground at a depth of two (2) ft. Care shall be taken during installation not to damage any

underground conduit in the vicinity. The Contractor shall use a Type 2 marker when the path of the fiber makes a directional change or crosses underneath a roadway and when capable shall place a marker on both sides of the roadway at crossing. The Contractor shall connect tracer wire to terminal at top of Type 2 marker. Type 1 markers shall only be placed on straight fiber runs between pull-boxes in the shoulder and the Contractor shall be limited to the use of Type 1 markers so that a type 2 marker shall be placed between any two (2) Type 1 markers. Type 1 markers shall not be placed in succession down a fiber path. Markers shall be installed with a maximum of 1000 ft between adjacent markers. The markers shall be orange in color, approved by the Engineer prior to ordering, and shall have the following information located on the upper portion of the marker in a readable format:

WARNING

CONTACT OUPS AND THE FOLLOWING NUMBERS 48 HRS BEFORE DIGGING

ODOT FIBER OPTIC CABLE (614-387-4113)

CITY OF COLUMBUS FIBER OPTIC CABLE (614-645-7393)

C. Measurement. Fiber optic cable wraps and markers shall be considered incidental to the fiber optic cable.

1620.11 Optical Fiber Connections. All optical fiber connectors shall be LC/UPC style unless otherwise noted. All optical fiber termination components shall meet or exceed the applicable provisions of EIA/TIA-455-A.

All optical fiber connectors shall be of industry standard and of type determined by the Engineer for single-mode optical fiber and shall meet or exceed the applicable provisions of EIA/TIA-455-2B, EIA/TIA-455-5A, and EIA-455-34. Optical fiber connectors shall satisfy all of the interface parameters of equipment components as may be defined by the transmission equipment specifications.

Single-mode pigtails shall be provided with factory pre-connectorized single-mode connectors. Connectors shall have a maximum loss of 0.5dB through each mated pair of single-mode fibers. Each connector shall be capable of 500 repeated matings with maximum increase in splice loss limited to 0.2dB.

The Contractor shall provide single mode fiber optic pigtails with color coded buffer tubes. Optical fiber cable used for pigtails shall be of the tight buffered type protected by aramid fibers.

1620.12 Patch Cables. The optical patch cords furnished under this contract shall be constructed of duplex single fiber, jacketed cable equipped with factory assembled optical connectors at both ends (LC/UPC Duplex).

The duplex cable shall use different colors for strain relief boots on either side of the cable, with like colors on either end of the same fiber (i.e. Fiber #1 strain relief boot is blue on both

ends of patch cable, Fiber #2 strain relief boot is white on both sides of cable). Additionally, all patch cables shall have unique identification labels on each end.

Patch cables installed at communications node sites shall be constructed using flexible interlocking coiled stainless steel armor under the cable jacketing. Additionally, patch cables shall be constructed using the same type of optical fiber as described in section 0 – “Fiber Optic Cable, various strand count”.

The sheath shall be flame retardant and coded NFR in accordance with the National Electric Code.

Patch cords for connections from fiber distribution panel (FDP) to FDP shall be equipped with connectors approved by Engineer on both ends of the patch cord.

The optical connectors on the other end of these patch cords shall be compatible with the connectors on the optical transceivers furnished by this project.

Optical fiber connectors shall satisfy all of the interface parameters of equipment components as may be defined by the transmission equipment specifications.

Unused single-mode fibers shall be terminated with a connector and protected by a suitable cap for preventing the intrusion of foreign material. All connectors shall be compliant with industry standard ANSI/TIA/EIA-568B.3. The connector shall comply with TIA/EIA Fiber Optic Connector Intermateability Standard (FOCIS) document, TIA/EIA-604-3.

The connector shall be pre-terminated on the fiber cable and core-aligned fusion spliced when applicable.

Connector shall be consistently capable of insertion losses <= 0.3 dB (typical) and shall be <= 0.75 dB when installed in accordance with the manufacturer’s recommended procedure and tested in accordance with FOTP-171. Connector reflectance shall be measured at the factory to be and <= -55 dB for Ultra Physical Contact (UPC).

Manufacturer shall be ISO 9001 and TL 9000 registered.

The manufacturer shall have an in-depth knowledge and more than 7 year history of manufacturing and supporting connector technology that does not require epoxy or polishing in the field. Proof of these qualifications and similar past project experience shall be presented to the Engineer prior to cable installation.

No-epoxy, no-polish quick mount single-mode connectors shall be provided.

Connector must be packaged in a manner that consists of multiple connectors in a single package, preferably a hardened, re-closable pack that is made of recyclable material.

Patch cables shall be considered incidental to the termination panels, GBIC modules, and Layer 2 switches.

1620.13 Termination Panel. The termination panel for traffic signal controller cabinets shall consist of a self-contained enclosure with capacity for a single optical adapter panel. Each optical adapter panel shall be capable of housing 12 duplex LC/UPC style connectors for a total of 24 fiber terminations per adapter. Additionally, termination panels shall be stackable - constructed such that multiple enclosures may be securely fastened together, without the need for drilling additional holes or use of additional hardware.

The termination panel enclosure shall include a built in splice tray to hold all fusion splices and be capable of securely storing fan out kits, slack loose fiber and buffer tubes required for up to 24 fiber connections. There shall be one cable entry hole on both ends, along the lengthwise axis, of the enclosure. Removable rubber grommets capable of accepting a cable of up to ¾" shall be included with both cable entry holes.

The termination panel housing shall be of metal construction with a powder coated finish and have predrilled holes/slots enabling it to be fastened to the shelf of the control cabinet. One side of the enclosure shall be hinged to allow easy access to inside of the enclosure.

Dimensions of the termination panel shall not exceed 6.5 in. (H) x 2 in. (W) x 5.5 in. (D).

Termination panels shall be installed in a location and orientation that provides required space for routing of drop cables and patch cables to equipment and conduit ensuring that minimum bend radii are not exceeded.

1620.14 Addition of New Intersection Drop. The work described in this section specifically applies to the addition of a new intersection drop for new traffic signals added to a corridor which is currently part of the CTSS.

A. Intersection Drop Added Between Existing Intersections. In addition to the 45-day advance notification, the Contractor shall notify the Fiber Construction Coordinator two working days in advance of the work to coordinate inspection schedules.

The Contractor shall install the termination panel and 24-strand drop cable in the signal controller cabinet. This work shall not take place without the inspector or Columbus signal technician present.

The Contractor shall perform the splice and jumper all 24 fibers in the new cabinet. The Contractor shall then extend the 24-strand cable to the proposed splice enclosure to make the splices in the new enclosure.

With the inspector or signal technician present, the Contractor shall disconnect fibers 1 through 4 on the adjacent intersections. Bidirectional testing shall be performed from both adjacent intersections according to the requirements of this specification.

Upon completion of testing, the Contractor shall reconnect patch cables at the adjacent intersections and leave the jumpers in place at the new intersection until the test results have been approved.

Once the testing results have been approved, the Contractor shall remove the jumpers and patch the intersection per the plans. The intersection will then be brought online.

B. Intersection Drop Added to the End of the Line. In addition to the 45-day advance notification, the Contractor shall notify the Fiber Construction Coordinator two working days in advance of the work to coordinate inspection schedules.

The Contractor shall install the termination panel and 24-strand drop cable in the signal controller cabinet. This work shall not take place without the inspector or Columbus signal technician present.

The Contractor shall perform the splice and jumper all 24 fibers in the new cabinet. The Contractor shall then extend the 24-strand cable to the proposed splice enclosure to make the splices in the new enclosure.

With the inspector or signal technician present, the Contractor shall disconnect fibers 1 through 4 on the adjacent intersection. Bidirectional testing shall be performed from the new fiber termination to the adjacent existing intersection according to the requirements of this specification.

Upon completion of testing, the Contractor shall reconnect patch cables at the adjacent intersection and leave the jumpers in place at the new intersection until the test results have been approved.

Once the testing results have been approved, the Contractor shall remove the jumpers and patch the intersection per the plans. The intersection will then be brought online.