SECTION 16570
TRAFFIC SIGNAL EQUIPMENT

PART 1 GENERAL

1.01 - Section Includes

A. Electrical
B. Conduit
C. Concrete Bases and Handholes
D. Poles and Mast Arms
E. Signals
F. Controllers and Cabinets

1.02 - Description of Work

A. All work shall be in accordance with the Contract Documents.
B. Electrical: includes furnishing and installing all electrical components.
C. Conduit: includes furnishing and installing conduit fittings associated with traffic signals.
D. Concrete Bases and Handholes: includes furnishing and installing bases and handholes associated with traffic signals.
E. Poles and Mast Arms: includes furnishing and installing the poles associated with traffic signals.
F. Signals: includes furnishing and installing the signals.
G. Controllers and Cabinets: includes furnishing and installing controllers, cabinets and accessories.

1.03 - Submittals

A. Submit test results as set forth in the Contract Documents.
B. Submit certificate of compliance indicating the materials incorporated into the Work comply with the Contract Documents.
C. The substitution of materials is allowed as set forth in General Conditions.
D. Supplier shall submit five copies of Shop Drawings of Signal Poles and Mast Arms to the Engineer for review prior to manufacture of the mast arm assemblies. Manufacture shall not begin until the Shop Drawings have been approved by the Engineer. The intent of the Engineer's review and approval is to assist the supplier in interpreting the Specifications. Shop Drawing approval shall not relieve the supplier of the responsibility for errors in the Shop Drawing or the requirements of the Specifications.

1.04 - Delivery, Storage and Handling

A. Deliver only materials that fully conform to these Specifications, or for which substitution has been approved as set forth in General Conditions.
    1. The Bidder awarded the Contract shall complete the equipment list by writing in the name of the equipment manufacturer and catalog number of each item listed which he proposes to install. Before beginning Work on the Project, the Contractor shall submit three copies of the equipment list, and three copies of catalog cuts for all materials supplied by the Contractor.
    2. Prior to ordering any materials the Contractor shall provide certification from the manufacturers of all electrical equipment, conduit, and cable stating said material complies with the Specifications.
B. Store material in accordance with the manufacturers' recommendations and in locations which will minimize the interference with operations, minimize environmental damage, and protect adjacent areas.

C. Remove and dispose of unacceptable materials in accordance with the Contract Documents.

1.05 - Scheduling and Conflicts

A. Schedule Work to minimize disruption of public streets and facilities.

B. Discontinue Work which will be affected by any conflicts discovered or any changes needed to accommodate unknown or changed conditions and notify the Engineer.

1.06 - Special Requirements

A. All work and materials incorporated into this Project shall conform to all applicable local, state, and Federal requirements.

B. Furnish upon request from the Engineer, a sample of any item or material proposed for use on for this Project.

C. Any modifications of the installation are subject to the approval of the Engineer.

D. Unless otherwise specified in the Contract Documents, the installation of all signal equipment shall be in accordance with the Traffic Signal Manual of the International Municipal Signal Association (IMSA).

E. The painted surface of any equipment damaged in shipping or installation shall be retouched or repainted in a manner satisfactory to the Engineer.

F. The Standard Specifications for Highway and Bridge Construction, current series, Iowa DOT, shall apply to these specifications as noted, and shall be referenced as the Standard Specifications.

PART 2 PRODUCTS

2.01 - Electrical

A. Service Conductor (Power Cable) shall be 600 volt, single conductor cable shall comply with the Standard Specifications and shall be U.L. listed for type “USE.” The sheath shall be black for the positive cable and white for the negative cables.

B. Signal cable shall be stranded and conform to the requirements of IMSA 19-1 or 20-1, or latest revision thereof. The number and size of conductors shall be as specified on the plans.

C. Loop detector lead-in cable shall conform to the requirements of IMSA 50-2, latest revision thereof.

D. Detector loop wire shall conform to the requirements of IMSA 51-5, latest revision thereof. The encasing tube shall be polyvinyl chloride.

E. Connectors shall be either insulated spring steel connectors or insulated set screw connectors. The spring shall have sharp edges, round edges will not be approved.

The set screw connectors shall be Ideal, Series 30-200; Holub, Catalog No. 10-307, Model SS-2 or approved equal.

Connectors shall be approved by the Engineer prior to incorporation in the Work.

F. Tracer wire shall be a #10 AWG wire single conductor, stranded copper, Type THHN, with UL approval and orange jacket.

G. Ground rods shall be high strength steel rods with chemically bonded copper coverings to provide high conductivity and to prevent electrolytic action. Rods shall be full length as shown on the plans with nominal diameter of 5/8 inch unless otherwise specified. Ground rods shall conform to the requirements of IMSA specification No. 62-1956, latest revision.

H. All ground wires shall be #6 AWG, bare, solid annealed copper wire unless otherwise specified on the plans.

I. All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA). All Work shall conform with the requirements of the National Electrical Code. All miscellaneous electrical equipment shall be approved.

J. Circuit breakers shall conform to manufacturer's requirements. Breakers shall be housed in approved enclosure, such as Square D model QO2L0RB or equivalent.

2.02 -

2.03 - Conduit

A. Galvanized rigid steel conduit (RSC) shall meet the requirements of ANSI Standard Specification C 80.1, latest revision. The number and size of conduits shall be as called for on the plans. Conduit shall be of standard length with each length bearing the UL approved label.

B. Polyvinyl Chloride (PVC) conduit shall be Schedule 80. Conduit shall be of standard length with each length bearing the UL approved label.

C. Conduit fittings shall conform to the requirements of ANSI Standard Specification C 80.4, latest revision. All fittings used with rigid steel conduit shall be galvanized steel. Fittings of aluminum or zinc alloys are not acceptable.

D. Unless otherwise specified in the Plan Documents, all conduit used for the electrical service system shall be galvanized rigid steel having the Underwriters Laboratories approval.

E. Conduit couplers shall be threaded-type.

F. High density polyethylene (HPDE) conduit, where specified in the Plan Documents, shall meet or exceed the requirements of ASTM F 2160 "Standard Specification for Solid Wall High Density Polyethylene (HPDE) Conduit Based on Controlled Outside Diameter (OD)". Joints and couplings shall meet or exceed ASTM F 2176 "Standard Specification for Mechanical Couplings Used on Polyethylene Conduit, Duct and Innerduct". Orange conduit will be required for underground fiber optic cable installation. Manufacturer's certification may be required for HDPE conduit.

2.04 - Concrete Bases and Handholes

A. Concrete for bases shall be Class "C" structural concrete, C-4 mix.

B. Reinforcement for bases shall meet the requirements of Section 2404 of the IDOT Standard Specifications for Highway and Bridge Construction, Current Series.

C. Precast concrete pipe used in constructing handhole shall be Type 2000-D.

D. Lid for precast concrete handhole shall be cast-iron Neenah R5900E or approved equal. Cover shall be Type 'C' (checkered top), with minimum weight 165 pounds. Manufacturer's name and "TRAFFIC SIGNAL" legend shall be cast on top of the cover.

E. Unless otherwise listed in the Plan Documents, precast polymer concrete handholes shall stackable, have bolted covers (PG style), and be sized 24" X 36" X 24" depth. The polymer concrete material shall meet or exceed all appropriate ANSI/ SCTE 77 tests and requirements. The bottom shall be "open" unless otherwise specified in the Plans. The lid shall be imprinted with the legend "TRAFFIC SIGNAL" and satisfy loading requirements of ANSI Tier 8. A minimum of four cable hooks will be installed in each junction box to support cables.

F. Handhole cable hooks shall be galvanized according to ASTM A 153.

G. Handholes shall be placed on course aggregate base, Iowa DOT Specification 4109, Gradation No. 5.

H. Plastic loop handholes shall be Pencell PE-10 or an approved equal.

2.05 - Pole and Mast Arm Assembly

A. General

1. The mast arms, support poles, and luminaire arms shall be continuous tapered, round or octagon steel poles of the anchor base type. The poles and mast arms shall be a minimum of 7 gauge fabricated from one length of steel sheet with one continuous arc welded vertical seam, unless otherwise approved by the

Engineer. The poles and mast arms shall be fabricated from corrosion resistant steel meeting requirements of ASTM A572 or A1011 GRADE 50 and the base and flange plates shall be fabricated from A36 structural steel. After manufacture, poles and mast arms shall have minimum yield strength of 48,000 p.s.i. The base plate shall be attached to the lower end of the shaft by a continuous arc weld on both the inside and outside of the shaft.

2. It may be permissible to fabricate poles and mast arms by welding two sections together.
3. Welding, fabrication, and inspection shall conform to the Iowa Department of Transportation (Iowa DOT) Standard Specifications Section 2525, a separate Specification. Pole manufacturers shall certify that only certified welding operators in accordance with Iowa DOT Standard Specifications were used. The welding consumables used shall be in accordance with the approved list furnished by the Iowa DOT.
4. Personnel performing nondestructive testing shall be qualified in accordance with the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A and applicable Supplements B (Magnetic Particle) and C (Ultrasonic). Evidence shall be presented for approval of the Engineer, concerning their qualifications. A report shall be required showing that welds have been inspected and found satisfactory. The cost of all nondestructive testing shall be paid by the supplier and will be considered incidental.

B. Mast Arms
   1. The mast arms and poles shall be designed in accordance with the 1994 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals and designed to support greater traffic signals and/or signs load as listed in these documents. Fabricator shall certify that the mast arms are capable of withstanding winds in the most critical direction up to 80 miles per hour, plus 1.3 gusting factor (104 mph maximum gusted wind) without failure. The length of the mast arms shall be as specified on the Plan Documents.
   2. When loaded with the signals and signs the mast arms shall have a slight rise. Unloaded the maximum angle between the mast arm and horizontal shall be 2 degrees to 5 degrees depending on the length of the mast arm, unless approved by the Engineer.

C. Poles
   1. The pole shall be designed to support the mast arm so when it is equipped with the traffic signals and/or signs it will provide a minimum of 15 feet and a maximum of 19 feet clearance from the street surface to the bottom of the signal heads or signs.
   2. The pole shall be equipped with two reinforced handholes with covers (4” x 6½” minimum). One handhole shall be located 18 inches above the base and 180 degrees with respect to the mast arm. The second handhole shall be located directly opposite the traffic signal mast arm. Securing the cover to the pole shall be done with the use of simple tools.
   3. Provide a lug in the pole base near the handhole to permit connection of a #6 AWG grounding wire.
   4. Provide a J-hook wire support (a curved 3/8” diameter steel bar) 6” to 12” above and 90 degrees with respect to the opening for each mast arm and luminaire arm.

D. Signal Pole and Mast Arm Loading: Traffic signal poles and mast arms shall be fabricated to the greater of the loading listed in the Plan Documents and the following signal head and signing loads:

1. Maximum Loading for Arms less than 36 Feet Long: 5-section head on end, 24”x30” sign centered 2 ft. inboard, video detection camera with 4-foot extension mounting 6 feet inboard, 3-section head 12 ft. inboard, 21”x120” metro sign centered 16 ft. inboard, 2 3-section pole-mounted heads, 2 2-section pole-mounted pedestrian heads, luminaire, 6” backplates on all signal heads.
2. Maximum Loading for Arms 36 to 47 Feet Long: 5-section head on end, 24”x30” sign centered 2 ft. inboard, video detection camera with 4-foot extension mounting 6 feet inboard, 3-section head 12 ft. inboard, 3-section head 24 ft. inboard, 21”x120” metro sign centered 28 ft. inboard, 2 3-section pole-mounted heads, 2 2-section pole-mounted pedestrian heads, luminaire, 6” backplates on all signal heads.
3. Maximum Loading for Arms greater than 47 Feet Long: 5-section head on end, 24”x30” sign centered 2 ft. inboard, video detection camera with 4-foot extension mounting 6 feet inboard, 3-section head 12 ft. inboard, 24”x30” sign centered 14 ft. inboard, 3-section head 24 ft. inboard, 3-section head 36 ft. inboard, 21”x120” metro sign centered 28 ft. inboard, 2 3-section pole-mounted heads, 2 2-section pole-mounted pedestrian heads, luminaire, 6” backplates on all signal heads.

E. Finish:

Unless otherwise specified on the Plan Documents, poles and mast arms shall be galvanized steel per the following:

1. The assemblies shall be hot-dipped galvanized to the requirements of ASTM A123 for fabricated products or ASTM A153 for hardware items.
2. Packaging: All parts shall be packaged, wrapped, or cradled in a manner which will insure arrival at the destination without damage to the surface.

F. Hardware

1. The mast arms and poles shall be equipped with all necessary hardware, shims and anchor bolts to provide for a complete installation without additional parts.
2. The anchor bolts shall meet the requirements of F1554 Grade 105 or approved equal.
3. Bolts attaching the arms to the pole shall meet the requirements of ASTM A325 or approved equal.
4. The anchor bolts shall be hot dip galvanized and have a 4 inch long 90 degree bend at the other end. The Fabricator shall submit drawings for the anchor bolts and base plate design. All hardware shall be steel, hot dipped galvanized meeting the requirements of ASTM A153, Class D, or shall have an electrodeposited coating of the same coating thickness, and so designed for this purpose.
5. Anchor bolt covers, pole top covers, and mast arm end covers shall be gray cast iron castings conforming to ASTM Designation: A48 Class 30 or fabricated from ASTM A36 Steel.

G. Luminaire Extension

1. Traffic signal pole assemblies which require luminaire extensions are indicated on the Plan Documents. The pole for the luminaire extension shall provide a continuous shaft as required for the mast arm.
2. The pole for the luminaire extension shall be vertical and shall provide a 35-ft. luminaire mounting height, unless approved by the Engineer. Luminaire arm shall be a single curved arm, unless otherwise noted on the Plan Documents.
3. The length of the luminaire arm shall be 15 feet, and the orientation of the luminaire arm shall be 10 degrees counterclockwise from the mast arm, unless otherwise noted on the Plan Documents.

4. A one-and-one-eighth inch (1-1/8") min. diameter hole shall be drilled in the pole directly opposite the luminaire arm attachment point and in line with the hole leading into the luminaire arm.

H. Future Luminaire Arm

1. The traffic signal assemblies without luminaire extensions shall be designed to support a future luminaire extension.
2. The pole shall have a 1" thick steel plate welded in the top of the pole to receive the future luminaire extension. The steel plate shall be tapped unless otherwise specified on the Plan Documents.
3. The future luminaire will be installed 35 feet above the pavement surface and the luminaire arm will extend 15 feet from the pole, unless otherwise specified on the Plan Documents.

2.06 - Signals

A. General

1. The signal heads shall be complete with all fittings and brackets for a complete installation. Each signal shall consist of a main body assembly, optical units, necessary screws, wing nuts, eyebolts, etc., and shall be delivered completely assembled. All hardware including hinge pins, wing nuts, eye bolts or latch bolts shall be made of a solid non-corrosive metallic material to prevent seizure or corrosion by the elements. Each signal shall be smooth both inside and outside and shall contain no sharp fins or projections of any kind. The doors and visors shall be flat black. All metal parts shall be painted with one coat of primer and two coats of a high grade Federal Black enamel. All parts of the vehicle signals shall be in compliance with the latest ITE Report on Adjustable Face Vehicle Traffic Control Signal Heads.
2. The electrical and optical system of the signal head shall be designed to operate on 115 volt, single phase, 60-Hertz alternating current.
3. All exterior surfaces shall be black.
4. Main Body Assembly of the signal unit shall consist of one or more polycarbonate sections have integral cast serrations so when assembled with the proper brackets they may be adjusted in increments and locked securely to prevent moving. The sections shall be designed so that when assembled they interlock with one another. All joints between sections shall be waterproof. The sections shall be held firmly together by locknuts or other means approved by the Engineer. Any open end on an assembled signal face housing shall be plugged with an ornament cap and gasket.
5. Doors and Optical Units
   a. The doors shall be made of polycarbonate. Each door shall be of the hinged type and shall beheld closed by a wing nut or other approved means. The hinge pins shall be designed so that the doors may be easily removed and reinstalled without the use of special tools. Each door shall have a polycarbonate visor designed to shield each lens. The inside of each visor shall be flat black.
   b. The optical system shall be so designed as to prevent any objectionable reflection of sunrays even at times of the day when the sun may shine directly into the lens. When the door of the optical unit is closed, all joints in the assembly between the interior and exterior of the reflector shall be closed against suitable gaskets in order that the units may be dust tight. Between the door and the lens, there shall be a neoprene gasket securely fastened around the outer surface of the lens. The gasket shall be engaged by the rim of the reflector holder when the door is closed, to render the union between the reflector holder and the door assembly dust tight.

c. The reflector shall be parabolic in design and made of specular Alzak aluminum.

d. The reflector holder shall be of non-ferrous or rust proofed metal and designed to separately support the reflector and socket in proper relation to the lens. The reflector holder shall be hinged to the left-hand side of the signal body when viewed from the front. On the right-hand side, the reflector holder shall be held in place by a spring catch or other quickly releasable means.

e. Both the hinge device and the spring catch or equivalent shall be of a flexible nature which will permit the reflector holder to be pushed inwardly for at least one-sixteenth of an inch and to align itself correctly with the lens when the door of the optical unit is closed and pressed against the rim of the reflector holder. By such means, the joint between the reflector holder and the lens shall be rendered dust-tight. It shall not be necessary to remove any screws or nuts in order to swing the reflector holder out of the body section to obtain access to the light socket.

f. The socket shall be arranged with a lamp grip so it will be impossible for the lamp to be loosened by vibration.

g. The wire entrance fitting shall be made of malleable iron or other approved material equipped with a standard 1-1/2" pipe fitting for attachment to the signal head. It shall be provided with weatherproofing means so that when it is attached to the top of the signal a weatherproof assembly results. Positive locking means shall be provided so that the signal cannot loosen from the fitting. The fitting shall be provided with an insulation bushing at the point where wires enter. The fitting shall be provided with self-locking features to prevent the signal head from turning out of directional adjustment in a strong wind. It shall be painted in color to match that of the signal.

B. Vehicle Signals

1. In addition to meeting the requirements of Section A., Vehicle Signals shall meet the following requirements:

   a. All signal indications shall be Light Emitting Diode (LED) Signal Modules.

   b. Visors shall be of the tunnel type not less than eight inches in length and shall be designed in a manner such that the visor may be easily installed or removed from the signal head.

   c. A terminal block shall be mounted in the back of the second section of the signal head. The terminal blocks shall be secured at both ends.

   d. Signals shall be shipped completely assembled with tunnel visors attached to the signal door.

C. Pedestrian Signals: In addition to meeting the requirements of Section A., Pedestrian Signals shall meet the following requirements:

1. Pedestrian signals shall consist of a single unit, nominal 16" x 18", with "egg crate" housing and mounting attachments. The left half shall display a "HAND" symbol and a "WALKING PERSON" symbol. The right half shall display clearance interval countdown numerals.

2. The signals shall operate with light emitting diode (LED) lamps that meet or exceed ITE PTCSI-2 LED Pedestrian Signal Specifications.

3. The lenses shall be made of vandal resistant polycarbonate or acrylic plastic. Unless otherwise specified on the Plan Documents, the symbols on these lenses shall be at least 9 inches high and shall be designed to produce a maximum legibility both day and night. The "HAND" symbol shall be Lunar White and the "WALKING PERSON" symbol and numerals shall be Portland Orange. The background or field around both messages shall be black.

D. Optically Programmable Signal Heads

1. Optically programmable signal heads shall meet all of the applicable requirements of Section A through Section B except as hereafter provided:
    a. Optically programmable signal heads shall permit the visibility zone of the indication to be controllable without the use of tunnel visors, louvers or tape. Fresnel and/ or refractive lenses are acceptable.
    b. Signal illumination shall be remotely programmable to the desired area of visibility by alignment of the LED array per section. If three or more optically programmable units are identified on the Plan documents, a programming unit must be furnished.
    c. Each signal lens shall be equipped with a visor, which encloses the top and both sides of the lens. The interior and exterior color shall be optical black.

E. Mounting Assemblies
    1. Mounting assemblies shall consist of 1-1/2 inch standard pipe and fittings. All members shall be so fabricated such that they provide plumb, symmetrical arrangement, and securely fabricated assemblies. Construction shall be such that all conductors are concealed within assemblies. Cable guides shall be used to support and protect conductors entering assembly through poles. All threads shall be coated with rust preventive paint during assembly.
    2. Support brackets, trunnions, and fittings shall be made of cast aluminum, steel, or cast iron. Bracket parts except for stainless steel parts shall be given one prime coat of metal primer and two coats of high quality black exterior enamel.
    3. Mounting assemblies shall be watertight and all open segments of the fittings shall be plugged with an ornamental plug and a gasket.
    4. Mast arm mounting brackets shall be Astro-brac cable-mount or approved equal and shall be furnished with all incidentals necessary for complete installation.
    5. Brackets for mounting the signal head on top of a pedestal shall provide support for both the top and bottom of the signal head.
F. Each signal shall be packed or crated separate and complete by itself. The outside of each package or crate shall clearly show the manufacturer, type, catalog number, Purchaser purchase order number and project. Mounting attachments may be shipped separate from the signals, but the boxes or crates shall be marked clearly with the same information as the signals. Mounting attachments of different types shall not be mixed in one box or crate.

2.07 - Traffic Signal Lamps

A. LED Vehicle Signal Modules shall comply with the latest revision of the “Equipment and Material Standards of the Institute of Transportation Engineers: Chapter 2a: VTCSH Part 2: Light Emitting Diode (LED) Vehicle Signal Modules” Note the following: Section 5.5 Dimming (Optional) is not required. Section 5.8 Failed State Impedance (Optional) is required. Compliance with all other sections of this standard is required.

2.08 - Backplates

A. Backplates shall be 0.125 inch thick thermoplastic and provide a minimum of a 5 inch black field around the assembly. Corners of the backplates shall be rounded with a 2½-inch radius.
B. Backplates shall be supplied with attaching bolts or screws in sufficient quantity to securely hold the backplates to the signal heads.
C. Backplates will be installed with all vehicle signal heads, unless otherwise directed by the Traffic Engineering Division.

2.09 - Aluminum Traffic Signal Pedestal

A. The pedestal shaft shall be fabricated of aluminum tubing with a wall thickness of not less than 0.125 inches. Shaft shall have a brushed aluminum finish.

B. The shaft shall be attached to a square cast-aluminum base with a handhole. The size of the handhole shall be at least 8½ inches by 8½ inches and equipped with a cover, which can be securely fastened to the base with the use of simple tools. A lug shall be provided near the handhole to permit connection of a #6 AWG grounding wire.

C. The length of the pedestal, from the bottom of the base to the top of the shaft, shall be 10 feet, unless otherwise noted in the Plans. The top of the shaft shall have an outer diameter of 4½ inches.

D. Signal head mounting assemblies shall be approved by the Engineer prior to installation.

E. Pedestals shall be equipped with all necessary hardware, shims and anchor bolts to provide for a complete installation without additional parts.

F. The pedestal base shall be designed to mount on four ¾-inch anchor bolts spaced evenly around a 12¾-inch diameter bolt circle.

2.10 - Pedestrian Pushbutton Detectors

A. Pedestrian pushbutton detectors shall be Bulldog BDLM2 (Momentary LED Model) manufactured by Polara, or approved equal. Each detector shall consist of a removable contact assembly mounted in a durable metal case. The contacts shall be entirely insulated from the case and operating button with terminals for making connections. The case shall have one outlet for ½ inch pipe. The operating button shall be made of brass or other non-rusting metal alloy and shall be of sturdy design. This button shall be weatherproof and shall not protrude out from the case. The entire assembly shall be weathertight, secure against electrical shock and of such construction as to withstand continuous hard usage. The contacts shall be normally open and no current flowing except at the moment of actuation.

B. A saddle shall be provided if necessary to secure a rigid installation and neat fit.

C. Pushbutton housing shall be black.

2.11 - Controllers

A. General Design Requirements

1. Traffic signal controllers shall be EPAC M52 manufactured by Siemens, unless otherwise specified in the Plan Documents. Controllers shall be new, Ethernet-ready, and fully compatible with existing controllers on CITY's the interconnected traffic signal system, The CITY's system is ACTRA (latest revision) by Siemens.

   a. General. The controller shall be provided with suitable load switches, external to the controller, for closing and opening signal light circuits. A load switch and a flash transfer relay shall be provided for each socket in the cabinet.

   b. Closing and Opening of Circuits/Minimum Capacity. The closing or opening of signal circuits shall be positive without objectionable dark intervals, flickering of lights, or conflicting signal indications. Each switch shall have a capacity of not less than 10 amperes of incandescent lamp load at 120 volts AC.

   c. NEMA Triple Signal Load Switch(s). External jack mounted load switches shall be provided in accordance with Part 5, "Solid-State Load Switches", Sec. TS 1-5.01, NEMA Traffic Control Systems Standards, TS1-1983.

2. Conflict Monitor Minimum Requirements. For actuated controllers of solid state design and construction or actuated controllers utilizing solid state load

switches, a separate external signal monitoring device shall be provided to monitor the occurrence of conflicting Green or Walk indications and shall cause the signals to go into flashing operation should such conflicts be sensed. This shall conform to Part 6, NEMA TS1-1983.

3. Flashing of Signals

   a. Minimum Requirements. Means external to the controller shall be provided to permit the substitution of flashing signal indications for the normal specified interval sequence. The indications to be flashed shall be as specified here or in the included interval sequence chart on the plans.

   Flashing Rate: Flashing shall be at the rate of not less than 50 nor more than 60 flashes per minute with approximately 50% on and 50% off periods. Flashing rate shall not vary so long as the power source remains within the specified limits.

   Capacity: The operation of the flashing circuit shall be accomplished in such a manner as to avoid undue pitting or burning or other damage to load switches at 10 amperes of tungsten lamp load at 120 volts, 60 hertz AC for 50 million times.

   b. Control of Flasher Mode.

   Police panel switch. Operation of flash mode from police panel shall put operation of controller into Stop Time Mode.

   Inside switch. An "auto-off-flash" mode switch shall be provided inside cabinet.

   c. Flashing of Vehicular Signals. Flashing of vehicular signal indications shall be obtained from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet. If the flashing is provided by two flashers, they shall be wired to assure that the flashing of all lenses on the same approach is simultaneous.

   d. Flashing of Pedestrian Signals (Pedestrian Clearance). When pedestrian interval timing functions are included, means shall be provided to permit flashing of the DON'T WALK pedestrian signals during the pedestrian clearance interval.

   e. Solid State Flasher. A solid state flasher with no contact points or moving parts shall be provided. The solid state flasher shall use zero point switching. This shall conform to Part 8, NEMA Traffic Control Systems Standards, TS1-1983.

4. Manual Control.

   a. Manual control enable: When specified, manual commands shall place vehicle calls and pedestrian calls (when pedestrian timing is included in the controller's sequence of operation) on all phases, stop controller timing in all intervals except vehicle clearances, and inhibit the operation of the external advance input during vehicle clearance.

5. Cabinet.

   a. Basic Construction. The controller and all associated equipment shall be provided in weatherproof metal cabinet of clean-cut design and appearance.

   b. Construction Material. The cabinet shall be constructed of sheet or cast aluminum.

   The cabinet and riser shall be natural, unfinished aluminum. All mounting attachments shall be natural, unfinished aluminum or finished with two coats of high grade aluminum colored paint.

   Door. A hinged door shall be provided permitting complete access to the interior of cabinet. When closed, the door shall fit closely to gasketing material, making the cabinet weather and dust resistant. The door shall be provided with a strong lock and key.

The door shall be designed to be opened only with the standard controller cabinet key currently used by the City of Cedar Rapids. A sample key will be made available to the successful bidder.

Auxiliary Door. A small, hinged and gasketed "door-in-door" shall be included on the outside of the main controller door. The auxiliary door shall not allow access to the controller, its associated equipment, or exposed electrical terminals but shall allow access to a small switch panel and compartment containing a signal shutdown switch, a flash control switch, and other specified functions.

The auxiliary door lock shall be equipped with a strong lock utilizing keys of a different design from those provided for the main cabinet door.

The auxiliary door lock shall be designed to be opened only with the standard auxiliary door key used by the City of Cedar Rapids. A sample key will be made available to the successful bidder.

Door Stop. The controller cabinet door shall be provided with a stop and catch arrangement to hold the door open at angles of both 90 degrees and 180 degrees, ± 10 degrees.

Mounting Shelves. The cabinet shall contain strong mounting table(s) or sliding way(s) to accommodate the mounting of the controller and all included auxiliary equipment. The mounting facilities shall permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller. Refer to Fiber Optic Cable specification for additional requirements.

Mounting Screws. Screws used for mounting shelves or other mounting purposes shall not protrude beyond the outside wall of the cabinet.

Outlet and Lamp. An electrical outlet shall be furnished and located in an accessible place near the front of the cabinet and each cabinet shall be provided with a light mounted in the cabinet in a manner which will provide adequate light to service all parts of the cabinet interior during nighttime hours and controlled by a toggle switch mounted on the inside control panel.

c. Size, Type and Mounting.

Size. The cabinet shall be of such size to adequately house the controller, all associated electrical devices and hardware, splice trays, and other auxiliary equipment herein specified.

Mounting. The cabinet shall be arranged and equipped for concrete base mounting. An aluminum cabinet riser, compatible in size, shape and material with the controller cabinet specified in the Plan Documents, shall be provided. The depth of the riser shall be 15 inches. Sufficient galvanized anchor bolts, clamps, nuts, hardware, etc., as required for the specified mounting type shall be furnished with each cabinet.

d. Ventilation. A thermostatically controlled duct fan unit with a minimum rating of 100 CFM in free air shall be installed in the cabinet to provide forced air ventilation through the cabinet. The fan unit shall be mounted to the inside top of the cabinet and shall be easily removed and replaced without having to dismantle any part of the cabinet or exhaust duct system. The thermostat controlling the fan shall be manually adjustable to turn on between 90 degrees F and 150 degrees F with a differential of not more than 10 degrees F between automatic turn-on and turn-off. The fan shall intake air through filtered vents located near the bottom of the cabinet or cabinet door and exhaust it through a weather-proof, screened duct located near the top of the cabinet. Fiberglass type dry filters shall be used to cover the air intakes into

the cabinet. These filters shall be easily removed and replaced and be of standard dimensions commercially available. The filters shall be provided with positive retainment on all sides to prevent warpage and entry of foreign matter around the edges.

e. Connecting Cables, Wiring and Panels.

Connecting cables. Electrical connections from the controller (and auxiliary devices when included) to outgoing and incoming circuits shall be made in such a manner that the controller (or auxiliary device) can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires leading therefrom.

In addition to the above, a mating plug/cable assembly shall be provided for all connectors on the controller (or auxiliary device).

Panels and Wiring. Each cabinet shall be furnished with suitable, easily accessible wiring panel(s). All panel wiring shall be neatly arranged and firm.

a) Wiring terminals. Terminals shall be provided, as a minimum, for the following:
Terminal with N.E.C. cartridge fuse receptacle, fuse, power line switch or magnetic circuit breaker, with integral power line switch, for the incoming power line.
Terminal, unfused, for the neutral side of the incoming power line.
Terminals and bases for signal load switches, outgoing signal field circuits, signal flasher, and outgoing signal field circuits.
Terminals for detector cables for all required auxiliary equipment.
Terminals for all conflict monitor inputs and outputs, for all NEMA defined inputs and outputs, and for all inputs and outputs defined by the controller manufacturer which may be in addition to the NEMA defined inputs and outputs.

b) Clearance between terminals. Provide adequate electrical clearance between terminals. Arrange controller, auxiliary equipment, panel(s), terminals and other accessories to facilitate entrance and connection of incoming conductors.

c) Signal circuit polarity. The outgoing signal circuits shall be of the same polarity as the line side of the power service; the common return of the same polarity as the grounded side of the power service.

d) Grounding conductor bus. An equipment grounding conductor bus shall be provided in each cabinet. The bus shall be grounded to the cabinet in an approved manner.

f. Fusing and Surge Protection.

Incoming AC Line. Suitable overcurrent protection shall be provided.

Branch AC Circuits. Suitable overcurrent protection devices shall be provided for each of the following AC power line input circuits:

1. Controller mechanism
2. Cabinet fan
3. Conflict monitor
4. Detector amplifiers
5. Flash transfer

Light & Outlet Fuse. A 15 ampere fuse and indicating type of fuse holder, wired in advance of the main circuit breaker for protection of the AC power input circuits to the cabinet light and the convenience duplex receptacle shall be provided.

Surge Protection. High energy transient surge protection shall be provided on the incoming AC power lines in order to minimize potential controller damage. This shall be a gas discharge lightning arrestor - 200-400 volts. A second such device shall be provided on the AC power line to the controller unit. This device shall be EDCO SHP 300-10 and FIL 300 combination filtering surge protection or approved equal.

g. Plastic Envelope. Secure a heavy-duty clear plastic envelope (min. dimensions 9 inches wide x 11 inches deep) to the inside wall of the cabinet door..

6. Guarantee. The equipment furnished shall be new, of the latest model fabricated in a first-class workmanlike manner from good quality material. The manufacturer shall replace free of charge to the purchaser any part that fails in any manner by reason of defective material or workmanship within a period of 18 months from date of shipment from the supplier's factory, but not to exceed one year from the date that the equipment was placed in operation after installation.

7. Wiring Diagrams and Documentation: One documentation package shall be supplied in each controller cabinet and three additional copies will be supplied for office use. Each package will consist of the following list of items for the cabinet and load facility and for each model of controller, conflict monitor, load switch, and flasher.

   a) Complete schematic diagram, accurate and current for unit supplied.
   b) Complete physical description of unit.
   c) Complete installation procedure for unit.
   d) Specifications and assembly procedure for any attached or associated equipment required for operation.
   e) Complete maintenance and troubleshooting procedures.
   f) Warranty and guarantee on unit, if any.
   g) Complete performance specifications (both electrical and mechanical) on unit.
   h) Complete parts list - listing full names of vendors and parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
   i) Pictorial of components layout on chassis or circuit boards.
   j) Complete stage-by-stage explanation of circuit theory and operation.

2.12 - Inductive Loop Vehicle Detector

A. Design Requirements

1. Operation

a. General

The detectors shall be designed to operate with loop and lead-in wire combinations having a wide variation in electrical characteristics. The electrical characteristics are a function of the length and width of the loop, the length and type of lead-in wires, and other factors. The detector shall operate with the usual configurations of loops and lead-in wires, standard with the Department, which have a 40 to 700 microhenry total inductance.

The detector shall provide reliable detection and maintain an output indication for a period of not less than three (3) minutes for a vehicle that causes a 0.02% change in the total inductance of the loop and lead-in system as measured at the detector loop input terminals. The detector shall provide operation as above with a loop system having any or all of the following characteristics:

1) A shunting resistance of 10,000 ohms or greater to a common or circuit ground bus.
2) A loop system quality factor (Q) of not less than 5.0, when connected to

the detector being tested. Q is defined as the ratio of the resonant operating frequency over the half-power bandwidth.

3) A total or equivalent inductance within the range of 40 to 700 microhenries at the detector loop input terminals.

4) A sensitivity adjustment or selector shall be provided to allow selection of a high, medium or low sensitivity adjustment.

b. Loop Energizing and Detector Sensing Circuits. The detector shall provide reliable detection of licensed motor vehicles. The detector shall provide an input (switch closure) only when vehicles are passing or stopped over the loop and shall detect all vehicles passing over the loop at speeds up to 80 miles per hour.

Turn on. When first turned on, while tuning or being tuned, the detector shall provide a continuous output pulse (switch closure), plus a visual indication, in both the presence and pulse modes of operation. On power failure, or loop failure that would cause the inductance to exceed the tuning range, the detector must place a continuous call.

Frequency. To prevent mutual interference "crosstalk", the detectors shall be provided with a three position frequency mode switch on the front panel.

Automatic Tuning. The detector shall be designed to be initially tuned to the loop and provide for automatic drift compensation.

Weather. The operation of the detector shall not be affected by changes in the inductance of the loop caused by environmental changes, such as rain, hail, snow, temperature humidity, nor shall the sensitivity be markedly affected.

c. Accuracy. The detector shall be able to detect all licensed vehicles, including motorcycles, accurately.

2. Detector Output. The detector output (switch closure) to the associated traffic control equipment shall be provided by means of a relay. The relay shall have a mechanical life of at least 1,000,000 operations. The contacts shall have a rating of at least 1.0 ampere at 120 volts AC or DC.

3. Visual Indicator. A long life light emitting diode shall be used to provide a visual indication of each vehicle detection. Lamps shall be easily replaceable without the use of tools. The indication must be readily visible in the indirect sunlight.

4. All indicator lights shall have a minimum design life of 20,000 hours at rated voltage unless an ON-OFF switch is provided to control the lights. If an ON-OFF switch is provided, the design of the lights need be only 1,000 hours at rated voltage.

5. Dielectric Strength. The detector shall withstand a dielectric strength test of 1,250 volts, 60 hertz per second, AC applied between the 120 VAC line-supply circuit and the terminals for the external loop for a period of one minute

6. Interchangeability and Design Life. All modules and components of the same type shall be interchangeable. The design life of all components, under conditions of normal operation, shall not be less than five years.

7. Delay Call. Unless otherwise specified on the Plan Documents, the detector, shall have a "Delayed Call" feature, shall be capable of ignoring a vehicle actuation unless it persists for more than a predetermined period of time. The predetermined time shall be adjustable from 0 to 25 second minimum on the front panel. The "Delayed Call" feature shall be inoperative during the green interval for the phase related to the amplifier.

8. Call Extension. Unless otherwise specific in the Plan Documents, the detector shall provide a “Call Extension” feature capable of holding a vehicle actuation for a specified duration after the vehicle has left the point of detection.

B. Mounting
   1. Unless otherwise specified in the Plan Documents, detectors shall be two – channel detectors and rack-mounted. A power supply shall be provided with the rack, of sufficient power for the number of slots.
   2. Detector Units shall be designed for use with loop combinations (two to four loops) in series or series-parallel. The detector model shall have a visual indication of a call and will not require external equipment for tuning or adjustment.
   3. Marking. Each detector shall be marked with the manufacturer's name, model, catalog, or type number, and serial number. The electrical input rating (voltage, frequency, and wattage) shall be included in the marking.

C. Components
   1. Inductors and Transformers. All inductors and transformers shall have their windings insulated and shall be impregnated to exclude moisture. All wire leads shall be color coded.
   2. Resistors and Capacitors. All resistors and capacitors shall be insulated and shall be marked with their resistance or capacitance value. Resistance and capacitance values may be indicated by the Radio Electronics Television Manufacturer's Association (RETMA) color codes. All electrolytic capacitors shall be marked to indicate polarity and voltage.
   3. Printed-Circuit boards. All printed-circuit boards shall be at least 1/16 inch thick and shall be made of glass-cloth silicone. National Electric Manufacturer's Association (NEMA) type G-10 glass epoxy or equivalent. The conductor material shall be copper, 0.0027 inch thick, having a weight of 2.0 ounces per square foot, with a protective solder coating. All printed-circuit board connectors (male and female) shall be gold plated over the copper base. The printed circuit-boards shall be securely mounted in such a way as to prevent flexing or bending of the boards, and shall be easily removable for servicing or replacement.
   4. Solid State Circuitry
      a. Components. Transistors, integrated circuits, or semi- conductor diodes shall be used for all amplifying, detecting, rectifying, counting logic, and regulator circuits. Transistors, integrated circuits, and diodes shall be marked with their type number and shall be types listed by the Radio Electronics Television Manufacturer's Association (RETMA).
      b. Proprietary parts. All electronic and electrical components must be of standard manufacture and available from a source other than the manufacturer of the loop detector unit.
   5. Temperature. The temperature of components shall not cause any appreciable reduction in component life when the detector is operated in an ambient temperature from 20 degrees to 180 degrees F.

D. Workmanship: The detector shall be fabricated, assembled, and wired in a workmanlike manner.

E. Documentation
   1. Contents. A documentation package shall be supplied in each controller cabinet for the inductive loop vehicle detectors which shall consist of the following:
      a) Complete schematic diagram, accurate and current for unit supplied.
      b) Complete physical description of unit.
      c) Complete installation procedure for unit.
      d) Loop specifications and loop assembly procedure.
      e) Complete maintenance and troubleshooting procedures.
      f) Warranty and guarantee on unit, if any.

g) Complete performance specifications (both electrical and mechanical) on unit.
h) Complete parts list - listing full names of vendors and parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
i) Pictorial of components layout on chassis or circuit boards.
j) Complete stage-by-stage explanation of circuit theory and operation.
k) Number of copies. At least three full documentation packages for each detector sensing unit model shall be supplied to the Engineer.

2.13 - Video Detection System

This specification sets forth the minimum requirements for a Video Detection System that monitors vehicles on a roadway via processing of video images and provides detector outputs to a traffic controller or similar device. Unless otherwise stated below, placement and operation of video detection components shall be subject to the specifications for loop detectors.

The system shall be composed of these principal items: the cameras, the field communications link between the camera(s) and the processor unit(s) along with any PC, video monitor or associated equipment required to set up the system.

The configuration will consist of the following components: Four (4) cameras (unless otherwise specified in the Plans), mounting assembly(ies), 1 to 4 rack-mounted detector cards, card racks(s), field video monitor (minimum 9 inch screen), software and all associated equipment required to set up and operate in a field environment. Material provided by the Contractor shall include two (2) sets of operations manuals and one (1) service manual with schematics and parts list for out-of–warranty repairs.

Detection

1. The system shall provide real-time vehicle detection.
2. The system software shall be able to detect either approaching of departing vehicles in multiple traffic lanes.
3. A minimum of 24 detector outputs for a multiple cameral processor and 6 detector outputs for a single camera processor shall be available.
4. A minimum of 16 detection zones per camera shall be available that are user-defined through interactive graphics.
5. The system shall compensate for minor camera movement (up to 2 percent of the field of view at 400 feet) without falsely detecting vehicles. The camera movement shall be measured on the unprocessed video input to the processor units.

Detection Zones

1. The system shall provide flexible detection placement anywhere within the combined field of view of the image sensors.
2. Placement of detection zones shall be by means of a graphical interface using the video image of the roadway. The monitor shall show images of the detection zones superimposed on the video image of traffic.
3. Detection zones shall be capable of being sized, shaped and overlapped to provide optimal road coverage and detection.
4. Detection zones shall be provided that are sensitive to direction of travel. The direction to be detected by each zone shall be user programmable.
5. When a configuration has been created, the system shall provide a graphic display on the monitor. When a vehicle occupies a detection zone, the zone on the live video shall indicate the presence of a vehicle.

6. Detection zones shall have the capability of implementing logical functions (including AND and OR), counting, and delay timing. These logical functions may be excluded in the provisions are made to bring each detector separately into the controller and the controller can provide these functions.
7. It shall be possible to save detector configurations on disk, to download configurations to the processor, and to retrieve the configuration that is currently running in the processor.
8. The user shall be able to redefine previously-defined detection zones and configurations using a mouse or keyboard.
9. Detection accuracy shall be comparable to properly operating inductive loops.
10. Equipment failure, either camera or processor, shall result in constant vehicle call on affected detection zones.

2.14 - Wireless Vehicle Detection

A. This specification sets forth the minimum requirements for a Wireless Vehicle Detection System that provides the required vehicle detection as indicated in the plans. All work, equipment and materials to provide a properly functioning Wireless Vehicle Detection System is included.

B. The system shall be comprised of these principal items: in pavement (flush to surface) wireless sensor unit at locations where detection is required, a base station at each traffic signal controller, any required amplifier units to ensure the strength of the wireless signal at the base station, along with any associated equipment required to set up the system. The equipment shall include any required mounting brackets and cable both internal and external to the traffic signal cabinet. The system shall also include any modifications to the traffic signal controller cabinet(s) necessary to provide the wireless vehicle detection.

C. The in-pavement wireless sensor unit and the amplifier unit shall be battery powered.

D. The Wireless Vehicle Detection System shall comply with FCC Part 15, UL, and Public Safety (Part 70).

A.

2.15 - Fiber Optic Cable

This work shall consist of furnishing and installing a fiber optic cable of the type, size and number of fibers specified.

General Requirements

Materials and Equipment

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products. The fiber optic cable shall be OFS BrightWave or Corning conforming to the following specifications. The fiber optic shall be manufactured utilizing Corning glass fiber conforming to the following specifications. All materials and equipment furnished shall be completely free from defects and poor workmanship. All fibers shall be glass and be manufactured by Corning or pre-approved equal. The cable shall be rated for

gigabyte data bandwidth. 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 foot of point of termination eliminating the requirement to convert to indoor cable.

Contractor Qualifications

Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. 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.

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.

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.

General Considerations

The cable shall meet all requirements stated within this specification.
The cable shall be new, unused, and of current design and manufacture.

Fiber Characteristics

All fibers in the cable must be usable fibers and meet required specifications.

Multi-mode Fiber

Core diameter: 62.5 +3.0um
Cladding diameter: 125.0 +2.0um
Core-to-cladding offset: <3.0um
Coating diameter 250 +15um
Graded Index
Attenuation uniformity: No point discontinuity shall be greater than 0.25 dB, except terminations or patch cords, at either 850nm or 1300nm. 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.

Factory cable rating shall be 3.5 dB/KM at 850 nM and 1.0 dB/KM at 1300 nM, or less. Installed tolerance shall be less than 3.85 dB/KM at 850 nM and less than 1.1 dB/KM at 1300 nM, testing tolerance. Multimode fiber shall be rated for serial gigabit Ethernet distances of 300 meters @ 850nM and 550 meters @ 1300 nM.

Single-Mode Fiber

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.

Factory cable rating shall be 0.40 dB/KM at 1310 nM and 0.30 dB/KM at 1550 nM. Installed tolerance shall be less than 0.44 dB/KM at 1310 nM and less than 0.33 dB/KM at 1550 nM, testing tolerance. Single mode fibers shall be rated for serial one gigabit Ethernet distances of 5000 meters @ 1310 nM and serial ten gigabit Ethernet distances of 10,000 meters @ 13xx nM and 40,000 meters @ 1550 nM.

Fiber Specification Parameters

All fibers in the cable shall meet the requirements of this specification. The testing tolerance attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable when installed.

The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km at 1550 nm, with 80 percent of the measured values no greater than 0.10 dB/km at 1550 nm.

Optical fibers shall be placed inside a loose buffer tube, minimum six (6) fibers per tube, normally twelve (12) fibers per tube. Actual number of fibers per tube shall be twelve fibers per tube unless specified differently on the Plans.

Multimode only – each buffer tube shall contain 12 or 6 fibers.
Single-mode only – each buffer tube shall contain 12 or 6 fibers.

The buffer tubes will meet EIA/TIA-598, “Color coding of fiber optic cables.”

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively and 5000 Meter for 1310 and 1550 nM.

Single-mode fibers shall be placed in the first buffer tubes. Multimode fibers shall be in the remaining buffer tubes. Fiber count, tubes of fiber, shall be as specified on the plans.

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

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

The cable shall use a completely dry cable design without the use of gels and 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.

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

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.

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 or MM) and sequential feet or meter marks. The markings shall be repeated every one-meter or three feet. The actual length of the cable shall be within –0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The 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 a contractor’s listing of place(s) of installation when installed by a Contractor.

The maximum pulling tension shall be 600 pounds (2700 N) during installation.

Where ever possible, six (6) buffer tubes with twelve (12) fibers each, or subsets specified, shall be provided and designated as follows:

Buffer Tube/Fiber	Tube/Fiber Color
#1, 1st tube or fiber	blue
#2, 2nd tube or fiber	orange
#3, 3rd tube or fiber	green
#4, 4th tube or fiber	brown
#5, 5th tube or fiber	slate
#6, 6th tube or fiber	white
#7, 7th tube or fiber	red
#8, 8th tube or fiber	black
#9, 9th tube or fiber	yellow
#10, 10th tube or fiber	violet
#11, 11th tube or fiber	rose
#12, 12th tube or fiber	aqua

Quality Assurance Provisions

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

All optical fibers shall be 100% attenuation tested at the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for both 850 and 1300 frequency for multimode and 1310 or 1550 frequency for single mode. This documentation shall be provided with each spool. The Contractor shall designate on the Plans and on this documentation the location where each spool has been installed and provide this data to the Engineer.

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 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 swing 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 a 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 a lubricant is used it shall be of water

based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination, minimum of 30 feet. This slack shall be in addition to installation slack as hereinafter specified. Additional slack cable shall be left in each hub cabinet, handhole, and at the top of each conduit riser. Excess slack at hub cabinets shall be re-pulled into the nearest handhole to provide a neat and orderly installation. The minimum slack amounts shall be as follows:

Hub or signal controller cabinet – 30 feet
Concrete Handhole – 20 feet
"Quazite" Handhole – 100 feet

B. Storage of minimum slack cable in controller cabinets and additional slack at handholes shall be coiled. The slack coils shall be bound at a minimum of 3 points around the coil parameter and supported in their static storage positions. 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, one (1) #10 AWG THHN, 600 volt single conductor cable (tracer), orange in color, shall be pulled with ten feet (10') slack in each handhole, except where rigid metallic conduit or other metallic conductors are installed.

C. All fiber cables shall be marked with a metallic identifier in the handhole adjacent to the traffic signal cabinet or hub cabinet and on the cable in the traffic signal cabinet or hub cabinet at the point of termination. The identifier, both in the cabinet and in the handhole, shall indicate the direction the cable is going, cable contents [SM or SM/MM], and the abbreviated location for the other end destination. Fiber cabling between traffic controllers and adjacent hub locations shall be outdoor rated, loose tube fiber, when not linked by a direct, continuous conduit installation.

MINIMUM BEND RADIUS

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

AFTER THE FIBER OPTIC CABLE INSTALLATION

E. 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 optical time domain reflectometer (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 cable is installed between traffic controller cabinets and fiber links between fiber distribution points (FDP) complete links, whether terminated or non terminated, shall be tested with an OTDR and a power meter. All fibers terminated shall be tested with a power meter. The Contractor may jumper termination points at controller cabinets to minimize the number of tests and run a single OTDR test between several controller cabinets, subject to the range of the OTDR. Links between FDPs shall be tested separately. Multimode fiber may be tested using 1300 nm and single mode may 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.

F. Data documentation shall include for each test between cabinets or between FDP sites, 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. Outdoor patch cords between FDP and controller units less than 151 feet do not need be OTDR tested.

G. Documentation provided to the Engineer shall include a 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	0.60 MM & 0.15 SM dB each
Unicam Terminations	1.0 dB set of 2 [In and Out]
Splices	0.08 each

1 KM = 0.3077 KF where KF is 1000 feet

H. Data documentation shall include for each test between cabinets or between FDP sites, 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.

CABLE TERMINATION

I. Terminations shall be made using the method recommended by the connector manufacturer. All fibers shall utilize a fanout kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube. All fibers terminated shall utilize a ceramic ferrule (outdoor connections), ST, mechanical termination equal to Siecor UniCam connectors, or be a wide temperature (40 to +170 degrees Fahrenheit) epoxy. Heat cured or epoxy type connections meeting the full temperature ratings are acceptable for this Project, including factory manufactured pigtails. The Contractor shall be required to 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. 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 the metal reinforced shrink tube protector. The contractor may terminate fibers by the use of UniCam mechanical termination connectors. All termination ST couplers shall be rated for dual fiber application, MM and SM.

BREAKOUT KITS

J. The breakout kits 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. The termination housing shall be installed within a wall or shelf mountable interconnect housing which shall provide for storing fibers, ample room for feed through cable, strain relief for multiple cables within unit, and

accommodate ST compatible connectors. All fiber pigtails shall be terminated through ST connectors on the wall or shelf mounted interconnect panel. All terminations shall be ST type, ceramic core (outdoor connections), and plug into the provided controller unit internal fiber optic modem. Acceptable enclosures for combination termination/splice points shall be MIC024 or WDC012 enclosures or pre-approved equal. 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 zero degrees to +150 degrees Fahrenheit. In the absence of pigtails meeting this temperature rating, fibers shall utilize loose tube fiber in fanout kit tubes and UniCam mechanical ST or epoxy approved connectors. These splices, fiber cable to pigtails, may be external to splice trays mounted internally to the enclosure, when shown on the wiring diagrams. All other splices, not specified to be installed external to the fiber splice tray, shall be installed in splice trays and be supported with heat shrink tubing. Acceptable splice trays include MIC024048 or 067 series or preapproved equal.

CONNECTORS

K. Connectors shall be mechanical ST (ceramic ferrule outdoor connections) compatible, field installable, and self aligning and centering or factory fabricated pigtails. Connectors to the special devices used for Ethernet network connections shall utilize a factory converter cable of SC to ST or manufacturer specified converter patch cord. Fiber optic equipment, used for terminating fibers, shall be rated for the type of connectors used. Connectors shall be Siecor CamLite, UniCam, or NEMA temperature rated epoxy type, or Engineer approved equal.

SPLICES

L. The fiber cable shall be installed in continuous runs between cabinets. No splices shall be allowed, unless shown on the plans or for testing. For testing of unterminated fibers, only mechanical splices may be used. Mechanical splices shall:

i. Use a fiber optic mechanical splice connector including a single connector element operable for providing optical fiber alignment and strain relief includes opposed splice components that define first and second grooves for receiving the bare glass portions of mating optical fibers, as well as the coated or buffered portion of at least one of the optical fibers when the splice components are biased together by an actuator.

ii. The mating optical fibers are aligned while the coated or buffered portion of one of the optical fibers is retained within the same connector element, thus eliminating positioning problems that occur when separate connector elements are utilized for fiber alignment and strain relief.

iii. The splice components may be unbiased to allow removal of at least one of the mating optical fibers without destroying the connector assembly or potentially damaging the optical fibers.

All other splices, where specified, shall be by fusion splice and shall be installed using an automatic fusion splicer. Splices between two fibers leaving the cabinet shall be supported in splice trays installed in splice enclosures. All splices shall be protected by heat shrink tubing designed for fiber optic splicing applications. Fibers being terminated in two separate termination/splice enclosures shall be supported between enclosures by the use of buffer tubing or approved equal support material or shall be pigtail patch cords. Termination / splice enclosures shall be separated by less than 12 inches unless a conduit is installed between enclosures. All splices shall be performed by an automated splicer device that verifies the final splice termination quality. All splices shall be nominally .03 to .05 dB loss but shall be less than a 0.08 dB loss.

LIGHT SOURCE

M. An LED light source with a wavelength that is the system wavelength, 850 and 1300 nm for multimode and 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 the 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 .05 dB and be temperature compensated stabilized to 0.01 dB over the operating range of the meter(s).

POWER METER

N. 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.

LAUNCH REFERENCE ATTENUATOR

O. The launch attenuator, two each for single and multimode 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 300 hundred foot fiber length, minimum, for multimode and 900 feet 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 launce 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.

P. 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 with out showing the extraneous noise caused by handhole coils or turns 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 to splice, jumper or patch cord. The Threshold Loss shall then be set to a value of 0.25 for multimode fiber tests and 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 this threshold shall be identified, such as jumper or patch cord. Events that are in excess 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 of leaving the splice tray (See Testing). For measured values recorded in excess of the above (0.25 MM and 0.10 SM) listed values, refer to the paragraph 12.2 specification as hereinbefore defined. The Engineer reserves the right to spot test fiber terminations, splices, or retesting 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 be cause for the Contractor to retest the entire fiber installation.

TESTING

Q. General

The Contractor shall provide all personnel, equipment, instrumentation

and supplies necessary to perform all testing. All testing shall be performed in an 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 Engineer may perform or require supplemental testing at any time. The Contractor shall provide one copy of operating software to read and view all OTDR traces.

R. Attenuation

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 the 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 optical cable shall be as measured by the OTDR rather than the fiber cable jacket as the fiber is a 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 shall be provided in the recorded documentation for each link distance. All distances shall be recorded in feet rather than meters for both recorded lengths.

S. 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 with 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 6, 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 a dB loss budget.

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

U. Each tube of a 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 a cable. Traffic multimode fiber measured in sections marked by traffic controller cabinets between Hub Sites may be subsectioned in an easy to understand format or may be jumpered using patch cords as a single OTDR Link with each section separated for power meter readings.

V. Continuity

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.

W. 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 NFL 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.

OTDR TESTING

X. An Optical Time Domain Reflectometer (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. 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.

Y. An Optical Time Domain Reflectometer (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 terminations on the fibers for a link have been completed. The fiber loss in dB/km and the 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.

DOCUMENTATION

Z. 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 test, 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 a floppy disk. (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.

AERIAL FIBER

AA. Existing communications cable, installed as span wire installation, shall be utilized to relash the aerial fiber optic cable and shall not be removed unless shown on the Plans or approved by the Engineer in writing. Where existing infrastructure does not exist, the Contractor shall furnish and install new span wire messenger cable for lashing the fiber cable. Snap ties or cable ties for lashing shall not be permitted on this project. All costs incurred in removing, disposing or reusing the existing communications cable shall be considered incidental to the cost of installing the new fiber optic cable.

BB. Installations, where all fiber optic cable is aerial before entering the controller, building or underground conduit system, shall be provided with a minimum of one hundred (100) feet coiled at the pole prior to going to the cabinet and one hundred feet coiled at the pole when exiting the cabinet. This one hundred foot section is in addition to the 20 feet minimum required for termination inside cabinets, buildings or other termination areas. Additional storage shall be required as specified on the Plans.

CC. Overhead Enclosures

The overhead shall be a six port enclosure capable of supporting a minimum of 48 fibers, loose buffer tubes, single fiber splices in trays of 12 splices each. The splice enclosure shall be fully waterproof, corrosion resistant, reentry capable and have gasketing for the entire length of the body as well as for each cable entry. The enclosure housing shall be sealed by the use of a permanent neoprene gasket and shall not require a flame to break the seal or to install. The cable entry section shall support a minimum of four ports of the size cable being installed, greater than one-half inch. Unused ports shall be sealed. Enclosures shall be stainless steel or ultraviolet stabilized black glass filled high density thermoplastic shell material. The enclosure shall be provided with built in shell stabilizers and air valve. The enclosure shall be provided with a heat shield to protect against extreme environment temperatures. The enclosure shall be provided with an adjustable aerial bracket mount and, where mounted inline, shall be provided with a vertical mount bracket. All aerial mount enclosures shall be provided with strength member brackets. The fibers shall be routed from the end plate to the splices trays using transition (transport) tubes.

4.11 WIRELESS COMMUNICATION SYSTEM (If specified in the plans)

A. This specification sets forth the minimum requirements for a Wireless Communication System that provides the required connectivity between traffic signal controllers for traffic signal interconnection as indicated in the plans. All work, equipment and materials to provide a properly functioning Wireless Communication System is included.

B. The system shall be composed of these principal items: the base station, the remote unit(s) located at the remote intersection(s) and the outdoor antenna(s) along with any associated equipment required to set up the system. The equipment shall include any required mounting brackets and cable both internal and external to the traffic signal cabinet. The system shall also include any modifications to the traffic signal controller cabinet(s) necessary to provide the wireless data communication.

C. The Wireless Communication System shall provide data communication via broadband with a minimum rating of 4.9 GHz.

D. The Wireless Communication System shall comply with FCC Part 15, UL, and Public Safety (Part 70).

4.13 ETHERNET COMMUNICATIONS SYSTEM (If specified in the plans)

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

The fiber optic Ethernet communications equipment shall include:

- Heavy Duty Field Switch shall be GarrettCom Magnum 6KQ
- Serial to FSK Converter shall be GarrettCom Magnum 100 Mb Fiber Media Converter
- Device server shall be 4-port, premium rated GarrettCom Magnum for Outdoors 10/100.
- Ethernet Access Device (EAD) shall be Actelis ML620
- Edge switches shall be ES42 PD as manufactured by GarrettCom

B. The system shall be primarily fiber optic cable based, but may include interface equipment to change from fiber optic communication to twisted pair copper wire communication as shown in the plans. The system shall also include interface equipment and cabling for CAT-5 communications.

C. 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.

4.14 SERVICE PEDESTAL AND BACK-TO-BACK BATTERY BACK-UP SYSTEM

If set forth in the Plans, the Contractor shall supply and install a combination battery back-up, electrical service with meter and lighting controller. Additional features must include transfer switch for generator power (lockage in use), metered disconnect for traffic signal, and un-metered disconnect for street lighting. Dedicated conduits shall connect the unit with the fiber hub cabinet, the adjacent signal pole base (for street lighting) and the designated quazite handhole (for traffic signal cabinet). The service pedestal shall be part of the continuously grounded system discussed in this specification.

A. The underground service distribution and control pedestals shall be constructed of anodized aluminum. The system shall provide uninterrupted, conditioned power (true pure sine wave) for the Traffic Controller Cabinet and fiber hub cabinet to eliminate Black-outs, Brown-outs, and Spikes on the signals and the control equipment. A typical intersection with a power outage, will operate as normal for 2 hours of run time and 8 hours of flash. Upon normal power resumption, the system shall recharge to 95% within 6 hours. Batteries shall be quick, hot swap replacement with no exposed terminals. The system shall monitor and record transient events and self-test the batteries, and provide local and remote data.

B. Service pedestal will include:

- Small and low profile with no exposed fasteners.
- Fabricated from anodized aluminum.
- Durable all welded construction.
- Vandal proof doors with hasp stress rated to 2,000 lbs.
- The cabinet shall be factory wired and tested before shipment.
- UL approved copper cable busing and control wiring.
- Meets EUSERC requirements.
- Shall provide both unmetered and metered circuits up to 200 Amps.

C. Cabinets and power specifications:

- Dual Cabinets external dimensions: 20.5” wide x 50’ high x 19.25” deep, excluding door handles.
- Cabinet shall be fabricated from 118” anodized aluminum.
- Internal parts shall be fabricated from 14 gauge cold rolled steel.
- Cabinet shall be all welded construction with welding materials

specifically designed for the material used.

- All fasteners, latches, and hardware shall be of stainless steel and all hinges shall be continuous piano style.
- There shall be no exposed nuts, bolts, screws, rivets, or other fasteners on the exterior.
- Removable backpan shall be mounted on 4 welded 1/4" studs.
- Cabinet doors shall have 2,000 lb. stress rated hasp, welded to the cabinet and door.
- Cabinets shall have fully framed side hinged outer doors with swagged close tolerance sides for flush fit with top drip lip and closed cell neoprene flange compressed gaskets.
- Base mounting detail shall be identical to existing cabinets for emergency replacement.

Deadfront Safety Door

- Distribution and control panel shall have a hinged deadfront panel with 1/4 turn latch and knurled knobs.
- Deadfront shall be hinged on the same side as the front door and shall open a minimum of 120°.

Power Distribution Panel

- Main breakers shall be 1 pole, 2 pole, 3 pole, or 4 pole, as appropriate for this installation, and in accordance with the local utility.
- Provide separate metered main, unmetered lighting main, and disconnects as required.
- There shall be no plug-in circuit breakers. Circuit breakers shall be industrial grade.
- All branch circuit breakers shall be installed in a vertical position, handle up for 'On', handle down for 'Off'.
- All busing shall be U.L. approved copper THHN cable busing, fully rated.

Battery Back-Up System

- Vandal-resistant construction.
- 1400 VA, 950 Watts, Industry Standard run time 3 hours - all LED Intersection.
- Typical Intersection (700 watts) run time 2 hours, with 6-8 hours of selected flash.
- Inverter Tit-out housing for easy maintenance.
- No tools required for inverter 110 contact connections and simple slide-in installation, weights 28 lbs.
- Full power bypass and isolation switches.
- Transient voltage protection.
- Power Analyzer with triple redundant Bypass
    - Conditioned power

    - Power Conflict Monitor with isolation and transfer module
    - Watchdog timer with redundant 5 ms delay and hard transfer to utility power
- Smart slot communications I/O module.
- RS 232 and USB ports for local or remote monitoring.
- Intelligent battery management system with microprocessor controlled smart battery charger, automatic self test, cell guard for longer life and faster recharge times.
- 24V 18AH batteris AGM/VRLA (absorbed glass mat/valve regulated lead acid), compact, lightweight only 25 lbs.
- Seismically rated fixed position framed battery trays.
- Quick swap hot battery replacement system.
- Heavy duty smart safety battery connection system, 30A silver plated plugs.
- Battery Manufacturer's 2 year warranty.

Control Compartment

- All components shall match existing components in use for maintenance of spare parts and known reliability.
- The cabinet shall be completely prewired in the factory.
- All control wiring is 19 strand #14 AWG THHN.
- All terminals shall be permanently labeled.

Nameplates and Drawings

- The function of circuit breakers, switches and other components as required shall be identified by laminated engraved plastic nameplates fastened with minimum of two 1/4", #4-40 machine screws.

2.16 -

2.17 - Equipment And Materials

A. Equipment and materials shall be of new stock unless the Plan Documents provide for the use of existing equipment, or equipment furnished by others. New equipment and materials shall be the product of reputable manufacturers of electrical equipment and shall meet the approval of the Engineer**.**

PART 3 EXECUTION

3.01 - General

A. The Contractor shall furnish and install all equipment and materials necessary for a complete and operative signal installation as shown on the plans and described in the Contract Documents. The Contractor shall perform all work required and furnish all labor, materials, equipment, tools, transportation and supplies necessary to complete the work in accordance with the Contract Documents.

B. The Contractor shall be a licensed electrical Contractor in accordance with City Ordinance and adherence to local Building Code shall be met.

C. The Contractor will be responsible for incidental sidewalk removal and replacement necessary to complete the signal construction. All waste material and debris shall be disposed of at a sanitary landfill at the Contractor's expense.

D. All incidental parts which are not shown on the plans or specified herein, and which are necessary to complete the traffic signal, or electrical systems, shall be furnished and installed as though such parts were shown on the plans or specified herein. All systems shall be complete and in operation to the satisfaction of the Owner at the time of completion of the work.

E. The Engineer or his representative shall have full freedom to observe all phases of the work performed by the Contractor and to discuss all matters dealing with the quality and progress of the work.

F. The Standard Specifications for Highway and Bridge Construction, current Series, Iowa DOT, as modified by these contract documents shall apply to this specification.

G. The above specifications are referred to as the Standard Specifications. Part 1 of the Standard Specifications shall not apply to this section.

H. The installation of the signals and signs shall be in conformance with the "Manual On Uniform Traffic Control Devices for Streets and Highways", latest adopted revision.

3.02 - Qualifications, Service Calls, And Warranty

A. Contractor's personnel are required to be knowledgeable of the traffic signal controller operation and wiring. Controller manuals and wiring schematics will be provided to the Contractor for his use on the project. These documents must be returned undamaged at the end of the project.

B. The Public Works Department Traffic Engineering Division will provide part-time observation of the Contractor's work. The Division's representative will be available during normal working hours (7:00 A.M.-3:30 P.M.) to review the Contractor's work. Contractor shall provide four hours advance notice to the Division for review of the work. Any service calls or review of the Contractor's work outside of the Department's normal working hours will be billed to the Contractor.

C. The Traffic Engineering Division will continue to provide service call maintenance during the project. If it is determined that the malfunction was caused by the Contractor's work, then the Contractor will be billed for the materials, labor, and equipment required to correct the malfunction and/or damage.

D. The Contractor shall guarantee all his work against defects due to poor workmanship or materials as specified in the Contract Documents.

3.03 - Concrete Bases For Poles And Controller

A. Conform to the Standard Details and Section 02600.

B. Excavations for bases shall be made in a neat and workmanlike manner. Whenever the excavation is irregular, forms shall be used to provide the proper dimensions of the foundations below grade. Construction of the bases may require hand excavation to verify location of utilities.

C. 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 and means shall be provided for holding them rigidly in place while the concrete is being placed. When located within or adjacent to a continuous sidewalk area, the top of the pole bases shall be set flush with the sidewalk or pavement surface.

D. All reinforcing bars, conduits, ground rods, and anchor bolts shall be installed rigidly in place before concrete is placed in the forms. Cap and protect conduit ends before placing concrete.

E. Anchor bolts for the signal poles or the controller shall be set in place by means of a template constructed to space the anchor rods in accordance with the manufacturer's requirements. The top of the bolts shall not vary more than 1/4 inch. The center of the template and the center of the concrete base shall coincide unless the Engineer directs otherwise.

F. 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. The exposed surface of the base shall have a wood floated surface finish. Exposed concrete surfaces shall be cured using white-pigmented curing compound or plastic film meeting the requirements of the Iowa DOT Standard Specifications.

G. The bottom of the foundations and bases shall rest securely on firm undisturbed ground. Where the foundation or base cannot be constructed as shown on the plans because of an obstruction, the Contractor shall use other effective methods of supporting the pole as may be designated by the Engineer.

H. After the concrete is placed in the form, it shall be vibrated with a high-frequency vibrator to eliminate all voids.

I. 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. The Contractor shall bear all costs of replacing work deemed unsatisfactory by the Engineer.

J. Unless otherwise specified, anchor bolts for poles where arms are to be perpendicular to the centerline of the street shall be installed so that a line through the center of one anchor bolt farthest from the curb and extended through the center of the adjacent anchor bolt closest to the curb will be perpendicular to the centerline of the street to within two degrees of arc unless otherwise specified.

K. 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.

L. Each base location shall be approved by the Engineer prior to construction. Base dimensions shown on the plans are minimum dimensions and based on stable soil conditions. Should extremely loose or sandy soil be encountered, the Contractor shall contact the Engineer for necessary base alterations.

M. Where shown on the plans, the Contractor shall remove the top of existing mast arm footings, anchor bolts, and conduits to 36 inches below the existing top of curb or edge of pavement elevation. Waste materials shall be removed from the site and disposed in accordance with local regulations. Backfilling for the removal shall be performed with mechanical compaction equipment meeting the requirements for backfilling conduit. The upper 6 inches of the removal area, if outside the proposed pavement, shall be backfilled with black dirt and seeded.

3.04 - Handholes

A. Handholes shall be a precast unit conforming to the requirements of the plans.

B. The ends of all conduit leading into the handhole shall fit approximately 2 inches beyond the inside wall. A drain conforming to the dimensions shown on the Plan Documents shall be constructed in the bottom of the handhole unless otherwise specified.

C. Frames and covers for handholes shall be set flush with the sidewalk or pavement surface. When installed in an earth shoulder away from the pavement edge, the top surface of the handhole shall be approximately 1 inch above the surface of ground. When constructed in unpaved driveways, the top surface of the handhole shall be level with the surface of the driveway.

D. Openings for conduit access shall be drilled to match the outside diameter of the conduit.

E. Grout conduit access after installing conduit.

F. Install galvanized cable hooks if not precast with the handhole.

G. Plastic loop and polymer concrete handhole construction shall meet the requirements for precast handholes except that cable hooks will not be required in plastic handholes.

3.05 - Conduit

A. Conduit shall be placed between structures as identified on the plans.

B. Conduit shall be installed without change in direction directly from one structure to another, unless approved by the Engineer. Change in direction may be considered for physical restrictions such as right-of-way restrictions, utilities, location of roadway slopes, retrofitting existing conduit stubs, and certain short sections of conduits.

C. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. Where it is necessary to cut and thread steel conduit, exposed threads will be field galvanized.

D. All conduit and fittings shall be free from burrs and rough places. Standard manufactured elbows, nipples, tees, reducers, bends, couplings, union, etc. of the same materials and treatment as the straight conduit pipe shall be tightly connected to the conduit.

E. Prior to installation of cable, all conduit ends shall be provided with a bushing to protect the cable from abrasion, except for open ends of conduit being placed for future use. Bushings shall have grounding fittings which shall be connected to the grounding system by a #6 ground wire as contained in these specifications.

F. All conduit placed for future use shall be threaded and capped with threaded metal pipe caps.

G. All conduits shall drain, except for specific locations approved by the Engineer. Contractor will not be allowed to bend conduits upward to accomplish the conduit clearances shown on the handhole details.

H. All conduit openings shall be sealed with an approved sealing compound after the cables are in place. This compound shall be a readily workable soft plastic. It shall be workable at temperatures as low as 30 degrees F, and shall not melt or run at temperatures as high as 300 degrees.

I.

3.06 - Trenching And Backfilling For Traffic Signals

A. Secure written approval of the City Forester/ Arborist prior to any trenching or excavation within the drip line of any tree.

B. Trenches shall be excavated to such depth as necessary to provide 12 inch to 18 inch cover over the conduit. All cinders, broken concrete or other hard abrasive materials shall be removed and shall not be used for backfill. The trench shall be free of such materials before the conduit is placed. No conduit shall be placed prior to inspection of the trench by the Engineer.

C. All trenches shall be backfilled as soon as possible after installation of conduit. Backfill material shall be deposited in the trench in layers not to exceed 6 inches in depth and each layer shall be thoroughly compacted before the next layer is placed. Hard materials shall not be placed within 6 inches of the conduit.

D. Whenever excavation is made across parkways, gravel driveways, or sodded areas, the sod, topsoil, crushed stone and 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 sidewalk pavements, and base courses and bituminous surfaces shall be replaced with new materials and the cost shall be incidental to the work.

3.07 - Pushed Conduit

A. It is intended that all conduit be placed without disturbing the existing pavement, and the term "pushed" is used. "Pushed" conduit shall be placed by jacking, pushing, boring or any other means necessary to place the conduit without cutting or removing pavement.

B. Removal of pavement will require prior approval of the Engineer. Replacement of removed pavement will be done according to plan details and no additional payment will be made.

C. Plan quantities for pushed conduit include at least two feet of pushed conduit behind each curb.

D. The maximum conduit depth at handholes for all conduits, including pushed conduit, is as shown on the plans. Contractor must push a mole (without conduit) at least four (4) times before consideration will be given to allowing an upward bend in the conduit.

3.08 - Electrical

A. All conductor cable combinations shall be shown on the plans. No substitutions will be permitted. Each signal head shall be wired separately from the handhole compartment in the pole base to the signal head.

B. The signal cable color codes shall be as follows:

Pedestrian Signals		5-Section Traffic Signals		3-Section Traffic Signals	
Walk -	Green	Green Ball -	Green	Green Ball -	Green
Don't Walk -	Red	Yellow Ball -	Orange	Yellow Ball -	Orange
Sig. Common -	White	Red Ball -	Red	Red Ball -	Red
		Green Arrow -	Black	Sig. Common -	White
		Yellow Arrow -	W/Bk	Spare -	Black
		Sig. Common -	White		
		Spare -	Blue		

C. One electrical splice in the handhole compartment of the pole base will be allowed for the signal circuit wiring. All signal circuit cable runs shall be one continuous length of cable from the connections made in the handhole compartment of the signal pole bases to the terminal compartment in the controller base.

D. Conductor groupings and splicings may be made in the terminal compartment in the controller cabinet.

E. The loop detector lead-in cable shall be one continuous length of cable from the terminal compartment of the controller cabinet to a splice made with the loop detector wires in the first handhole or pole base handhole compartment provided adjacent to the loop detector. Details of the loop detector splices are shown on the plans.

F. 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 or other suitable devices. Frame-mounted pulleys, or other suitable devices shall be used for pulling the cable out of conduits into handholes. Only vegetable lubricants may be used to facilitate the pulling of cable.

G. Each signal cable shall be identified with an identification tie in the controller cabinet, handholes, pole base handhole, pedestal handhole and at any splice or junction location. Identification ties shall be provided both on the cable from the controller and the cables leading to the heads for a splice in a pole base handhole. Identification shall be permanent and water-proof. Once installed, the tie shall not be removable except by cutting it loose from the cable.

Identification ties shall be marked as follows:

Heads: Head number, number of sections
Loops: Loop number, direction and location (stop lines, advance, or left turn loop)
Pedestrian push button: Location, street crossing

H. Cable slack shall be four feet in handholes, two feet in signal bases and in the terminal compartment of the controller base. No slack will be allowed in the loop detector lead-in cable after the initial splice.

I. Connectors shall be of the proper size for the number and size of the wires being connected.

J. Clean wire ends thoroughly after the insulation is stripped off to insure complete contact with another wire or the connector. Discard section of cable if strands are damaged when insulation is removed. Nicked or damaged conductor strands will not be permitted inside of connectors. Loose wire ends shall not be used as "shims" to make a connection.

K. Do not apply electrical tape to the finished connections. Extend signal cable insulation beneath the insulated portion of the connector. Redo any connection with exposed bare wire.

L. Arrange covered connections so they will not be in contact with the metal poles. Connections in the poles shall be pointed up to prevent accumulation of moisture in the connection.

M. Loop detector splices shall be capable of satisfactory operations under continuous immersion in water.

N. Cable connections in signal heads and controller cabinets shall be made at the terminal blocks provided for this purpose. All stranded wires inserted under a binder head screw shall be equipped with a solderless pressure type spade connector with a pre-insulated shank. All solid wire shall have an eye and shall not have a terminal connector.

O. Service cable shall be continuous from the disconnect switch located on the service pole to the terminal compartment of the controller cabinet.

P. Interconnect cable shall be continuous from controller to controller.

Q. A tracer wire shall be installed as incidental in all conduits with signal cables, detector lead-in cables, or communication cables. The tracer wire shall be identified in the controller cabinet, handholes, and poles by means of identification tags. The tracer wire shall be spliced in the handholes to form a continuous network.

R. If approval is granted by the Engineer for use of PVC or HDPE conduit carrying signal cable, ground wire shall be installed in all such conduit, and shall be incidental.

S.

3.09 - Pole Erection

A. All poles are to be erected vertically and securely bolted to the cast-in-place concrete foundations at the locations shown on the plans.

B. Leveling shall be accomplished by the use of nuts on each anchor bolt. One nut shall be turned on each anchor bolt and the pole placed in position on these nuts. The top nuts shall then be placed loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts.

C. After the pole is securely fastened, install stainless steel mesh in the area between the pole and the base. The material and the method of attachment shall be approved by the Engineer.

D. Each pole shall be grounded from the pole to the foundation ground rod by a No. 6 AWG bare copper ground wire.

E. Poles shall be placed so that modifications and/or attachments are correctly oriented, as indicated on the plans.

F. The foundations must be given seven days to cure before poles are erected. The centers of the poles are to be set back from the curb by distance shown on the plans. Poles shall be erected so that they are plumb with traffic signals installed, in line, and all the same relative height above the centerline of the street and with the mast arms correctly oriented as shown on the plans.

G. Poles must be erected so that they are plumb with traffic signal heads. The manufacturer recommendation for raking should be observed when setting the pole to assure that it is plumb when the load is applied.

H. Mast arm assemblies shall be furnished and installed by the Contractor, unless otherwise stated in the Plan Documents. When pre-used painted mast arm

assemblies are specified, the Contractor shall prime and paint the mast arm assemblies with the following method:

1. Remove all rust, scale, and loose paint from the surface by sanding or power tool cleaning (SSPC-SP-3). Contractor to use care when power tool cleaning to avoid burning, polishing, or grinding surface dirt into the existing paint surface. Hand tool cleaning (SSPC-SP-2) will be allowed only in areas accessible to power tool cleaning.
2. Remove all chalking, dirt, and other foreign material from the entire surface by application of petroleum solvent (i.e. paint thinner, mineral spirits, etc.) and wiping the entire surface with clean rags.
3. All bare metal surfaces exposed by the cleaning operation shall be spot primed the same day to avoid flash rusting.
4. After the primed areas have dried, apply one coat of finish paint.
5. Primer and paint must be approved by the Engineer.

3.10 - Detector Loops

A. Detector loops shall be installed in accordance with the plans. Adjustments in the locations shall be made to minimize the location of the loop wire across construction joints. Locations of the loops shall be subject to the approval of the Engineer. The cabinet end of the cable shall be clearly tagged identifying the loop.

B. The slot for the loop shall be constructed as per Plan Documents. The slot shall be completely clean of all loose debris and have a smooth bottom.

C. Slot shall be sealed with a one-part epoxy, Chem-Que 290S or approved equal.

D. New PCC pavement shall not be sawed until seven days after pour unless approved by Engineer.

E. Detector loops shall be connected to the controller with shielded lead-in cable. Lead-in cable, detectors, and cabinet modifications are incidental to detector loop(s). No splices will be allowed in this cable.

F. Unless otherwise noted on the Plan Documents, each loop shall be provided with a separate continuous lead-in cable from the splice in the first handhole to the cabinet.

G. Upon completing the loop installation in the field cabinet and prior to sealing the loop in the pavement, the Contractor shall notify the Engineer who may meter the loops by test instruments capable of measuring electrical values of installed loop wires and lead-ins to measure induced AC voltage, inductance in microhenries, high-low "Q" indication, leakage resistance in megaohms, and the resistance of the conductors in ohms.

   1. An acceptable load installation shall be defined as follows:
      a) Induced voltage test: No deflection on the pointer of a volt meter
      b) Inductance: The inductance reading on the loop tester is approximately the calculated value or with approval of the Engineer is between 100 mh and 200 mh.
      c) Loop Q: Deflection of the pointer to the upper side of the scale.
      d) Leakage to Ground: Deflection of the pointer to above 100 megaohms.
      e) Loop Resistance: The resistance reading on an ohm meter is approximately the calculated value.
   2. An unacceptable loop installation shall be defined as follows:
      a) Inductance: The inductance reading is below 90 mh or above 250 mh.
      b) Leakage to Ground: Deflection of the pointer to below 100 megaohms.
      c) Loop Resistance: The resistance reading is 50% more than calculated.

3.11 - Signals

A. All signal faces and indicators shall be furnished by the Contractor and installed as shown on the plans. Pole mounted signal heads and pedestrian push buttons are

shown on the plans and schematic drawings in schematic form only. Pole mounted signal heads are generally intended to be mounted on the face of pole with respect to oncoming traffic. Modifications are required when the view of the pole mounted signal indication is blocked. Pedestrian pushbuttons shall be installed on the face of the pole in 90° increments with respect to the mast arm. The pushbutton shall be located on the pole face so the arrow on the pushbutton sign directs pedestrians to the appropriate crosswalk.

B. All optically limited signal heads shall be properly masked or programmed to limit their field of view as directed by the Engineer.
C. Backplates shall be installed and properly secured for the traffic signal heads.
D. All signal heads shall be kept securely covered until such time as the signals are put into operation.
E. The location of signal heads in which the view of the indications is blocked or partially blocked by utility poles, trees or other physical obstructions shall be adjusted to a location approved by the Engineer. Standard heights and locations shown on the plans are typical for unobstructed locations. Signal heads installed without approval of the Engineer, which in the opinion of the Engineer are obstructed, shall be relocated at the Contractor's expense. Holes in the poles due to this signal relocation shall be plugged in a manner acceptable to the Engineer.

3.12 - Controller Cabinet

A. The controller cabinet shall be mounted with the back of the cabinet toward the intersection such that the signal heads can be viewed while facing the controller, unless otherwise directed by the Traffic Engineering Division.
B. All field wiring must be directly attached to the wiring lugs. Attachment of wiring shall be in a neat and workmanlike manner.
C. All conduit openings in the controller cabinet shall be sealed with an approved sealing compound. This compound shall be a readily workable at temperatures as low as 30 degrees F and shall not melt or run at temperatures as high as 300 degrees F.
D. All wiring diagrams, service manuals, instructions for installing and maintaining the equipment and advice as to timing and operation shall be delivered to the Engineer in good condition.
E. The Engineer or his representative shall inspect the installation before activation and shall be present at the time the controller is activated to assure that the controller is installed in accordance with the manufacturer's recommendations.

3.13 - Ground Rods

A. Ground wires shall be connected to ground rods with one piece nonferrous clamps which employ set screws as tightening devices. Connections to ground rods need not be taped.
B. Each steel pole or pedestal shall be firmly connected to the ground rod provided, by means of the grounding terminal as specified. Placing the ground wire under an anchor bolt nut, anchor bolt cover, or similar device will not be permitted.

3.14 - Equipment Testing

A. When the Contractor's work is complete and the project is open to normal traffic, the Contractor shall notify the Engineer in writing the date the signal will be ready for testing. City procedure for operation of new traffic signal installations will apply, unless expressly modified by the Engineer.
B. Initial traffic signal timings and timing adjustments will be provided by the Engineer. The Contractor shall deliver the controller and cabinet to the Traffic Engineering Department for testing and programming at least ten working days prior to planned installation.

C. Upon concurrence of the Engineer, the Contractor shall place the signal in operation for a consecutive 30-day test period. Any failure or malfunction of the equipment supplied or installation performed by the Contractor shall be corrected at the Contractor's expense and the signal tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated satisfactorily for 30 consecutive days.

D. If the signal is to operate independently of other signals or signal systems, it shall be tested as a single installation.

E. If the signal is part of a system, the test period shall not be started until all signals in the system are ready to be tested. The system shall be tested as a unit.

F. The Contractor shall initiate correction of any failure malfunction of the signal installation within 24 hours of notification by the Engineer. The Engineer will correct any failure or malfunction of the signal installation not investigated by the Contractor within the above time period, and will deduct its expenses from the Contractor's final payment.

G. Ground testing shall conform to Section 2523.21 of the Iowa DOT Standard Specifications for Highway and Bridge Construction.

3.15 - Clean-Up

A. Upon completion of the work in this Section, remove from the site all rubbish, trash debris resulting from operations. Leave the site in a neat and orderly condition.

END OF SECTION 16570