



**DEVELOPMENTAL SPECIFICATIONS
FOR
INTELLIGENT TRANSPORTATION SYSTEMS**

**Effective Date
June 20, 2023**

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

15106.01 DESCRIPTION.

A. This section includes furnishing all work, apparatus, and materials to construct, install, and place in operation, to the Engineer's satisfaction, a complete ITS as shown in the contract documents.

B. Definition of Abbreviations.

AC – Alternating Current
AWG – American Wire Gauge
CSR – Combined Stress Ratio
EMT – Electric Metallic Tube
GFCI – Ground Fault Circuit Interrupter
IP – Internet Protocol
ITU-T - International Telecommunications Union – Telecommunications Standardization Sector
LED – Light Emitting Diode
MVDS - Microwave Vehicle Detection System
NOC – Network Operations Center
OSP – Outside Plant
RMS – Root Mean Square
SC – Subscriber Connector
SCTE - Society of Cable Telecommunications Engineers
SM – Single Mode
TMC – Traffic Management Center
UPC - Ultra-Physical Contact
UV – Ultraviolet
XHHW - Cross-linked Polyethylene, High Heat and Water Resistant

C. Special Requirements.

1. Comply with NEC, latest edition adopted by the State of Iowa.
2. Comply with TIA latest editions.

3. EIA latest editions.
4. IEEE Standards and Practices.
5. ANSI Standards and Practices.
6. NEMA Standards.
7. UL Standards.

D. Submittals.

1. Material List.

Complete and submit one electronic pdf file of the materials list to the project Engineer within 14 calendar days after award of the project contract. Include the name of the materials, supplier and catalog number of each item listed.

2. Construction Schedule.

- a. Fourteen calendar days before the preconstruction conference, submit to the Engineer one electronic pdf file of the detailed construction schedule including dates of commencement for each major work item, duration of each major work item and completion of each major work item on each segment of the proposed construction.
- b. Major items of work to be included on the schedule shall include, but are not limited to the following:
 - Duration of material procurement,
 - Installation of conduit, handholes, building entrances, and fiber optic cable,
 - Bridge attachments,
 - Installation of device cabinets, foundations, and poles,
 - Installation and energizing of power,
 - Splicing and termination of fiber optic cables, and
 - Duration of fiber testing and submission of test reports.
- c. The construction schedule shall comply with [Section 1108](#) of the Standard Specifications. In addition to limitations of operations in [Article 1108.03](#) of the Standard Specifications, work shall not be performed that may result in an unplanned network disruption during an ICN moratorium date. Request moratorium dates from the ICN NOC at ICNServicedesk@iowa.gov, 1-800-572-3940, or 515-725-4400.
- d. Coordinate with the ICN NOC to schedule all splicing work.
- e. Upon acceptance of the schedule, the Contractor will be expected to adhere to these dates as proposed unless modified with the approval of the Engineer.
- f. Submittal and approval of the proposed construction schedule by the Engineer is required before the Contractor can commence construction activities.
- g. The cost of preparing and revising the construction schedule shall be included in the bid item for Mobilization.

3. Shop Drawings.

- a. Before any items are ordered or installation is started, submit the following list of shop drawings for approval according to [Article 1105.03](#) of the Standard Specifications:
 - Power Installed Foundation.
 - Pole.
 - Transformer Base.
 - Pole Mount Cabinet Mounting Assemblies.
 - Cabinet Foundation.
 - Cabinet.
 - HDPE Conduit.

- Schedule 80 HDPE Conduit.
 - Conduit Splice Kit.
 - Rigid Steel Conduit and Fittings.
 - Duct Plugs.
 - Duct Seal.
 - Handholes.
 - Test Stations.
 - Fiber Markers.
 - Ground Rods.
 - Exothermic Welding Kit.
 - Copper Cable (Power).
 - Copper Cable (Ground).
 - Tracer Wire.
 - Tracer Wire Splice Kit.
 - Fiber Optic Cable.
 - NEMA 3R 240/120 1.0 kVA Transformer.
 - Meter Pedestal.
 - OTDR Meter with Calibration Certificate from Manufacturer within last year.
 - Fusion Splicer with Calibration Certificate from Manufacturer within last year.
 - Fiber Optic Splice Closure.
 - Fiber Optic Splice Tray.
 - Module Connector Housing Splice Cassettes.
 - Connector Adaptor Panel.
 - Single Panel Housing.
 - Fiber Connector and Pigtails.
 - One Rack Unit Connector Housing.
 - Four Rack Unit Connector Housing.
 - Cameras.
 - Sensors.
 - Additional drawings may be required on a project specific basis in accordance with the contract documents.
- b.** Submittal for power installed foundation shall include all structural calculations and be accompanied by a shop drawing that at a minimum illustrates a schematic of the foundation with a summary of the design criteria, material data, foundation data and orientation details. Design calculations and shop drawing for power installed foundation shall be sealed by a Professional Engineer licensed in the State of Iowa.
 - c.** Submittal for poles shall include all structural calculations and be accompanied by a shop drawing that at a minimum illustrates a schematic of the proposed pole and transformer base with a summary of the design criteria, material data, pole data and details of handholes, pole top, pole base and pole orientation. Design calculations for poles and transformer bases shall be sealed by a Professional Engineer licensed in the State of Iowa.
 - d.** The Engineer will review the shop drawings/catalog cuts for the purpose of assuring general conformance with the project design concept and contract documents.
 - e.** The Engineer will provide approval or rejection of shop drawings within 14 calendar days of the Contractor's submission. Re-submit the shop drawings for approval within 7 calendar days of the Engineer's rejection.
 - f.** Provide written notice of any deviations from the requirements of the contract documents or Special Provisions.
 - g.** Engineer's approval of shop drawings/catalog cuts does not relieve the Contractor of responsibility for providing satisfactory materials complying with the contract documents. Errors not detected during review do not authorize the Contractor to proceed in error.
 - h.** Order all materials requiring production lead time greater than 4 weeks within 7 calendar days of receiving the approved shop drawing(s).
 - i.** Submit to the Engineer proof of material purchase order in electronic PDF format.

4. Warranty.

- a. Transfer all required standard materials warranties on the date of final acceptance to the Contracting Authority.
- b. Warranty periods shall not commence prior to final acceptance of the work and shall remain in effect until at least 1 year after the final acceptance for all cables and equipment furnished and installed for the project.

E. As-Built Documentation.

1. General.

- a. Maintain written records of daily construction progress, areas worked, and quantities installed to aid in the completeness of as-constructed documentation.
- b. Provide as-built documentation package with the following:
 - 1) Documentation of fiber cable sequentials at building entrances, cabinets, and in/out of handholes.
 - 2) Master record set of plans (maintained throughout construction) documenting any deviations from the design shown in the original contract documents.
 - 3) Confirmation that splicing was completed as planned or redline corrections on how it was spliced.

2. GPS Data Recording Staking Assistance.

- a. The Engineer will be responsible for collecting GPS data of all installations including, but not limited to, conduit and/or cable routing and handholes.
- b. Coordinate and assist the Engineer in this effort by staking, flagging or otherwise locating all installed features until such time that the GPS data can be collected.
- c. Mark the conduit alignment at least every 50 feet to allow GPS data to be collected. For any segments that are bored, make note on the flag or stake of the bore depth at the location that is being marked.
- d. The cost of GPS data recording staking assistance shall be included in the bid item for Mobilization.

15106.02 MATERIALS.

A. General.

1. Provide any items, equipment, or materials not specifically addressed in the contract documents but required to provide a complete and functional installation. The level of quality shall be consistent with other specified items. All miscellaneous electrical equipment and materials shall be listed for its specific application.
2. Material requirements apply to new construction, relocation, and maintenance of the Intelligent Transportation System.

B. ITS Construction Survey.

1. General.

ITS construction survey includes equipment and supplies required for fiber optic conduit path and ITS construction surveying and staking necessary for construction of the project as shown in the contract documents.

2. Lath.

Provide wood lath that is approximately 3/8 inch thick by 1 1/2 inches wide by 48 inches long

3. Survey Equipment.

Utilize survey equipment with a level of accuracy that will result in less than 6 inches of error horizontally.

C. Power Installed Foundation.

1. General.

- A. This specification is for a power installed foundation compatible for use with, and support of, 45 foot steel breakaway poles.
- B. Foundations and baseplate should be of steel construction.
- C. Ensure the foundation and baseplate are hot dip galvanized inside and out according to ASTM A153.
- D. After galvanizing, the manufacturer identification and fabrication date shall be permanently stamped to the baseplate in minimum 1/2 inch letters.
- E. The manufacturer shall utilize industry recognized written quality control for materials and manufacturing processes.

2. Fabrication Specifications.

- a. All foundations shall be designed in accordance with the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 2013."
- b. Mill certifications shall be supplied as proof of compliance with the specifications. The Fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the AISC Quality Certification Program. All welding shall be in accordance with [Article 2408.03, B](#) of the Standard Specifications. Tackers and welders shall be qualified in accordance with the code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected. Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt-welded pole and arm splices shall be ultrasonically or radiographically inspected.
- c. The baseplate shall be perpendicular to the shaft axis (± 1 degree) and hole and concentric (± 0.188 inches) to shaft axis.
- d. Pilot point and shaft axis to be concentric (± 0.125 FIM) and in line (± 2 degrees)
- e. Preheat, tumbleblast, handgrind, and clean baseplate on all welded areas prior to galvanizing.
- f. All material is to be new, unused and mill traceable meeting the following specifications:

Baseplate: ASTM A36 (Latest Revision) Structural Steel (Conform to AASHTO Tech. Bul. No. 270)

Shaft: ASTM 252 (Latest Revision) Grade 2, steel pipe piles.
 Alternate material: ASTM A53 (Latest Revision) Type E or S, Grade B, steel pipe
 OR
 ASTM A500 (Latest Revision), Grade B, structural steel tubing

Helix: ASTM A635 (Latest Revision) 1/2 inch thick hot rolled steel plate or coil.

Pilot Point: ASTM A575 (Latest Revision) 1 1/4 inch diameter hot rolled steel bar.

- g. Two slots with minimum dimensions of 2.5 inches in width and 12 inches in length shall be cut into the shaft of the foundation, perpendicular to the base plate to allow for conduit entry during installation. The top of these conduit entryway openings shall be 12 inches from the bottom of the base plate.
- h. The baseplate shall be permanently marked to indicate the conduit entryway openings in the shaft.
- i. An 8 inch diameter hole shall be constructed in the baseplate to allow access between the shaft and pole foundation.
- j. The bolt circle of the foundation shall be variable such that it will be compatible with the bolt circle of the pole design.

- k. At a minimum, the foundation base plate thickness shall match the base plate thickness of the pole in the contract documents.

3. Design Calculations.

- a. The device loadings specified in this document shall be used in all AASHTO design calculations. Calculations and detailed drawings shall be submitted demonstrating compliance with the AASHTO specification.
- b. Assume a soil profile of uniform cohesive soil (sand) with an angle of internal friction of 30 degrees and a unit weight of 100 pounds per cubic foot. Also, assume the water table is at a depth that will not affect lateral capacity.
- c. Using the determined loads and assumed soil profile, the size of the foundation (shaft diameter, shaft length, base plate thickness, etc.) needed for adequate service shall be calculated using Broms Method for Lateral Pile Support.
- d. A minimum factor of safety of 2.5 shall be used when recommending an adequate foundation.

D. Poles.

1. General

- a. All poles shall be tapered steel poles, 45 feet in length (excluding the transformer base).
- b. Poles shall satisfy the requirements of [Article 1107.06](#) of the Standard Specifications.
- c. The poles shall be designed to satisfy deflection requirements.
- d. The poles shall be provided with two handholes with removable covers. The handhole openings shall be reinforced with a minimum 0.432 inch wide hot rolled steel rim. The first handhole shall be located 1.5 feet above the base plate (measured from bottom lip of handhole) and have minimum outside dimensions of 6 inches by 10 inches. The second handhole shall be oriented directly above the first handhole but located 40 feet above the baseplate (measured from bottom lip of handhole) and have minimum outside dimensions of 3 inches by 5 inches.
- e. Ensure each pole has an approved grounding provision for use during installation and that it is accessible and will function as intended after the galvanization process. Ensure the grounding lug is readily accessible through the handhole and from the bottom of the pole shaft.
- f. Poles shall include a removable end cap at the top of the pole with a J-hook cable support above the upper handhole.
- g. Ensure the poles and base plates are hot dip galvanized inside and out according to ASTM A123.
- h. Unless otherwise noted in this specification, materials shall meet the applicable minimum requirements of [Section 4185](#) of the Standard Specifications.

2. Pole Design Calculations and Fabrication Specifications

- a. All poles shall be designed in accordance with the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 2013".
- b. The device loadings specified in this document shall be used in all AASHTO design calculations and pole deflection evaluations and the poles shall be capable of withstanding winds up to 90 mph with a 1.14 gust factor without failure. Calculations and detailed drawings shall be submitted demonstrating compliance with the AASHTO specification.
- c. Mill certifications shall be supplied as proof of compliance with the specifications. The Fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification will be required to ensure that the fabricator has the personnel, organization, experience, procedures, knowledge, equipment, capability and commitment to fabricate quality pole structures. All welding shall be in accordance with [Article 2408.03. B](#), of the Standard Specifications. Tackers and welders shall be qualified in accordance with the code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected. Longitudinal welds

suspected to contain defects shall be magnetic particle inspected. All circumferential butt-welded pole and arm splices shall be ultrasonically or radiographically inspected.

- d. All poles shall be designed to support the specified camera, sensor and device cabinet and shall be stiffened or otherwise manufactured to meet allowable deflection criteria contained herein. Pole design shall assume the following loadings. All mounting heights are measured from the base of foundation to bottom of equipment.

Radio Communication Equipment and Mounting Bracket

Weight: 10 pounds
Surface Area: 3 square feet
Mounting Height: 44 feet

Camera and Mounting Bracket

Weight: 12 pounds
Surface Area: 1.5 square feet
Mounting Height: 40 feet

Roadway Sensor

Weight: 4.2 pounds
Surface Area: 1.5 square feet
Mounting Height: 25 feet

Device Cabinet

Weight: 600 pounds
Surface Area: 6 square feet
Mounting Height: 5 feet

- e. The pole top deflection shall not exceed 1 inch in a 30 mph (non-gust) wind. Close consideration must be given to the effective projected area of the equipment along with the weight when designing the pole to meet the specified deflection performance criteria. The calculations shall include a pole, base plate, and anchor bolt analysis. The pole calculations shall be analyzed at the pole base, at 5 foot pole intervals/segments and at any other critical pole section. At each of these locations, the following information shall be given:
- The pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.
 - The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each pole segment.
 - The axial force, shear force, primary moment, total moment, axial stress, bending stress, allowable axial stress, allowable bending stress, and combined stress ratio (CSR).
 - The pole's angular and linear deflection.
- f. All pole shafts shall have a minimum yield strength of 55 ksi and conform to ASTM A595 Grade A or ASTM A572 Grade 55. The shaft shall have a constant linear taper and contain only one longitudinal seam weld. Circumferential welded tube butt splices and laminated tubes are not permitted. Longitudinal seam welds within 6 inches of base plate welds shall be complete penetration welds.
- g. Base plates shall conform to ASTM A36. Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration butt weld with backup bar.
- h. Anchor bolts shall conform to the requirements in [Article 4185.02, B, 2](#) of the Standard Specifications.

E. Cabinet Foundations.

All concrete shall meet the requirements of [Section 2403](#) of the Standard Specifications. Use Class C concrete for cabinet foundations and all other non-paving concrete construction.

F. Device Cabinets.

1. General.

- a. Cabinets shall be dimensioned as identified in the contract documents.
- b. Cabinets shall be corrosion resistant, NEMA Type 3R compliant, constructed of welded sheet aluminum with a minimum nominal thickness of 1/8 inch.
- c. Cabinets shall be complete with all required internal components, fully wired back panel, side mount DIN rails, terminal strips, and stainless steel hardware.
- d. Cabinets shall meet the requirements of ASTM B-209 for 5052 H-32 aluminum sheet. The aluminum shall be smooth and the exterior shall be left in its unpainted natural color.
- e. The cabinet shall be effectively sealed to prevent the entry of rain, dust, and dirt.
- f. All exterior seams for cabinet and doors shall be continuously welded.
- g. Edges, seams, fittings, and hardware shall be finished free from burrs and sharp edges.
- h. Use Type 316 stainless steel for all mounting hardware.
- i. Use 3/4 inch wide and 0.03 inch thick banding for pole mounted cabinets.

2. Cabinet Doors.

- a. The cabinet door shall be sturdy, torsionally rigid, and attached by a continuous heavy duty stainless steel butt hinge. The door shall substantially cover the full area of the front of the cabinet and have a stainless steel, pad-lockable handle.
- b. The cabinet door shall be provided with a door stop catch mechanism to hold the door open at three positions; 90 degrees, 120 degrees and 180 degrees. Both the door and door stop mechanism shall be of sufficient strength to withstand a wind load of 5 pounds per square foot of door area applied to both inside and outside surfaces.
- c. A closed-cell neoprene gasket shall be provided to act as a permanent and weather resistant seal at the cabinet door facing. The gasket material shall be of a non-absorbent material and shall maintain its resiliency after long-term exposure to the outdoor environment. The gasket shall have a minimum thickness of 1/3 inch. The gasket shall be located in a channel provided for this purpose either on the cabinet or on the door. An "L" bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniformly dust and weather resistant seal around the entire door facing.
- d. LED cabinet light shall be provided and operated by door switch.
- e. Each cabinet door shall be provided with a high quality, heavy duty tumbler-type lock. Two, No. 2 keys for each tumbler lock shall be provided for each cabinet. All locks for the project shall be keyed identically to key pattern 9R46142 or as otherwise identified by the Engineer. Keys shall be given to the Engineer. Do not attach keys to the exterior of the cabinet at any time during storage or installation.
- f. A heavy-duty clear plastic envelope shall be provided, securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet wiring diagrams and equipment manuals. Minimum dimensions shall be 9 inches wide by 12 inches deep.

3. Electrical Components, Connecting Cables and Wiring.

- a. Provide cabinets equipped and configured with internal power components as shown in the contract documents.
- b. One four position service entrance terminal block with tin plated aluminum connectors, nickel plated steel screws, and a current rating up to 70 Amps.
- c. One 20 Amp single pole breaker (Main).
- d. One 15 Amp single pole breaker (Equipment).
- e. One 15 Amp single pole breaker (Auxiliary).
- f. One 120/240 VAC surge protector with surge current at minimum of 100 KA, nanosecond response time, and an operating temperature of -40°F to +185°F.
- g. One auxiliary four-terminal electrical block rated for a maximum 250 VAC RMS maximum voltage and 20 Amps current.
- h. One 15 Amp GFCI receptacle in Ivory color.
- i. One 15 Amp Duplex receptacle in Ivory color.

- j. One ten outlet, remotely resettable, Power Distribution Unit with eight individually switched circuits and two unswitched (always on) outlets. Built in surge suppressor, lithium-ion battery, resettable circuit breaker, minimum cord length of 6 feet, and a 10/100 autosensing, Static IP, RJ-45 Ethernet Interface.
 - k. One seven TAP Ground Bar.
 - l. One seven TAP Neutral Bar.
 - m. All miscellaneous wiring, harnesses connectors and attachment hardware.
 - n. All conductors used on the cabinet wiring shall be No. 14 AWG or larger with a minimum of 19 strands. Conductors shall conform to NEC.
- 4. Ventilation.**
- a. Vents.**
 - 1) Furnish cabinets containing a suitably designed rain tight vent or vents that:
 - a) Are equipped with suitable screens or dust filters, and
 - b) Allow the release of excessive heat and/or any explosive gases which may enter the cabinet.
 - 2) Ensure when filters are utilized, positive retainment is provided on all sides to prevent warpage and entry of foreign matter around the edges.
 - 3) The filters shall be dry type, easily removed and replaced, and standard dimensions commercially available.
 - b. Vent Fan.**
 - 1) A thermostatically controlled vent fan is furnished to provide air circulation within the cabinet.
 - 2) The thermostat controlling the fan is manually adjustable to turn on between 90°F and 150°F with a differential of not more than 10°F between automatic turn on and turn off.
 - 3) The fan is located with respect to the vent holes to direct the bulk of the air flow over the internal components within the cabinet.
 - 4) Ventilation fan shall be fused separately and wired after the main AC+ circuit breaker.
- 5. Grounding.**
- a. The cabinet internal ground shall consist of one or more ground bus-bars permanently affixed to the cabinet and connected to the grounding electrode.
 - b. Use bare stranded No. 6 AWG copper wire between bus-bars and between the bus-bar and grounding electrode.
 - c. Each copper ground bus-bar shall have a minimum of 20 connector points. Each connector point shall be capable of securing at least one No. 6 AWG conductor.
 - d. AC neutral and equipment ground wiring shall return to bus-bars.
- 6. Pedestal.**
- a. Clean-cut in design and appearance to match cabinet.
 - b. Dimensioned as identified in the contract documents.
 - c. Corrosion resistant, NEMA Type 3R compliant, constructed of welded sheet aluminum with a minimum nominal thickness of 1/8 inch.
 - d. Complete with all stainless steel hardware.
 - e. Meet the requirements of ASTM B-209 for 5052 H-32 aluminum sheet. The aluminum shall be smooth and the exterior shall be left in its unpainted natural color.
 - f. Effectively sealed to prevent the entry of rain, dust, and dirt.
 - g. All exterior seams shall be continuously welded.
 - h. Edges, seams, fittings, and hardware shall be finished free from burrs and sharp edges.
- G. Conduit.**
- 1. High Density Polyethylene Conduit.**
 - a. HDPE conduit shall be smooth wall and orange in color for communications.
 - b. HDPE conduit shall be smooth wall and orange, red, or black with a red stripe in color for power. Verify conduit color requirements with local electrical utilities.

- b c.** Comply with ASTM F 2160 (conduit) and ASTM D 3350 (HDPE material), minimum SDR 13.5 or 11 as specified in the contract documents.
- c d.** Sequential foot markings printed on HDPE.
- d e.** Continuous reel or straight pieces to minimize splicing.
- e f.** For dissimilar conduit connections provide an adhesive compatible with both materials.

2. Rigid Steel Conduit

Comply with [Article 4185.09](#) of the Standard Specifications.

3. Electric Metallic Tube Conduit

- a.** Listed and labeled in accordance with NEC.
- b.** EMT conduit shall be steel.
- c.** Comply with UL 797 and UL Category Control Number FJMX.
- d.** Zinc alternate corrosion-resistant coating exterior.
- e.** Zinc with organic top coating interior coating.
- f.** EMT fittings shall comply with UL 514B and UL Category Control Number FKAV.
- g.** EMT fittings shall be steel die cast.
- h.** Coupling shall use compression coupling or raintight compression coupling with distinctive color gland nut setscrew coupling. Setscrew couplings with only a single screw per conduit is unacceptable.

H. Handholes.

1. General.

- a.** Constructed of epoxy or polyester resin mortar with woven glass fiber reinforcement.
- b.** Handhole materials shall not support combustion when tested in accordance with ASTM D 635.
- c.** Water absorption shall not exceed 2% of the original weight of material under test conditions per ASTM D 570.
- d.** Functional without failure throughout a temperature range of -50°F to +170°F.
- e.** Walls shall not deflect more than 0.24 inches per foot of length of box when installed and subject to an ASTM C 857 TIER 22 load.
- f.** Meet or exceed ANSI/SCTE 77 requirements.
- g.** Lid strength shall be tested to 33,750 pounds (Tier 22).
- h.** Lid shall have skid resistant surface.
- i.** Label all handhole lids. ITS 36x24x36 and ITS 48x30x36 handhole shall be labeled as 'FIBER OPTIC'. ITS 30x17x24 handhole lids shall be labeled 'ELECTRICAL'.

2. Test Station.

- a.** 78 inch triangular flexible orange plastic marker with five separate access terminals, isolation lever, and set screw to hold terminal concealment cap on.
- b.** Orange in color with a black cap.
- c.** Place Engineer approved custom warning decals on all sides.
- d.** Use bare stranded No. 6 AWG copper wire between terminal board and the ground rod.
- e.** An Isolation Ground Switch is an alternative when above ground test stations cannot be used. Supply isolation ground switches to mount on the interior of handholes. This alternative shall only be used at locations specified in the contract documents.

3. Ground Rod.

- a.** Use copper bonded steel ground rod.
- b.** Ground rod shall be 5/8 inch by 8 feet.

4. Fiber Marker.

- a.** Supply triangular post markers orange in color with an orange cap.
- b.** Markers shall be 78 inch, polyester resin with reinforcing fibers, and remain flexible from -40°F to +140°F.

- c. Place Engineer approved custom warning decals on all sides.

I. Wire and Cable.

1. Power Wire.

Comply with [Article 4185.11](#) of the Standard Specifications.

2. Tracer Wire.

- a. Single conductor copper clad steel, No. 10 AWG with orange colored HDPE jacket.
- b. Use a direct bury, self-stripping, locking connector system used for making connections to underground tracer wire systems on all mainline and lateral connections.
- c. Use locking tracer wire connectors compatible with No. 10 AWG copper clad steel wire.
- d. Use one-piece connectors that utilize mechanical compression.
- e. Use a sealed wire connection system for use in damp, wet, raintight, watertight, submersible, and direct bury locations.
- f. Tracer Wire Tags.
 - 1) Self-laminating polyester material.
 - 2) 1.5 inch by 0.75 inch.
 - 3) Black text with a white background.
 - 4) Specific for wire and cable applications.

3. XHHW Wire.

- a. Use annealed stranded bare copper conductors per ASTM B3 and B8.
- b. Use Class B stranding per ASTM B8.
- c. Use flame retardant cross-linked polyethylene insulation.
- d. Use UL listed wire.
- e. Wire shall be rated for 194°F (90°C) wet/ dry and -40°F (-40°C) operating temperatures.

4. Grounding/Bonding.

Comply with [Article 4189.01](#) of the Standard Specifications.

5. Fiber Optic Cable.

a. General.

- 1) The cable shall meet the latest applicable standard specifications by ANSI, EIA and TIA for the single-mode fiber cable of the size specified per the contract documents.
- 2) Provide all fiber optic cable for installation.
- 3) Provide the Engineer the manufacturer's production test provided with the spool.
- 4) Provide the Engineer with documentation of wasted cable.
- 5) The buffer tubes shall be compatible with standard hardware and shall have 12 fibers per tube, the fibers shall not adhere to the inside of the buffer tube, each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598-B "Optical Fiber Cable Color Coding" and be colored with ultraviolet (UV) curable ink.
- 6) The cable core shall be water blocked with dry water blocking materials to improve access and handling of individual tubes.
- 7) The cables shall be designed for point-to-point applications as well as mid-span access and provide a high-level of protection for fiber installed in the outside plant environment.
- 8) The optical fiber shall be fully capable of handling existing and legacy single-mode applications which traditionally operate in the 1310 nm and 1550 nm regions and shall also be designed to operate the full-spectrum from 1260 nm to 1625 nm for optical transmission.
- 9) The optical fiber shall be designed to provide optimum performance from 1260 nm to 1625 nm intended for 16 channel Course Wavelength Division Multiplexing applications.
- 10) The optical fiber glass shall be manufactured by one of the U.S. based manufacturing companies.

- 11) The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8.
 - 12) The jacket or sheath shall be free of holes, splits, and blisters.
 - 13) Mark cable jackets with the manufacturer's name, month, and year of manufacturer, sequential foot markings, the symbol for communication cable as required by Section 350G of the NESC, fiber count, and fiber type. The actual length of the cable shall be within -0/+1% of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.
 - 14) The maximum pulling tension shall be 600 pounds during installation (short term) and 200 pounds installed (long term).
 - 15) The shipping, storage, and operating temperature range of the cable shall be -40°C to +70°C (-40°F to 158°F). The installation temperature range of the cable shall be -30°C to +70°C (-22°F to 158°F).
- b. Single-Mode, Fiber Optic OSP Cable – Dielectric Loose Tube.**
- 1) Fiber optic, single-mode, graded loose tube dielectric cable constructed with industry standard 2.5 mm buffer tubes stranded around a central strength member.
 - 2) Single-mode, dispersion-unshifted fiber meeting International Telecommunications Union – Telecommunications Standardization Sector (ITU-T) G.652D/G.657.A1 requirements.
 - 3) Cables shall be sheathed with MDPE. The minimum nominal jacket thickness shall be 1.3 mm. Jacketing material shall be applied directly over cable core and water swellable tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
 - 4) The cable jacket shall contain no metal elements and shall be of a consistent thickness.
- c. Single-Mode, Fiber Optic OSP Cable – Single Armored Loose Tube.**
- 1) Fiber optic, single-mode, graded loose tube armored cable constructed with industry standard 2.5 mm buffer tubes stranded around a central strength member.
 - 2) Single-mode, dispersion-unshifted fiber meeting ITU-T G.652D/G.657.A1 requirements.
 - 3) Armored cables shall have an armor layer applied directly over the water swellable tape and cable core. The armor shall be a corrugated steel tape, plastic-coated on both sides for corrosion resistance, and shall be applied around the outside of the water swellable tape and cable core with an overlapping seam with the corrugation in register. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be sheathed with MDPE. The minimum nominal jacket thickness shall be 1.3 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- d. Cable Identification Tags.**
- 1) Use self-laminating rigid vinyl material rated for indoor/outdoor use. No adhesives.
 - 2) Use tags with yellow background and black legend colors.
 - 3) Pre-printed with "CAUTION/ FIBER OPTIC CABLE/ TYPE____/ COUNT____."
 - 4) Rated for use up to 176°F.
 - 5) 2 inch by 3.5 inch by 16 mil.
 - 6) Use indelible ink, etching, or a label maker which does not fade in sunlight, or in buried or underground applications. No handwriting.

6. Microwave Vehicle Detection System (MVDS) Cable.

Supply all necessary materials and incidental items required to install the MVDS cable furnished by the Contracting Authority.

J. Meter Pedestals.

1. Verify requirements with local electrical utilities.
2. 100 amp, 120/240 volt circuit breaker.

3. Six phase.
4. Meter pedestals and power connections shall comply with the requirements of the NEC, contract documents, electrical utility, and all generally accepted standards and requirements for the electrical components and power terminations in the individual power source.

K. Transformers.

1. NEMA 3R enclosure.
2. Single phase 1.0kVA; 60 Hz.
3. 240V primary, 240/120V secondary.

L. Fiber Optic Accessories and Hardware.

1. Fiber Optic Splice Closures.

- a. Supply an outside plant case that provides environmental protection of cable and splices from water and dirt and that is designed to be submersed in water and installed underground for splicing fiber optic cables in handholes.
- b. The splice closure shall be compatible with all sizes of fiber cables listed in the contract documents and large enough to accommodate the number of splices plus an additional 10% at locations where splices are shown in the contract documents.
- c. The closures shall be a single-ended dome type splice closure manufactured from impact resistant polymer material with the following properties:
 - 1) Cable entry shall be manufactured of similar material to the dome body and shall seal the closure with re-usable compressed gel-sealing technology instead of heat shrink, that accommodate a wide range of cable sizes.
 - 2) Closures shall be re-enterable and re-sealable without the need for specialized tools or equipment or any additional parts.
 - 3) No encapsulated materials shall be allowed.
 - 4) Be provisioned for a minimum of six cable entries.
 - 5) Hinging splicing trays that provide controlled access to splices and slack storage.
 - 6) Splice and storage compartments accessible via a removable dome-clamp system.
 - 7) The closure shall allow for the storage of at least eight unopened buffer tubes.
 - 8) The closure shall be 11.5 inch diameter by 23 inch length, unless otherwise specified in the contract documents.
 - 9) No factory installed trays.
 - 10) Slack basket size shall be compatible with splice closure.
 - 11) No ground-feed through lugs.
 - 12) The closure shall include the standard valve for flash testing.
- d. The splice closure shall contain all splice trays, storage baskets, splice sleeves, organizing materials, and any other incidental materials required to complete the splices at the locations shown in the contract documents.
- e. After splicing is complete, flash test the fiber optic cable and closure for leaks.
- f. Splice sleeves shall be from the same manufacturer as the splice closure and be compatible with all common fiber coatings. The sleeve shall consist of a clear outer heat shrink material, have a low temperature hot melt adhesive to encapsulate the splice, and include a stainless steel rod to ensure proper alignment and rigidity.
- g. To seal tracer wire entering splice closure, use quick install gel sealing plugs, for a three cable seal.

2. Fiber Optic Splice Trays.

Splice trays shall be from the same manufacturer as the splice closure. The size of the splice tray shall be compatible with the splice closure and have capacity for 12, 24, or 72 splices as noted in the contract documents.

3. One Rack Unit Connector Housing.

- a. Termination/splice housings shall provide for termination capabilities, splice protection, and associated fiber/pigtail storage.
- b. Meets ANSI, TIA, and EIA-568A and 606 standards.
- c. The housing shall be powder-coated metal with a polycarbonate tray.
- d. Includes a durable polycarbonate-tinted front door for viewing jumpers and removable translucent top covers,
- e. Accepts panels, modules, and cassettes. Connector position panel fitting standard 19 inch EIA racks or cabinets, with standard mounting, and hinged to allow complete access to the interior of the termination panel.
- f. Supply appropriate cables and adapters to satisfy intended operation and use. The termination unit shall be lightweight and designed to operate fully from -40°C to 70°C (-40°F to 158°F).
- g. Rack mountable closet connector housing shall hold two six-duplex connector adapter panels.

4. Four Rack Unit Connector Housing.

- a. Termination/splice housings shall provide for termination capabilities, splice protection, and associated fiber/pigtail storage.
- b. Meets ANSI, TIA, and EIA-568A and 606 standards.
- c. The housing shall be powder-coated metal with a polycarbonate tray.
- d. Includes a durable polycarbonate-tinted front door for viewing jumpers and removable translucent top covers,
- e. Accepts panels, modules, and cassettes. Connector position panel fitting standard 19 inch EIA racks or cabinets, with standard mounting, and hinged to allow complete access to the interior of the termination panel.
- f. Supply appropriate cables and adapters to satisfy intended operation and use. The termination unit shall be lightweight and designed to operate fully from -40°C to 70°C (-40°F to 158°F).
- g. Rack mountable closet connector housing shall hold twelve six-duplex connector adapter panels.

5. Module Connector Housing Splice Cassettes

- a. Use closet connector housing splice cassette modules for splice protection of connector pigtails.
- b. Includes splice organizer.
- c. Closet connector housing splice cassette modules shall be from the same manufacturer as the connector housing.

6. Floor Mount Equipment Rack

Use 19 inch wide floor mountable EIA rack.

7. Wall Mount Equipment Rack

Use 19 inch wide wall mountable EIA rack.

8. Single Panel Housing.

- a. Surface mounted termination/splice housings shall provide for termination capabilities, splice protection, associated fiber/pigtail storage, and stackable for growth capacity.
- b. Surface mount housing shall be intended for splicing and management, and cross-connect or both for up to 12 fibers.
- c. Top and bottom cable entry grommets for incoming fiber, fiber jumper.
- d. Manufactured of metal and black in color.
- e. 160 mm by 140 mm by 50 mm (6.3 inch by 5.5 by 2 inch).
- f. Hinged front door, universal mounting brackets, jumper bend limiters, labels for identifying fiber terminations.

- g. Wall mountable single panel housing shall hold one six-duplex SC connector adapter panel and splice organizer.

9. Connector Adaptor Panel

- a. Use six-duplex SC connector adaptor panel with splice organizer.
- b. Connector adaptor panel shall be from the same manufacturer as the single panel housing.

10. Six Duplex Connector Adapter Panel.

- a. Termination adapter panels shall be duplex SC.
- b. 6 adapters per panel.
- c. Accommodate a fiber count of 12 strands, single-mode.
- d. UPC polish type.
- e. Adapter panels shall be from the same manufacturer as the housing.
- f. Housing material shall be composite and blue in color.

11. UPC/SC Factory Terminated Fiber Connector and Pigtails.

- a. All fiber connectors used on this project, including in shelves, cabinets, or panels, shall be factory installed connectors.
- b. No field terminated connectors will be allowed.
- c. Connectors shall be SC/UPC having a typical insertion loss (single-mode) of 0.15 dB or less, a maximum loss of 0.35 dB or less, with typical reflectance of -55 dB, and temperature stability from -40 °C to 75 °C (-40°F to 167°F).
- d. Fiber used for pigtails must be of the same manufacturer as the main fiber cable.
- e. Pigtails shall be rated for the environment they are installed in.
- f. Pigtails shall be spliced in accordance with the splicing specifications and in fiber shelves or panels using manufacturer splice organizers.
- g. Include splice and connector sleeves.

15106.03 CONSTRUCTION.

A. General Responsibilities.

1. Stake all handholes and proposed conduit alignment per coordinates provided in the contract documents a minimum of 5 working days prior to construction and for approval by the Engineer. The Engineer will authorize any changes in location in writing before performing the installation. No additional compensation will be provided for additional work associated with or resulting from unauthorized changes to the contract documents.
2. The Contracting Authority will stake all pole locations. Do not adjust pole locations without approval by the Engineer. The Engineer will authorize any changes in location in writing before installation by the Contractor.
3. Figured dimensions on the plans shall be taken as correct but shall be checked before starting construction. Bring any errors, omissions, or discrepancies to the attention of the Engineer and the Engineer's decision thereon will be final. Correction of errors or omissions on the drawings or specifications may be made by the Engineer when such correction is necessary for the proper execution of the work.
4. Assign a responsible staff member that will work with the Engineer on decisions regarding order of work and coordination as needed throughout the duration of this project.
5. Provide the Engineer any requests to perform work during the dates of special events a minimum of 5 calendar days prior to the event. The decision of the Engineer regarding the request will be final.
6. Comply with any special provisions and limitations identified in the contract documents.

B. Material and Equipment Storage and Construction Site Access.

1. Secure a designated material storage area for this project. Any request to store material in the ROW in order to complete the current work activity shall be approved by the Engineer.
2. Construction equipment may be stored within the ROW during non-working hours if it is outside of the roadway clear zone, as far from the traveled way as practical and as approved by the Engineer. Do not store equipment at the toe of any roadway slope.
3. No worker vehicles will be allowed to park in the ROW or access a job site directly from an Interstate or Freeway facility. Access to the job site for both workers and materials shall only be via interchanges or intersecting roadways unless otherwise approved by the Engineer. Park worker vehicles off-site or at a location acceptable to the Engineer.
4. Do not leave open holes or mounds of dirt unprotected during non-working hours.

C. ITS Construction Survey

1. The Contracting Authority will stake permanent ROW corners per [Section 2526](#) of the Standard Specifications.
2. **Documentation.**
Format the survey work documentation in a manner acceptable to the Engineer. Ensure documentation is sufficient to prove means and methods used to transfer design intent to construction stakes. Check tie-ins with existing roadways, structures, and utilities prior to staking; notify the Engineer if discrepancies are found.
3. **Qualifications.**
Perform ITS construction survey directly by or under responsible charge of a Professional Land Surveyor licensed in the State of Iowa.
4. Place stakes at the following locations and label with item being staked:
 - Handholes.
 - Conduit and/or cable alignment direction changes.
 - Critical conduit locations where contract documents specify depth greater than standard and trenchless (bored) installation methods as described in Section 2553 of the Standard Specifications.
 - Transitions from plow to bore or bore to plow.
 - At locations requiring specific depths to avoid existing or future facilities.
 - A minimum of 100 feet apart along plowed conduit.
 - A minimum of 25 feet apart along bored conduit.
 - At other locations as noted within the contract documents.
5. Label stakes marking bore locations with required minimum conduit depth below existing grade.

D. Disruption to Existing Fiber Networks.

1. **Planned Work Near Existing Fiber Networks.**
 - a. Ensure continuous operation of the existing fiber networks and systems during construction of the project.
 - b. Do not work on splicing, disconnecting and/or in any way disrupting normal operation of the existing fiber networks or systems without approval from all affected parties. Affected parties will be noted in the contract documents and may include the Iowa DOT, the ICN,

and local agencies. Provide a written request to the respective parties for approval at least 10 calendar days before work is done near an existing fiber network or equipment. Submit a copy of the written request to the Engineer in all cases. In addition to the written request, submit the work plan and schedule for approval by the Engineer. The work plan shall include all fiber strands and the parties possibly affected.

- c. Restore the disrupted system upon completion of the work within the allowable working hours as noted in the contract documents. Remain on site until the affected parties give notification that the disrupted systems are fully operational. Failure to restore disrupted systems and equipment within the allowable working hours will constitute an unplanned disruption.

2. Unplanned Disruption.

- a. Apply [Article 1107.15](#) of the Standard Specifications and the following:
- b. In the event of an unplanned disruption, simultaneously notify the Engineer and any other affected party's representative(s). The notice shall include the type of facility damaged and the extent of the damage. Immediately stop all work in progress and expend all its efforts to restore the disrupted system(s) and/or correct the problem causing the disruption.
- c. Remain on site until the affected parties give notification that the disrupted systems are fully operational. Unplanned disruptions shall result in the assessment of a price adjustment.
- d. No extension of time for delays caused by repairing disrupted systems will be granted.
- e. Correct any unplanned disruptions determined by the Engineer to be caused by the Contractor at no additional cost to the Contracting Authority. If repairs are not made in a timely manner, any costs incurred by the Contracting Authority to restore the disruption will be charged to the Contractor.

3. Price Adjustment.

A price adjustment will be assessed at the rate of \$250.00 per 15 minutes, for each 15 minute period that the proper operation of an existing fiber optic network element is not restored following an unplanned disruption.

E. Finishing Activities.

Upon completion of the work at each project area, thoroughly clean the site and restore it to a condition at least equal to that existing prior to construction. Project area is defined as the approximate area disturbed during a normal week of work. During and after completion, employ appropriate measures for erosion control, where applicable. Seed and fertilize work areas upon completion of work in accordance with the contract documents.

F. Power Installed Foundation.

1. General.

- a. If the power installed foundation is provided by the Iowa DOT, coordinate with the Iowa DOT regarding the time and location for the Contractor to accept the power installed foundation and deliver the power installed foundation to the field for installation or to the Contractor's construction yard for storage.
- b. Install the power installed foundations in accordance with the contract documents and the manufacturer's recommendations.
- c. Contact the Engineer a minimum of 7 calendar days in advance to arrange a field review prior to placing the power installed foundation.
- d. Notify the Engineer immediately if an obstruction conflicts with a proposed power installed foundation location. The Engineer will relocate or determine another effective means of supporting the structure to eliminate the conflict. Payment will not be made for re-work or extra work as the result of an unauthorized relocation of a power installed foundation.

2. Installation Details.

- a. Install all power installed foundations as staked by the Engineer and set level and to the proper elevation.
- b. After power installed foundation is in place, hand dig with shovel in order to install conduits into the provided conduit entrances. Seal all conduit openings using duct plugs or as directed by the Engineer.
- c. Install a sufficient number of conduits sized as indicated in the contract documents. Locate all conduits as indicated in the contract documents.

3. Improper Installation.

Remove and reinstall, at no additional cost to the Contracting Authority, all power installed foundations improperly installed or with improperly installed anchor bolts, conduit, or any other foundations components as determined by the Engineer.

G. Poles.

1. General.

- a. If the poles are provided by the Iowa DOT, coordinate with the Iowa DOT regarding the time and location for the Contractor to accept the poles and deliver the poles to the field for installation or to the Contractor's construction yard for storage.
- b. Install the pole in accordance with the contract documents and the manufacturer's recommendations.
- c. Refer to [Articles 2522.03, H, 2, b through h](#) of the Standard Specifications for nut tightening procedure and requirements.
- d. If pole has structural damage do not erect and notify the Engineer.
- e. Repair any surface damage to galvanized components using a zinc-rich paint acceptable to the Engineer.
- f. After drilling holes, apply a zinc-rich paint acceptable to the Engineer to the bare metal.

2. Pole Erection.

- a. Erect poles (including camera mounting system and poles) and securely bolt to the power installed foundation base plate such that the pole is vertical to the centerline of the nearest adjacent major roadway.
- b. Use leveling nuts on each anchor bolt installed below the pole flange. Adjust the pole's vertical position by adjusting both the upper and lower nuts.

3. Grounding

- a. Use a minimum of three copper bonded steel ground rods per steel pole. Ground rod shall be 5/8 inch by 8 feet.
- b. The maximum grounding resistance shall be 20 ohms or less.
- c. All ground connections shall be exothermic weld.

4. Pole Removal.

- a. Remove ITS poles, including foundation to a depth of 2 feet below established grade.
- b. Furnish, place, and compact backfill according to [Section 2552](#) of the Standard Specifications.
- c. Deliver salvaged materials to the location specified in the contract documents.

H. Cabinet Foundations.

1. General.

- a. Install cabinet foundations in accordance with the contract documents and the manufacturer's recommendations.
- b. All cabinet foundations shall include a concrete maintenance pad area that is cast and reinforced as a single unit with the cabinet foundation dimensioned as shown in the contract documents.

- c. Prepare and submit for Engineer approval, design plans and details for all cabinet foundations at no additional cost to the Contracting Authority.
- d. Contact the Engineer a minimum of 7 calendar days in advance to arrange a field review prior to placing the cabinet foundation.
- e. Notify the Engineer immediately if an obstruction conflicts with a foundation. The Engineer will relocate or determine another effective means of supporting the structure to eliminate the conflict. Payment will not be made for re-work or extra work as the result of an unauthorized relocation of a foundation.

2. Installation Details.

- a. Install all foundations as located by the Engineer. Securely rest all foundations on firm ground and set level to the proper elevation.
- b. Form the upper portion of all concrete foundations and for all instances where the excavation is irregular in shape to provide the proper dimensions. Forming materials shall be level and braced to avoid displacement, warping, or deflection from the specified pattern during construction and curing.
- c. Install and secure anchor bolts, conduits, and reinforcement before concrete placement. Use a rigid template to position anchor bolts in accordance with the appropriate pattern. The center of the template and the center of the concrete base shall coincide unless otherwise directed by the Engineer.
- d. Install a sufficient number of conduits sized as indicated in the contract documents. Locate all conduits as indicated in the contract documents. Seal all conduit openings using duct plugs or as directed by the Engineer.
- e. Place all concrete within 90 minutes of batching and consolidate using a high-frequency vibrator during construction.
- f. Modification of a foundation after construction is not allowed.
- g. Cover all anchor bolts to protect them against damage and to protect the public from possible injury until erecting.
- h. Allow a minimum of 7 calendar days curing of concrete foundations before setting cabinets.

3. Improper Installation.

Remove and reinstall, at no additional cost to the Contracting Authority, all foundations improperly installed or with improperly installed anchor bolts, conduit, or any other foundation components as determined by the Engineer.

I. Device Cabinets.

1. General.

- a. If the device cabinets are provided by the Iowa DOT, coordinate with the Iowa DOT regarding the time and location for the Contractor to accept the device cabinets and deliver the device cabinets to the field for installation or to the Contractor's construction yard for storage.
- b. Install cabinets and hardware in accordance with the contract documents and the manufacturer's recommendations.
- c. Do not penetrate the top of any cabinets without prior authorization by the Engineer.
- d. Do not allow screws used for mounting shelves or other mounting purposes to protrude beyond the outside wall of the cabinet.
- e. All exterior connections shall be watertight.
- f. Contact the Engineer a minimum of 7 calendar days in advance to arrange a field review prior to placing the cabinets.

2. Mounting.

- a. Orient cabinets as shown in the contract documents unless otherwise directed by the Engineer.
- b. Ensure sufficient clamps, nuts, hardware, etc., as required for the specified mounting type, are furnished with each cabinet.

- c. Seal all conduit openings in the device cabinet using duct plugs or as directed by the Engineer.
- d. Mounting heights shall be as indicated or at minimum requirement allowed under current applicable electrical codes, whichever is greater.

J. Conduit.

1. High Density Polyethylene Conduit.

a. General.

- 1) Install conduit in accordance with the contract documents and the manufacturer's recommendations.
- 2) Follow all general guidelines covering the construction of buried conduit.
- 3) Install conduit by plowing, boring, or other approved methods within the public ROW and in a manner that minimizes atypical damage from construction operations.
- 4) The minimum bending radius of HDPE conduit shall be the larger of 20 times the outside diameter or the HDPE manufacturer's recommendations for minimum bending radius.
- 5) Open trench installation is only permitted within 25 feet of any handhole, structure, or other similar improvements, and any other requested locations approved by the Engineer.
- 6) At the discretion of the Engineer, verify the integrity of the conduit structure in a manner acceptable to the Engineer.
- 7) Tunneling under the pavement or water jetting shall not be permitted.
- 8) No excavations are permitted to cross any roadways or any other paved or other similarly improved areas. At these locations, install conduits by boring method unless otherwise directed or approved in writing by the Engineer.
- 9) No direct-buried cable is allowed.
- 10) Seal all conduit openings using duct plugs or as directed by the Engineer, at all conduit openings at the handholes, foundations, and building entrances.
- 11) Thread and cap all rigid steel conduit ends with standard conduit caps until wiring is installed. Before wiring is installed, replace caps with threaded insulating bushing in accordance with [Article 2523.03, N](#) of the Standard Specifications.
- 12) Expose and protect at all times any existing conduit at locations identified in the contract documents.

b. Installation Clearances.

- 1) Depth of all conduit installation shall be a minimum of 48 inches unless otherwise specified in the contract documents.
- 2) Maintain the typical offsets from referenced locations as shown in the contract documents.
- 3) Maintain the minimum depth throughout the length of all conduit installations.
- 4) Maintain a minimum of 2 feet of separation when underground conduits parallel an existing facility.
- 5) Maintain a minimum of 2 feet vertical separation when crossing existing utilities.
- 6) Maintain a minimum of 15 feet vertical separation from top of rail when crossing existing railroad, unless otherwise specified in the contract documents.
- 7) Maintain a minimum of 5 feet vertical separation from bottom of culvert when crossing existing culverts, unless otherwise specified in the contract documents.

c. Conduit Splicing.

- 1) Install conduit with minimal splices between handholes and structures as shown on contract documents.
- 2) All mechanically joined conduit splices shall use compression couplings designed for underground placement and blown-in fiber installation.
- 3) Butt fusion welding and solvent welding of conduits will not be allowed.
- 4) All conduit splices shall be designed to be watertight to 200 psi.
- 5) Conduit splicing is incidental to the connected items of work.

d. Facilities Protection.

- 1) The Contractor is responsible for entering new conduit installations into the Iowa One-Call system and providing all utility locates when requested through One-Call ticketing services or by the Engineer. Perform any locating services within 48 hours of receiving notice that location services are needed.
- 2) The Contractor is responsible for protecting, locating, and maintaining the conduit throughout construction and until final acceptance.
- 3) Prior to final acceptance and transition of ownership in the Iowa One-Call system, meet with the Engineer to demonstrate the locate system is working properly throughout the entire locate system.
- 4) If more than 48 hours lag is expected behind a segment installation, install additional protective measures acceptable to the Engineer.

e. Backfilling.

- 1) Apply [Section 2552](#) of the Standard Specifications and the following.
- 2) Backfill trenches and other excavations in lifts of 6 inches or less in compacted depth. Compact each layer thoroughly before placing subsequent layers.
- 3) Remove all cinders, broken concrete, or other hard or abrasive materials in the backfill material before commencing backfilling operations.
- 4) Remove and dispose of surplus and unsuitable materials upon completion of the backfilling operations in the area.
- 5) Place and carefully hand tamp backfill under and around the structures in lifts not to exceed 4 inches in loose thickness. Use a suitably sized mechanical tamper for all areas inaccessible to rollers.
- 6) Perform operations in a manner that minimizes soil erosion and employs appropriate storm water pollution prevention measures during all construction operations.
- 7) Maintain work areas in a neat, clean, and orderly condition at all times.
- 8) Upon completion of conduit/cable placing operations and any other work in an area, remove all debris, materials, tools, and equipment from the area and restore the disturbed area(s) to original or better condition within 24 hours or as soon as practicable as determined by the Engineer. Backfill all excavations and grade all disturbed areas during the restoration process.
- 9) Remove and dispose of rock and debris excavated and remaining after backfilling as directed by the Engineer.

f. Surface Restoration.

- 1) Replace or reinstall features removed as a part of the work, such as sidewalks, driveways, curbs, roadway pavement, unpaved areas, or any other items.
- 2) Immediately repair or replace any unauthorized disturbance or damage. Replace improved landscaping, lawns, scrubs, and hedge removed or damaged during construction in a manner acceptable to the Engineer. Re-sod damaged lawns using like grasses.
- 3) Complete restoration according to the applicable sections of the Standard Specifications.

g. Multiple Duct Installation.

Install multiple ducts, in continuity, at locations indicated in the contract documents unless authorized in writing by the Engineer.

h. Plowing Plowed Conduit Installation.

- 1) Use equipment and construction methods subject to the approval of the Engineer that cause minimal displacement of the soil.
- 2) Furnish competent supervision at all times at the site of plowing operations to assure compliance with the contract documents.
- 3) The equipment shall be capable of extending the plow in order to maintain the required minimum depths under all terrain conditions.
- 4) The reel carrier shall be of adequate size and be configured so that the reel sizes being used can be safely handled.
- 5) Avoid damaging any paved surfaces, ditches, or other similar surface features. Immediately repair any damage to such features to the satisfaction of the Engineer.

- 6) Perform plowing in accordance with standard industry practices using a prime mover with hydrostatic type steering and a vibratory plow. The design of the plowshare shall be such that the buried conduit passing through the plow shall not bind and shall not be bent in a radius less than 20 times the outside diameter of the conduit and maintains the structural integrity of the conduit. The feed chute shall have a removable gate for the purpose of inspection and to allow the conduit to be removed from or inserted into the feed chute at any intermediate point between splice locations. The conduit path inside the feed chute shall have low friction surfaces and be free of burrs and sharp edges to prevent damage to the conduit as it passes through. Smooth any welds before use. Internal guide rollers shall not be used. Exercise care during the plowing operation to avoid conduit damage. Feed the conduit into the ground through the plow loose and at no tension.
 - 7) Excavate as needed start and finish pits and pits at points of intersection in advance of plowing. Expose ends of casings and crossings of foreign utilities before the start of plowing operations for a conduit segment. Exercise care in the use of trenching and excavating tools and equipment to avoid damaging installed and intersecting conduits or other facilities.
 - 8) Restore plow furrowed areas to conform to the surrounding terrain using a rubber-tired tractor or heavy truck or a vibratory roller having a weight of 3 tons and a drum width between 4 and 6 feet or by other suitable means approved by the Engineer.
- i. **Conduit in Trench.**
- 1) Use equipment and construction methods subject to the approval of the Engineer that cause minimal displacement of the soil.
 - 2) Excavate open trench straight as practicable. Shape the trench to be smooth, free from any sharp edges, and clear of debris and loose rock. Excavate only gradual grade changes.
 - 3) Do not leave trenches unattended at any time or open during non-working hours unless approved in writing by the Engineer. Install barriers or other protective measures to prevent livestock or persons from falling into an open trench when appropriate.
 - 4) Notify the Engineer immediately if solid rock is encountered at any location. Excavate rock trenches using a rock saw or other suitable equipment. The excavation, backfill, and road crossings in solid rock areas shall conform to the requirements stated above unless specifically exempted in this section.
 - 5) Rock excavation will be considered extra work and will be paid according to [Article 1109.03, B](#) of the Standard Specifications. Obtain approval from the Engineer before commencing any rock excavation.
- j. **Trenchless Bored Conduit Installation.**
- 1) Use equipment and construction methods subject to the approval of the Engineer that cause minimal displacement of the soil.
 - 2) Bore all crossings beneath roadways, streets, other paved surfaces, railroads, or other structure in accordance with requirements and regulations of the authority having jurisdiction and as directed in the contract documents.
 - 3) Limit bore hole sizes to the outside diameter of the conduit being placed.
 - 4) Locate bore pits a minimum of 2 feet from the edge of pavement or shoulder unless otherwise directed by the Engineer.
- k. **Lower Conduit in Place.**
- 1) Expose existing conduit in an open trench. Excavate to the depth specified in the contract documents.
 - 2) If necessary, cut the conduit on either end of excavation to lower the conduit to the depth specified in the contract documents. Install split conduit with locking ridges and adhere a split coupling to each end of the split conduit.
 - 3) The Contractor is responsible for protecting the existing cable inside the conduit.
 - 4) Move cable slack needed to lower conduit as specified in the contract documents.
 - 5) Ensure the bottom of the conduit rests securely on firm undisturbed soil.
 - 6) Item includes the transition of conduit from existing depth to new depth specified in the contract documents.

- 7) Backfill open trench according to [Section 2552](#) of the Standard Specifications and the additional requirements for conduit backfilling listed above.

2. Rigid Steel Conduit.

Comply with [Article 2523.03](#) of the Standard Specifications.

3. Electric Metallic Tube Conduit.

Comply with National Electric Code (NEC).

K. Handholes.

1. Handhole Installation.

- a. Install handholes in accordance with the contract documents and the manufacturer's recommendations.
- b. Install the type and size of handholes at the locations indicated in the contract documents.
- c. Set top of all handholes level and flush with the pavement or soil grade.
- d. Install aggregate bedding a minimum of 12 inches below and 6 inches beyond the outside edges of the handhole as identified in the contract documents. Aggregate material shall meet Gradation No. 3 or 5 of the Aggregate Gradation Table in [Article 4109.02](#) of the Standard Specifications.
- e. Conduit shall enter the handhole from the bottom and extend conduit ends between 4 and 6 inches above the aggregate bedding.
- f. Side penetrations of the handholes are not permitted.
- g. Terminate each tracer wire run in test stations in accordance with the contract documents.
- h. Install ground rods as indicated in the contract documents.
- i. Ground test station to ground rod with exothermic weld.
- j. Seal all conduit openings using duct plugs, or as directed by the Engineer, at all conduit openings at the handholes after cable installation.
- k. Rodent proof all handholes per the contract documents.
- l. Place suitable backfill material according to [Section 2552](#) of the Standard Specifications. Backfill is incidental to each handhole being installed and will not be paid for separately.
- m. Do not install lid bolts.

2. Test Station

- a. Secure test station by placing over steel U- or T-post.
- b. Set test station at or near right-of-way, if possible.

3. Handhole Removal.

- a. Remove and dispose of handholes unless otherwise specified in the contract documents.
- b. Restore disturbed surfaces to match adjacent areas.

L. Wire and Cable.

1. General.

- a. Install wire and cable in accordance with the contract documents and the manufacturer's recommendations.
- b. All installations and connections shall comply with the contract documents and all generally accepted codes and standards.
- c. The Engineer will resolve all conflicts.

2. Tracer Wire.

- a. Install tracer wire inside conduit as indicated on the contract documents.
- b. Where new tracer wire is installed:
 - Splice tracer wire only in handholes to form a continuous network using splice kits listed for wet locations.

- Leave 50 foot coil of tracer wire in all ITS handholes when being terminated at the test station.
 - Install one tracer wire per armored fiber optic cable between the splice closure and test station.
 - Test all tracer wire for continuity, with approval by the Engineer prior to final acceptance.
- c. Labeling Requirement: Place tags on all tracer wire identifying the direction of the tracer wire at every test station.

3. XHHW Wire.

- a. Install XHHW wire inside conduit as indicated on the contract documents.
- b. Comply with [Article 2523.03](#) of the Standard Specifications.

4. Grounding/Bonding.

- a. Ground all installations as indicated in the contract documents.
- b. Installation of grounds is incidental to the cost of the connected items of work.
- c. Ground all installations in accordance with the requirements of NEC. Supply and install additional grounding rods and equipment as necessary to satisfy such requirements at no additional cost to the Contracting Authority.

5. Fiber Optic Cable.

a. General.

- 1) If the fiber optic cable is provided by the Iowa DOT, coordinate with the Iowa DOT regarding the time and location for the Contractor to accept the fiber optic cable and deliver the fiber optic cable to the field for installation or to the Contractor's construction yard for storage.
- 2) Remove fiber optic cable from the reel in accordance with the manufacturer's recommendations.
- 3) Do not twist or bend the fiber optic cable in excess of the limits recommended by the manufacturer.
- 4) As the cable is fed into the duct and conduit system use a manufacturer approved water-based cable lubricant for all fiber optic cable installations.
- 5) Protect at all times all proposed cables, cable ends, and any exposed portions of fiber optic cable from damage including water intrusion.
- 6) Replace in kind any existing pull tape or tracer wire that is used as a pull rope for fiber optic cable installation. The cost of any tracer wire or pull tape replacement will be subsidiary to the fiber optic cable installation.
- 7) Expose and protect at all times any existing buried fiber optic cable at locations identified in the contract documents for splicing.

b. Fiber Optic Cable Testing.

- 1) Visually inspect fiber optic cable prior to installation. Report any defects to the Engineer.
- 2) Pre-acceptance of Contracting Authority provided fiber (on-reel), test all strands of fiber (uni-directional) with an OTDR at 1310 nm and 1550 nm to verify attenuation, continuity and length of the cable. Measured length by the OTDR shall match manufacturer cable foot markings plus manufacturer provided helicity. Provide the Engineer with a PDF copy of the OTDR traces. Fiber test results submitted to the Engineer that exceed the max attenuation loss specification will be identified as Out of Specification.
- 3) Test all strands of fiber per the contract documents with an OTDR at 1310 nm and 1550 nm to verify attenuation, continuity, and length of the cable. Measured length by the OTDR shall match manufacturer cable foot markings plus manufacturer provided helicity. Measured post installation length shall match pre-installation (on-reel) length +/- 50 feet for each strand. Provide the Engineer with a PDF copy of the OTDR traces. Fiber test results submitted to the Engineer that exceed the max attenuation loss specification will be identified as Out of Specification.

- 4) The fiber optic cable is to have a maximum attenuation of 0.4 dB/km at 1310 nm and 0.3 dB/km at 1550 nm when measured with an OTDR. Fiber test results submitted to the Engineer that exceed the max attenuation loss specification will be identified as Out of Specification.
 - 5) Replace, as directed by the Engineer, any defect discovered during final acceptance at no additional cost to the Contracting Authority. Consider a defect to be any cable with an OTDR measured length that differs from the actual cable footage, excluding manufacturer's helicity.
 - 6) All test equipment shall be factory certified within the last year. Provide copies of the certification 10 calendar days prior to testing.
 - 7) Test results will be recorded on a form supplied by the Contractor, with data compiled in PDF format through the meter manufacturer's software. No additional alteration using software from the Contractor beyond the meter manufacturer's software will be allowed. Submit test results in a format approved by the Engineer. Hand completed test forms on each fiber over to the Engineer. Provide native test (electronic version) with no alterations and meter software for viewing of fiber traces. At a minimum, show the following:
 - Cable and fiber identification (as approved by the Engineer).
 - Operator Name.
 - Date and Time.
 - Setup and test parameters including wavelength, pulse width, range, scale and ambient temperature.
 - Test results for OTDR test in both directions for total fiber trace, splice loss/gain (dB), connector loss (dB), all events greater than 0.05 dB, measured length from cable markings and total length from OTDR.
 - Test results for attenuation test including measured cable length (cable marking), total length (from OTDR test), number of splices (from as-built) and total link end-to-end attenuation in each direction and the bidirectional average.
 - 8) OTDR testing shall use a launch and receiving cable. Each cable shall be a minimum 1000 meters (3290 feet), or greater than the dead zone for the OTDR used for this test, whichever is larger.
- c. Fiber Optic Cable Installation.**
- 1) Utilize a suitable cable feeding method between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct.
 - 2) Utilize dynamometers and breakaway pulling swings to ensure that the pulling line tension does not exceed 600 pounds.
 - 3) The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. To prevent the cable from twisting, attach a pulling eye and swivel to the cable. Use the pulling eye and swivel to pull the cable through the conduit.
 - 4) Do not force cables around sharp corners and take precautions during installation to prevent the cable from being kinked, gouged, or crushed.
 - 5) Minimum bending radius during installation shall not be less than 20 times the outside diameter of the cable or as recommended by the manufacturer, whichever is greater.
 - 6) Pulling of the cable shall be hand assisted.
 - 7) Approved installation methods include pulling, high air speed blowing, air- assist, push/pull installation, and air blown cable. Installation shall comply with all manufacturers' recommendations for cable installation including pulling tensions, bending radii, and methods, including use of rollers.
 - 8) Carefully inspect the cable for jacket defects. If defects are noticed, immediately stop the pulling operation and notify the Engineer. The Engineer will make a determination of acceptability or will reject the cable.
 - 9) Install the fiber cable in continuous runs as marked in the contract documents. End of reel splices or butt splices not shown in the contract documents shall be pre-approved by the Engineer and are incidental to the cost of the installation of the cable. If approved, perform the end of reel or butt splices in existing splice vaults as shown in

the contract documents. The cost associated with the end of reel or butt splices including splice closures, storage baskets, splice trays, protective sleeves, and all accessories shall be included in their respective items and shall not result in additional cost to the Contracting Authority.

- 10) No splices will be allowed unless indicated in the contract documents or approved by the Engineer.
 - 11) Seal all conduit openings using duct plugs or as directed by the Engineer, at all conduit openings at the handholes after cable installation.
- d. Fiber Optic Cable Removal.**
Remove and dispose of fiber optic cable unless otherwise specified in the contract documents.
- e. Facilities Protection.**
- 1) In the event it is suspected that cable damage has occurred prior to final acceptance, test the cable with an OTDR within 72 hours after notification and submit a copy of the OTDR test to the Engineer upon completion.
 - 2) Replace or repair, as directed by the Engineer, any damage occurring before final acceptance at no additional cost to the Contracting Authority. Perform any repairs or replacements as soon as reasonably possible unless otherwise approved by the Engineer.
 - 3) Replace or repair any defect in the installed cable at no additional cost to the Contracting Authority. Consider a defect to be any condition resulting in a negative or adverse effect on current or future operations of the completed fiber optic communication system as determined by the Engineer.
 - 4) Replace or repair any existing wiring that is damaged during fiber optic cable installation, as directed by the Engineer, at no additional cost to the Contracting Authority.
- f. Slack Coils.**
- 1) Leave sufficient slack at each end of the cable to allow proper cable splicing and termination. The minimum slack amount shall be as follows or as indicated in the contract documents:
 - Intermediate pulling handhole – 100 feet
 - Splice point handhole – 150 feet
 - 2) Foot marker and cable size text shall be legible on the cable jacket coiled in the handhole.
 - 3) Neatly coil slack cable in handholes. Bind the slack coils at a minimum of 3 points around the coil perimeter.
 - 4) Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames and terminals.
 - 5) For storage purposes, the minimum bending radius shall not be less than 10 times the outside diameter of the cable or as recommended by the manufacturer, whichever is greater.
- g. Cable Identification.**
- 1) Place tags on all fiber optic cable identifying the owner and direction of the cable.
 - 2) Use tags to label fiber optic cable in every cabinet, handhole, and building termination.
 - 3) Tags shall clearly identify where each individual cable run originated and where it ends (handhole to handhole, handhole to cabinet, handhole to building, etc.). Include mileposts for handholes.
 - 4) Engineer will approve tag content before installation.
 - 5) For joint fiber installations with the Contracting Authority, where the fiber will be owned by the other agency (or entity), install typical identifiers and/or markings for that fiber.
- h. Lower Fiber Optic Cable in Place.**
- 1) Expose existing direct buried fiber optic cable in an open trench. Excavate to the depth specified in the contract documents.
 - 2) The Contractor is responsible for protecting the existing fiber optic cable.
 - 3) Ensure the bottom of the fiber optic cable rests securely on firm undisturbed soil.

- 4) Item includes the transition of fiber optic cable from existing depth to new depth specified in the contract documents.
- 5) Backfill open trench according to [Section 2552](#) of the Standard Specifications and the additional requirements for conduit backfilling listed above.

6. Microwave/Radar Vehicle Detection System Cable.

- a. Apply [Article 2523.03, Q](#) of the Standard Specifications and the following:
- b. Install MVDS and Radar cable in continuous runs from the unit to the controller as splicing shall not be permitted.
- c. Install additional slack at the locations shown in the contract documents.

M. Meter Pedestals.

1. Apply [Article 2523.03, C](#) of the Standard Specifications and the following:
2. Install meter pedestals and power connections in accordance with the contract documents, the manufacturer's recommendations, NEC, and all requirements of local electrical utility.
3. Coordinate installations in advance as noted on the contract documents.
4. Provide all conduit, breaker enclosures, circuit breakers, wiring and accessories, neutral bars and accessories, ground bars and accessories, terminations and grounding in the power source.
5. Coordinate and schedule all locally required inspections of electrical work prior to putting a location into service.
6. Coordinate with the Engineer and power provider to request that electrical service at a device location be initiated.

N. Transformers.

1. Install transformer in accordance with the contract documents, the manufacturer's recommendations, NEC, and the manufacturer's recommendations.
2. Do not penetrate the top of any cabinets without prior authorization by the Engineer.
3. All exterior connections shall be watertight.
4. Ensure sufficient clamps, nuts, hardware, etc., as required for the specified mounting type, are furnished with each cabinet.
5. Provide all conduit, breaker enclosures, circuit breakers, wiring and accessories, neutral bars and accessories, ground bars and accessories, terminations, and grounding in the power source.

O. Fiber Optic Splicing.

1. Fusion Splices.

- a. Use fusion splices to splice all continuous fiber runs in splice closures and factory terminated connector pigtails.
- b. Splices shall be allowed only in the splice closures as located in the contract documents.
- c. Maximum attenuation per splice as estimated by the fusion splicer shall not exceed 0.02 dB. Any splice exceeding 0.02 dB at the time of splicing shall be re-spliced.
- d. Splice shall provide three axis core alignment using light injection and loss measurement techniques.

- e. No mechanical splices of fiber cable will be allowed.
- f. All fusion splice equipment shall be factory serviced within the last year. Provide copies of factory service 10 calendar days prior to splicing.
- g. Maintain on site at all times all materials necessary to immediately install temporary and/or permanent repairs to active fiber damaged during the course of work, including availability of additional splicing equipment.

2. Existing Fiber Optic Splice Closure Work.

- a. Provide a responsible supervisor at all times to monitor work being done at all splice locations having active fibers present.
- b. The Engineer will notify the Contractor of any known active fiber optic cables in the work area.
- c. Coordinate and supervise all work to avoid unplanned service interruptions of active facilities while performing the work.
- d. The Engineer will approve any planned network interruptions by the Contractor before initiating the interruption.
- e. Notify the Engineer at least 5 working days before commencing any work near active or potentially active fiber optic cables.
- f. Notify the Engineer immediately if any active fibers are damaged.
- g. Maintain on site at all times all materials necessary to immediately install temporary and/or permanent repairs to active fiber damaged during the course of work, including availability of additional splicing equipment.
- h. Do not commence any work until repair measures are on site.
- i. The Contractor is responsible for any direct or indirect costs related to the damage of the active fibers.

3. Splicing Requirements.

- a. Obtain approval from the ICN NOC prior to any splicing work.
- b. Maintenance windows for splicing are restricted to Monday night through Thursday night.
- c. Complete cable cuts (insertion splice locations) require a minimum notice of 14 calendar days to the ICN NOC. Splicing work at insertion splice locations shall be separated by a minimum of 10 working days.
- d. Multiple maintenance windows per week may be scheduled for splicing that does not impact ICN traffic depending on NOC approval.
- e. Only one splicing crew is allowed per night. Multiple locations may be spliced in the same night. Notify ICN NOC prior to splicing work and upon completion of splicing before moving to the next location.
- f. Prior to splicing, notify the following project contacts unless specified elsewhere in the contract documents:
 - ICN NOC,
 - Engineer,
 - Iowa DOT TMC, and
 - Iowa DOT Statewide ITS Maintenance Contractor.

4. Fiber Optic Cable Acceptance Testing.

- a. Test splicing termination to termination per the contract documents with an OTDR at 1310 nm and 1550 nm to verify attenuation and continuity of strands for the entire length of cable. Provide the Engineer with up to two copies of any software required for viewing electronic files of the OTDR traces.
- b. Each splice is to have an averaged loss value of 0.07 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm. Splice test results submitted to the Engineer that exceed the 0.07 dB or less specification will be identified as Out of Specification.
- c. Each connector is to have an averaged loss value of 0.25 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm. Connector test results submitted to

the Engineer that exceed the max loss of 0.25 dB specification will be identified as Out of Specification.

- d. All test equipment shall be factory certified within the last year. Provide copies of the certification 10 calendar days prior to testing.
- e. Test results will be recorded on a form supplied by the Contractor, with data compiled in PDF format through the meter manufacturer's software. No additional alteration using software from the Contractor beyond the meter manufacturer's software will be allowed. Submit test results in a format approved by the Engineer. Hand completed test forms on each fiber over to the Engineer. Provide native test (electronic version) with no alterations and meter software for viewing of fiber traces. At a minimum, show the following:
 - Cable and fiber identification (as approved by the Engineer).
 - Operator Name.
 - Date and Time.
 - Setup and test parameters including wavelength, pulse width, range, scale and ambient temperature.
 - Test results for OTDR test in both directions for total fiber trace, splice loss/gain (dB), connector loss (dB), all events greater than 0.05 dB, measured length from cable markings and total length from OTDR.
 - Test results for attenuation test including measured cable length (cable marking), total length (from OTDR test), number of splices (from as-built) and total link end-to-end attenuation in each direction and the bidirectional average.
- f. OTDR testing shall use a launch and receiving cable. Each cable shall be a minimum 1000 meters (3290 feet), or greater than the dead zone for the OTDR used for this test, whichever is larger.

15106.04 METHOD OF MEASUREMENT.

- A. ITS Construction Survey.**
Lump sum item; no measurement will be made.
- B. ITS Power Installed Foundation.**
By count.
- C. ITS Steel Pole.**
By count.
- D. ITS Steel Pole, Remove and Reinstall.**
By count.
- E. ITS Steel Pole, Remove.**
By count.
- F. ITS Cabinet Foundation.**
By count.
- G. ITS Device Cabinet.**
By count.
- H. ITS Device Cabinet, Remove and Reinstall.**
By count.
- I. ITS Conduit, of the type and install method specified.**
Linear feet shown in the contract documents.
- J. ITS Conduit, lower in place.**
Linear feet shown in the contract documents.

- K. Expose Existing Conduit.**
Linear feet shown in the contract documents.
- L. ITS Handhole, of the type specified.**
By count.
- M. ITS Handhole, Remove.**
By count.
- N. ITS Fiber Marker.**
By count.
- O. ITS Test Station.**
By count.
- P. ITS Isolation Ground Switch.**
By count.
- Q. ITS Ground Rod.**
By count.
- R. ITS Tracer Wire and XHHW Copper Wire, of the type specified.**
Linear feet shown in the contract documents.
- S. Fiber Optic Cable, of the type specified.**
Linear feet shown in the contract documents.
- T. Fiber Optic Cable, Remove.**
Linear feet shown in the contract documents.
- U. Fiber Optic Cable, Lower in Place.**
Linear feet shown in the contract documents.
- V. Expose Existing Direct Buried Fiber Optic Cable.**
Linear feet shown in the contract documents.
- W. ITS Meter Pedestal.**
By count.
- X. ITS Transformer.**
By count.
- Y. Equipment Rack, of the type specified.**
By count.
- Z. Unit Connector Housing, of the type specified.**
By count.
- AA. Module Connector Housing Splice Cassettes.**
By count.
- BB. Connector Adaptor Panel, Six Duplex SC.**
By count.

CC. Single Panel Housing.

By count.

DD. UPC/SC Factory Terminated Fiber Connector and Pigtails.

By count.

EE. Fiber Optic Splice Closure.

By count.

FF. Existing Fiber Optic Splice Closure Work.

By count.

GG. Fiber Optic Splice Tray, of the type specified.

By count.

HH. Fiber Optic Splice.

By count.

II. Fiber Optic Cable Acceptance Testing.

Lump sum item; no measurement will be made.

15106.05 BASIS OF PAYMENT.

A. ITS Construction Survey.

Payment will be at the lump sum price for ITS Construction Survey. Payment is full compensation for staking and re-staking.

B. ITS Power Installed Foundation.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing, if specified, and installation of all power installed foundations.
 - b. Including all surface excavations, repair or restoration of any nearby areas.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

C. ITS Steel Pole.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing, if specified, and installation of all poles and accessories,
 - b. Including all conduit entrances and attachments, all necessary electric grounding materials, and
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

D. ITS Steel Pole, Remove and Reinstall.

1. Each.
2. Payment is full compensation for:
 - a. The removal, storage, and installation of all poles and accessories,
 - b. Including all conduit entrances and attachments, all necessary electric grounding materials, and

- c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

E. ITS Steel Pole, Remove.

1. Each.
2. Payment is full compensation for:
 - a. The removal and salvaging of all poles and accessories.
 - b. Furnish all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

F. ITS Cabinet Foundation.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all cabinet foundations,
 - b. Including all surface excavations, repair or restoration of any nearby areas, concrete, steel reinforcement, and anchors, and
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

G. ITS Device Cabinet.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing, if specified, and installation of all cabinets,
 - b. Including all internal components and accessories required to provide a complete cabinet installation per the contract documents,
 - c. Providing and installing all mounting materials, cable pulling, routing and management, cable termination, and all necessary electric grounding materials, and
 - d. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

H. ITS Device Cabinet, Remove and Reinstall.

1. Each.
2. Payment is full compensation for:
 - a. The removal, storage, and installation of all cabinets,
 - b. Including all internal components and accessories required to provide a complete cabinet installation per the contract documents,
 - c. Providing and installing all mounting materials, cable pulling, routing and management, cable termination, and all necessary electric grounding materials, and
 - d. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

I. ITS Conduit, of the type and install method specified.

1. Per linear foot.
2. Payment is full compensation for:
 - a. The furnishing and installation of all conduits per the contract documents.

- b. Including all surface excavations or surface preparation work, repair or restoration of any disturbed areas to pre-construction conditions, proper water/moisture drainage materials.
- c. Open trench installation is incidental to bored or plowed conduit installations and will not be paid for separately.
- d. Conduit mounting on new or existing infrastructure.
- e. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents

J. ITS Conduit, Lower in Place.

- 1. Per linear foot.
- 2. Payment is full compensation for:
 - a. Lowering of existing conduit in place per the contract documents.
 - b. Including all surface excavations and restoration.
 - c. Furnishing all labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

K. Expose Existing Conduit.

- 1. Per linear foot.
- 2. Payment is full compensation for:
 - a. Exposing of existing conduit per the contract documents.
 - b. Including all surface excavations and restoration.
 - c. Furnishing all labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.

L. ITS Handhole, of the type specified.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all handholes and lids.
 - b. Including all surface excavations, repair or restoration of any nearby areas, concrete, proper water/moisture drainage materials, all necessary electric grounding materials and installation.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

M. ITS Handhole, Remove.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The removal and disposal of all handholes and lids per the contract documents.
 - b. Including all surface excavations and restoration.
 - c. Furnishing all labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

N. ITS Fiber Marker.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all fiber markers.

- b. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

O. ITS Test Station.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all test stations.
 - b. Including all necessary electric grounding materials and installation.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

P. ITS Isolation Ground Switch.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all test stations.
 - b. Including all necessary electric grounding materials and installation.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

Q. ITS Ground Rod.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all ground rods.
 - b. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

R. ITS Tracer Wire and XHHW Copper Wire, of the type specified.

- 1. Per linear foot.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all wire per the contract documents.
 - b. Including the proper installation of the wire into existing conduit and new conduit systems, supply and installation of splices and connectors, and slack, coiled, or stored wire.
 - c. Furnishing all materials, labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.
 - d. Prior to final acceptance, meet with the Engineer to demonstrate the locate system is working properly throughout the entire locate system.

S. Fiber Optic Cable, of the type specified.

- 1. Per linear foot.
- 2. Payment is full compensation for:
 - a. The furnishing, if specified, installation of all cable per the contract documents.
 - b. Including the proper installation of the cable into existing conduit and new conduit systems, and slack, coiled, or stored cables.
 - c. Furnishing all labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.

T. Fiber Optic Cable, Remove.

1. Per linear foot.
2. Payment is full compensation for:
 - a. The removal and disposal of all cable per the contract documents.
 - b. Furnishing all labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.

U. Fiber Optic Cable, Lower in Place.

1. Per linear foot.
2. Payment is full compensation for:
 - a. Lowering of existing direct buried fiber optic cable in place per the contract documents.
 - b. Including all surface excavations and restoration.
 - c. Furnishing all labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.

V. Expose Existing Direct Buried Fiber Optic Cable.

1. Per linear foot.
2. Payment is full compensation for:
 - a. Exposing of existing fiber optic cable per the contract documents.
 - b. Furnishing all labor, tools, equipment, consumable items, and other incidental items necessary to meet the requirements of the contract documents.

W. ITS Meter Pedestal.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all meter pedestals.
 - b. Providing and installing all mounting materials, cable pulling, cable coil, routing and management, cable termination, and all necessary electric grounding materials.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

X. ITS Transformer.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all transformers.
 - b. Providing and installing all mounting materials, cable pulling, routing and management, cable termination, and all necessary electric grounding materials.
 - c. Furnishing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

Y. Equipment Rack, of the type specified.

1. Each.
2. Payment is full compensation for:

- a. The furnishing and installation of all equipment racks.
- b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

Z. Unit Connector Housing, of the type specified.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all unit connector housings.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

AA. Module Connector Housing Splice Cassettes.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all module connector housings splice cassettes.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

BB. Connector Adaptor Panel, Six Duplex SC.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all connector adaptor panels.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

CC. Single Panel Housing.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all single panel housings.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

DD. UPC/SC Factory Terminated Fiber Connector and Pigtails.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all fiber optic splice closures.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

EE. Fiber Optic Splice Closure.

1. Each.
2. Payment is full compensation for:
 - a. The furnishing and installation of all UPC/SC factory terminated fiber connectors and pigtails.

- b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

FF. Existing Fiber Optic Splice Closure Work.

- 1. Each.
- 2. Payment is full compensation for:
 - a. Providing all coordination, materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

GG. Fiber Optic Splice Tray, of the type specified.

- 1. Each.
- 2. Payment is full compensation for:
 - a. The furnishing and installation of all fiber optic splice trays.
 - b. Providing and installing all materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

HH. Fiber Optic Splice.

- 1. Each.
- 2. Payment is full compensation for:
 - a. Providing all coordination, materials, labor, equipment, and other incidental items necessary to meet the requirements of the contract documents.

II. Fiber Optic Cable Acceptance Testing.

Payment will be at the lump sum price for Fiber Optic Cable Acceptance Testing. Payment is full compensation for providing testing results of installed fiber optic cable in a format that is accepted by the Engineer as described in the contract documents.