SP- 232007
(New)

SPECIAL PROVISIONS
FOR
FIBER INSTALLATION

Black Hawk County
HDP-8155(775)--71-07

Effective Date
July 16, 2024

THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

232007.01 DESCRIPTION.

A. Scope.

1. It is the intent of this specification to provide for the construction of fiber, conduits and hardware.

2. Included items of work: All aspects of the fiber installation shall be in accordance with the manufacturer's recommendations and per the specifications herein. Where conflicts occur, this specification shall govern.

B. Submittals.
The following items shall be submitted:

1. Submit technical data sheets on each product used.

2. Contracting Authority is to review all material submittals related to the project. This includes, but is not limited to, relevant material specifications sheets that include manufacturer, part numbers, size, performance and shop drawings.

3. Allow a minimum of 5 working days for the Engineer to review.

4. All products seeking approval either as "approved equivalent" or otherwise, shall be submitted as a product substitution request prior to ordering. Failure to submit a product substitution request may preclude product from being utilized on the project. All product substitution requests are to be reviewed and approved by the Contracting Authority. Not all requests will be approved, and all decisions are final, without recourse.

5. SDS for all products used.

6. Manufacturer's installation recommendations.

7. **Field Quality Control and Final Acceptance Testing.**
   All systems shall be tested as defined within this document to include, conduit proofing, cabling continuity and splice loss, compaction of disturbed earth, and any additional requirements set forth as a conditional approval of permitting or as directed by the Contracting Authority.

8. **Testing**
   - **a.** The Contractor shall perform fiber testing on 100% of all fiber strands installed. Testing shall be completed using the following standards using equipment calibrated within the past 12 months.
   - **b. Post Installation Testing.**
     - **1)** All fiber strands shall be tested once they are in their final configuration. Test documentations shall be provided to the City as part of the project deliverables. Acceptance testing shall be completed utilizing two wavelengths of 1310 and 1550nm. Acceptance testing shall utilize both OTDR and Powermeter testing. OTDR test shall be delivered to the City in both raw trace format as well as .pdf copies. Powermeter test shall be documented and delivered on a Powermeter test form.
     - **2)** All backbone splicing shall have a bi-directional dB loss no greater than -0.20dB at each patch panel port. Testing for PON cabinets shall be uni-directional dB loss no greater than -0.20dB. All connectors shall have a dB loss no greater than -0.50dB.
     - **3)** In the event any fiber splice or termination test with a dB loss higher than the maximum loss, fiber splices shall be broken and re-spliced until allowable dB loss can be achieved. In the event a fiber stand has been re-spliced three different times and cannot meet these standards, an exception document shall be provided identifying the fiber, splice locations, and documentation showing the three attempts of re-splicing.

C. Delivery, Storage and Handling.

1. Construction materials shall not be stored in streets, roads, or highways for more than five days after unloading. All materials or equipment not installed or used in construction within five days after unloading, shall be stored elsewhere by the Contractor at their expense unless authorized additional storage time. Any damage to streets, roads, or highways will be repaired at the Contractor's expense.

2. Construction equipment shall not be stored onsite for more than five days prior to incorporating into the project. Time necessary for repair or assembly of equipment may be authorized by the Engineer.

3. Excavated material, except that which is to be used as backfill in the adjacent trench, shall not be stored in public streets unless otherwise permitted. After placing backfill, all excess material shall be removed immediately from the site.

4. The foregoing provisions are in addition to and not in limitation of any other rights or remedies available to the Contracting Authority.

232007.01 MATERIALS

The Contractor shall be responsible for providing materials necessary to complete all work described in the work order to deliver a complete and working system. Contractor shall provide cut sheets with material specifications to the City for all materials for approval prior to ordering.

A. General Guidelines.

All cable, unless specifically called out, shall be single-mode cable, rated for the environment in which it is installed. Installations shall be OSP rated dielectric.

1. **Preapproved Product Sets.**
   The following product sets are preapproved for this project. Except as noted, all others will require a substitution request to be completed and approved as per these documents. The Contracting Authority will not consider product sets that have not been preapproved or accepted as per the substitution request process.

2. Fiber-optic cable and connection/termination products shall be manufactured by one of the following:
   a. Optical Cable Corporation
   b. Corning
   c. OFS
   d. CommScope
   e. Or approved alternate

B. Fiber Optic Cable.
All cables shall be loose tube.

C. Bend Radius.
The main risk of damage to the fiber-optic cable is by overlooking the minimum-bend radius. It is important to know that the damage occurs more easily when the cable is bent under tension, so when the installation is in process be sure to allow for at least the minimum-bend radius. The number of 90-degree turns on a pull shall not exceed four.

D. Single-Mode Optical Fiber.
Each optical fiber shall be glass and consist of a doped silica core surrounded by concentric silica cladding. All fibers in the buffer tube shall be usable fibers and shall be sufficiently free of surface imperfections and occlusions to meet the optical, mechanical, and environmental requirements of these specifications. The coating shall be a dual layered, UV cured acrylate. The coating shall be mechanically or chemically strippable without damaging the fiber.

E. Buffer Tubes.

1. The loose buffer tubes shall be single or dual layered in construction. For single layer, use polypropylene. For dual layer, the inner layer shall be made of polycarbonate and the outer layer shall be made of polyester. Buffer tubes shall provide clearance between the fibers and the inside of the tube to allow for expansion without constraining the fiber. The fibers shall be loose or suspended within the tubes and shall not adhere to the inside of the tube. Each buffer tube shall contain 12 fibers based upon the total fiber count in the cable and the fiber assignment table as shown on the plans and these special conditions. No individual fiber tube shall contain more than 12 fibers. The number of buffer tubes for the fiber-optic cable shall be approved by the Engineer before ordering.

2. The loose buffer tubes shall be extruded from a material having a coefficient of friction sufficiently low to allow free movement of the fibers. The material shall be tough and abrasion resistant to provide mechanical and environmental protection of the fibers yet designed to permit safe intentional "scoring" and breakout, without damaging or degrading the internal fibers.

3. Dry buffer tubes are preferred. If gel fill fiber is needed the following shall be adhered to. Buffer tube filling compound shall be a homogenous, hydrocarbon-based gel with anti-oxidant additives. It shall be used to prevent water intrusion and migration. The filling compound shall be non-toxic and dermatologically safe to exposed skin. It shall be chemically and mechanically compatible with all cable components, non-nutritive to fungus, non-hygroscopic and electrically non-conductive. The filling compound shall be free from dirt and foreign

matter and shall be readily removable with conventional, nontoxic solvents.

4. Buffer tubes shall be stranded around a central member by a method such as the reverse oscillation stranding process that will prevent stress on the fibers when the cable jacket is placed under strain.

5. Each buffer tube shall be distinguishable from other buffer tubes in the cable by using the same color coding as specified for fibers elsewhere in this document.

F. Central Member.

The central member, which functions as an anti-buckling element, shall be a glass reinforced plastic rod with similar expansion and contraction characteristics as the optical fibers and buffer tubes. To provide the proper spacing between buffer tubes during stranding, a symmetrical, linear, overcoat of polyethylene may be applied to the central member to achieve the optimum diameter.

G. Filler rods.

Fillers may be included in the cable cross-section. Filler rods shall be solid medium or high-density polyethylene. The diameter of filler rods shall be the same as the outer diameter of the buffer tubes.

H. Stranding.

1. The buffer tubes shall be helically wrapped using the reverse lay stranding process around the central member in order to decouple the buffer tubes and optical fibers from the mechanical forces experienced during installation.

2. Completed buffer tubes shall be stranded around the central member using stranding methods, lay lengths, and positioning such that the cable shall meet mechanical, environmental, and performance specifications. A polyester binding shall be applied over the stranded buffer tubes to hold them in place. 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.

I. Core and Cable Water-Block Material.

The cable core shall use a dry, water-blocking material to block the ingress and migration of water. The water-blocking performance shall be equivalent to flooded optical cables when tested in accordance with industry standards (ICEA, RUS). Dry, water-blocking material is used in optical cables to enhance the ease of handleability while maintaining reliable water-blocking performance.

J. Tensile Strength Member.

Tensile strength shall be provided by high tensile strength Aramid yarns and/or fiberglass which shall be helically stranded evenly around the cable core and shall not adhere to other cable components.

K. Ripcord.

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

L. Outer Jacket.

1. The all-dielectric cables (no armoring) shall be sheathed with medium or high-density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and shall not adhere to the Aramid strength material. The polyethylene shall contain carbon black to provide ultra-violet light protection, and it shall not promote the growth of fungus. The jacket shall be free of holes, splits and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness.

2. The jacket or sheath shall be marked with the manufacturer's name, the words "Optical Cable", the number of fibers, fiber type, month and year of manufacture, and sequential measurement markings every meter. The actual length of the cable shall be within ±1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The print height of the marking shall be approximately 2.5 mm and must be permanent and weatherproof. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

M. Quality Assurance.
The manufacturer(s) of supplied optical cable, optical cable assemblies and hardware shall be TL 9000 registered.

N. Fiber Characteristics.

1. 100% of the optical fibers shall meet or exceed the requirements contained in this specification.

2. The cable shall be tested in accordance with TIA/EIA-455-3A (FOTP-3), "Procedure to Measure Temperature Cycling Effects on Optical Fiber, Optical Cable, and Other Passive Fiber-Optic Components." The average change in attenuation at extreme operational temperatures (-40°C to +70°C) shall not exceed 0.05 dB/km at 1550 nm. The magnitude of the maximum attenuation change of each individual fiber shall not be greater than 0.15 dB/km at 1550 nm. This figure includes an allowance of up to 0.05 dB/km for measurement repeatability. All fibers within the finished cable shall be composed primarily of silica and shall have a matched clad index of refraction profile as well as the physical and performance characteristics that shall meet the requirements in the following table:

Table 1 – Field Characteristics

Parameters	Value
Mode	Single
Type	SMF-28 or approved equal. See Materials A.2.
Core Diameter	8.3 µm (nominal)
Cladding Diameter	125 µm ± 1.0 µm
Core to Cladding Offset	≤ 0.8 µm
Coating Diameter	245 µm ±10 µm
Cladding Non-circularity defined as: [1- (min. cladding dia ÷ max. cladding dia.)]x100	≤ 1.0%
Proof/Tensile Test	100 kpsi, min.
Attenuation:	
@ 1310 nm	≤ 0.4 dB/km
@ 1550 nm	≤ 0.3 dB/km
Attenuation Uniformity	No point discontinuity greater than 0.1 dB at either 1300 nm or 1550 nm
Attenuation at the Water Peak	≤ 2.1 dB/km @ 1383 ±3 nm
Attenuation at Extreme Operational Temperatures	≤ +0.05 dB @ 1310 nm or 1550 nm
Chromatic Dispersion:	
Zero Dispersion Wavelength (λ_o)	$1301.5 \leq \lambda_o \leq 1321.5$ nm
Zero Dispersion Slope	≤ 0.092 spy/($nm^2 \bullet km$)
Maximum Dispersion:	≤ 3.5 peso/(nm•km) for 1285 - 1330 nm ≤ 18 spy/(nm•km) for 1550 nm
Cut-Off Wavelength	<1260 nm
Mode Field Diameter (Petermann II)	9.3 ± 0.5 µm at 1310 nm 10.5 ± 1.0 µm at 1550 nm

O. Color Coding.

1. Optical fibers shall be distinguishable from others in the same buffer tube by means of color-coding according to the following:

1. Blue (BL)
2. Orange (OR)
3. Green (GR)
4. Brown (BR)
5. Slate (SL)
6. White (WT)
7. Red (RD)
8. Black (BK)
9. Yellow (YL)
10. Violet (VL)
11. Rose (RS)
12. Aqua (AQ)

2. The colors shall be targeted in accordance with the Munsell color shades and shall meet TIA/EIA-598B "Color Coding of Fiber Optic Cables" and RUS 7 CFR 1755.900.

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

P. Splice Cases.

1. All splice cases used on this project shall be CommScope FOSC 450, PLP COYOTE Dome Closures, or Corning FDC closures. The following sizes shall be used:

- FOSC 450A – Holds up to 96 fiber splices
- FOSC 450B – Holds up to 144 fiber splices
- FOSC 450C – Holds up to 192 fiber splices
- FOSC 450D – Holds up to 576 fiber splices

2. All cases shall be sized to accommodate cable sizes that are housed in the splice case. Contractor shall include splice trays, label all fiber coming in and out of splice case, and protect each fusion splice with heat shrink protectors.

Q. Fiber-Optic Cable Termination Assemblies.

1. Cable termination assemblies (connectors, pigtails and couplers) shall be products of the same manufacturer. The cable used for cable assemblies shall be made of fiber meeting the performance requirements of these special conditions for the F/O cable being connected, except that the operating temperature shall be modified to -20°C to +70°C.

2. Manufacturer's attenuation test results shall be provided for all cable assemblies.

R. Optical Fiber Connectors.

1. All optical fiber termination components shall meet or exceed the applicable provisions of TIA/EIA-455-B, Standard Test Procedure for Fiber-Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber-Optic Components.

2. All backbone optical fiber connectors shall be of industry standard LC Ultra polished UPC, all PON applications shall be of industry standard SC Angle polished APC, type for single-mode optical fiber and shall meet or exceed the applicable provisions of TIA/EIA-455-2C (FOTP-2), Impact Test Measurements for Fiber-Optic Devices, TIA/EIA-455-5B (FOTP-5), Humidity Test Procedure for Fiber-Optic Components, and TIA/EIA-455-34A (FOTP-34), Interconnection Device Insertion Loss Test. When tested in accordance with FOTP –2, the connector assembly shall be subjected to ten impact cycles by being dropped from a height of 1.5 m. The maximum insertion loss measured before and after the impacts shall be $\leq$ 0.50 dB. The mean insertion loss of the before and after impacts shall be $\leq$ 0.30 dB. The insertion loss increase measured

before and after the impacts shall be ≤ 0.30 dB. The maximum reflectance measured before and after the impacts shall be ≤ - 40 dB. When tested in accordance with FOTP – 5, the connector assembly shall be subjected to test conditions of 75°C and 95% relative humidity for 7 days. Measurements of loss and reflectance shall be made at the beginning of the test, at a minimum of six-hour intervals during the test, and at the end of the test. The maximum insertion loss measured before, during or after the test shall be ≤ 0.50 dB. The mean insertion loss of the before, during or after the test shall be ≤ 0.30 dB. The insertion loss increase measured before, during or after the test shall be ≤ 0.30 dB. The maximum reflectance measured before, during or after the test shall be ≤ - 40 dB.

3. Optical fiber connectors shall satisfy all interface parameters of equipment components as may be defined by the transmission equipment specifications. All optical fiber connector assemblies shall be machine angle polished for low back-reflection and low insertion losses at both 1310 nm and 1550 nm wavelengths.

4. Single-mode pigtails shall be provided with factory pre-connectorized single-mode connectors of the "LC-UPC" type for backbone applications. Single-mode pigtails shall be provided with factory pre-connectorized single-mode connectors of the "SC-APC" type for PON applications. Connectors shall have maximum insertion loss of 0.5 dB or better. Connectors shall have a composite barrel with a “push-pull” connection design, ceramic (zirconia) ferrule. Each connector shall be capable of 200 repeated matings with a total maximum additional increase in insertion loss after 200 matings limited to 0.30 dB.

5. Each connector shall have a return loss (back reflection) equal to or better than 0.50 dB.

6. All connectors shall be factory-assembled and tested. There shall be no fabrication of connectors in the field.

7. All unmated connectors shall have protective caps installed.

S. Couplers.

Couplers shall be made of nickel-plated zinc or a glass reinforced polymer that is consistent with the material forming the associated IC connector body. The design mechanism for mounting the coupler to the connector panel may be flanged or threaded but shall coincide with the connector panel punch-outs. All coupler sleeves shall be ceramic of the split clamshell or clover leaf design. The temperature operating range for couplers shall be the same as that specified for the SC connectors.

T. Pigtails.

Pigtails shall be of simplex (one fiber) construction, in 900 μm tight-buffer form, surrounded by Aramid for strength, with a connector on one end. The outer jacket shall be yellow PVC with a nominal diameter of 3 mm, marked with the manufacturer’s identification information. All pigtails shall be of adequate length for the intended connection purpose, but not less than two meters in length. Pigtails installed in conduit shall follow the installation procedures outlined for fiber-optic cables, except that the pulling tension shall not exceed 110 pounds.

U. Fiber Termination Panels.

Fiber terminations shall be housed in a rack mounted fiber termination panel, sized appropriately for the cable size installed. All materials including fiber panel housing, pigtails, splice cassettes, trays, connector panels and all other materials required for a complete working system shall be provided by the Contractors and shall be included in Contractor pricing.

232007.XX CONSTRUCTION.

A. General.

1. During installation, use a swivel eye for pulling the fiber-optic cable and conduit system including use of a 600 pound breakaway.

2. Review the manufacturer's installation instructions prior to commencing with the installation. If any questions arise during installation, refer to the manufacturer's installation instructions or notify the project Engineer.

3. All fibers in the cables shall be usable fibers and shall be free of surface imperfections and occlusions, in order to meet or exceed all the optical, mechanical, and environmental requirements contained in this specification.

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

a. Interfere with the cable installation employing accepted cable installation practices.
b. Degrade the transmission performance and environmental resistance after installation.
c. Inhibit proper connection to interfacing elements.
d. Otherwise yield an inferior product.
e. Each fiber optic outside plant cable for this project shall be all-dielectric, dry water-blocking material, duct type, with loose buffer tubes, and shall conform to these special conditions.

5. Fiber-optic cables shall be supplied in the configurations shown on the plans and specified in these special conditions.

6. The optical fibers shall be contained within buffer tubes. The buffer tubes shall be stranded around an all-dielectric central member. Aramid yarn and/or fiberglass shall be used as a primary strength member and a medium or high-density polyethylene outside jacket shall provide for overall protection.

7. All fiber-optic cable on this project shall be from the same manufacturer who is regularly engaged in the production of optical fiber material.

8. The cable shall be qualified as compliant with Chapter XVII, of Title 7, Part 1755.900 of the Code of Federal Regulations, “REA Specification for Filled Fiber Optic Cables.”

B. Reel Placement.
Have the reel set adjacent to the handhole and use a fiber-optic manhole pulling block assembly.

C. Cable Slack.
Coil a minimum of 100 feet of cable for Mid-Cable access (MCA) and 55 feet of cable for reel ends and butt splices. Coils are to be made only at splice locations of locations indicating a storage loop.

D. Cable Tags.
All cables shall be tagged and labeled at each splice location, fiber termination panel and building entrance. Tags shall read cable size, count and origin and end (to and from).

E. Strength.
The fibers in the cable will shatter under considerable impact, pressure or if pulling tensions exceed 600 pounds, although not apparent from the outside of the cable. With fiber-optic cable the jacket of the cable and the Kevlar layer directly beneath give the cable its strength, note and repair all nicks and cuts.

F. Cable Marking.

1. The optical fiber cable outer jacket shall be marked with manufacturer's name, the month and year of manufacture, the words "Optical Cable," telecommunications handset symbol as required by Section 350G of the NESC, fiber count, fiber type and sequential meter marks. The markings shall be repeated every two feet. The actual length of the cable shall be within -0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The marking shall be approximately –0/+1% of the actual length of the cable in height and must be permanent and weatherproof.

2. The fiber-optic cable shall consist of, but not be limited to, the following components:
   - Single-mode optical fiber
   - Buffer tubes
   - Central member
   - Filler rods (as needed per cable type)
   - Stranding
   - Dry-filled, water blocking tape and water blocking yarn
   - Tensile strength member
   - Ripcord
   - Outer jacket

G. General Cable Performance Specifications.

1. The fiber-optic cable shall withstand water penetration when tested with a 1 meter static head or equivalent continuous pressure applied at one end of a 1 meter length of filled cable for one hour, no water shall leak through the open cable end. Testing shall be done in accordance with TIA/EIA-455-82 (FOTP-82), "Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable."

2. The cable shall exhibit no flow (drip or leak) for 24 hours at 80°C. The weight of any compound that drips from the sample shall be less than 0.05 grams. A representative sample of cable shall be tested in accordance with TIA/EIA-455-81B (FOTP-81), "Compound Flow [Drip] Test for Filled Fiber Optic Cable". The test sample shall be prepared in accordance with method A.

3. Crush resistance of the finished fiber-optic cables shall be 220 N/cm applied uniformly over the length of the cable without showing evidence of cracking or splitting when tested in accordance with TIA/EIA-455-41 (FOTP-41), "Compressive Loading Resistance of Fiber Optic Cables." The 220 N/cm load shall be applied at a rate of 2.5 mm per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm. Alternatively, it is acceptable to remove the 220 N/cm load entirely and apply the 110 N/cm load within 5 minutes at a rate of 2.5 mm per minute. The 110 N/cm load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm load. The change in attenuation shall not exceed 0.4 dB during loading at 1550 nm for single-mode fibers and 1.0 dB during loading at 1300 nm for multimode fiber. 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.

4. The cable shall withstand 25 cycles of mechanical flexing at a rate of 30 ±1 cycles/minute with a sheave diameter not greater than 20 times the cable diameter. The cable shall be tested in accordance with Test Conditions I and III of TIA/EIA-455-104A (FOTP-104), “Fiber Optic Cable Cyclic Flexing Test.” 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. The repeatability of the measurement system is typically ± 0.05 dB or less. The cable jacket shall exhibit no cracking or splitting when observed under 5X magnification.

5. Impact testing shall be conducted in accordance with TIA/EIA-455-25B (FOTP-25) "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies." The cable shall withstand 20 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. 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.

6. Using a maximum mandrel and sheave diameter of 560 mm, the finished cable shall withstand a longitudinal tensile load of 2700 N applied for 1 hour (using "Test Condition II" of the test plan). The test shall be conducted in accordance with TIA/EIA-455-33 (FOTP-33), "Fiber Optic Cable Tensile Loading and Bending Test." The measured fiber tensile strain shall be $\leq$ 60% of the fiber proof strain. The cable shall not experience a measurable increase in attenuation when subjected to the rated residual tensile load, 890 N. The repeatability of the measurement system is typically ± 0.05 dB or less.

7. The cable shall be capable of withstanding a bending radius of 15 times the cable diameter under tensile loading and ten times the cable diameter under a no-load condition.

H. Splicing.

1. General Guidelines.

a. This section describes minimum requirements for splicing and connecting of the specified optical fiber cables.

b. Fiber-optic cable shall be installed without splices except where specifically allowed on the plans or described in these special conditions. The single-mode fiber-optic cables used for distribution shall be spliced in pull boxes or at aerial slack locations as shown on plans. When splicing into a distribution cable, only those fibers associated with the count transferring onto the distribution cable shall be severed. All other fibers shall remain intact. The Engineer may allow additional splices between these specified locations.

c. At no point shall cables be severed out of the convenience of the installation contractor. Splices shall only be performed at planned locations. Any situation where this can be accomplished shall be preapproved prior to adding any additional splices to the network.

2. Labeling.

All splice cases, trays and fiber termination panels shall be properly labeled as to identify cable size, fiber count and routing of each fiber strand.

3. Splicing.

a. Optical fibers shall be spliced using the fusion splice method and the insertion loss shall not exceed 0.20 dB of loss per splice when tested using a bi-directional average.

b. All closures shall include all necessary hardware items to support the cable adjacent to the closure and to terminate the lashing wire (if aerial). The fiber organizer trays shall be supplied as part of the Splice Case Closure.

c. Cable closures shall be installed in accordance with the manufacturer's instructions. Splicing shall be performed in accordance with RUS Splicing Standard Bulletin 1753F-401 (PC-2).

d. Field splicing is permitted for the following:

1) Connection of cable reel sections.

2) Connection of a mainline service distribution cable to a service drop cable or a breakout cable.

3) Connection of service drop cable or breakout cable to an optical fiber pigtail at cabinets or the patch panels.

4) Connection of the backbone cable to an optical fiber pigtail at a hub patch panel.

e. The Contractor shall not exceed the maximum number of field splices permitted as shown in the plans. Completed splices shall be placed in a splice tray. The splice tray shall then

be placed in a watertight splice enclosure. Field splices shall be conducted only at locations as shown in the plans as an approved splice location.

f. All splicing equipment shall be in good working order, properly calibrated with calibration certificate showing proof of calibration within the past 12 months. Craftmanship shall meet all industry standards and safety regulations. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.

g. All splices shall be protected with a thermal shrink sleeve.

h. All fibers shall be labeled in the splice tray with permanent vinyl markers. Pigtail ends shall also be labeled to identify the destination of the fiber. Pigtail ends shall also be labeled to identify the destination of the fiber.

i. 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.

4. Photos.

Contractor shall take a photo of each splice tray and document as part of the deliverables with the test results. All photos shall be labeled with location, date, tech name, company, and description of the completed splice.

M. Underground Construction.

1. General Guidelines.

Governing Iowa Department of Transportation Standard Specifications will be used as well as all applicable codes in force.

2. Locates.

a. Contractor shall follow all state laws pertaining to the Locates rules and regulations.

b. Contractor shall call 811 at least two business days and not more than ten business days prior to excavations. Notification can be completed by utilizing one of the following methods:

- Call 811
- www.callbeforeyoudig.com

c. Contractor shall utilize sound judgement when completing underground utility excavations and installations. No guess work as to where existing utilities are located. All practical means necessary shall be utilized to locate existing utilities to include locates, soft digs and spot holes, and ground penetrating radar shall be considered to avoid conflicts. Contractor's pricing shall include these in their pricing as a cost of doing business.

3. Special Considerations.

a. All bore pits shall be compacted to 95% density in roadways, roadway shoulders, roadway prism and driveways and 85% density in unpaved areas.

b. The Contractor's trench safety system shall be a protective system designed and maintained by a competent person and shall meet accepted engineering requirements or practices. This trench safety system may require the use of a support system in locations not designated in the contract as requiring a support system.

4. Conduit Placement.

a. The standard quantity for the City's Backbone Network shall be a quantity of two 2 inch conduits. The conduit shall be placed as shown on the contract documents.

b. Warning Tape shall be required for all buried cable installation process except when directional boring operation are used and shall be as follows:

- Extra Stretch terra tape
- Minimum of six inches wide

- Orange in color with black lettering which reads “Caution Buried Fiber Optic Cable Below”
- Placed in the Trench a minimum of twelve inches above all conduit/ fiber.

5. Depth of Placement.

a. Unless otherwise specified by the contract documents, the depth of buried cable or wire placed shall be measured from the top of the cable or wire to the surface of ground or rock and must be as shown below:
  1) Minimum depth in soil (Mainline) – 42 inches.
  2) Minimum depth at ditch crossings – 42 inches.
  3) Minimum depth in rock – 24 inches.

b. In the case of a layer of soil over rock, either the minimum depth in rock, measured to the surface of the rock, or the minimum depth in soil, measured to the surface of the soil, may be used at the Contractor’s option.

c. When rock excavating is required, trench must be 24 inches deep and 10 inches wide (or greater).

d. Either the minimum depth in rock must be achieved or some other method may be employed by the Contractor to provide adequate protection to the cable or wire as agreed to by the Engineer, e.g. concrete cap.

6. Conduit Type.

a. Directional Boring/Plowing.

Conduit for directional boring shall be HDPE with a minimum rating of SDR 11 type.

b. Trenching.

Conduit type for open trench shall be PVC with a minimum rating of Schedule 40.

c. Innerduct.

Inner duct, where required, shall be of the corrugated type and orange in color. Inner duct requirements (size and amount) will be determined by the Engineer.

7. Conduit Turns and Transitions.

All conduit turns shall be made with 45 degree bends or sweeps. At no time shall 90 degree bends be utilized in the outside plant arena, unless it is already existing conduit, and approved by the City.

8. Conduit Proofing.

All conduit installed shall be proofed utilizing a mandrel and shall include the installation of a continuous, jet-line pull-string. Duct proofing shall ensure new conduit is continuous, free from dirt and debris and conduit is in good usable condition.

9. Trace Wire.

A No. 12 AWG insulated solid trace wire shall be placed along with all conduits put in place or pulled through one of the conduits installed. This trace wire shall maintain continuity from end station to end station. It is acceptable to use vaults/hand holds for joining the trace wire, while keeping these joints visible and out of the way of the fiber cable. Tracer wire shall only be installed in new conduit. Tracer wire is not needed on existing duct.

10. Marker Posts.

Easily visible, marked, HDPE orange dome fiber-optic marker posts shall be placed above the conduit at all major transitions to said conduit (turns greater than 25 degrees, etc.). Fink plated marker posts are required where necessary. Marker posts will display the City of Waterloo logo and will be marked “Underground Fiber Cable.” Fink test locations shall be installed and properly grounded at every splice location.

11. Conduit Entering Handholes/Manholes.

All conduits shall be stubbed up underneath the bottom of each handhole/manhole leaving at least 8 inches but no more than 12 inches of visible conduit exposed. Conduit and inner ducts

shall be capped until use. After use they shall be plugged appropriately to maintain the integrity of the conduit/inner duct from dirt and water.

12. **Locate Information.**
All splice points, vaults, handhole/manhole, and conduit turns of 45 degrees or greater shall receive a GPS coordinate that is marked and labeled back onto the as-built plans.

13. **Box Sizing.**
All boxes utilized MUST meet the Standard Specifications and be on the DOT approved equipment list. Handholes shall be polymer composite 24 inches by 36 inches, concrete base and lid, Tier-15 rating lid and 20k load rating. The following sizes are to be used unless specifically called out for in the design:
- 17 inches by 30 inches by 24 inches (20K Load)
- 24 inches by 24 inches by 24 inches (20K Load)
- 24 inches by 36 inches by 24 inches (20K Load)
- 30 inches by 48 inches by 24 inches (20K Load)

14. **Box Spacing.**
a. Handholes and vault spacing on backbone shall be installed as designed. If any adjustments in location of handholes needs to be made, new location needs to be preapproved by the Engineer.
b. As an overall guideline, handhole spacing on the backbone shall be held to a maximum distance of 1000 feet between handholes to assist in pulling and access to the network. Any 90 degree turn, major intersection of place of future connectivity or splice locations will also require a handhole or vault to be placed.

15. **Box Placement.**
a. All handholes and vaults shall be installed flush with the existing grade unless otherwise specifically directed. Box installation shall include a 6 inch base or crushed stone or gravel for drainage purposes. Any earth disturbed in the immediate area surrounding the box shall be compacted to avoid any future wash outs. All box, handholes, vault installations shall include all restoration. Box pricing shall also include placement of all bolts to secure lid.
b. Have all boxes approved prior to purchasing/installation of said boxes per the material submittal requirements. All box lids shall have “FIBER” embedded on them.

232007.XX METHOD OF MEASUREMENT.

A. Fiber Handholes.
By Count.

B. Fiber Conduit.
Linear feet shown in the contract documents.

232007.XX BASIS OF PAYMENT.

A. Fiber Handholes.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, and installation of the handholes and junction boxes.

B. Fiber Conduit.

1. Per Linear Foot.

2. Payment is full compensation for materials, equipment, excavation, and installation of the conduit and the wiring/cables between the handholes.