SP- 231060
(New)

# SPECIAL PROVISIONS
# FOR
# TRAFFIC SIGNALIZATION

**Story County**
**STP-A-0155(713)--86-85**

**Effective Date**
**March 18, 2025**

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

## 231060.01 DESCRIPTION.

### A. General.

**1.** Sections 2525 and 4189 of the Standard Specifications, as modified by these special provisions, shall apply to this project. The installation of the traffic control signals and appurtenances shall be in conformance with the MUTCD, as adopted by the Iowa DOT per IAC 761, Chapter 130.

**2.** These Special Provisions cover the work described in the contract documents. It covers furnishing all labor, equipment and materials, and performing all required operations to complete the work as per contract documents and to provide a completely operational and working signal system. Unless otherwise modified by the Special Provisions, all work, including equipment, material and installation, shall be in accordance with the Standard Specifications. Where reference is made to the codes, the safety orders, the general orders, the standards, laws, and ordinances, it shall mean the version of the reference that is in effect on the bid advertising date.

**3.** The Contractor shall be responsible for ONE-CALL locates of the traffic and interconnect cables installed under this project until acceptance of the project by the City.

**4.** At the completion of the project, the Contractor shall provide the City with as-built drawings of the fiber optic system.

**5.** At the completion of the project, the Contractor shall mark the vertical and horizontal location of all conduits with paint and flags. The Contractor shall use their GPS equipment to map the conduit, footing, and handhole locations utilizing a method approved by the City.. Contractor shall provide a location deliverable in the format of an electronic format that is compatible for import into the City's ArcGIS software program.

6. The Contractor shall measure the distance from the bottom of mast arm mounted signal heads and signs to the roadway surface beneath the signal or sign. The measurements shall be provided to the Engineer.

7. The Contractor shall submit to the Engineer a list of traffic signal items (catalog cuts acceptable) that are proposed for installation.

8. The Contractor must have an IMSA Level II certified Signal Technician on site at all times when work is being performed.

9. The Contractor shall notify the Engineer in writing of any discrepancy or ambiguity as to the intent or meaning of the contract documents or Special Provision before starting to work on that area. the Engineer will supply the Contractor in writing with the intent. The decision of the Engineer will be final and conclusive.

10. Fiber optic wiring (splicing & terminations) diagrams are provided to define the fiber optic wiring of all traffic cabinets, hubs, and facilities. Discrepancies of any wiring diagrams shall be resolved with the Engineer prior to installation. Changes to the wiring diagrams may occur during the project based on user demand and other projects interacting with this project. The Contractor shall maintain accurate quantities of splices and termination at each location during the project. Wiring diagrams shall be red-lined as part of the “normal As-Built” records provided to the Engineer.

**B. System Integration.**

1. The Contractor shall coordinate with the City’s Communications Coordinator/System Integrator to facilitate with system integration of the project.

2. City’s Communications Coordinator/System Integrator will program, network, connect, and test the complete communication system including all network switches, and any other component of the complete and functional system.

3. City’s Communications Coordinator/System Integrator shall supply the IP address Schema. The IP address schema will include a plan for all devices on the network, both supplied by this contract and devices supplied by other projects. The address inventory shall be provided to the City at project completion as part of “Normal As-built” records.

4. The coordination with the City’s Communications Coordinator/System Integrator shall be considered incidental to the project and no additional compensation shall be provided for this effort.

**C. Definitions.**

Terms used in this Special Provision shall have the meanings defined below:

- City means City of Ames, Iowa, or its representatives.
- APWD means City of Ames Public Works Department.
- Punch List means a list of items that need to be corrected by the Contractor on the project before the final acceptance can be made.
- Response Time means the elapsed time from when the Contractor is given a notice to take certain actions to the time the Contractor actually starts the action.
- LED means light emitting diode.
- IP means Internet Protocol.
- APS means Accessible Pedestrian Signals.

**D. Related Specifications and Standards.**

The Contractor shall comply with all of the standards listed below unless otherwise modified by contract documents or Special Provisions:

- ANSI Standards.
- ASTM Standards.
- ASA Standards
- EIA Standards
- IMSA Standards.
- ITE Standards.
- MUTCD
- NEC
- NESC
- NEMA Standards.
- Specifications of the UL
- TIA Standards.
- TIA/EIA 568
- NTCIP (The National Transportation Communications for Intelligent Transportation System Protocol.)
- All pertinent local, state and federal laws and regulations covering installation, material, design, construction, and operation.

## 231060.02 MATERIALS AND CONSTRUCTION.

**A. Equipment and Materials.**

**1.** Equipment and materials shall be of new stock unless the plans provide for the relocation of or the use of fixtures furnished by others. New equipment and materials shall be the product of reputable manufacturers of electrical equipment, and shall meet Engineer approval.

**2.** A PDF file of catalog cuts and manufacturer's specifications shall be furnished for all standard "off-the-shelf" items.

**3.** Engineer review of shop drawings and catalog cuts shall not relieve the Contractor of any responsibility under the Contract documents.

**4.** All electrical equipment shall conform to the standards of NEMA, and all material and work shall conform to the requirements of the NEC, the Standards of ASTM, the ASA, and local ordinances. Miscellaneous electrical equipment and materials shall be UL approved.

**5.** Wherever reference is made in these specifications or in the standard provisions to the code, the safety orders, the general order, or the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect at the date of advertising of these Specifications.

**6.** Certification from the manufacturers of all electrical equipment, signal supports, conduit and cable shall be supplied by the Contractor stating said materials complies with these Specifications.

**7.** Any existing equipment designated to be removed on the project shall remain the property of the City. The Contractor shall contact the City to coordinate pick-up of equipment by City forces.

**B. Schedule of Unit Prices.**

Complete and forward to the Engineer a Microsoft Excel copy of a list of unit costs for each item listed on the Schedule of Unit Prices/Bill of Materials by the preconstruction meeting. The Schedule

of Unit Prices/Bill of Materials will be provided to the Contractor. The sum of the costs for each item shall equal the total Contract Lump Sum price for the traffic signal installation(s). The unit costs will be used to prepare progress payments to the Contractor. The unit costs will also be used to establish the total cost for any Extra Work Orders related to traffic signal installation work items unless otherwise negotiated.

**C. Testing and Maintenance of Signal Equipment.**

**1.** Notify the Engineer the date the signal or signal system will be ready for testing once the project is open to traffic.

**2.** Upon authorization of the Engineer, place the signal or communication system in operation for a consecutive 30 day test period. The signal(s) and communication network shall not be placed into operation without prior notification and authorization of the Engineer. Any failure or malfunction of the equipment furnished by the Contractor, exclusive of minor malfunctions (such as lamp burnouts or power outages) occurring during the test period, shall be corrected at the Contractor's expense and the signal or communication system tested for an additional 30 consecutive day period. This procedure shall be repeated until all installed equipment has operated satisfactorily for 30 consecutive days.

**3.** A representative from the manufacturer and/or supplier of signal controller shall be at the project site when the signal controllers are ready to be turned on, to provide technical assistance including, as a minimum, programming of all necessary input data. Signal timing and phasing data to remain as existing.

**4.** After signal turn on and prior to final acceptance of the completed traffic signal system, the Contractor shall respond, within 24 hours, to perform maintenance or repair of any failure or malfunction reported.

**D. Guarantee.**

The Contractor shall transfer all required equipment warranties on the date of final acceptance to the Contracting Authority.

**E. Handholes.**

**1.** Handholes shall be installed at the locations shown on the plans, and at such additional points, as the Contractor, at his own expense, may desire to facilitate the work.

**2.** Type 1 Handholes shall include a cast iron ring and cover (Neenah R-5900E or approved equal) may be rated light duty for non-traffic areas (145 pounds minimum); but shall be rated heavy duty for traffic areas (320 pounds minimum) where shown on the plans. Deviations in weights shall not exceed plus or minus five percent. The cover shall have the words TRAFFIC SIGNAL cast on the top of the cover. Cable hooks – Four cable hooks shall be provided in all handholes as detailed on the plans. Cable hooks shall be galvanized steel with a minimum diameter of 3/8 inch and a minimum length of 5 inches and anchored in the wall of the hand hole utilizing appropriate anchoring devices.

**3.** Type 3 Handholes shall be Quazite 24 inch by 36 inch "PG" Style (Stackable) Assembly or approved equal. The handhole shall have a one-piece cover rated for heavy-duty loading. The legend "Traffic Signal" shall be on the lid and be secured by two stainless steel bolts. A minimum of four cable hooks will be installed in each handhole to support the signal cables.

**4.** Type 4 Handholes shall be Quazite 30 inch by 48 inch "PG" Style (Stackable) Assembly Model No. PG3048BB36, or approved equal. The handhole shall have a two-piece cover rated for heavy-duty loading. The legend "Traffic Signal" shall be on both pieces of the lid and be

secured by two stainless steel bolts. A minimum of four cable hooks will be installed in each handhole to support the signal cables.

**5.** Handholes shall be installed in a neat and workmanlike manner. When the use of forms is required they shall be set level and of sufficient thickness to prevent warping or other deflections from the specified pattern. A means shall be provided for holding conduit runs rigidly in place while the concrete is placed. All conduits shall enter the hand hole at a depth of 12 inches from the top of the hand hole. Any deviations from this requirement shall be approved by the Engineer. The ends of all conduit leading into the hand hole shall fit approximately 2 inches beyond the inside wall. A coarse aggregate drain of 1 inch clean stone or gravel conforming to the dimensions shown on the plan details shall be provided. Cast iron rings and covers for handholes shall be set flush with sidewalk and pavement. The cast iron rings and covers shall be set 1inch below finished grade when placed in soil so as to prevent damage from snow removal equipment.

**F. Conduit System.**

**1.** The number, type, and size of conduit shall be as shown on the plans. Conduit shall meet the requirements of Section 2525 and Article 4185.10 of the Standard Specifications.

**2.** Conduit shown on the plans as rigid steel shall be galvanized steel meeting the requirements of ANSI Standard Specification C80.1, latest revision.

**3.** Conduit shown on the plans as PVC conduit shall meet the requirements of NEMA TC-2, Type 2, and applicable UL Standards. HDPE conduit, green in color, with an SDR of 13.5 will be allowed to be used in place of PVC conduit.

**4.** Conduit shall be placed as shown on the plans. Change in direction of conduit shall be accomplished by bending such that the conduit will not be injured or its internal diameter changed. Bends shall be of uniform curvature and the inside radius of curvature of any bend shall not be less than six times the internal diameter of the conduit.

**5.** When it is necessary to cut and thread steel conduit, no exposed threads will be permitted. All couplings shall be tightened until the ends of conduits are brought together so that an electrical connection will be made throughout the entire length of the conduit run. All conduit and fittings shall be free from burrs and rough places and all conduit runs shall be cleaned, swabbed, and reamed before cables are installed. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. Damaged galvanized finish on conduit shall be painted with zinc rich paint. All fittings used with rigid steel conduit shall be galvanized steel only.

**6.** Whenever HDPE conduit needs to be joined with PVC conduit, one of the following couplers shall be used:

- Duraline E-Loc Couplers may be used for 2 inch and smaller conduits
- Duraline Shur-Lock II Couplers may be used for all sizes

No other couplers shall be used without the prior approval from the Engineer.

**7.** Approved conduit bushings shall be installed on the exposed ends of rigid steel conduit. Bell end fittings shall be installed on the exposed ends of PVC or HDPE conduit. In all bases, conduit shall extend a minimum of 4 inches above the finished surface.

**8.** Conduit buried in open trenches shall be placed a minimum of 24 inches deep unless otherwise directed by the Engineer or on the plans. Open trench methods of placing conduit will be permitted except where the conduit is to be placed under existing pavement. Conduit in pavement areas shall be placed to a minimum depth of 24 inches below the finished pavement surface or as directed by the Engineer.

**9.** The backfill material in open trenches shall be deposited in layers not to exceed 6 inches in depth and each layer shall be thoroughly compacted before the next layer is placed. Backfill material shall be free of cinders, broken concrete, or other hard or abrasive materials. All surplus material shall be removed from the public right-of-way.

**10.** Whenever excavation is made across parkways, driveways or sodded areas, the sod, topsoil, crushed stone or gravel shall be replaced or restored as nearly as possible to its original condition and the whole area involved shall be left in a neat and presentable condition. Concrete sidewalks, pavements, base courses, and bituminous surfaces shall be replaced with new materials. Surface restoration shall be completed in accordance with the current edition of "Specification Standards for Public Improvements" of the City and shall be considered incidental to the bid items of the project and will not be paid for separately.

**11.** "Pushed" conduit shall be placed by jacking, pushing, boring, or any other means necessary to place the conduit without cutting, removing, or disturbing existing pavement. The size of a bored hole shall not exceed the outside diameter of the conduit that is to be placed. Tunneling under the pavement or water jetting will not be permitted. Pits for boring shall not be closer than 2 feet to the back of curb unless otherwise directed by the Engineer.

**12.** All conduit openings in the controller cabinet, hub cabinet, hand holes, and bases shall be sealed with an approved sealing compound. This compound shall be readily workable soft plastic. It shall be workable at temperatures as low as 30°F, and shall not melt or run at temperatures as high as 300°F.

**G. Wiring.**

**1.** Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow, and green to green. Circuits shall be properly labeled at the controller by durable labels, or other appropriate methods, attached to the cables.

**2.** All vehicle and pedestrian signal cable runs shall be continuous from connections made in the handhole compartment of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed in underground hand holes unless specifically called for on the plans. Cable runs for radar detection cables and emergency vehicle preemption cables shall be continuous from the unit to the control cabinet.

**3.** Power lead-in cable runs shall be continuous from the power company service point to the meter socket and from the meter socket to the controller cabinet.

**4.** Slack for each cable shall be provided by a 4 foot length in each hand hole and a 2 foot length in each signal pole, pedestal and controller base (measured from the hand hole compartment in the pole to the end of the cable). Coil cable slack in hand hole and place on the hooks.

**5.** Cables shall be pulled through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging on the ground or pavement. This shall be accomplished by means of reels mounted on jacks, frame mounted pulleys, or other suitable devices. Only vegetable lubricants may be used to facilitate the pulling of cable.

**6.** The various types of connectors (RJ45, spade, etc.) used throughout the signal installations shall be crimped using the proper crimping tool designed specifically for the connector being used.

**7.** All connections made in the pole base shall be done using Scotchlok model No. 314 Self-Stripping Electrical Pigtail Connectors or an approved equivalent. Where it is required to splice into existing interconnect in handholes, splices shall be made using watertight connectors.

## H. Electrical Cable.

### 1. General.

Electrical cable for intersection signalization shall be rated 600 volts minimum. The number of conductors and size of all electrical cable shall be as shown on the plans. All wire shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable. Home runs for cables shall be labeled as follows:

| | |
|---|---|
| NW corner is red | SE corner is blue |
| NE corner is green | SW corner is orange |

### 2. Power Lead-In Cable.

Power lead-in cable shall be 600 volt, single conductor, stranded copper, Type USE, with UL approval and size as shown on plans.

### 3. Signal Cable.

Signal cable shall be 600 volt, multi-conductor copper wire. Signal cable shall meet the requirements of IMSA Specification 19-1, latest revision thereof for polyethylene insulated, polyvinyl chloride jacketed signal cable. All conductors shall be No. 14 AWG. unless otherwise specified on the plans. The conductors shall be stranded and not solid.

### 4. Tracer Wire.

A tracer wire shall be installed in all conduits with the exception of conduits between detector loops and hand holes. The tracer wire shall be a No. 10 AWG, single conductor, stranded copper, Type THHN, with UL approval and an orange colored jacket. The tracer wire shall be spliced in the hand holes and controller to form a continuous network. The splice shall be a soldered connection and then covered with a wire nut.

### 5. Emergency Vehicle Preemption Optical Detector Cable.

The cable shall meet the requirements of IPCEA-S-6l-402/NEMA WC 5, Section 7.4 600 volt control cable 75°C, Type B. The cable shall contain three conductors, each of which shall be No. 20 AWG stranded, tinned copper with 25 mil minimum average thickness low-density polyethylene insulation. Insulation shall be color coded 1-yellow, 1-blue, 1-orange. The shield shall be aluminized polyester film with a nominal 20% overlap. A No. 20 AWG stranded, tinned, bare drain wire shall be placed between the insulated conductors and the shielded in contact with the conductive surface of the shield. The jacket shall be black PVC with a minimum rating of 600 volts and 80°C and a minimum thickness of 45 mil. The jacket shall be marked.

### 6. 3-Pair No. 18 AWG Cable.

The cable shall be Belden 9773 cable.

### 7. Coaxial Cable.

The cable shall be Belden 8281 coaxial cable.

### 8. Cat5E Cable.

The cable shall be Cat5E outdoor use rated cable.

## I. Fiber Optic Cable, and Connections.

**1.** All designed interconnect systems shall use single-mode fiber optic interconnect cable. All fiber optic components required to provide proper communication with the City traffic signal network shall be furnished and installed as part of this item. The work shall consist of furnishing and installing a fiber optic cable of the type, size, and number of fibers specified. All fiber optic materials and equipment procured and installed as part of this specification shall be OFS or Corning brand, or Engineer approved equal.

2. **General Requirements.**
   a. **Materials and Equipment.**
   Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of the products. All materials and equipment furnished shall be completely free from defects and poor quality. All fiber shall be loose tube construction for both indoor and outdoor installation. Indoor cabling shall use plenum rated conduit to within less than 50 feet of point of termination eliminating the requirement to convert to indoor cable.
   b. **Contractor Qualifications.**
   Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. The technicians performing terminations and splices shall be IMSA Fiber Optic Level 2 Certified, be a Fiber Optic Association (FOA) Certified Fiber Optic Technician, or hold an approved equal certification. The Contractor upon request of the Engineer shall provide documentation of qualifications and experience for fiber optic equipment installations. The Engineer shall determine if the Contractor is qualified to perform this work. The Contractor shall have attended a certified fiber optic training class mandated by these specifications prior to starting work.
   c. **Codes Requirements.**
   The fiber optic cable installation shall be in accordance with or exceed all minimal requirements of State codes, National Codes, and manufacturer codes as applicable.
   d. **Miscellaneous Equipment.**
   The Contractor shall furnish and install all necessary miscellaneous connectors and equipment to make a complete and operating installation in accordance with the plans, standard sheets, standard specifications, special provisions, and accepted good practice of the industry.
   e. **General Considerations.**
   The cable shall meet all requirements stated within this specification. The cable shall be new, unused, and of current design and manufacture.

3. **Single-Mode Fiber Characteristics.**
   **a.** All fibers in the cable must be usable fibers and meet required specifications.
   - Typical core diameter: 8.3um
   - Cladding Diameter: 125 +1.0um by fiber end measurement
   - Core-to-cladding offset: <1.0um
   - Coating Diameter: 250 +15um
   - Attenuation uniformity: No point discontinuity shall be greater than 0.1 dB, except terminations or patch cords, at either 1310nm or 1550nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

   **b.** Factory cable rating shall be 0.35 dB/KM at 1310nm and 0.25 dB/KM at 1550nm. Installed tolerance shall be less than 0.44 dB/KM at 1310nm and less than 0.33 dB/KM at 1550nm, testing tolerance.
   **c.** All Single mode fiber shall be rated for multi-frequency, four frequencies, equivalent to the AllWave OFS specification and shall be rated to withstand extended aging under water impregmentation conditions.

4. **Fiber Specification Parameters.**
   **a.** All fibers in the cable shall meet the requirements of this specification. The testing tolerance attenuation specification shall be the maximum attenuation for each fiber over the entire operating temperature range of the cable when installed.
   **b.** The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km at 1550nm, with 80% of the measured values no greater than 0.10 dB/km at 1550nm.
   **c.** Optical fibers shall be placed inside a loose buffer tube, with 12 fibers per tube.
   **d.** The buffer tubes will meet EIA/TIA-598, “Color coding of fiber optic cables.”

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

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

**g.** The cable shall use a completely dry cable design without the use of gels or filling compounds. Dry water blocking material shall be used around the buffer tubes as well as internal to the tubes. Water blocking gels shall not be acceptable on this project.

**h.** Buffer tubes shall be stranded around a central member. Acceptable techniques include the use of the reverse oscillation, or "SZ", stranding process.

**i.** All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and flooding compound. Cable jacketing shall utilize the newer designs to provide maximum flexibility without loss or appreciable dB attenuation. Cable diameter shall not exceed 0.50 inch.

**j.** The jacket or sheath shall be marked with the manufacturer's name, the words "optical cable", the year of manufacture, number of fibers, type of fiber (SM) and sequential feet or meter marks. The markings shall be repeated every on-meter or three feet. The actual length of the cable shall be within -0/+1% of the length marking. The marking shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm. A copy of the manufacturer fiber definition and shipping sheet identifying all tests, results and fiber indexes shall be provided to the Engineer on delivery of cable to the City or shall be included with the Contractor's list of place(s) of installation when installed by the Contractor.

**k.** The maximum pulling tension shall be 600 pounds during installation.

**l.** Two or 12 buffer tubes with 12 fibers each, or subsets specified, shall be provided and designated as follows:

| Buffer Tube/Fiber | Tube/Fiber Color |
|---|---|
| No. 1, 1st tube or fiber | blue |
| No. 2, 2nd tube or fiber | orange |
| No. 3, 3rd tube or fiber | green |
| No. 4, 4th tube or fiber | brown |
| No. 5, 5th tube or fiber | slate |
| No. 6, 6th tube or fiber | white |
| No. 7, 7th tube or fiber | red |
| No. 8, 8th tube or fiber | black |
| No. 9, 9th tube or fiber | yellow |
| No. 10, 10th tube or fiber | violet |
| No. 11, 11th tube or fiber | rose |
| No. 12, 12th tube or fiber | aqua |

**5. Quality Assurance Provisions.**

**a.** All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

**b.** All optical fibers shall be 100% attenuation tested by the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for both 1310 and 1550 frequency. This documentation shall be provided with each spool. The Contractor shall designate on the plans and document the location where each spool has been installed and provide this data to the Engineer.

**6. Cable Installed in Ducts and Conduits.**

**a.** A suitable cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct/conduit off the reel. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified. Precautions shall be taken during installation to prevent the cable from being "kinked" or "crushed". A pulling eye shall be

attached to the cable and used to pull the cable through the duct and conduit system. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or breakaway pulling swings shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on the cable during installation shall not be such that the cable is twisted or stretched. The pulling of cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked, or forced around a sharp corner. If lubricant is used it shall be of water based type and approved by the cable manufacturer. Unless otherwise specified, slack in handholes shall be 100 feet in Type III and Type IV handholes, 50 feet in Type I and Type II handholes, and 10 feet in 18 inch handholes. This slack cable requirement may be deleted where existing handholes or through points lack sufficient area to maintain the minimum bend requirements. Where slack has been deleted, extra slack equal to the amount that would have been distributed in the through points shall be equally divided between the two controller cabinets and shall be in addition to the slack mandated at the cabinets. Slack cable shall be coiled and the coils bound at three points around the coil perimeter and supported in their static storage position. Additional slack cable shall be left in each hub cabinet and handhole. Excess slack at hub cabinets shall be re-pulled into the nearest handhole to provide a neat and orderly installation.

**b.** Storage of minimum slack cable in controller cabinets and additional slack at pull boxes shall be coiled. The slack coils shall be bound at a minimum of three points around the coil perimeter and supported in their static storage positions. If stored in a handhole, fiber shall be stored along the outer most walls to allow unabated ingress and egress. The binding material and installation shall not bind or kink the cable. Storage of additional slack cable adjacent to conduit risers and support poles shall be as visibly marked/tagged as “CAUTION – FIBER OPTIC CABLE”. Maximum length of cable pulling tensions shall not exceed the cable manufacturer’s recommendations. Along with the fiber optic cable, on No. 10 AWG THHN, 600 volt single conductor cable (trace wire), orange in color, shall be pulled with 10 feet of slack in each pull box or handhole. All fiber cables shall be marked with a metallic or preapproved identifier in the handhole adjacent to the traffic signal cabinet or hub cabinet and on the cable in the hub cabinet at point of termination. The identifier, both in the cabinet and in the handhole, shall indicate the direction the cable is going, cable contents (SM), date of installation (Month/Year), and the abbreviated location for the other end destination.

**7. Minimum Bend Radius.**

For static storage, the cable shall not be bent at any location to less than ten times the outside diameter of the cable or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the outside diameter of the cable or as recommended by the manufacturer.

**8. After the Fiber Optic Cable Installation.**

**a.** Each section of the cable shall be tested for continuity and attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an OTDR to locate points of localized loss caused by bends or kinks. If this is not successful the Contractor shall replace the damaged section of cable with no additional payment. Splices will not be allowed to repair the damaged section. After all fiber is installed, all fibers, whether terminated or non-terminated, shall be tested with an OTDR. All fibers terminated shall be tested with a power meter. Each OTDR trace, for documented test result submittal shall be displayed individually and not be combined with other fiber traces as overlays. Single mode fiber shall be tested at 1310 nm. The results of the OTDR test shall be provided on an electronic media (disk) and paper printout. The OTDR wave, pictorial diagram of dB loss over the length of fiber tested, shall be provided along with the measured data values. The printout shall contain the manufacturer’s fiber optic Index of Refraction to the third decimal point for the fiber provided. The Contractor

shall provide the Engineer with a written report showing all the values measured compared to the calculated values for length and coupler/connector losses at the completion of these tests.

**b.** Documentation provided to the Engineer shall include written indication of every splice termination, patch cord, etc. for cable being measured. Power meter measurement recordings shall indicate the exact measured distance (OTDR or field measurement with cross reference for oscillation multiplier) on the sheet showing the power meter readings. Any deviations between fiber readings in the same tube shall be notated for OTDR graphs as well as deviations greater than 5% on power meter readings. Rated values for acceptable installation shall be based on the following parameters:

| | |
|---|---|
| Patch cords/Pigtails | 0.15 dB each (SM) |
| Terminations | 1.0 dB set of two (In and Out) |
| Splices | 0.08 dB each |

1 KM = 0.3077 KF where KF is 1000 feet

**c.** Data documentation for each test between buildings, hubs, or cabinets shall include, the length of fiber as measured by OTDR, frequency used in test on OTDR by each fiber type, distance to each splice, termination, or patch cord jumper, dB loss rating by manufacture from spool documentation index of refraction by type of fiber in section, and the dB loss of each section as measured in the final test for each fiber. A special test shall be made on all continuous spliced fiber from start to end that includes the total dB loss measured and the OTDR plot on electronic disk. Splice points shall be identified on the trace.

**9. Fiber Optic Termination.**

**a.** Terminations shall be made using the method recommended by the connector manufacturer.

**b.** All fibers shall utilize a fan-out kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube.

**c.** All fibers terminated shall utilize a ceramic ferrule (outdoor connections), ST, mechanical termination with a wide temperature (-40°F to +170°F) epoxy. Heat cured or epoxy type connections meeting the full temperature ratings are acceptable for this Project, including factory manufactured pigtails.

**d.** The Contractor shall provide proof of purchase of sufficient quantities of ceramic terminations for outdoor terminations to verify ceramic connector usage or temperature ratings on epoxy or heat cured processes prior to terminating any fibers.

**e.** The Contractor may terminate fibers by splicing factory pigtails to the fiber ends and then connecting the pigtail to the fiber coupler in the fiber tray. When splicing pigtails to terminate, all splices shall be provided with metal reinforced shrink tube protector.

**f.** All termination couplers shall be rated for SM fiber application.

**10. Fiber Termination Panels.**

**a.** The Contractor shall provide and install termination panels with 144, 24 and 12 position capacity as indicated in the Tabulation of Equipment at each traffic signal cabinet, fiber hub, or City of Ames building. Refer to the plans for locations of each specific fiber optic termination panel.

**b.** The Fiber Termination Panel shall include all required equipment to provide a fully functional panel; this includes breakout kits, fiber distribution units, housing, etc.

**c.** The breakout kits, fiber distribution units, or termination boxes used to terminate each fiber cable in the cabinet shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials.

**d.** All fiber pigtails shall be terminated through ST connectors on the wall interconnect panel. All terminations shall be ST type, ceramic core (outdoor connections).

**e.** Splices to pigtail fiber, where used shall utilize fan out kit protection to the fiber, heat shrink tubing with metal bar reinforcement and 900 micron rated pigtail insulation.

Splices to factory pigtails shall use pigtails that are rated for a minimum temperature range of 0°F to +150°F. In the absence of pigtails meeting this temperature rating, fibers shall utilize loose tube fiber in fan-out kit tubes and ST connectors.

**f.** Traffic cabinet fiber optic termination panels shall be Corning CCH-02U Closet Connector Housing with Corning CCH-CP6-19T Closet Connector Housing Panels for ATC style cabinets (newer cabinets) and Corning SPH-01P wall-mount housing with Corning CCH-CP6-19T Closet Connector Housing Panels for NEMA TS1/TS2 cabinets (old cabinets). Corning SPH-01P are stackable and shall be stacked in accordance with the amount of terminations in the cabinet. Blanks shall be provided for all sections that do not have terminations.

**g.** City of Ames building and cross connect cabinet fiber optic termination panels shall be Corning CCH-04U Closet Connector Housing with Corning CCH-CP6-19T Closet Connector Housing Panels. Termination panels shall be mounted on available rails and fastened with appropriate hardware.

**11. Connectors.**

Connectors shall be ST (ceramic ferrule-outdoor connections) type, field installable, and self-aligning and centering or factory fabricated pigtails. Fiber optic equipment used for terminating fibers shall be rated for the type of connectors used. Connectors shall be NEMA temperature rated epoxy type or Engineer approved equal.

**12. Duplex Patch Cords.**

Patch cords shall have connectors on each end and shall contain a pair of fibers per cord (Duplex). The patch cords shall be factory made, buffered, and strengthened with aramid yarn to reduce the possibility that accidental mishandling will damage the fibers or connection. The patch cords shall be yellow. The connectors on each end shall ST – ST for cross connect cabinets and ST – LC for switch connections in traffic cabinets and buildings.

**13. Splice Enclosure (In-Ground).**

**a.** Splice Enclosures shall provide capacity of 144 fiber splices**.**

**b.** The Enclosure shall be: suitable for outdoor applications with a temperature range of 22°F to 140°F, protect splices from moisture and damage, non-reactive and not support galvanic cell action, waterproof, re-enterable, sealed with a gasket, permit selective splicing to allow one or more fiber strands to be cut and spliced without disrupting other fibers, equipped with a basket to accommodate the slack from all fibers routed into the enclosure, capable of holding splice trays from various manufacturers, input/output capacity of four 18mm cables, equipped with a termination block to terminate the central strength members of the fiber optic cables.

**c.** Splice trays shall be: compatible with fiber splices and splice enclosure, equipped with polyethylene tubes to protect exposed individual fibers within the enclosure, stackable within the splice enclosure. Vinyl markers shall be supplied to identify each fiber to be spliced. Each splice shall be individually mounted and mechanically protected on the splice tray. Loose tube buffers shall be secured with a tube guide or channel snap. Slack fiber shall be placed in an oval shape along an inside wall of the tray.

**14. Fiber Optic Fusion Splice.**

Splice all optical fibers as shown in the plans or as directed by the Engineer.

**a.** Make all splices using a fusion splicer that automatically positions the fibers using either the Light Injection and Detection (LID) system or the High-resolution Direct Core Mounting (HDCM) system. Provide all equipment and consumable supplies.

**b.** Secure each spliced fiber in a protective groove. Completely re-coat bare fibers with a protective room temperature vulcanizing (RTV) coating, gel, or similar substance, prior to insertion in the groove, so as to protect the fiber from scoring, dirt or micro bending.

**c.** Prior to splicing to fiber installed by others, measure and record the optical loss over that fiber.

**d.** Use a different splice tray for each buffer tube color. If an enclosure contains multiple buffer tubes of the same color, but none of the tubes are spliced to fibers in the other tubes of the same color, use a separate splice tray for that tube.
**e.** All splices shall be nominally 0.03 to 0.05 dB loss but shall be less than a 0.08 dB loss.

**15. Light Source and Power Meter.**
**a.** An LED light source with a wavelength that is the system wavelength, 1310 and 1550 nm for single mode shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical apertures (NA) and core diameter. The accuracy of the combined light source and power meter shall be less than 0.05 dB and be temperature compensated stabilized to 0.01 dB over the operating range of the meter(s).
**b.** The Contractor shall provide one each light source and power meter and/or one each 650 nM visible light source, to the Engineer complete with all attachments for measuring individual fibers of single mode at both 1310 and 1550 nm for spot testing/inspecting of installed and terminated fibers. This test kit shall include one each 200X power zoom scope for observing fiber ends for smoothness and fractures. AC power adapters shall be provided with all light and power meters as well as battery operation. This test kit shall remain the property of the City. This test kit shall be made available from the beginning to completion of the project and be on-site at all times.
**c.** The detector in the power meter shall have an effective numerical aperture and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 DBMS to -40 DBMS. The power meter shall have an accuracy of +/- 0.5 dB through the operating temperature and minimum resolution of 0.1 db.

**16. Launch Reference Attenuator.**
**a.** The launch attenuator, two for single mode fiber testing, shall be utilized for all OTDR tests such that one launch cable shall be at the beginning of the fiber being tested and the second launch cable shall be on the end of the fiber being tested past the final connector. Only one launch cable shall be required when testing non-terminated fiber. The launch attenuator(s) shall be of the same fiber core size and type as the fiber under test. The attenuator shall emulate 900 foot fiber length, minimum, for single mode fiber or as specified by the OTDR manufacturer for stabilization of the pulse generation. Launch cables shall be of identical length for incoming and outgoing light during tests. ST connectors shall be utilized with each attenuator to connect the device to the test device, OTDR. One launch cable shall be installed on the start of the fiber being tested and one launch cable shall be installed on the end of each terminated to view the dB loss of the final connector.
**b.** The OTDR shall have the Threshold Loss set at a value to show each splice or termination junction of a single fiber in each tube without showing the extraneous noise caused by handhole coils or turs into the cabinets. This level is normally a value (Threshold Loss) between 0.3 and 0.8 on the OTDR. This trace shall be provided for one fiber in each tube tested and each “event” shall be marked as splice, jumper or patch cord. The Threshold Loss shall then be set to a value of 0.10 for single mode fiber tests. The test of each fiber installed shall be conducted and any recorded events above the threshold shall be identified, such as jumper or patch cord. Events that are in excess of the provided values shall be corrected prior to documentation submittal, such as terminations in excess of the rated value or bends in the fiber at the point of a splice entering or leaving a splice tray (See Testing). For measured values recorded in excess of the above (0.10 for SM) listed values, refer to the fiber parameters specification as hereinbefore defined. The Engineer reserves the right to spot test fiber terminations, splices, or re-testing of all fibers in a section to insure proper quality assurance both during and after installation and testing. Deviations from Engineer testing and report documentation shall be reviewed and the Contractor shall be able to retest any or all

challenged measurements to verify a valid test. Inconsistent test results, in the sole opinion of the Engineer, shall cause the Contractor to retest the entire fiver installation.

**17. Testing.**

**a. General.**

The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing and is considered incidental to the project. All testing shall be performed in the accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the Engineer as hereinbefore specified. The Contractor shall provide one copy of operating software to read and view all OTDR traces.

**b. Attenuation.**

**1)** The end-to-end attenuation shall be measured for each fiber for each link after installation and termination. A patch cord jumper cable shall be connected to both the light source and the receive cable to the power meter by the use of a connector (barrel). The two reference cables shall then be connected via a termination coupler and power meter "zeroed" to eliminate the line loss. This process results in a reading of the actual line loss (dB) of the input connector, fiber cable, exiting connector, and any other splices or jumpers installed in the measured test link. The calculated "loss" shall not include the input or departing cables in the loss calculation. The calculated fiber loss measured shall list the number of terminations, including the input and departing connectors, the number of splices and the number of patch cords used to jumper the link(s) into the measured final link. The measured values for each terminated fiber in each tube shall include the Tube number, fiber number, number of feet in the link, the number of splices, the number of patch cords, and the number of connectors, if any. The length of the optical cable shall be as measured by the OTDR rather than the fiber cable jacket as the fiber is in reverse oscillation process resulting in a greater optical distance than the fiber cable jacket. The value for both the OTDR length and the cable jacket length shall be provided in the recorded documentation for each link distance. All distances shall be recorded in feet for both recorded lengths.

**2)** Fibers that are not continuous from beginning of the link to the end of the link shall be noted in the documentation; otherwise all fibers in a single tube may be listed in a single data entry for all required data listed above for all fibers in the tube. The fiber documentation for each fiber shall identify the fiber being tested by either fiber number or fiber coating color and be recorded by complete tube, Tube 1 through Tube 12, fiber 1 through fiber 12. The direction of the test shall be recorded for information purposes only to resolve discrepancies in replicating the test during inspections of the final installation. The power meter reading recordings shall log total dB loss over the length of the fiber measured, equivalent to the dB loss budget.

**3)** The output power levels at the network hardware transmitters or receivers shall be measured and recorded for system documentation. The power meter shall be connected to the transmitter side do the equipment with a system jumper. The transmit power level shall then be read and recorded.

**4)** Each tube of the cable shall be in the same file divider where the tube cover OTDR page shows the overview of all splices, patch cords, terminations from start to end. The second section shall include all Power Meter readings and the mandated documentation to show the calculated line loss (losses). The third section shall contain all OTDR traces, one trace per screen. The fourth section shall include the spool sheet for the fiber installed on the test section. An "explanation" sheet may be included where required to clarify an unusual reading that is valid but difficult to be explained through traditional data presentation, such as a video feed fiber that is attached to a jumper to provide continuous feed from the start to end of the tube length where other fibers in the same tube are simply spliced. The above format shall be repeated for each tube of the cable.

**c. Continuity.**

**1)** Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receiver fiber. The visible light tester shall be utilized to illuminate faulty terminations or fibers with excessive bends failing to pass light.

**2)** To perform continuity test, a high-intensity red light (Visible Fault Identifier) light source shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end. One each 650 nm red VFL (Visual Fault Locater) light source shall be furnished to the Engineer by the Contractor on request during the testing of the fiber by the Contractor for spot testing. This device shall be made available during testing of continuity to the Engineer to assist in verifying fault locations and connector bleeding.

**d. OTDR Testing.**

**1)** An OTDR shall be used to evaluate the quality and length of cable reels prior to their use on the project. A minimum of one fiber per tube per reel shall be tested if payment for stored goods is requested. The fiber loss in dB/km and the length of each reel shall be recorded in the documentation. The maximum attenuation of the cable shall be as hereinbefore specified. This test does not require an electronic document; but is provided to insure that the fiber has been received in useable quality without shipment damage. The test results of the Contractor OTDR tests of received spools shall be provided to the Engineer, in a minimum of hard copy print, prior to receiving payment for stored goods.

**2)** An OTDR shall be used to evaluate the quality and length of cable installed on the project. This test shall be conducted on all fibers, terminated and not terminated, and shall be conducted after all termination on the fibers for a link have been completed. The fiber loss in dB/km and length of each reel shall be recorded in the documentation. The index of refraction, minimum of three decimal points, provided by the manufacturer on the spool documentation shall be used for the test on the OTDR. The maximum attenuation of the cable shall be as hereinbefore specified. A hard copy of OTDR signature traces, electronically and in printed form, for all fiber links shall be made and provided in the documentation as specified. The data provided shall be in easy to understand format and of sufficient detail to verify the results. Fiber testing shall include only one fiber trace per graph. One copy of the operating system software to view the fiber graphs shall be provided with the final documentation.

**e. Documentation.**

The result of all testing shall be recorded along with date of test, name of person performing test, brand name, model number, serial number of equipment used during testing, and any other pertinent information and data. The Contractor shall be responsible to provide input to the Engineer reviewing the recorded data documentation to resolve all questions or data discrepancies. A copy of the evaluation calculation equations to be used may be obtained by the Contractor by request and by supplying an electronic copy. (The evaluation FO Calculator is an Excel program worksheet that calculates design dB Loss based on required inputs.) Documentation shall be considered incidental to bid items and no additional compensation shall be provided. Fiber optic cable test results shall be provided to the Engineer, and the City of Ames Traffic Engineer.

## J. Ethernet Communication System.

**1.** This specification sets forth the minimum requirements for an Ethernet based traffic signal interconnect and communications system. All equipment and materials to provide a properly functioning Ethernet communications system is included.

**2.** The Contractor shall procure and supply all Ethernet Communication System switches, SFPs, and switch appurtenances to the City's system integrator for this project for integration,

testing, programming, and installation. All items shall be delivered a minimum of 60 days prior to scheduled installation to allow time for programming and initial testing.

**3.** The fiber optic Ethernet communications equipment shall include:

**a.** The Ethernet layer 3 switches shall be Cisco C9300-24S, with C9300-NM-8X.

**1)** Minimum switching bandwidth of 208 Gbps.

**2)** Minimum forwarding rate of 150 Mpps

**3)** IP network protocols: OSPFv1 and OSPFv2, RIPv2, VRRP (Virtual Router Redundancy Protocol), Multicast routing protocol PIM-SM (Protocol Independent Multicast – Sparse Mode), and IPv6 OSPF routing protocol.

**4)** Support Layer 2 technology for VLANs, RSTP, SNMPv1-3, IGMPv1,v2,v3 snooping, NTP and LACP

**b.** Harsh environment Layer 2 Switch shall be configured with minimum of four Gigabit Ethernet RJ45/SFP combo uplink ports and 12-10/100-TX RJ-45 fast Ethernet ports and power supply. The Ethernet switch shall be EtherWAN EX73934E and meet the following minimum requirements or equivalent approved by the Engineer.

**1)** Minimum Non-blocking forwarding bandwidth of 11 Gbps

**2)** 8K Unicast MAC addresses, and IGMPv1,v2,v3 snooping

**3)** Management via console CLI, Web, SNMP, RMON, HTTPS, and SSH

**4)** Operating temperature -40° F to 165° F for extreme environment

**5)** 1K VLANs, VLANs, GVRP, QoS, LACP, RSTP, LLDP, NTP, SNMPv1-3, Port-Security, Storm Control.

**6)** Event notification by e-mail, SNMP trap, syslog, digital input and relay output

**c. Single Mode (SM) SFP Transceivers.**

The provided SFP transceivers shall operate on both the Layer 2 and Layer 3 switches in the traffic signal cabinets or other Layer 3 locations shown in the plans. The SFP transceivers are considered subsidiary to the Layer 2 and Layer 3 switches, and no direct payment will be made. All SFP/SFP+ transceivers shall be by Gencom.

**1)** 1000Base-LX/LH (LC) Single Mode SFP transceivers shall support EXT temperature and 1310 nm 10KM distance. The number of SFPs for each Layer 2 and Layer 3 switch as indicated in the Tabulation of Equipment shown in the plans. SFP shall be compatible with specified network equipment.

**2)** 1000Base-EX (LC) Single Mode SFP transceivers shall support EXT temperature and 1310nm 40km distance. The number of SFPs for each Layer 2 & Layer 3 switch as indicated in the Tabulation of Equipment shown in the plans. SFP shall be compatible with specified network equipment.

**3)** 10GBASE-LR-X (LC) Single Mode SFP Transceivers shall support EXT temperature and 1310 nm 10KM distance. The number of SFPs for each Layer 3 switch as indicated in the Tabulation of Equipment shown in the plans. SFP shall be compatible with specified network equipment.

**4)** 10GBASE-ER (LC) Single Mode SFP Transceivers shall support EXT temperature and 1310 nm 40KM distance. The number of SFPs for each Layer 3 switch as indicated in the Tabulation of Equipment shown in the plans. SFP shall be compatible with specified network equipment.

**5)** 1000BASE-T Copper SFP Transceiver. The number of SFPs for each Layer 3 switch as indicated in the Tabulation of Equipment shown in the plans. SFP shall be compatible with specified network equipment.

**d.** The system shall be primarily fiber optic based. The system shall also include interface equipment and cabling for CAT-5e communications, except cable installed in conduit external to a controller cabinet shall be CAT-6.

**e.** All equipment, terminations, connectors, terminal blocks, and any other hardware to construct the system shall be designed for outdoor use in typical traffic signal system conditions. All equipment shall include mounting brackets to secure the equipment in the cabinet.

**K. McCain Transparity Adaptive Specifications.**

1. **General Requirements.**
   - **a.** The Contractor shall:
     - Provide all necessary licensing for new intersections.
     - Set up/configure new intersections into existing Transparity Automated Transportation Management Software
   - **b.** The system shall implement different strategies individually or in combination to suit different prevailing traffic conditions. These strategies include:
     - Maximizing arterial bandwidth in the direction with the heaviest volume
     - Favoring arterial bandwidth in the direction with the heaviest volume while providing semi-preferential progression in the direction with lower volumes.
     - Balanced progression when both directions of travel have equal volumes.
     - Distribute phase times in an equitable fashion relative to demand.
     - Implementing peer-to-peer synchronization when user-defined traffic conditions are met.
   - **c.** The system shall manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections.
   - **d.** The system shall change the operational strategy based on changing traffic conditions.
   - **e.** The system shall detect repeated phase failures and control signal timing to prevent phase failures.
   - **f.** The system shall modify the sequence of phases to support the various operational strategies.
   - **g.** The system shall fix the sequence of phases at any specified location.
   - **h.** The system shall set signal timing parameters (such as minimum green, maximum green, extension time, and clearance interval) to comply with MUTCD and Contracting Authority policies.

2. **Network Characteristics.**
   - **a.** The system shall be capable of running Adaptive signal control all traffic signals concurrently.
   - **b.** The system shall Adaptively control a minimum of 12 independent groups of signals.

3. **Security.**
   The system shall have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by an administrator, and conform to the Contracting Authority's access and network infrastructure security policies.

4. **Traffic Controller Hardware and Software.**
   The system shall support all ATC controllers running Omni eX firmware.
   - 2070LX controllers
   - ATC eX series NEMA controllers
   - FLeX ATC series controllers

5. **Cycle Length Optimization.**
   The system shall calculate optimum cycle length according to the user specified coordination strategy.
   - **a.** The system shall limit cycle lengths to a user-specified range (minimum/maximum cycle length).
   - **b.** The system shall limit changes in cycle length to not exceed a user specified value.
   - **c.** The system shall permit the user to program different maximum cycle lengths for different levels of traffic volumes.
   - **d.** The system shall permit the cycle length increase or decrease beyond the incremental change limit when traffic conditions meet user specified criteria.

6. **Phase Split Optimization.**
   - **a.** The system shall calculate phase lengths for all phases at each signal controller to suit

the current coordination strategy.

**b.** The system shall be capable of adjusting the phase split-cycle ratio as the phase demand increases or decreases (equitable distribution).

**c.** The system shall be capable of calculating phase green times in splits or force-offs.

**7. Offset Optimization.**

**a.** The system shall calculate offsets to suit the current coordination strategy for each signal controller within a coordinated group.

**b.** The system shall measure the ratio of directional volume and calculate the appropriate mode of progression. The system shall determine if progression shall be preferential for the favored direction, semi-preferential or balanced for each direction.

**c.** The system shall make use of real-time link speed or user-defined design speed in offset optimization.

**1)** The system shall collect real-time link speed from single loop system detectors.

**2)** The system shall collect real-time link speed from a pair of speed trap detectors.

**d.** The system shall be capable of utilizing Tru-Traffic software for offset optimization.

**8. Pedestrians.**

**a.** The system shall permit the use of phase splits smaller than the time required for pedestrian walk and clearance time to accommodate infrequent pedestrian operation, as defined by operator, and then recover upon servicing a long pedestrian interval.

**b.** The system shall permit users to define which phases are to be reduced upon servicing a pedestrian cycle over-run. The system shall permit users to define the amount of time to be reduced from each phase upon servicing a pedestrian cycle over-run.

**c.** The system shall permit the use of phase split times that accommodate the full duration of pedestrian walk and clearance time as to prevent the need for cycle recovery.

**d.** The system shall accommodate early or delayed start of walk and exclusive pedestrian phases.

**9. Non-Adaptive Situations.**

**a.** The system shall detect traffic conditions during which Adaptive control is not the preferred operation and implement a pre-defined operation while that condition is present. For example, running free when volumes drop below an operator defined threshold.

**b.** The system shall permit scheduling of pre-determined operations by time of day.

**c.** The system shall permit the operator to over-ride Adaptive operation.

**10. System Responsiveness.**

**a.** The system shall modify the Adaptive operation to closely follow changes in traffic conditions.

**b.** The system shall constrain the selection of cycle lengths to those that provide acceptable operations, such as when two-way progression solutions are desired.

**c.** The system shall permit users to define the frequency of changes in Adaptive signal timing parameters.

**d.** The system shall permit users to define the number of phase demand events that shall indicate the presence of a trend in phase demand.

**e.** The system shall permit users to define the amount of split utilization that results in no change to phase split time.

**11. Complex Coordination And Controller Features.**

The system shall implement the following advanced controller features while maintaining Adaptive operation:

**a.** Operate at least four overlap phases.

**b.** Permit different phase sequences under different traffic conditions.

**c.** Allow one or more phases to be omitted under certain traffic conditions or signal states.

**d.** Prevent one or more phases being skipped under certain traffic conditions or signal states.
**e.** Allow detector logic at an intersection to be varied depending on local signal states.
**f.** Allow any phase to be designated as the coordinated phase.
**g.** Allow the operator to specify unused time from a preceding phase to be used by the next phase in sequence or coordinated phases.
**h.** Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the Adaptive operation to be based on data from a specific detector, or by excluding specific detectors.
**i.** Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination.
**j.** Allow Protected/permissive phasing and alternate left turn phase sequences.
**k.** Use of flashing yellow arrow to control permissive left turns and right turns.

**12. Monitoring and Control.**
**a.** The system shall monitor and control all required features of Adaptive operation from the following locations:
- Contracting Authority's Traffic Management Center
- Contracting Authority Yard/Maintenance Facility
- Remote Facilities Operated by Contracting Authority
- Local Controller Cabinets

**b.** The system shall provide user access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system from the access points defined for those system components.
**c.** The system shall provide access the traffic signal system and Adaptive systems through the use of graphics, menus and tables.

**13. Performance Reporting.**
**a.** The system shall automatically monitor the Adaptive signal control operation.
**b.** The system shall store, and report data used to calculate signal timing and have the data available for subsequent analysis.
**c.** The system shall store and report data that can be used to measure traffic performance under Adaptive control.
**d.** The system shall store all operational data and signal timing parameters calculated by the Adaptive system.
**e.** The system shall be able to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
**f.** The system shall generate historic and real time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.

**14. Failure Notification.**
**a.** The system shall immediately notify maintenance and operations staff of alarms and alerts.
**b.** The system shall maintain a complete log of alarms and failure events.

**15. Preemption and Priority.**
**a.** The system shall accommodate emergency vehicle preemption technology used by the Contracting Authority.
**b.** The system shall accommodate and support transit signal priority operations.

**16. Failure and Fallback.**
**a.** The system shall fall back to Time of day (TOD) or isolated free operation, as specified by the operator, in the event of equipment, communications, and software failure.
**b.** The system shall operate non-Adaptively when a user-specified detector fails.
**c.** The system shall operate non-Adaptively when the number of failed detectors within the

Adaptive group exceeds a user-defined value.

**d.** The system shall operate non-Adaptively upon loss of communication with any controller within the Adaptive group.

**17. Constraints.**

**a.** The system shall support use of the following equipment:
- ATC Controller type: 2070LX, ATC eX series NEMA, FLeX ATC.
- Detector type: Inductive Loops, Video Detection, Wireless Sensors, and Radar.
- Communication system: Ethernet or Serial

**b.** The system shall use equipment and software acceptable under current agency IT policies and procedures.

**18. Training and Support.**

**a.** All staff involved in operation and maintenance shall receive appropriate training.

**b.** Maintain the system to correct system faults that are not defects in materials and workmanship.

**c.** The system shall remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.

**d.** The system provider shall offer support plans to the agency for the duration of the product life cycle to maintain the system and software applications and perform updates and repairs as needed.

**19. External Interfaces and Integration.**

**a.** The system shall be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the Adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.

**b.** The system shall support interfaces to Connected Vehicle technology, environments and applications.

**1)** The local controller shall support the Signal Phase and Timing application (SPaT). Vendor shall have demonstrated support of SPaT messages within the U.S. DOT Connected Vehicle Test Bed.

**2)** The central system shall support a Center-to-Center interface for connected vehicle applications.

**c.** The system shall support a regional Center-to-Center interface for the exchange of real-time and historical data.

**d.** The system shall support integration with Tru-Traffic signal timing optimization during Adaptive operations.

**e.** The system shall support integration and collection of system detector data from Sensys SNAPs server.

**f.** The system shall support collection of data from Wavetronics HD detectors.

**g.** The system shall support integration with Iteris VRAS.

**h.** The system shall support integration with EDI ECcom.

**20. Maintenance.**

Each maintaining agency shall require all applicable equipment to be readily accessible by service personnel.

## L. Concrete Bases.

**1.** Concrete bases for poles, signal controller cabinets and cross connect cabinets shall be poured to form a monolithic foundation and shall conform to the dimensions shown on the plans. Excavations for these bases shall be made in a neat and workmanlike manner. The bottom of all foundations shall rest securely on firm undisturbed ground. The material for the forms shall be of sufficient thickness to prevent warping or other deflections from the specified pattern. The forms shall be set level or sloped slightly to blend with the adjacent ground level and means shall be provided for holding them rigidly in place while the concrete is being deposited. All

conduits shall be installed and held rigidly in place before concrete is deposited in the forms. A ground rod (s) shall be placed at each pole and controller base as shown on the plans. Anchor bolts for the signal poles or the controller cabinet shall be set in place by means of a template constructed to space the anchor bolts in accordance with the manufacturer's requirements. The center of the template and the center of the concrete base shall coincide unless the Engineer shall direct otherwise. Concrete shall be consolidated by vibration during placement.

**2.** The top of the base shall be finished level and the top edges shall be rounded with an edger having a radius of 1/2 inch. In sidewalk areas, adjacent to sidewalks, or in other paved areas, the top 10 inches of the base shall be formed square and shall be flush with the surrounding paved area. Preformed expansion material shall be provided between the base and the other paved area. When installed in an earth shoulder away from the pavement edge, the top of the concrete base shall be approximately 2 inches above the surface of the ground. The exposed surface of the base shall have a rubbed surface finish.

**3.** After the foundation or base has been poured, absolutely no modification of any sort may be made. If the anchor bolts, conduit, or any part of the foundation or base is installed in an incorrect manner as determined by the Engineer, the entire foundation or base shall be removed and a new foundation or base installed at the Contractor's expense.

**4.** Prior to setting poles, the anchor bolts shall be covered in such a manner as to protect them against damage and to protect the public from possible injury. The foundations must be given a minimum of seven days to cure before poles are erected.

**5.** Footings shall be Class C structural concrete meeting the requirements of Section 2403 of the Standard Specifications.

**6.** Reinforcing steel shall be the type and size as shown on the plans and shall conform to the requirements of Section 2404 of the Standard Specifications.

**M. Bonding and Grounding.**

**1.** All conduit, steel poles, and pedestals shall be bonded to form a continuous system, and be effectively grounded. Bonding jumpers shall be No. 6 AWG bare copper wire or equal connected to the ground rod by Cadweld connectors. Bare copper ground wires shall be connected together by an approved mechanical crimp type of connector. Split bolt connectors will not be used.

**2.** Grounding of the conduit and neutral at the service point shall be accomplished as required by the National Electric Safety Code, except bonding jumpers shall be No. 6 AWG or equal.

**3.** Ground electrodes shall be provided at each signal pole and at the controller as detailed on the plans.

**4.** A No. 6 AWG bare copper ground wire shall be installed in all PVC conduits that carry 120 volt signal cables.

**N. Signal Appurtenances.**

The cross connect cabinets shall be installed at the location indicated on the Plans with the back of the cabinet toward the intersection, unless otherwise directed by the Engineer. The cross connect cabinets shall be installed on pre-placed caulking material on the concrete base. After the cabinet is installed in place the Contractor shall also place caulking material around the base of the cabinet.

**O. Replacing Damaged Improvements.**

1. The Contractor is to restore to its original condition any disturbed areas at sites including, but not limited to; pull box/handhole, conduit, pole base installations, and relocated signs. Restoration shall be accomplished by placing material equivalent to that of the adjacent undisturbed area. Disturbed unpaved areas shall be fertilized, seeded, and mulched.

2. The Contractor shall take special care to minimize the disturbance of the existing ground.

3. Improvements such as sidewalks, curbs, driveways, roadway pavement and any other improvements removed, broken, or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials found on the work or with materials of equal quality. The new work shall be left in serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway, or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed. Surface restoration, including sidewalk, driveway, and street surface replacement, and seeding or sodding, shall be completed in accordance with the current edition of "Specification Standards for Public Improvements" of the City. Surface restoration shall be considered incidental to the bid items of the project and will not be paid for separately.

**P. Vehicle Detection System.**

1. The proposed video detection systems shall be a Model AI Tracked Entity Detection System manufactured by NoTraffic, Inc. and be compatible with City existing equipment.

2. The system shall communicate wirelessly from mast-arm mounted sensors to cabinet equipment.

3. The system shall be power utilizing existing/spare traffic signal system wiring/cabling from cabinet to base of traffic signal pole. Conductors used to be coordinated with the City. Contractor shall install new 3-conductor power cable from mast-arm mounted sensor unit to base of signal pole, power cable to be provided by detection system equipment vendor.

4. Contractor/equipment vendor to install and configure vehicle detection system and integrate vehicle data/communication feeds into traffic signal controller and existing Transparity Automated Transportation Management Software.

**Q. Traffic Monitor Camera System.**
The proposed traffic monitor camera systems shall be a Model Q6075-E manufactured by Axis, Inc. and be compatible with City existing equipment.

**R. Signal Cabinet Uninterruptible Power Supply/BBS.**
The proposed uninterruptible power supply/BBS systems shall be a Model SP 1250DLE manufactured by Clary, Inc. and be compatible with City existing equipment.

**S. Controller.**

1. The proposed Controllers shall be an ATC EX2 with fiber optic communications interface manufactured by McCain, Inc. and be compatible with City existing equipment.

2. Contractor/equipment vendor to install and configure controller and integrate into existing Transparity Automated Transportation Management Software.

**T. Conflict Monitor.**
The proposed conflict monitors shall be a Model MMU2-16LEIP manufactured by EDI, Inc. and

be compatible with City existing equipment.

**U. Detector Card.**
The proposed detector cards shall be a Model LMD602T manufactured by EDI, Inc. or as necessary per the proposed video detection system and be compatible with City existing equipment.

**V. Emergency Vehicle Preemption System.**
The existing preemption detector shall be removed and replaced with either a Strobecom II Model DETOC1-1C-B and DETOC22-1C-B as manufactured by TOMAR. Refer to Plans for locations of specific preemption detector. 3/4 inch NPT to 1/2 inch NPT reducers shall be used to mount the new detectors to the existing brackets. The existing optical signal processor card shall be removed and replaced with a Strobecom II Model 4140V2-4 as manufactured by TOMAR. The existing cables will be utilized for the new system.

**W. Hub/Cross Connect Cabinet and Auxiliary Equipment.**

**1.** This work shall consist of furnishing and installing new cabinets and base adapters.

**2.** Provide a Standard Type 332, aluminum cabinet.

**3.** All cabinets shall include a separate grounding system. Connection to ground must be bare No. 6 AWG copper wire or equivalent bonding strap. Contractor to test grounding system upon installation. Resistance shall be 10 ohms of less.

**4.** Cabinets to be powered from existing adjacent traffic signal cabinets. Contractor shall furnish electrical service and power cables needed for a fully functional cabinet. The electrical service and any required power cables are considered incidental to the cost of the cabinet and no direct pay shall be made.

**5.** All powered cabinets shall be wired for three-wire 240/120-volt AC service. Provide a lightning arrestor designed to protect 120/240 VAC split phase breaker panels. The protector shall use metal oxide varistors as the protective elements. The response time shall be under five nanoseconds and the maximum surge current shall be at least 40,000 amps. The clamping voltage shall not exceed 400 volts. The device shall protect line-to-line and line-to-neutral.

**6.** Provide an additional surge protector just for the circuits powering the communication and traffic management equipment. This shall be a filtering, two-stage surge protector. Install it on the load side of the appropriate breaker. The protector shall provide radio frequency noise filtering and be capable of protecting equipment drawing a total of at least 10 amps. If the maximum load on the circuit exceeds 10 amps, the contractor shall split the load among multiple circuits, each with a surge protector. The protector shall clamp both the main line and the main neutral at 250 volts, both relative to each other and relative to the cabinet ground. The response time shall be such that the voltage never exceeds 250 volts. The surge protector shall suppress surges of up to 20,000 amps.

**7.** All circuit breakers shall be molded case units with quick-make, quick-break, trip-free mechanism, and with a minimum interrupting capacity of 10,000A (RMS Symmetrical). The circuit breakers shall be of fixed trip type and UL listed. Circuit breakers shall be listed on the latest Qualified Products List QPL-W-C-375 maintained by the Defense Supply Center.

**8.** All doors shall have cabinet identification labels displaying the cabinet identifier. The Engineer will provide a list of the identifiers for each location, as well as the format for the labels.

**9.** All seams shall be continuously welded and ground smooth.

**10.** All fasteners must be stainless steel.

**11.** All cabinets shall have a natural aluminum finish, free from blemishes.

**12.** Provide terminal blocks for all conductors entering the cabinet. The blocks shall be the barrier type with nickel-plated brass screw terminals and solid backs. Terminal blocks for conductors carrying more than 60 volts must be covered by a clear acrylic shield.

**13.** The cabinet shall be equipped with the following:

- Rack: For mounting 19 inch equipment. The mounting rails must have holes of the EIA standard size and spacing for the entire height of the cabinet.
- Mounting panels: For terminal blocks, breakers, surge protectors and other small items on the back and side walls.
- LED light: Controlled by a door switch.
- Duplex ground fault interrupt outlet: For use by technicians. No permanent traffic management equipment shall be plugged into the GFI outlet.
- Thermostatically controlled fan and heater: The fan shall move 100 CFM through vents at the top of the cabinet. The air intake shall be through louvers in the door, and the air shall pass through a replaceable filter as it enters the cabinet. The heater shall use at least 250 watts and shall be designed to prevent accidental contact with dangerous heat or voltage.
- Electrical distribution system: Consisting of two 10 amp main circuit breakers, one within the signal cabinet connected to the existing circuit power feeds and the second within the Cross Connect cabinet. These breakers shall serve the communication and traffic management equipment in the cabinet. Provide at least four outlets on this circuit. The main breaker shall also power auxiliary devices in the cabinet, such as the fan, light, and GFI technician outlet.
- Sunshield: On the top.

**231060.03 METHOD OF MEASUREMENT.**

Measurement for Traffic Signalization will be lump sum.

**231060.04 BASIS OF PAYMENT.**

**A.** No separate payment will be made for work covered in this specification except as set forth below. Contract Unit Prices shall include all costs for each item of work.

**B.** If items, for which no unit prices are shown on proposal, or schedule of unit prices, are required during construction, contract price shall be adjusted on basis of unit price negotiated with Contractor.

**C.** Traffic Signalization will be paid for at the contract lump sum price bid, which price shall be full compensation for furnishing all equipment, materials, and all other work necessary or incidental to the construction of the complete signal installation and for all equipment, tools, labor, and incidentals necessary to complete the work.