



SPECIAL PROVISIONS
FOR
TRAFFIC SIGNALIZATION

Linn County

ESL-4775(622)--7S-57

Effective Date:

December 15, 2009

THE IOWA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS,
SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND
ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER
THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

City of Marion Traffic Signal Specifications

For project - ESL-4775(622)--7S-57

3.03 GENERAL

A. Contractor's Investigation of Work

It shall be the responsibility of the CONTRACTOR to examine the site of the work to determine what is required and the equipment and labor necessary for the performance of the contract. By submission of a proposal for this work, the CONTRACTOR represents that he has investigated the character of the work and conditions which may be encountered, and the quantities and the types of related work, and agrees to complete the contract in accordance with the plans and these Special Provisions for the prices specified in his proposal without making claim for any extras. The CONTRACTOR shall care for all work until final completion.

B. Signs and Barricades

The CONTRACTOR shall be responsible to provide additional traffic control from that shown in the construction plans, as needed, to adequately mark the construction area for safe vehicular and pedestrian travel through the construction areas. The signs and barricades shall comply with the current edition of Part 6 of the Manual On Uniform Traffic Control Devices. Flashing warning lights shall be provided for night time use. The CONTRACTOR shall at all times conduct his operation in such a manner as to insure the safety of the motorist, the pedestrian, and his own employees. He shall perform his work in such a manner and sequence as to maintain vehicular and pedestrian traffic at all times and to maintain access to adjacent private properties.

At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway or sidewalk normally open for traffic. Open holes shall have orange safety fencing placed around them and marked with flashing barricades.

C. Protection of Utilities

The CONTRACTOR shall contract all utility companies having utilities in the project area to determine the exact location of all buried utilities. The utility companies request a 48 hour notice prior to excavating. Contact Iowa One Call 1-800-292-8989.

The depth and location of utilities shown on the plans are approximate and should be treated as such. The CONTRACTOR shall work closely with utility companies during construction; any conflicts shall be brought to the immediate attention of the CONTRACTING AUTHORITY.

The CONTRACTOR shall protect the identified utilities from damages due to his operations. The CONTRACTOR shall be responsible for any damages to located and identified utilities.

D. Traffic Signal Preconstruction Conference

Prior to commencing construction, a traffic signal pre-construction conference will be held to work out the details of accomplishment of the traffic signal portion of the project. Items of consideration to be discussed at the pre-construction conference include coordination with utility companies, law enforcement and fire agencies, coordination between CONTRACTOR and City, traffic control, scheduling, and any other items pertinent to the successful completion of the project.

E. Removal of Excess Excavation

All excess earth, pavement debris and other materials removed for the project construction will be the property of the contractor and shall be legally disposed of by the CONTRACTOR in any legal area of disposal or as otherwise directed by the CONTRACTING AUTHORITY.

F. Cleanup and Restoration

The term cleanup applies to the backfilling and required compacting of trenches and related excavation, the removal of access materials, the shaping of streets adjacent to the excavation, the shaping of parking, and the related work necessary to restore the construction area to its original condition and usability.

3.04 CONDUIT SYSTEM

- A. The number, type and size of conduit shall be as shown on the plans. Conduit shown on the plans as rigid steel shall be galvanized steel meeting the requirements of ANSI Standard Specification C80.1, latest revision. Conduit shown on the plans as polyvinyl chloride (PVC) shall be rigid polyvinyl chloride conduit (schedule 80), meeting the requirements of NEMA TC-2, type 2 and applicable UL Standards. All materials and methods for attaching and making fittings shall comply with the manufacturer's recommendation and shall be subject to approval of the CONTRACTING AUTHORITY. Fittings used with rigid steel conduit shall be galvanized steel only.
- B. CONTRACTOR may substitute HDPE conduit (Schedule 80) for PVC conduit on pushed conduit runs at no additional cost to the contracting authority. Connections shall be made with approved fittings only.
- C. Change in direction of conduit shall be accomplished by bending the conduit. Bends shall be made so that the conduit will not be injured or its internal diameter changed. Bends shall be of uniform curvature and the inside radius of curvature of any bend shall not be less than six times

the internal diameter of the conduit. Extend conduit two (2) to four (4) inches above finish surface in all bases.

- D. When heating PVC conduit for a bend, an approved conduit heating device shall be used. Direct flame shall not be applied to the conduit.
- E. When it comes to cut and thread steel conduit, no exposed threads will be permitted. All couplings shall be tightened until the ends of conduits are brought together so that an electrical connection will be made throughout the entire length of the conduit run. All conduit and fittings shall be free from burrs and rough places and all conduit runs shall be cleaned, swabbed and reamed before cables are installed. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. Where galvanized finish on conduit has been injured in handling, such places shall be painted with zinc rich paint.
- F. Standard manufactured elbows, nipples, tees, reducers, bends, couplings, unions, etc., of the same materials and treatment as the straight conduit pipe shall be used throughout the conduit line.
- G. Conduit bushings shall be installed on the exposed ends of rigid steel conduit. Bell end fittings shall be installed on the exposed ends of the PVC conduit.
- H. Pushed conduit shall be placed by jacking, pushing, boring or any other means necessary to place the conduit without cutting, removing or disturbing existing pavement. The size of a bored hole shall not exceed the outside diameter of the conduit that is to be placed. Tunneling under the pavement or water jetting will not be permitted. Pits for boring shall not be closer than two (2) feet to the edge of pavement without approval from the ENGINEER.
- I. All conduit openings in the controller cabinet, handholes and bases shall be sealed with an approved sealing compound. The compound shall be 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 F.
- J. Conduit shall be placed as shown on the plans. Place conduit buried in open trenches a minimum of eighteen (18) inches deep under non-paved areas. Place conduit buried in open trenches a minimum of twenty-four (24) inches deep under areas to be paved. Depth shall be measured from the proposed finish surface elevation. Open trench methods of placing conduit will be permitted unless the conduit is to be placed under existing pavement as indicated on the plans. No conduit shall be placed or backfilled prior to inspection by the ENGINEER.
- K. Deposit backfill material in layers not to exceed six (6) inches in depth and compact thoroughly before the next layer is placed. Backfill material shall be free of cinders, broken concrete or other hard or abrasive materials. The CONTRACTOR shall be responsible for removal and disposal of all excess materials unless otherwise stated in the contract documents.

3.05 **Wiring**

- A. All wiring shall be in conformance with the National Electrical Code. Wiring shall be completed by a licensed electrician in conformance with Iowa Code Section 103.
- B. Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow-to-yellow, and green-to-green. Circuits shall be properly labeled at the controller and each pole by durable labels, or other appropriate methods, attached to the cables.
- C. All cable runs shall be continuous from connections made in the handhole compartment of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed in underground handholes unless specifically allowed by the CONTRACTING AUTHORITY. Each traffic signal head shall have an individual cable run from the pole base to the signal head on the mast arm or on the side of pole.
- D. Power Lead-In cable runs shall be continuous from the secondary service point to the meter socket and from the meter socket to the controller cabinet. The size and number of conductors shall be as shown on the plans.
- E. Slack for each cable shall be provided by a four (4) foot length in each handhole and a two (2) foot length in each signal pole or pedestal and controller base (measured from the handhole compartment in the pole to the end of the cable). Coil cable slack in the handhole and place on the cable hooks.
- 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 cable(s), 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 cables out of conduits into handholes. Only NEC or UL approved lubricants may be used to facilitate the pulling of cable.
- G. Loop detector lead-in cable shall be continuous from the terminal in the controller cabinet to a splice made with the detector loop leads in the first handhole or pole base provided adjacent to the detector.
- H. Each conduit shall have a poly fiber pull line installed along with any cables or wires.
- I. All cables shall be neatly routed and bundled inside the controller cabinet.
- J. Tracer wire shall be spliced in the handholes and controller to form a continuous network.

- K. Each wiring or conduit run shall contain additional nylon or mule tape for future use.

3.06 ELECTRICAL CABLE

A. General

1. Electrical cable for intersection signalization shall be rated 600 volts minimum.
2. The number of conductors and size of all electrical cable shall be as shown on the plans.
3. All Wire shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable.

B. Power Lead-In Cable

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

C. Signal Cable

1. Signal cable shall be multiconductor or copper wire and meet the requirements of IMSA specifications 19-1

D. Detector Lead-In Cable

1. Detector lead in cable shall meet the requirements if IMSA specification 50-2

E. Loop Detector Wire

1. Loop detector (with plastic tubing) wire shall conform to the requirements of IMSA 51.5

F. Tracer Wire

1. A tracer wire shall be installed in all conduits.
2. The tracer wire shall be a #10 AWG, single conductor, stranded copper, Type THWN or XHHW, with UL approval and an orange colored jacket.

G. Communications

1. Communication cable for signal interconnection circuits shall single mode fiber optic cable with terminated LC connections. The panels for the fiber optic communications shall be of the same make and model to that of the City of Marion's existing fiber optic infrastructure.
2. If stated on the approved plans and specifications, it shall be the contractors responsibility to integrate the traffic signal system within the city's existing fiber optic system. All work with the city's fiber optic communication system and integration into the traffic signal system shall be performed by the vendor who holds the contract with the City of Marion for the maintenance of the fiber optic system. It will be the contractors responsibility to complete all necessary integration of the traffic signal system through the specified fiber optic maintenance vendor as determined by the City of Marion.

H. Video Cable

1. Cable shall be as per manufacturer of video detection equipment specifications.

3.07 HANDHOLES

- A. Furnish precast concrete handhole, or poured in place concrete handhole, each with cast iron ring and cover. The body of a handhole shall meet the requirements for Class 1500D concrete pipe as applicable.
- B. Cast Iron ring and cover may be rated light duty for non-traffic areas (145 pounds minimum); but shall be rated heavy duty for traffic areas (320 pounds minimum) where shown on the plans. Deviations in weights shall not exceed plus or minus five percent. The cover shall have the words TRAFFIC SIGNAL cast on the top of the cover.
- C. Cable hooks shall be galvanized steel with a minimum diameter of 3/8 inch and a minimum length of 5 inches.
- D. Additional handholes may be installed at the Contractor's expense, to facilitate the work.
- E. Provide four (4) cable hooks in all handholes. Anchor in the wall of the handhole utilizing appropriate anchoring devices.
- F. Handholes shall be installed in a neat and a workmanlike manner. When the use of forms is required they shall be set level and of sufficient thickness to prevent warping or other deflections from the specified pattern. A means shall be provided for holding conduit runs rigidly in place while the concrete is placed. All conduits shall enter the handhole at a depth of 12 inches from the top of the handhole. The ends of all conduit leading into the handholes shall fit approximately 2 inches beyond the inside wall. Cast iron rings and covers 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 one inch above the surface of ground. When constructed in unpaved driveways, the top surface of the handhole shall be approximately level with the surface of the driveway.
- G. The handhole shall be installed on a minimum of 12" of pea gravel

3.08 CONCRETE BASES

- A. Concrete bases for poles and cabinets shall be poured to form a monolithic structure. Concrete bases for poles and cabinets shall conform to the dimensions shown on the plans. Excavations for these bases shall be made in a neat and workmanlike manner. The CONTRACTOR shall pump excavation dry from water prior to pouring the base. The bottom of all foundations shall rest securely on firm undisturbed ground. The material for the forms shall be sufficient thickness to prevent warping or other deflections from the specific pattern. The forms shall be set level or sloped slightly to blend with the adjacent ground level and means shall be provided for holding them rigidly in place while the concrete is being deposited. All conduits and anchor bolts shall be

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

- B. Prior to placing concrete, each base elevation, reinforcing and forms shall be inspected by the ENGINEER.
- C. After the foundation or base has been poured, absolutely no modifications of any sort may be made. If the anchor bolts, conduit, or any part of the foundation or base is installed in an incorrect manner as determined by the ENGINEER, the entire foundation or base shall be removed and a new foundation or base installed at the CONTRACTOR'S expense.
- D. Prior to setting poles, the anchor bolts shall be covered in such a manner as to protect them against damage and to protect the public from possible injury. The foundations must be given seven days to cure before poles are erected.
- E. Concrete for concrete bases and handholes shall be class C structural concrete meeting the requirements of Section 2403 of the Iowa Department of Transportation Standard Specification.
- F. Each base shall be vibrated in accordance with Iowa Department of Transportation Specifications, Section 2403.09
- G. Reinforcing steel shall be of the type and size as shown on the plans and shall conform to the requirements of Section 2404 of the Iowa Department of Transportation Standard Specifications.
- H. Finish the top of the base level and round top edges with a ½" radius edge. In sidewalk areas, adjacent to sidewalks, or in other surrounding paved areas, the top ten (10) inches of the base shall be formed square and 1" above finished grade. Provide preformed expansion material between the base and adjacent pavement. When installed in an unpaved area away from a pavement edge, the top of the concrete base shall be approximately two (2) inches above the surface of the ground. The exposed surface of the base shall have a rubbed surface finish.

3.09 BONDING AND GROUNDING

- A. All conduit, steel poles and pedestals shall be bonded to form a continuous system, and be effectively grounded. Bonding jumpers shall be No. 6 AWG bare copper wire or equal connected by approved clamps.
- B. Grounding of the conduit and neutral at the service point shall be accomplished as required by the National Electrical Safety Code, except bonding jumpers shall be No.6 AWG or equal.
- C. Ground electrodes shall be provided at each signal pole and pedestal and at the controller as detailed on the plans.
- D. A #6 AWG bare copper ground wire shall be installed in all conduits that carry 120-volt signal cables.

3.10 POLES, MAST ARMS

- A. This section of the Specification describes minimum design, material, and fabrication requirements for the traffic signal poles. Poles shall be manufactured in accordance with the requirements of the latest Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals as approved by the AASHTO.
- B. The mast arms and support poles shall be continuous tapered, round, steel poles of the transformer base type as shown on the plans. The poles and mast arms shall be fabricated from one length of steel sheet with one continuous arc welded vertical seam, unless otherwise approved by the ENGINEER. Traffic signal posts, arms and luminaire extensions will be hot-dipped galvanized with a two coat liquid paint with a zinc primer and top coat application. The poles shall be black in color and shall incorporate the geometric and architectural elements as illustrated within the plans.
- C. The poles and mast arms shall be fabricated from low carbon (minimum carbon 0.30%) steel of U.S. Standard gauge. The base and flange plates shall be of structural steel conforming to AASHTO M 183 (ASTM A 36) and cast steel conforming to ASTM A 27, Grade 65-35 or better.
- After manufacture, poles and mast arms shall have minimum yield strength of 55,000 PSI.
- D. The mast arms shall be designed to support traffic signals and/or signs as shown on the plans and indicated in the Special Provisions. They shall be certified by the fabricator that the mast arms are capable of withstanding winds up to 80MPH with a 1.3 gust factor without failure; that only certified welding operators in accordance with AWS D1.1-80 or latest revisions were used; and that only electrodes as modified by AASHTO 1981 Standard Specifications for Welding Structural Steel for Highway Bridges were used.
- E. The pole shall be designed to support the traffic signals and/ or signs as shown on the plans. The pole shall be equipped with a minimum 8-inch x 12-inch handhole and cover located in the transformer base of the pole. Securing of the cover to the base shall be done with the use of simple tools. Hardware shall be corrosion resistant. Vertical pole configuration shall provide for two-piece combination pole with internal tapped plate connection to allow for addition or removal of luminaire pole extension.
- F. Where a combination street lighting/signal pole is specified on the plans, the above applies with the luminaire arm to be mounted in the same vertical plane as the signal arm unless otherwise indicated on the plans.

The luminaire arm shall be of the single member type and be that of the design illustrated in the plans.

The luminaire arm shall provide the spread and nominal mounting height as shown on the plans.

Where a combination street lighting/signal pole is specified on the plans, the pole shall be equipped with a minimum 4 inch x 6 inch handhole and cover located opposite the signal mast arm.

- G. The mast arms and poles shall be equipped with all the necessary hardware, shims and anchor bolts to provide for a complete installation without additional parts.

The anchor bolts shall meet the requirements of ASTM A 36 or better.

The anchor bolts shall be hot dip galvanized for a minimum of 12 inches on the threaded end.

The anchor bolts shall be threaded a minimum of 6 inches at one end and have a 4-inch long, 90-degree bend at the other end.

- H. The fabricator shall submit drawings for anchor bolts and base design. All hardware shall be steel, hot dipped galvanized meeting the requirements of ASTM A 153, Class D or electrodeposited coated of the same coating thickness and so designed for this purpose.

- I. Welding and fabrication shall conform to the Structural Welding Code AWS D1-180, as modified by AASHTO 1981 Standard Specifications for Welding of Structural Steel Highway Bridges. Longitudinal butt welds shall have a minimum 60 percent penetration for plates 3/8 inch and less in thickness, and minimum of 80 percent penetration for plates over 3/8 inch in thickness.

Personnel performing nondestructive testing shall be qualified in accordance with the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-IA 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 either found satisfactory or found unsatisfactory but repaired and reinspected and found satisfactory. The cost of all nondestructive testing shall be paid by the Contractor and will be considered incidental to other items in the contract.

The mast arms and pole assemblies shall be galvanized inside and out in accordance with ASTM A 123, latest revision. The mast arms and poles shall be painted black with a two coat liquid paint with a zinc primer and top coat application.

- J. If the painted or galvanized surface of any equipment is damaged in shipping or installation, such equipment shall be retouched or repaired in a manner satisfactory to the ENGINEER.
- K. The City of Marion may option to furnish decorative mast arms and poles in an effort to assure architectural and design constituency throughout the City of Marion.

3.11 NEMA CONTROLLER

- A. The Controller shall be a NEMA TS-2 and provide:
1. Two through eight phase operation.
 2. Fully prompted, menu driven programmability.
 3. The following internal functions:
 - a. Local time base scheduler including automatic accommodations for daylight savings time.
 - b. Local coordination control.
 - c. Local preemption control with a least four (4) programmable internal preemption sequences.
 4. Means for receiving actuation on all phases. The actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way shall cause the retention of right-of-way by the traffic phase for the set Passage time from the end of the actuation but subject to the Maximum green. The actuation of any detector on a traffic phase not having the right-of-way shall cause the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence.
- B. The controller shall be microprocessor type, solid state with NTCIP compliance. The controller shall work with the City of Marion's existing Centrac central software and emergency vehicle preemption system.
- C. The controller shall utilize digital timing concepts for interval settings for all phases and shall contain vehicular and pedestrian circuits and timing for all phases. The length of timing settings shall not deviate by more than plus or minus 100 milliseconds from the set value at a power source frequency of 60HZ.
- Controller timing shall be a set by means of a front-panel keyboard with momentary contact pushbuttons for entering data. It shall not be necessary to remove or change wires or contacts or to use any tools in making interval adjustments.
- D. The controller shall be of the latest model with the most current software and documentation.
- E. Mount the control devices, indicators, fuse holders, switches, input/output connectors, and other components required for controller operation on the front panel of the controller. The front panel of the unit shall be permanently marked to identify the fuses, indicators, switches controls, etc.
- F. Components shall be amply de-rated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperatures and maximum applied voltage, a material shortening

of life or shift in values shall not occur. Components under 24 hours a day operating conditions in their circuit applications shall have a minimum life of five (5) years.

- G. Each phase shall have identical control parameters, which may be independently set.
- H. Provide indications, labeled appropriately, to facilitate the determination of the operation of the controller unit. These indications shall consist of the following, as a minimum:
 - 1. Phase (s) in service
 - 2. Next phase(s) to be serviced.
 - 3. Presence of vehicle and pedestrian calls, including memory and detector actuations.
 - 4. Ring status indicators, including the following: Minimum Green; Passage; Yellow Clearance; Red Clearance; Walk; Pedestrian Clearance; Reason for Termination; and Red State.
- I. The controller shall be capable of programming each phase to operate in the following modes:
 - 1. Non-locking/locking vehicle detector memory
 - 2. Vehicle recall
 - 3. Pedestrian recall
- K. Data shall be retained in a memory medium, which does not require battery backup.
- L. The timing of the maximum Green shall commence at the beginning of the Green interval. In the absence of detector actuations or assertion of recall switches, the right-of-way indications shall remain on the traffic phase on which the last actuation occurred.
- M. Transfer right-of-way to conflicting phases only after the display of the appropriate change clearance intervals.
- N. Pedestrian actuations received during steady or flashing DON'T WALK indications a phase shall cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence. Successive pedestrian actuations shall not cause extension of pedestrian intervals.

During coordinated operation if phases are placed in a pedestrian recall mode of operation to operate the controller as a pre-timed controller, the WALK intervals shall automatically adjust with changes in the timing plans to provide the maximum amount of WALK interval possible in the phase.
- O. If power is interrupted, the controller shall be capable of automatic reorientation upon power resumption and shall require no manual initiation or switching.

- P. The controller shall be IP addressable with an ethernet port for communications. The controller shall utilize an external ruggedized fiber optic switch for fiber optic communications. The switch shall have a minimum of two pairs of LC fiber optic ports and eight electrical ports. The switch shall operate at gigabit speeds and shall be compatible with the City of Marion's existing Ruggedcom fiber optic switching system.

3.12 NEMA CONTROLLER CABINET AND AUXILLIARY EQUIPMENT

- A. The traffic signal cabinet shall be a NEMA TS-2 type 2 style cabinet. The controller and associated equipment shall be housed in a sturdy, unpainted aluminum cabinet having no sharp edges, corners or projections. The size of the cabinet shall provide ample space for housing the controller and auxiliary equipment. Provide a hinge door, with an approved doorstop assembly, permitting complete access to the interior of the cabinet. When closed, the door shall fit closely to neoprene or other suitable gasketing material, making the cabinet weatherproof and dust- tight. Door shall be provided with a strong lock and two sets of keys. Door hinges and pins shall be of a non-corroding material. The cabinet shall contain strong mounting tables, sliding trays or other suitable supports for the controller and associated equipment.
- B. In addition to the main door of the controller cabinet, there shall be an auxiliary police door provided in the main door provided with a strong lock and keys (two) of different design than that of the main door of the cabinet. The panel behind the auxiliary police door shall contain a switch to change from normal function to flashing operation. The controller shall remain in full operation during flashing operation. Provide a signal on-off switch to interrupt power to the signal heads only and continue controller operation. There shall also be an auto/manual switch with a pushbutton on a coiled cord to allow manual signal operation.
- C. Locate a maintenance panel on the inside of the main door containing the following test switches:
1. Controller Power Switch
 2. Detector Test Switches
 3. Stop Time Switch
 4. Signal Flash Switch
- D. The cabinet shall be provided with the following:
1. A heavy-duty clear plastic envelope, securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet wiring diagrams. Minimum dimensions shall be 9" wide x 12" deep.
 2. A ventilation fan controlled by a thermostat, and suitable dust filters for the capacity of the ventilating system. The filters shall be dry type, easily removed and replaced, and standard dimensions commercially available. Ventilation fan shall be fused separately and wired after the main AC+ circuit breaker.

3. At least an 8-position back panel when the plans call for being able to expand to four phases and at least a 12-position back panel when the plans call for being able to expand to eight phases.
4. Power protection devices include the main AC+ power circuit breakers, radio interference suppressors, and lighting and surge protectors. These devices shall be in addition to any protection devices furnished with the controller and auxiliary equipment. The protection devices shall be mounted on a panel that is securely fastened to an interior wall of the cabinet.

The AC+ field service shall be connected directly to a circuit breaker. This circuit breaker shall be a single pole, nonadjustable, magnetic breaker rated for 117 VAC operations. It shall be equipped with a solderless connector suitable for terminating the power lead-in wire. The circuit breaker shall be capable of manual operation and shall be clearly marked to indicate the "ON" and "OFF" positions.

The distribution of the 117 VAC throughout the cabinet shall not occur until the AC+ has first passed through the power protection devices.

- a. Radio interference suppressors (RIS), adequate in number to handle the power requirements for the cabinet, shall be wired in series with and after the main AC+ circuit breaker. The RIS shall be designed to minimize interference in all broadcast, transmission and aircraft frequency bands.
 - b. The lighting arrestor/surge suppressor on the AC service, shall be an ACP 340 manufactured by EDCO Inc., or approved equal which meets or exceeds the following requirements:
 1. Capable of withstanding repeated 20,000 ampere surges (minimum of 25).
 2. Have internal follow current limiters (resistive elements).
 3. Contain a minimum of three (3) active clamping stages.
 4. Self extinguish within 8.3 milliseconds after trailing edge surge.
 5. Parallel impedance of limiters must be less than 15 ohms.
5. An easily accessible AC+ convenience outlet with a 3-wire grounding type receptacle with ground fault protection. This receptacle shall be separately fused from the main AC+ circuit breaker.
 6. An incandescent lamp receptacle mounted on the interior wall of the cabinet, which accommodates a standard base light bulb. A manual switch mounted on the maintenance panel shall control the lamp. Fuse and connect lamp with the convenience outlet.
 7. The cabinet shall be equipped with a battery backup system capable of supporting a red flash time for a minimum of eight hours and full signal operation for a minimum of four hours.
 8. A complete system documentation. The minimum documentation shall consist of:

- a. Three (3) complete operations manuals for each controller and all associated equipment including equipment wiring diagrams, schematics, and parts lists sufficient for ordering any parts.
 - b. Three (3) sets of cabinet wiring diagrams. Indicate corresponding phase numbers for each movement from the intersection layout diagram on the cabinet wiring diagram.

- E. Use molded composition barrier type terminal blocks for termination of the incoming and outgoing signals within the cabinet assembly. Each terminal block shall be of one-piece construction with a minimum of twelve terminals. Each terminal shall have a threaded contact plate with a binder head screw. The terminal blocks shall have a minimum rating of 600 volts.

Arrange terminal block facilities in function groupings and mount to either panels or brackets fastened to the interior walls of the cabinet. Retain each terminal block using either machine or self-tapping screws, which are easily removed and replaced.

The minimum terminals are as follows:

 - 1. Terminal with circuit breaker with integral power line switch for the incoming power line.
 - 2. Terminal unfused for the neutral side of the incoming power line.
 - 3. Terminals and bases for each vehicle and pedestrian signal circuit.
 - 4. Terminals for vehicle phase detector and pedestrian pushbuttons cables. Terminals for vehicle detectors include AC+, AC neutral, relay common, relay closure, and the loops or probes from the field.
 - 5. Terminals and bases for signal flasher and outgoing signal field circuits.
 - 6. Terminals for controller input and output circuits including those circuits not used on the project.
 - 7. Terminals for required auxiliary equipment.

Provide adequate electrical clearance between terminals. Label terminals in accordance with the cabinet wiring diagrams. Terminals shall be accessible without removal of equipment contained in the cabinet.

- F. Furnish hardware necessary for assembly and installation of the cabinet.

- G. Electrical connections from the controller and auxiliary devices 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. This may be accomplished by means of a multiple pin jack; a spring connected mounting or approved equivalent arrangement.

- H. Neatly train wiring throughout the cabinet and attach to the interior panels using nonconductive clamps or tie-wraps. Bundles of cables shall be laced, tied, or enclosed in a sheathing material. The cabinet wiring shall not interfere with the entrance, training, or connection of the incoming or outgoing field conductors. Arrange the controller, auxiliary equipment, panel(s), terminals and other accessories within the cabinet to facilitate the entrance and connection of incoming conductors.

Except where terminated by direct soldering, wires shall be provided with terminal lugs for attachment to terminal blocks using screws. Wires shall be identified and labeled in accordance with the cabinet wiring prints.

All wire insulation shall have a minimum rating of 600 volts.

- I. The outgoing signal circuits shall be of the same polarity as the line (+) side of the power service. The incoming signal indication conductors shall be common and of the same polarity as the grounded (-) side of the power service. The neutral (-) side of the power service shall be connected to the cabinet in an approved manner to a copper ground bus located on the panel with the main AC+ circuit breaker. The cabinet shall, in turn, be connected to an earth ground through ground level.
- J. Load switches shall provide LED indicator lights on the front of the load switch to designate the active circuit. There shall be an LED for the input to the load switch and a separate LED for the output from the load switch. The closing or opening of signal circuits shall be positive without objectionable dark intervals, flickering of lights, or conflicting signal indications.
- K. Install the controller cabinet on pre-placed caulking material on the concrete base. After the cabinet is installed, place silicon-caulking material around the base of the cabinet.
- L. For card rack style detectors, mount detector-mounting racks on shelf in the controller cabinet. Wire all detector slots in the cabinet to provide future use. Label card rack positions with loop numbers.

3.13 CONFLICT MONITOR

- A. Provide a solid-state conflict monitor within the cabinet external to and electrically independent of the controller and enclosed in a finished metal case. The monitor shall detect the occurrence of conflicting Green, Yellow, or Walk indications and shall cause the signals to go into predetermined flashing operation with stop timing applied simultaneously should conflicts be sensed.
- B. The conflict monitor shall utilize liquid crystal displays providing four indicators that display an active Red, Yellow, Green and Walk input for each channel monitored.
- C. If the actual conflict has been cleared, a reset switch (front mounted) on the conflict monitor shall return the controller to normal operation when depressed.
- D. The conflict monitor shall have an IP addressable ethernet port.

3.14 FLASHER

- A. Provide a separate solid-state flasher to permit substitution of flashing signal indications for normal vehicle or pedestrian actuated operation. The solid-state flasher shall have no contact points or moving parts and shall utilize zero-point switching. The flasher unit shall have a built-in effective radio interference filter. LED indicator lights shall be provided on the front of the flasher to indicate

the active circuit. Flashing rate shall not vary when the power source remains within the specified limits.

- B. Obtain flashing of vehicular signal indications from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet. If two flashers provide the flashing, they shall be wired to assure that the flashing of all indications on the same approach is simultaneous.
- C. The cabinet shall contain a power and flash transfer relay assembly to transfer the AC+ power and operation from the controller and load switches to the solid-state flasher. Either the flash mode switches, located on the Police and maintenance panels, or the conflict monitor, shall control this transfer relay assembly. The plug-in transfer relays shall be rated at a minimum of 10 amps per pole and shall be enclosed in a transparent case for protection against dust and for visual observance of operation.

3.15 TRAFFIC SIGNAL VIDEO DETECTION

- A. The video detection system shall be installed, set up and tested by manufacturer authorized, trained personnel. Detection areas or zones shall be tested in daylight and during nighttime to ensure the detection operates correctly in low light conditions. Fog or snow shall be simulated to ensure the video detection system goes to a fail-safe condition and places calls on all approaches while the fog or snow condition exists. Once the fog or snow condition is removed, the detection system must return to normal operation on its own, with no outside input such as a reset power down, or reprogramming.
- B. The vendor shall supply all documentation and software necessary to back up the video detection settings and data to a personal computer. The manufacturer or the manufacture's authorized designee shall supply training to contracting authority video detection system, documentation and software.
- C. The video detection system shall utilize MPEG-4 video streaming with the option of power over ethernet applications directly from the cabinet to the video source. Each video camera shall be IP addressable. Crimp on or compression coaxial cable wire or coaxial connections shall not be used.
- D. The video detection system shall also be equipped with one pan, tilt, and zoom camera for purposes of traffic flow and public safety observation. The camera shall be integrated into the City of Marion's existing video and media system.

3.16 EMERGENCY VEHICLE PREEMPTION SYSTEM

- A. Emergency vehicle preemption system shall be compatible with NEMA controller. The preemption system shall operate off of the City of Marion's Centracs central software package via special functions application. The emergency vehicle preemption system shall be capable of operating up to six pre-determined preemption routes that can be activated through a remote server or host.
- B. It shall be the contractor's responsibility to integrate the preemption system for all new traffic signal devices.

3.17 INDUCTIVE LOOP VEHICLE DETECTOR

- A. Provide a detector harness for each detector amplifier. The harness shall be tagged to indicate the detector number(s) and phase. In case of a failure in the power supply unit for the card rack, fail-safe operation will be provided in that a constant call will be placed on all detector channels.
- B. The detector unit shall be solid state, digital, dual channel, providing detection channel with a minimum inductance range of 50 to 1500 micro-henries. Output circuits of the detector unit shall be provided by relays.
- C. The detector unit shall include the following capabilities:
 - 1. Detection of all licensed motor vehicles.
 - 2. Indicator light for visual indication of each vehicle detection.
 - 3. Fail-safe operation (continuous call) in the event of detector loop failure.
 - 4. Respond to an absolute change (ΔL).
- D. The detector unit shall be capable of disabling delay timing by external means during that detector's associated green phase. The delay inhibit on each detector unit shall be in effect during the associated green phase.
- E. The detector unit shall contain a fuse or other reliable protection in the power supply. The fuse shall provide short circuit protection to the power supply and be accessible without removal of the case.
- F. The detector unit shall be capable of normal operation without interference and false calls between sensor units ("crosstalk"). It shall be possible to install the connecting cable in the same conduit as the signal cables, power cables and other detector cables without affecting the normal operation of the detector.
- G. For card rack style detectors, mount detector-mounting racks on shelf in the controller cabinet. Wire all detector slots in the cabinet to provide for future use. Label card rack positions with loop numbers.
- H. A sensitivity adjustment or selector shall be provided to allow selection of a high, medium, or low sensitivity adjustment. Increments shall include: High, .02 percent; Medium, .06 percent + .01 percent; Low, .125 + .025 percent.
- I. 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, and humidity, nor shall the sensitivity be markedly affected.

- J. 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 life of the lights need be only 1,000 hours rated voltage.
- K. 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 F to 180 degrees F.

3.18 LOOP DETECTOR INSTALLATION

- A. Location of loop detectors shall be approved by the ENGINEER prior to placement or sawcutting.
- B. Saw shall be equipped with a depth gauge and horizontal guide to assure proper depth and alignment of the slot. Provide a clean, straight, well-defined saw cut without damage to adjacent areas. Overlap saw cuts to provide full depth at corners.
- C. Remove jagged edges or protrusions in the saw cuts before installing loop wire. The saw cuts must be cleaned to remove cutting dust, grit, oil, moisture or other contaminants. Flush saw cuts clean with a stream of water under pressure, and dry the slots using oil-free compressed air.
- D. Install detector loop wire in the bottom of the saw cut. If necessary, hold down by means of a material such as tape or doubled-over pieces of the plastic tubing.
- E. The field loop conductors and tubing shall be continuous from the terminating handhole or base with no splices permitted. At the time of placing the loop wire in the saw cuts, the ends of the tubing shall be sealed to prevent any entrance of moisture into the tubing. Loop wires and tubing that are not embedded in the pavement shall be twisted with at least five (5) turns per foot.
- F. Label each loop with durable tags corresponding to loop numbering as shown on the plans. Loops that are physically adjacent in an individual lane or adjacent lanes shall be wound with opposite rotation (i.e. #1CW, #2 CCW, #3 CW, etc.). Rotation reversal can be accomplished by reversing leads at the handhole.
- G. Solder electrical splice between the detector lead-in cable and the loop wire using resin core solder. Provide a watertight protective covering for the spliced wire, the shielding on the detector lead-ins and the end of the tubing containing the loop wires. The use of open flame to heat the wire connection will not be permitted. The Contractor shall use a soldering iron, gun, or torch equipped with a soldering tip. Refer to the splice method to be used.
- H. Meter the installed loops by test instruments capable of measuring electrical values of loop wires and lead-ins to measure induced AC voltage, inductance in micro henries, high-low "Q" indication, leakage resistance in megohms, and the resistance of the conductors in ohms. Provide the City Engineer a report on company letterhead indicating the inductance and leakage to ground test values for each loop. An inductance and leakage to ground test shall also be conducted and reported for the total detector lead-in and loop system with the test being conducted at the controller cabinet. Before beginning the required test period, the City Engineer may independently meter any or all loops. Should any loop be found unacceptable, the Contractor

may be required to complete additional tests, as required, at his own expense. An acceptable loop installation shall be defined as follows:

1. Inductance: The inductance reading on the loop tester is approximately the calculated value.
2. Leakage to Ground: Deflection of the pointer to above 100 megohms.
3. Resistance: The resistance of the circuit is approximately the calculated value.

Any loop not meeting the requirements for an acceptable loop installation shall be repaired or replaced. The Contractor shall bear all costs of replacing loop installations deemed unsatisfactory by the City Engineer.

I. Loop Detector Sealant

1. Sealant shall be rapid cure, high viscosity, liquid epoxy, or approved equal, formulated for use in sealing inductive wire loops and leads embedded in asphaltic concrete and Portland cement concrete. The sealant shall be usable on grades of 15 percent or less without excessive flow of material.
2. Sealant shall be two-component systems, which consists of a resin constituent identified as pourable, and a hardener identified as quick setting. Approval of other sealants shall be based on specification and/or test data regarding physical properties, performance properties and chemical resistance.
3. Cured sealant shall be unaffected by oils, gasoline, grease, acids and most alkalis. The mixing of components and the filling of the cut shall be in accordance with the directions of the manufacturer.

J. Splicing

1. As an acceptable alternate, the Contractor may use a 3M Company Scotchcast Kit, DBR or DBY mechanical splices, or approved equal, for splices.
2. The splice may be made by the following method:
 - a. Remove all lead-in cable coverings leaving four inches of insulated wire exposed.
 - b. Remove the insulation from each conductor of a pair of lead-in cable conductors and scrape both copper conductors with knife until bright. The ground wire and shield will be removed to the end of the outer jacket. The ground wire and sheath will be taped at the end of the outer jacket to prevent any electrical contact.
 - c. Remove the plastic tubing from the loop wires for 1-1/2 inches.

- d. Remove the insulation from the loop wires and scrape both copper conductors with knife until bright.
- e. The conductor shall be connected by a soldered "Western Union" tape splice, and then enclosed in a wire nut. The wire nut shall then be inserted into a gel filled tube. The end of the gel filled tube will be closed with the hinged cover. One wire will exit the tube on each side of the hinged cover.

3.19 TRAFFIC SIGNAL HEADS

- A. The housing for the individual signal sections shall be made of a durable polycarbonate clean, smooth and free from flaws, cracks, blowholes, and other imperfections and containing no sharp fins or projections. The housing shall be a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together with openings and positive locking devices in the top and bottom so that it may be rotated between waterproof supporting brackets capable of being directed and secured at any angle in the horizontal plane. Provide doors with lenses with watertight gaskets, hinges and means to secure to the body of the housing by simple locking devices of non-corrosive material.
- B. The optical system shall prevent any objectionable reflection of sunrays. Lenses shall be vandal resistant polycarbonate.
- C. The visors section shall be durable polycarbonate not less than 0.10" in thickness designed to fit tightly against the door and not permit any perceptible filtration of light between the visor housing door. Visors shall be of the tunnel-type at least 8" long for 12" rectangular signals, at least 9 ½" long for 12" diameter signals, and angle slightly downward.
- D. Equip each three-section signal head with six position terminal block and each five-section signal head with an eight position terminal block for termination of field wiring.
- E. The signal heads shall be black in color. Door fronts and visors shall be black. The color shall be an integral part of materials composition.
- F. Where shown on the plans, furnish and attach 5" backplates to the signal faces. Construct backplates of two-piece durable black capable of withstanding a 100 M.P.H. wind.
- G. Signal mounting hardware for side of pole-mounted signals shall consist of 1 ½ inch pipe and appropriate fittings and shall be galvanized. Signals shall be secured to pole by stainless steel banding.
- H. Mast arm signal head assemblies shall be rigid mounted utilizing an assembly consisting of both top and bottom brackets which are easily adjustable in both horizontal and vertical planes. They shall be Pelco Astro Bracket or equivalent.

3.20 TRAFFIC SIGNAL INDICATORS

A. General:

1. LED traffic modules, designed as retrofit replacements for existing signal lamps, shall not require special tools for installation. Retrofit replacement LED signal modules shall fit into existing traffic signal housings built to the VTCSH Standard without modification to the housing.
2. Installation of a retrofit replacement LED signal module into an existing signal housing shall only require the removal of the existing optical unit components (i.e. lens, lamp module, gaskets, and reflector) shall be weather tight and fit securely in the housing; and shall connect directly to existing electrical wiring.

B. LED SIGNAL MODULE:

1. The retrofit LED signal module shall be capable of replacing the optical unit.
2. Tinting (Optional): The lens shall be tinted or shall use transparent film or materials with similar characteristics.
3. The LED signal module lens may be a replaceable part without the need to replace the complete LED signal module.

C. Environmental Requirements:

1. The LED signal module shall be rated for use in the ambient operating temperature range, measured at the exposed rear of the module of -40°C (-40°F) to $+74^{\circ}\text{C}$ ($+165^{\circ}\text{F}$).
2. The LED signal module shall be protected against dust and moisture intrusion per the requirements of NEMA Standard 250-1991, Section 4.7.2.1 and 4.7.3.2, for Type 4 enclosures to protect all internal LED, electronic, and electrical components.
3. The LED signal module lens shall be UV stabilized.

D. Construction:

1. The LED signal module shall be a single, self-contained device, not requiring onsite assembly for installation into an existing traffic signal housing. The power supply for the LED signal module may be either integral or packaged as a separate module. The power supply may be designed to fit and mount inside the traffic signal housing adjacent to the LED signal module.
2. The assembly and manufacturing process for the LED signal assembly shall be designed to assure that all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

E. Materials:

1. Materials used for the lens and signal module construction shall conform to ASTM specifications for the materials where applicable.
2. Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

F. Module Identification:

Each individual LED signal module shall be identified for warranty purposes.

1. Each LED signal module shall be identified on the backside with the manufacturer's name and serial number.
2. The following operating characteristics shall be identified: nominal operating voltage, power consumption, and Volt-Ampere.
3. Modules shall have a prominent and permanent vertical indexing indicator (i.e., UP ARROW or the word UP or TOP, for correct indexing and orientation inside a signal housing).
4. Modules conforming to this specification may have the following statement: "Manufactured in Conformance with the Interim Purchase Specification of the ITE for LED Vehicle Traffic Signal Modules" on an attached label.

3.21 TRAFFIC SIGNAL PEDESTALS

- A. The pedestal shaft shall be fabricated of aluminum tubing with a wall thickness of not less than 0.125 inches. It shall have a satin brush or spun finish. The top of the shaft shall have an outer diameter of four and one-half (4 -1/2) inches and be provided with a pole cap.
- B. The pedestal base shall be cast aluminum, square in shape, with a handhole. The size of the handhole shall be at least four (4) inches by six (6) inches and equipped with a cover, which can be securely fastened to the shaft with the use of simple tools. Bases shall have a minimum weight of twenty (20) pounds and shall have a four (4) bolt pattern uniformly spaced on a 12-1/2 inch diameter bolt circle. The exterior of the base shall be smooth and have a neat appearance.
- C. Four (4) three-fourths (3/4) inch by fifteen (15) inch hot rolled steel anchor bolts shall be supplied, complete with all hardware required for installation. The anchor bolts shall have a right angle bend at the bottom end and be hot dip galvanized at the threaded end.
- D. The fabricator shall certify that the pedestals are capable of withstanding winds up to 80 MPH with a 1.3 gust factor without failure.

3.22 PEDESTRIAN PUSH BUTTONS

- A. Pedestrian push button detectors shall be the direct push contact type that meets ADA requirements and will include an audible and visual confirmation of the switch closure. The entire assembly shall be weather tight, secure against electrical shock, and able to withstand continuous hard usage. The contacts shall be normally open with no current flowing except at the moment of actuation. The housing shall be made of aluminum alloy or stainless steel and furnished with suitable mounting hardware.
- B. Venders will furnish pushbutton signs conforming to the requirements of the MUTCD R10-3e and consistent with the legend as shown on project plans.
- C. Pedestrian signals shall consist of two signals sections with rectangular lenses and mounting attachments as shown in the contract documents. The pedestrian signal indications shall have a visual countdown timer. The two sections shall fit rigidly and securely together with or without a spacer. Any space shall be no more the ½ inch thick.
- D. All pedestrian indicators shall be LED.

3.23 SIGNS

- A. All traffic signs shall conform to the requirements of MUTCD.
- B. Street name signs shall be white letters. Clear View font, a minimum of 8-inches high on a green background. The sign shall have a white boarder, 0.75 inches wide. The sheeting material for the signs shall be encapsulated lens sheeting.
- C. Mount signs on the mast arms utilizing a universally adjustable mast arm mounted sign bracket, Pelco Astro Sign Brac or equivalent.
- D. The City of Marion may option to provide the specified signs for each individual project.

3.24 TESTING AND MAINTENANCE OF SIGNAL EQUIPMENT

- A. The CONTRACTOR shall notify the CONTRACTING AUTHORITY the date the signal or signal system will be ready for testing.
- B. Upon concurrence of the CONTRACTING AUTHORITY, the CONTRACTOR shall place the signal or signal system in operation for a consecutive 30-day test period. The signal(s) shall not be placed into operation without prior notification of the Engineer and concurrence by the Engineer that the signal(s) are ready to be placed into operation. Any failure or malfunction of the equipment, exclusive of minor malfunctions (such as lamp burnouts) occurring during the test period, shall be corrected at the CONTRACTOR'S expense and the signal or system tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated satisfactorily for 30 consecutive days. The CONTRACTOR will not be required to pay for energy consumed by the system and working days will not be charged during this trial period.

- C. The CONTRACTOR shall secure the services of an authorized factory representative of the solid-state controller manufacturer to be on site at the time the equipment is turned on. The representative shall verify all systems are working correctly and make all necessary adjustments to get all specified functions of the equipment working properly. This may include the coordination unit, interconnect functions, preemption and vehicle detection. The representative shall have on hand the necessary tools, test equipment, spare modules, spare detector amplifiers and other miscellaneous parts and equipment to complete the verification of the system.
- D. After signal turn on and prior to the final acceptance of the completed traffic signal system, the CONTRACTOR shall respond, within 24 hours, to perform maintenance or repair of any failure or malfunction reported.
- E. Electrical field testing of all systems shall be performed by the City with the assistance of the CONTRACTOR, before final acceptance of the work. Such tests shall include:
 1. Insulation resistance test shall be made with all lamps or ballasts disconnected from the circuit and all neutral line properly grounded. Insulation resistance shall have a range of 100 meg-ohms to infinity, and shall be measured with the City's meg-ohm meter.
 2. Ground resistance measurements shall be made with all ground rods disconnected from the circuit neutral wire. The resistance to earth of each individual grounding installation shall not be greater than 25 ohms, and shall be measured with the City's resistance meter.
 3. If any conductor fails, the CONTRACTOR shall remove it at his expense and replace it with new.

3.25 GUARANTEE

- A. The CONTRACTOR shall fully guarantee the traffic control signal installation against defective equipment, materials, and workmanship. Should any defect develop under normal and proper operating condition within 12 months after acceptance of the completed installation by the CONTRACTING AUTHORITY, this malfunction shall be corrected by, and at the expense of the CONTRACTOR, including all labor, materials, and associated costs.
- B. This guarantee shall be provided in writing on company or corporation letterhead stationary by the CONTRACTOR to the Contracting Authority prior to final acceptance. The CONTRACTOR shall transfer all required equipment warranties on the date of final acceptance to the Contracting Authority.

3.26 BASIS OF MEASUREMENT AND PAYMENT

- A. The Traffic Signal Installation(s) measured as a lump sum item will be paid for at the contract lump sum price bid, which price shall be full compensation for furnishing all equipment, materials, and all other work necessary or incidental to the construction of the complete signal installation and for all equipment, tools, labor, and incidentals necessary to complete the work in accordance with the contract documents.