SECTION 16740

SINGLE MODE FIBER OPTIC CABLE SYSTEM

1. Description. Furnish and install single mode fiber optic cable as shown on the plans.

A. Submittals. Provide the Engineer all submittals identified in the specification no later than two (2) weeks following award of the contract. Do not purchase cable for use on this project prior to receiving written approval of submittals for fiber optic cable by the Engineer. Additional details about submittals can be found in the specific equipment sections below. Refer to Submittal Checklist for Fiber Optic Specifications at the end of this specification.

2. Materials.

A. General Requirements. Provide new corrosion resistant materials that comply with the details shown on the plans and the requirements of this item.

Provide splicing kits, fiber optic cable caps, moisture/water sealants, connectors, patch cords, aerial cable storage systems, and accessories to complete the fiber optic communication system. Furnish equipment for installation, splicing, and testing.

B. Cable Requirements. Furnish fiber optic cable suitable for underground conduit and aerial environment.

Do not purchase cable for use on this project prior to receiving written approval of submittals for fiber optic cable by the Engineer, as established in Section 1A.

All fiber optic cable(s) supplied and utilized on this project will be from a single manufacturer.

Manufacturers proposing to supply fiber optic cable for this project will be Certified ISO-9001 and TL 9000 Certified.

Fiber optic cable manufacturer proposed for this project will demonstrate, as a prerequisite, engagement in the production of each and every fiber optic cable(s) specified herein, for a continuous period of twenty years.

All cables supplied for this project will be produced utilizing the construction processes noted herein and warranted by manufacturer. Ensure that all proposed fiber optic cable is compatible with existing equipment/infrastructure.

(1). Submittal Requirements for Fiber Optic Cable Manufacturers. Submit documentation for the fiber optic cable manufacturer that documents, as a minimum, the following information:

a. Manufacturer ISO-9001 and TL 9000 Certification.

b. "Proof of Compliance" with (Bellcore (Telcordia)) GR-20-CORE, Issue No. 2 TL9000.

c. Documentation for each cable, indicating that the cable is listed by the Rural Utilities Service (RUS), 7CFR 1755.900 or PE-90, if cable is in transition to RUS and be fully compliant with ANSI/ICEA S-87-640.

d. Manufacturing Site Testing Procedures. The Engineer reserves the right to require verification of any or all of the manufacturer's test procedures and those test results. When required by the Engineer, the cable manufacturer issuing the test data as verification of testing will conduct this testing, and/or the testing will be performed in the presence of the Engineer or his Agent.

(2). Cable. Single Mode Fiber Optic Cable

All fiber optic cable will be loose tube telecommunications grade designed for high speed transmission of voice, data, and video communications. The cable will combine a loose buffered fiber with a UV rated outer jacket and be designed for high strength duct and aerial installations. The tube or central core will be wrapped with water blocking tape, multiple polymer strength members that run laterally, and a medium density polyethylene (MDPE) jacket. This central core will have a pulling strength of 600 pounds.

a. Buffer Requirements.

Provide cable that incorporates filled loose buffer tubes, which allow the cable to expand or contract without causing any stress on the fibers. The fibers will be spiraled loosely inside each buffer tube. The loose buffer tubes will be filled with a soft moisture resistant compound to prevent the ingress of moisture to the fibers. The compound will act as a lubricant to permit the fibers to "float" inside the buffer tube. Ensure filling is a non-toxic, non-hygroscopic, non-nutrient to fungus and electrically non-conductive. These buffer tubes will be stranded around a dielectric anti-buckling element. Ensure cable core will also have water-blocking technology to prevent moisture entry and migration in the cable.

b. Core Tape.

Ensure a layer of non-hygroscopic tape is wrapped around the stranded buffer tubes, making a complete core unit. The tape will act as a heat barrier to prevent deformation and adhesion between the buffer tubes and the outer polyethylene jacket.

c. Strength Members.

The strength of the cable will be obtained by either layers of aramid yarn or fiberglass yarns, if required. Protect strength layer by a non-hygroscopic tape to ensure no adhesion to the outer jacket. The strength elements will provide the mechanical strength required to support the cable and provide cushioning against crushing. All fiber optic cable will withstand the compressive load of 125 lbf per inch at 20° C with no detectable damage to the fibers. The strength layer must be decoupled from the outer jacket.

d. Trunk Cable.

Single mode fiber optic trunk cable will be utilized to connect the network data loop to all drop cables via the fusion splice process. Each cable will have traceability of each fiber back to the original fiber manufacturer's fiber number and parameters of the fiber. The optical fibers will meet all optical fiber specifications as listed in Section 2B(4)a.

The fiber count for each trunk cable will be as indicated in the project drawings.

e. Drop Cable.

Single mode fiber optic drop cable will be utilized to connect the trunk cable to field equipment via fusion splicing. Each cable will have traceability of each fiber back to the original fiber manufacturer's fiber number and parameters of the fiber. The optical fibers will meet all optical fiber specifications as listed in Section 2B(4)a.

The fiber count for each drop cable will be as indicated in the project drawings.

A fan-out kit will be required within the Secondary Fiber Distribution Unit (SFDU) on the terminal end of each drop cable that is utilized for this project. The fan-out kit will be installed in a climate controlled environment. Ensure that the length of all drop cables, not indicated by drawings, is adjusted for field conditions. Additional costs caused by failure to establish the lengths of any and all drop cables in the field will be at the Contractor's expense.

f. Color Coding of Buffer Tubes.

Color coding of buffer tubes will be in accordance with EIA-TIA-598-B, "Coding of Fiber Optic Cable".

g. Fiber Optic Cable Jacket Marking.

Fiber optic cable will be sequentially marked at two (2) feet or one (1) meter intervals. Length marks will not run through zero on any length of cable. The length markings will be in units of "feet". The maximum variance between the actual cable length and marked cable length will be ±1%.

Cable markings will be indent printed with white characters on the outer jackets. The characters will be approximately 3 mm in height and spaced to produce good legibility.

If re-marking is required during manufacturing, the existing markings must be completely removed. The cable may then be re-marked with yellow characters. Only one re-marking per cable permitted in accordance with GR-20-CORE Bellcore (Telcordia).

All loose tube fiber optic cable, for each length of cable, will be marked with the following legend:

- Manufacture Name
- "OPTICAL CABLE"
- Year of Manufacture.
- "CITY OF HOUSTON"
- Number of Fibers
- "SM FOC – CALL CITY OF HOUSTON 311"

h. Submittals for Fiber Optic Cable.

Documentation will consist of catalog sheets, engineering drawings, and maintenance procedures for all fiber optic cables to be used on this project. As a minimum, fiber optic cable submittals will include the following information:

- Current Catalog Cut Sheet
- Manufacture's production cable cross section drawings
- Manufacture's confirmation letter listing the optical fiber cable(s)
- Current RUS "Listing Letter" for said cable manufacturer
- Letter of certification warranting compliance with GR-20-CORE TL 9000
- Cable manufacturer's installation procedures and technical support information associated with the cable proposed for use.

(3). Packaging and Shipping of Fiber Optic Cable.

a. Requirements.

The cable will be packaged, wound on spools or reels. Each package will contain only one continuous length of cable. The packaging will be constructed so as to prevent damage to the cable during shipping and handling.

When the cable length creates a reel weight exceeding 800 pounds, the manufacturer will be required to supply the cable on a large wooden reel, the reel will be lagged with wooden staves. The cable will be covered with a thermal wrap. The outer end of the cable will be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable will project a minimum of ten feet into a slot in the side of the reel or into a housing on the inner slot of the drum, in such a manner to make it available for testing. An arbor hole of 1-1/2 inch minimum is required. Finally, end seals will be applied to each end of the cable to prevent moisture from entering the cable.

Reels will be permanently marked with an identification number that can be used by the manufacturer to trace the manufacturing history of the cable and the fiber.

Each reel will be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.

b. Submittal. Submit manufactures cut sheets for all fiber optic cable to be used.

(4). Optical Fiber Materials. Optical fiber will be glass and consist of a germania-doped silica core surrounded by concentric silica cladding. The fiber will be a matched clad design manufactured by the Outside Vapor Deposition (OVD) process. All fibers will be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of these specifications.

The optical fiber utilized in the manufacture of all fiber optic cable for this project will be produced by one manufacturer. The optical fiber characteristics will be in accordance with Section 2B(4)a.

a. Optical Requirements.

Only dispersion unshifted single mode fiber as specified by EIA 492-BA000, Class 4a will be utilized in the manufacture of all cable for this project.

All fibers will be coated with a dual layer acrylate protective coating. The coating will be mechanically or chemically strippable without damaging the fiber.

Each optical fiber will be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m^2).

The required optical fiber grade will reflect the maximum individual fiber attenuation, to guarantee the required performance of every fiber in the cable at 23 ± 5° C on the original shipping reel.

The optical fiber will comply with all optical and mechanical requirements over a storage temperature range of –50° C to +70° C, an installation temperature range of –40°C to +70° C, and an operating temperature range of -30° C to +70° C.

PARAMETERS	SINGLE MODE
Type	Step Index
Core Diameter	8.2 µm (Nominal)
Cladding Diameter	125 µm ± 1 µm
Core to Cladding Diameter	0.5 µm
Coating Diameter (OSP)	245 µm ± 5 µm
Cladding-Noncircularity	1.0%
Proof Tensile Test	100 kpsi (0.7 GN/m^2)
Max Attenuation:	
@ 1310 nm (SM)	0.4 dB/km
@ 1550 nm (SM)	0.3 dB/km
Chromatic Dispersion	
Zero Dispersion	1302/1322 nm
Zero Dispersion Slope	0.092 ps/(nm^2•Km)
Maximum Dispersion	≤3.5ps/(nm^2•Km) for 1285-1330 nm ≤ 18ps/(nm^2•Km) for 1550 nm
Cut-Off Wavelength	1260 nm

b. Submittal. Submit documentation for the optical fiber that sufficiently documents that, optical fiber meets all criteria specified in Section 2B. Provide the manufacturer's Standard Operating Procedure (SOP) for installation of this cable.

c. Color Coding of Individual Optical Fibers. Individual optical fibers will be color coded in accordance with EIA-TIA-598-B, "Optical Fiber Cable Color Coding". The fibers will be colored with ultraviolet (UV) curable inks.

(5). Pull Tape. No pull ropes, twine, or pull strings will be used on this project for the purpose of installation. Further, if the plans and specifications indicate pull tape for future use do not substitute pull ropes, twine or pull strings for pull tape.

a. Requirements. Pull tape will be prefabricated woven polyester tape made from low friction, high abrasion resistant yarns providing a low coefficient of friction. Pull tapes will be prelubricated. Pull tapes will be printed with sequential footage markings for accurate measurement. Pull tapes will be ½ inch wide and have a minimum tensile strength of 1,250 pounds.

b. Submittal. Submit manufacturer cut sheets for pull tape to be used on this project.

(6). Underground Marking Tape. Underground marking tape will be used in all areas where trenching is utilized to install underground conduit. Use marking tape in conjunction with marking posts and marking discs.

a. Requirements. The technical specifications of underground marking tape are identified below, along with applicable testing methods necessary to establish that a cable submitted for approval meets these specifications.

TEST PROPERTY	THRESHOLD SPECIFICATION	REQUIREMENTS
Standard Weight	ASTM D2103	20 lbs/100 feet
Thickness – Overall	ASTM D210	4 mil
3 in. Tensile Break – MD	ASTM D882	35 lbs/ft
3 in. Tensile Strength – MD	ASTM D882	4 kpsi
3 in. Tensile Break – TD	ASTM D882	38 lbs/ft
3 in. Tensile Strength – TD	ASTM 882	5 kpsi
Elongation – MD – MD	ASTM 882	530 %
Elongation – TD – TD	ASTM 882	660 %
Tear Strength	ASTM D2261	1.5 lbs/ft

b. Labeling Requirements for Underground Marking Tape. Underground marking tape will be a 3-inch wide, tear resistant, corrosion resistant elastic PVC orange tape, imprinted with the legend "SM FOC – CALL CITY OF HOUSTON 311". This legend will be printed every three (3) feet in black letters.

c. Submittal. Submit manufacturer cut sheets and all applicable documentation necessary to establish that the specifications are met for the underground marking tape to be used on this project.

(7). Underground Cable Marking Post and Marking Discs. Underground cable marking posts will be used everywhere feasible and practical in all areas where fiber optic cable is installed in underground conduit. This is the preferred method of marking, since it is very visible. Marking posts should be placed every 500 feet in urban area, and every 1000 feet in suburban areas, as well as at every intersection corner and every change in direction. Exception would be locations like downtown where all surfaces are paved, where discs would be more practical.

Use marking discs set in concrete or pavement where the use of marking posts is not feasible and practical, i.e., areas such as downtown where everything is paved and for aesthetics.

a. Requirements. Technical specifications of underground marking posts are identified below.

- Line Markers will be made from ultraviolet-stabilized High Density Polyethylene (HDPE)
- Minimum 3-1/2" O.D. tubular design
- Text will be hot-stamped into the fittings with an extra u-v clear coat.
- Crossing casing vents will be used to help maintain atmosphere conditions.
- Line markers will require no maintenance after installation.

b. Submittal. Submit manufacturer cut sheets for underground marking posts and discs to be used on this project.

C. Fiber Optic Connectors

(1). Requirements.

a. Fiber Optic Connectors will be field installed, SC compatible for single mode applications or ST compatible if specified as such on the plans. Ensure that all connectors are the same as the manufacturer's cable.

Connectors will be compliant with TIA/EIA 604 and have a tensile strength of 10 pounds, with ≤ 0.2 dB change.

Durability will be ≤ 0.3 dB change for 500 rematings per FOTP – 21.

b. Fiber Optic Connectors will not exceed the maximum loss listed below for each connector type:

Connector Type	Installation	Max. Loss
SC™ Single Mode	Field	0.50 dB (Insertion)
SC™ Single Mode	Field	≤ -40 dB (+18° C to +26° C) Reflectance

Connector Type	Installation	Max. Loss
ST™ Single Mode	Field	0.50 dB (Insertion)
ST™ Single Mode	Field	≤ -40 dB (+18° C to +26° C) Reflectance

(2). Submittal. Submit manufacturer cut sheets for fiber optic connectors to be used on this project.

D. Fiber Optic Adapters

(1). Requirements.

a. Fiber Optic Adapters will be SC type. If ST type adapters are specified on the plans ensure compatibility with ST style connectors.

SC

Body Parts	Metal or ceramic
Sleeve	Zirconia
Testing	TIA/EIA 604 and TIA 586 B.3 compliant

ST

Body Parts	Brass or Nickel Plated Brass
Body Construction	Precision-machined
Sleeve	Zirconia
Panel Thickness	0.06" minimum to 0.13" maximum
Withdrawal Force	200-600 grams
Testing	TIA/EIA 604 compliant
Durability	≥ 500 cycles per EIA 455-21

b. Adapter unit will include Nut, lockwasher, and dust cap.

E. Patch Cords

(1). Requirements. All fiber patch cords will meet National Electric Code (NEC) jacketing requirements for this project's application and will have outer jacket coloration of yellow for single mode patch cords. All duplex patch cords will be of a zip cord design and will have connector boots of two (2)

colors, namely white or off-white for one leg of the duplex cord (non-printed zip leg) and red for the opposite leg (printed zip leg) or the duplex cord.

Connector losses will not exceed those established in Section 2C(1)b.

No splices of any type are allowed within an assembly. Each assembly is to be fully tested and those test results placed on a test tag for each mated pair of connectors. Connectors will then be attached to one end of each pair within the assembly. Each assembly will be individually packaged within a plastic bag with the submitted manufacturer's part number marked clearly on the outside of said bag. Label each installed patch cord as directed by the Engineer.

(2). Submittals for Patch Cords

Submit catalog sheets, engineering drawings and specifications for patch cords for approval prior to commencement of work.

F. Equipment Racks and Bays. Install equipment racks and bays at designated locations as shown on the plans, as detailed in accordance with these specifications, and as directed.

(1). Requirements. Provide all new equipment in strict accordance with the details shown on the plans and in the specifications.

At the "head end" and hubs all distribution hardware, network electronics, video equipment, VDS processors, and all controllers and miscellaneous electronics will be mounted within a 7 feet high by 24 inch wide bay or cabinet for 19 inch wide mounting rack(s). Each installed and populated individual rack segment will be identified as a "bay". The primary structure material of each rack will be factory painted steel. Each rack will be field attachable to one another in a modular configuration. The frames themselves will be equipped with components that will allow for the field management of cables, jumpers and pigtails as may or may not be used in the interconnect system. All these components will be manufactured in such a way as to meet all fiber bend radius requirements. Above and below each rack will be an enclosed fiber management system allowing for proper field cross connect management. All rack ends will be sealed with "end caps" thus protecting any patch cords, cable, or pig tails which may be routed at that location. Between each rack will be mounted jumper management rings or loops that allow for the efficient management, routing, and protection of all cable patch cords/jumpers, or pig tails used within the rack system to interconnect the network electronics. Additionally, management troughs will be mounted at the top and bottom of each rack and ten made continuous as bays are attached.

(2). Submittal. Submit all manufacturer's cut sheets for equipment racks and bays.

G. Fiber Optic Cable Aerial Storage System. Install a Fiber Optic Cable Aerial Storage System at designated locations as shown on the plans, as detailed in accordance with these specifications, and as directed.

(1). Requirements. Provide all new equipment in strict accordance with the details shown on the plans and in the specifications.

Aerial Location. Used to store, and protect the minimum bend radius, of a surplus length of fiber cable at splice points, or for future expansion along aerial messenger span fiber optic cable installations.

- The storage units will be a snowshoe type, designed to maintain the minimum bending radius of the fiber optic cable indicated in the fiber optic cable specifications.
- The snowshoe storage units will be constructed of aluminum with continuous welds at crossbars and ends.
- Each snowshoe storage unit will be double coated with a baked on, polyester powder coat finish.
- Design snowshoe with 12" radius with a channel width (I.D.) of 1.25".
- Tie eyelets will accommodate both stainless steel and tie wrap securing methods.
- To counteract wind loading, aerial fiber optic cable storage units should be installed as close to span support poles as feasible.
- Do not install snowshoe above a roadway or driveway.
- All installation hardware including stainless steel mounting bolts, stainless nuts and washers are included.
- Ensure quantity of fiber optic cable stored is per plan drawings.

(2). Submittals for Fiber Optic Aerial Storage System

Submit catalog sheets, engineering drawings and specifications for a Fiber Optic Aerial Storage System to the Engineer for approval prior to commencement of work.

3. Construction. Install fiber optic cable without changing the optical and mechanical characteristics of the cables.

Perform all work in a workmanlike manner and meet the highest industry standards, and in accordance with the requirements of the latest editions of the NEC and National Electrical Safety Code.

A. Installation

(1). Installation Methods

Install fiber optic cable and communication equipment in accordance with the manufacturer's recommended practices.

Install fiber optic cable on poles or in conduits as specified in the plans. In conduits, if required, relocate existing cable to allow new fiber optic cable routing in conduits. When pulling the cable, do not exceed the bending radius. Ensure a minimum bend radius with no load at 10 x fiber optic cable diameter. Minimum bend radius at maximum stringing tension is 20 x fiber optic cable diameter. Use rollers, wheels, or guides that have radii greater than the bending radius. Provide separate grooved rollers for each cable when simultaneously pulling multiple cables. Use a lubricating compound to minimize friction. Use fuse links and breaks. Measure the pulling tension. Do not exceed a pulling tension of 2700 N (600 lbf).

Seal conduits with a two (2) part urethane after installing cable.

Bury an approved copper tracer wire directly above and along the entire length of the conduit as directed by the field engineer. Ensure tracer wire is continuous between communication service boxes.

(2). Fusion Splicing

Fusion splicing is the only approved splicing method.

Fusion splicing consists of aligning the cores of two clean (stripped of coating), cleaved fibers or a group of such fibers (mass splice) and fusing the ends together with an electric arc. The fiber ends are positioned under a microscope or a high resolution video monitor and then aligned using various precision movement micro-positioners (commonly stepping motors or piezoelectric devices). High voltage electrodes contained in the splicer conduct an arc across the fiber ends as the fibers are moved together, thus fusing the fibers together. Optimum core alignment will be verified prior to splicing and splice estimated devices and profile alignment algorithms. Fusion splicing equipment will provide the operator with reference estimated splice loss measurements. Further, it will automatically align fibers, determine cleave quality and fuse the fibers. No splice will result in a loss of more than 0.03 dB, as measured by an Optical Time Domain Reflectometer (OTDR) bi-directionally.

Maintain records of the OTDR measurements and submit this documentation to the City of Houston for review and final approval of the fiber optic cable plant. Perform optical power meter test on the single mode fiber at 1310 nm and 1550 nm. All testing requirements are detailed in Section 4.

4. Testing.

Perform tests in accordance with testing requirements in this Item. All optical fibers within each cable will be factory tested by the manufacturer for continuity and to establish the attenuation of each fiber prior to shipping. Testing will be conducted and the results documented in accordance with GR-20-CORE (Bellcore (Telcordia)) Issue 10. This testing will be conducted immediately prior to shipping while the fiber is on the reel and the results will be provided with each cable reel and affixed within the reel wrapping. An additional copy of the test documentation will be provided to the Engineer under separate cover. As a minimum, the results provided in these reports will indicate attenuation for each fiber in the cable in units of dB/km at both 1310 nm and at 1550 nm.

A. Test Methods.

(1). Optical Time Domain Reflectometer (OTDR) Tests. Use the OTDR to measure fiber optic cable for overall attenuation (signal loss dB/km), fiber cable length, and identify fiber optic cable anomalies such as breaks. Perform four (4) OTDR tests. They are as follows:

- Acceptance test
- Pre installation test
- Post termination test
- Final end to end test

OTDR Settings:

a. Use the file name of the fiber scan to indicate the location or direction the test was run from, as well as the fiber number being tested.

b. Set the "A" cursor at the beginning of the fiber trace and set the "B" cursor at the end of the fiber trace. The distance to cursor "B" indicates the length of the fiber cable segment being measured.

c. Match the index of refraction to the index of the factory report.

d. Set the loss indicator to dB's/km for the acceptance test.

e. The reflectance is automatically set internally by the OTDR.

f. Set the pulse width at a medium range. Change the pulse width to a slow pulse width when an anomaly occurs on the fiber trace so that it can be examined closely.

g. Set the average to medium speed. Change the average to slow speed when an anomaly appears on the fiber trace to allow for closer examination of the anomaly.

h. Set wavelength at 1310 nm and 1550 nm for singlemode cable so the cable is tested at both windows for each type of cable.

Show all settings on test result fiber scans.

(2). Optical Power Meter Test. Use the optical power meter test to check fiber optic cable for fiber optic cable anomalies such as breaks causing dB loss.

Test single mode fiber optic cable at both 1310 nm and 1550 nm. In order to evaluate results solely for the fiber optic cable, initially calculate loss from connector to connector and subtract this value when testing the fiber optic cable.

(3). Pre-Installation Tests. Test and record the fiber optic cable at the site storage area prior to installation.

Test each optical fiber in the cable from one end with an OTDR compatible with wavelength and fiber type. Check testing for length, point discontinuity, and approximate attenuation. Record each measurement by color, location, and type of fiber measured. Perform a measurement from the opposite end of that fiber in case a measurement cannot be made from one end. Wait for notification if loss per km exceeds manufacturer's test data by more than 0.5 dB/km or point discontinuity greater that 0.2 dB.

Perform this test within three (3) days from receipt of the fiber optic cable. Test overall attenuation (dB/km), total cable length, anomalies, or cable problems. Test cable at both windows (1310 nm and 1550 nm for single mode cable).

Compare factory test results against test results and return to manufacture if different. If identical, document the test results. Deliver documentation for future reference.

(4). Post Installation Tests. Immediately perform the post installation test after the fiber optic cable has been installed. Re-test and re-record each optical fiber in the cable after installation, before termination, for loss characteristics. Test both directions of operations of the fiber.

Test cable for overall attenuation, cable segment length, and damage. Use the same OTDR settings for Post Installation Test as the Pre-Installation

Test. Replace any cable segment that is damaged during the test and document test results. Deliver tests results for future reference.

(5). Post Termination Test. Perform the post termination test as the cable is terminated or spliced, whether there is termination of fiber cable to fiber cable or fiber cable to equipment. Check attenuation, fusion or termination point problems, and overall fiber cable segment. Determine if the attenuation and quality of the termination meets the specification; if not, repeat the termination until it meets specification requirements. Test the fiber segment for attenuation and anomalies after termination acceptance. Document and submit test results as stated in this Item after fiber segment acceptance.

Test the splices at 1310 nm for single-mode and provide printouts of the splice tests. Take tests in both directions and record the average.

Use a launch reel of the same type of fiber to test the fusion splices on pigtails.

Use the same OTDR settings for Post Termination Test as the Post Installation Test and Pre-Installation Test, except move the "B" cursor to the middle of the termination or splice point. After the termination, return "B" cursor to the end of the fiber segment and measure overall length and attenuation. Conduct Power Meter Test after termination of cable is completed.

(6). Subsystem Tests. Perform Network Subsystem Tests after integration to the fiber optic network. Test the capability of the fiber optic cable to transmit video and digital information. Complete and submit approved data forms for review and rejection or acceptance.

Correct and substitute components in the subsystem if the Subsystem Tests fail and repeat the tests.

Prepare and submit a report if a component was modified as result of the Subsystem Test failure. Describe in the report the failure and action taken to remedy the situation.

(7). Final End to End Test. Perform Final End to End Test on the entire system with both the OTDR and Power Meter after fiber cable segments of the system are terminated.

Perform the Final End to End Test:

- Measure the overall fiber cable system length.
- Measure the overall system attenuation, and

- Check for anomalies.

Document and submit results as stated in this Item, after test acceptance.

B. Test Procedures. Submit test procedures and data forms for the pre-installation, post-installation, subsystem, and system integration test for approval. Test procedures will require approval before performing tests. Submit one (1) copy of the data forms containing data and quantitative results, as well as an authorized signature. Submit a copy of the OTDR and Power Meter Test results as an electronic copy; supply original software packages and PC for OTDR results interpretation.

C. Submittals for Installation

Submit documentation including all OTDR, optical Power Meter Tests, and end-to-end attenuation tests performed on the as-built cable system. Submit three (3) units each of the hardware components/equipment required for the OTDR and the power meter tests to Engineer.

5. Documentation Submittal Checklist for Fiber Optic Specifications. This is a summary of the submittals included in this Specification.

A. Fiber Optic Cable Technician Qualifications

Submit documentation to ensure that Fiber Optic Cable Technician meets all requirements stated in Section 6A.

B. Fiber Optic Cable Manufacturer

Manufacturer ISO-9001 and TL 9000 Certification. Proof of compliance with Bellcore (Telcordia) GR-20-CORE, Issue No. 1 TL 9000. Documentation for each cable indicating that the cable is listed by the Rural Utilities Service (RUS), 7CFR 1755.900 or PE-90 if in transition to RUS. Manufacturing Site testing procedures and results.

C. Cable Documentation

Current Catalog Cut Sheet. Manufacturer's production cable cross section drawings. Manufacturer's confirmation letter listing the optical field cables. Current RUS "Listing Letter". Letter of certification for GR-20-CORETL 9000 compliance. Manufacturer's installation procedures and technical support information.

D. Packaging and Shipping of Fiber Optic Cable

Submit manufacturer's test results documented in accordance with GR-20-CORE Issue 10. Attenuation for each fiber in the cable in units of dB/km at both 1310 nm and 1550 nm.

E. Optical Fiber Materials

Documentation that cable meets all requirements of Section 2B(4) and manufacturer's SOP for installation.

F. Pull Tape

Manufacturer's cut sheets for pull tape.

G. Underground Marking Tape

Manufacturer cut sheets and documentation necessary to ensure that tape meets all specifications under Section 2B(6).

H. Underground Cable Marking Posts and Discs

Manufacturer's cut sheets for proposed posts and discs.

I. Fiber Optic Connectors

Manufacturer's cut sheets for fiber optic connectors for proposed use.

J. Patch Cords

Submit catalog sheets, engineering drawings and specifications for patch cords for approval.

K. Equipment Racks and Bays

Manufacturer's cut sheets for equipment racks and bays for proposed use.

L. Testing

Submit OTDR, Optical Power Meter, and end-to-end attenuation tests performed on as-built cable system.

6. Training Requirements for Technicians

A. Fiber Optic Cable Technician Qualifications

(1). Work To Be Performed By Fiber Optic Technicians
Any task requiring the opening of the fiber optic cable jacket, installation of fiber optic connectors, fusion splicing together of two fibers, or the testing of any fiber optic cable, drop cable, or patch cords will be performed by Fiber Optic Technicians that have been pre-approved by the Engineer.

(2). Minimum Requirements for Fiber Optic Technicians

Certifications – All fiber optic technicians will maintain Fiber Optic Installer Certification by the Electronic Technical Association (ETA) or approved equal. It should be noted that approved fiber optic technicians will maintain

all certifications on their person at all times while working on the subject project.

Training – All fiber optic technicians will be able to demonstrate their participation in at least one of the following:

a. Attendance and successful completion of at least one four day "Installation of Fiber Optic Products School" conducted by a major manufacturer of fiber optic products within one calendar year of the commence work date of this project. Said course outline will be submitted for review by the Engineer in order to determine if the course content is adequate to address the work requirements established in Section 6A(1).

b. Demonstration of attendance and successful completion of an independent generic four (4) day school that encompasses all aspects of outside plant fiber optic technician certification within one calendar year of the commence work date of this project. Said course outline will be submitted for review by the Engineer in order to determine if the course content is adequate to address the work requirements established in Section 6A(1).

Work History for Fiber Optic Technicians – All Fiber Optic Technicians who will perform work on this project will be able to demonstrate a minimum of three (3) years work experience, with a minimum of eighteen (18) months continuous work experience during this timeframe.

Work experience will be any work activity involving those work elements described in Section 6A(1).

B. Submittals for Fiber Optic Technician Qualifications

Submit to the Engineer all documentation necessary to demonstrate that all fiber optic technicians providing services on this contract meet the minimum requirements established in Sections 6A(1) and 6A(2), prior to the start of construction. Written approval of the technicians submitted for review by the Engineer is required prior to beginning any work on the fiber optic cable plant. Address any deficiencies noted by the Engineer prior to beginning any work on the fiber optic cable plant.

7. Measurement. This Item will be measured by the foot of cable furnished, installed, spliced, connected, stored, and tested.

8. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Fiber Optic Cable System" of the type, and number of fibers as applicable. This price is full compensation for furnishing and installing all cable; for relocating or removing cables as required; for pulling through conduit or duct; testing; for

installing cable along messenger cable; for minor relocation of messenger cable on poles; splicing; connecting; and for materials, equipment, labor, tools, documentation, warranty, training and incidentals.

END OF SECTION