
TRAFFIC SIGNALS**PART 1 - GENERAL****1.01 SECTION INCLUDES**

- A. Underground
- B. Detection
- C. Communications
- D. Cabinet and Controller
- E. Poles, Heads, and Signs

1.02 DESCRIPTION OF WORK

This part of the specifications includes the furnishing of all material and equipment necessary to complete, in place and operational, traffic control signal(s) as described in the project plans.

1.03 SUBMITTALS

Comply with Division 1 - General Provisions and Covenants, as well as the additional requirements listed below. All of the following must be submitted within 30 days after awarding of the contract for the project. Verify the method of submittal with the Jurisdiction.

- A. Schedule of Unit Prices:** Submit a completed schedule of unit prices. Estimates of the work performed on the project will be made by the Jurisdiction and the unit costs will be used to prepare progress payments to the Contractor.
- B. Material and Equipment List:** Submit a completed list of materials and equipment to the Jurisdiction for written approval before any equipment or materials are ordered.
- C. Contractor Certification:** Submit the name(s) and contact information of the International Municipal Signal Association (IMSA) Level II Certified Traffic Signal Technician(s) working on the project and a copy of their IMSA certificate.
- D. Shop Drawings/Catalog Cuts:** Submit PDF shop drawings file for traffic signal poles and structures to be furnished on the project. Submit single PDF of catalog cuts files and list manufacturer's specifications for all items in the project documents.
- E. Fiber Optic Cable:** Submit a splicing schematic.

1.04 SUBSTITUTIONS

Comply with Division 1 - General Provisions and Covenants.

1.05 DELIVERY, STORAGE, AND HANDLING

Comply with Division 1 - General Provisions and Covenants.

1.06 SCHEDULING AND CONFLICTS

Comply with Division 1 - General Provisions and Covenants.

1.07 SPECIAL REQUIREMENTS

- A. Comply with the current edition of the MUTCD as adopted by the Iowa DOT.
- B. Electrical equipment complying with current NEMA requirements.
- C. Ensure materials and work conform to current NEC and IMSA requirements.

1.08 MEASUREMENT AND PAYMENT**A. Traffic Signal:**

- 1. **Measurement:** Lump sum item; no measurement will be made.
- 2. **Payment:** Payment will be at the lump sum price for traffic signal installation. Partial payment will be made according to the approved schedule of unit prices for those materials installed.
- 3. **Includes:** Lump sum price includes, but is not limited to, furnishing and installing all pole foundations, poles, wiring, conduit, heads, signs, detection equipment, traffic signal control equipment (including pedestrian equipment), traffic signal controller and cabinet, and associated appurtenances for a complete, fully operation installation.

B. Temporary Traffic Signal:

- 1. **Measurement:** Lump sum item; no measurement will be made.
- 2. **Payment:** Payment will be at the lump sum price for temporary traffic signal. 80% of the lump sum bid amount will be paid upon completion of the installation and successful initial operation of the signal; the final 20% will be paid upon removal of the temporary traffic signal and cleanup of the site.
- 3. **Includes:** Lump sum price includes, but is not limited to, furnishing, installing, maintaining, and removing poles; wiring; traffic signal control equipment including pedestrian equipment if specified; implement all modifications of signal timing, signal placement and display due to Contractor initiated changes in the construction staging plan established by the Contracting Authority; relocation of trailer mounted temporary traffic signal systems; placement in another physical location to address changes in construction staging; and all appurtenances.

C. Traffic Signal Removal:

- 1. **Measurement:** Lump sum item; no measurement will be made.
- 2. **Payment:** Payment will be at the lump sum price for traffic signal removal.
- 3. **Includes:** Lump sum price includes, but is not limited to, removal of poles, concrete pads, foundations, wiring, traffic signal cabinet and equipment, pedestrian signal equipment, and handholes; delivery of removed materials to the location specified in the contract documents; furnishing, placing, and compacting backfill in all excavations; and restoring disturbed surfaces.

PART 2 - PRODUCTS**2.01 UNDERGROUND****A. Handhole:****1. General:**

- a. **Cable Hooks:** Unless otherwise specified, provide four galvanized steel cable hooks with a minimum diameter of 3/8 inch and a minimum length of 5 inches.
- b. **Granular Base:** Comply with the following gradations; however, the Engineer may authorize a change in gradation, subject to materials available locally at the time of construction.

Sieve	Percent Passing
2"	100
1 1/2"	80 to 90
1"	15 to 20
3/4"	0 to 0.5

- c. **Cover:** Include "TRAFFIC SIGNAL" as a message on the cover. Alternate messages may be required as specified in the contract documents.

2. Precast Concrete Handhole:

- a. **Pipe:** Comply with ASTM C 76. Minimum Class III, Wall B (Iowa DOT Class 2000D). Four, 8 inch knockouts (conduit entrance points) equally spaced around the handhole.
- b. **Casting:** Gray cast iron and certified according to requirements of AASHTO M 306 for a 16,000 pound proof-load (HS-20).

3. Composite Handhole and Cover: Composed of mortar consisting of sand, gravel, and polyester resin reinforced by a woven glass fiber mat or of resin mortar and fiberglass. Ensure the handhole and cover has a minimum ANSI/SCTE 77 2017 Tier 15 rating. Provide a skid resistant surface on the cover. Provide two 3/8-16 UNC stainless steel hex head bolts with washers.**4. HDPE Handhole and Cover:**

- a. **Size:** Provide handhole and cover with a minimum inside diameter of 24 inches and a minimum of 24 inches in depth. Handhole to be conical in shape with the taper from bottom to top.
- b. **Loading:** Ensure handhole, any extensions, and cover comply as a complete unit with ANSI 77 with a minimum Tier 15 rating.
- c. **Resin:** HDPE resin to comply with ASTM D 790 for minimum flexural modulus of 142,000 psi and ASTM D 638 for minimum yield strength of 3,100 psi when using a Type IV specimen, 2 inch per minute test speed, and 0.075 inch thick molded sample.
- d. **Cover:** Ensure cover has a skid resistant surface meeting PROWAG requirements with stainless steel bolts meeting manufacturer's requirements. Ensure cover fits handhole to meet PROWAG vertical surface discontinuity requirements when placed in pedestrian walkways.

B. Conduit:**1. General:**

- a. Furnish weatherproof fittings of identical or compatible material to the conduit. Use standard factory elbows, couplings, and other fittings.
- b. Use a manufactured conduit sealing compound that is readily workable material at temperatures as low as 30°F and will not melt or run at temperatures as high as 300°F.

2.01 UNDERGROUND (Continued)

- c. Furnish flat polyester pull tape with a minimum pulling strength of 1,250 pounds and permanent sequential footage markings.
- 2. Steel Conduit and Fittings:**
 - a. Comply with ANSI C80.1.
 - b. Use weatherproof expansion fittings with galvanized, malleable iron, fixed and expansion heads jointed by rigid steel conduit sleeves. As an option, the fixed head may be integral with the sleeve, forming a one piece body of galvanized malleable iron.
 - c. Provide steel bushings.
 - 3. Plastic Conduit and Fittings:**
 - a. PVC:**
 - 1) PVC Schedule 40 plastic conduit and fittings complying with NEMA TC-2 (pipe), NEMA TC-3 (fittings), and UL 651 for Schedule 80.
 - 2) Solvent welded, socket type fittings, except where otherwise specified in the contract documents.
 - 3) Threaded adaptors for jointing plastic conduit to rigid metal ducts.
 - 4) Provide bell end fittings or bushings.
 - b. HDPE:**
 - 1) Comply with ASTM F 2160 (conduit) and ASTM D 3350 (HDPE material), SDR 13.5.
 - 2) Use the color specified in the latest NEC or approved by the owner.
 - 3) Continuous reel or straight pieces to minimize splicing.
 - 4) For dissimilar conduit connections, provide an adhesive compatible with both materials.
- C. Wiring and Cable:** Provide wire that is plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable.
- 1. Power Cable:** Comply with [Iowa DOT Article 4185.11](#).
 - 2. Signal Cable:** Comply with IMSA Specifications 19-1 (PVC jacket) or 20-1 (polyethylene jacket) for polyethylene insulated, 600 volt, solid, multi-conductor copper wire, #14 American Wire Gauge (AWG).
 - 3. Tracer Wire:** Comply with #10 AWG, single conductor, stranded copper, type thermoplastic heat and water resistant, nylon-coated (THWN), with UL approval, and an orange colored jacket.
 - 4. Ethernet Cable:** Provide outdoor use rated cable. Provide either Category 5E (CAT5e) or Category 6 (CAT6) cable.
 - 5. Fiber Optic Cable and Accessories:**
 - a. Furnish fiber optic cable of the mode type, size, and number of fibers specified in the contract documents, and all associated accessories.
 - b. Meet the latest applicable standard specifications by ANSI, Electronics Industries Association (EIA), International Telecommunication Unit (ITU), and Telecommunications Industries Association (TIA).
 - c. Multimode Fiber:
 - Core Diameter: $62.5 \mu\text{m} \pm 1.0 \mu\text{m}$
 - Cladding Diameter: $125.0 \mu\text{m} \pm 2.0 \mu\text{m}$
 - Core Concentricity: $\pm 1\%$
 - Max. Attenuation: 3.50 dB/km @ 850 μm

2.01 UNDERGROUND (Continued)

- d. Single-Mode Fiber: Meet attributes of ITU-T G.652.D Table 2 and/or ITU-T G.657.A1 for low loss bend as specified in the contract documents.
- e. Glass reinforced plastic rod central member designed to prevent the buckling of the cable. Cable core interstices filled with water blocking tape to prevent water infiltration. Dielectric fillers may be included in the cable core where needed to lend symmetry to the cable cross-section.
- f. Buffer tubes of dual layer construction with a polycarbonate inner layer and polyester outer layer. Each buffer tube filled with a water-swellable yarn or tape. Buffer tubes stranded around the central member using reverse oscillation or "SZ" stranding process. Gel-free cable and buffer tubes.
- g. Buffer tubes and fibers meeting TIA/EIA-598A, "Color coding of fiber optic cables," with 12 fibers per buffer tube.
- h. Cable tensile strength provided by a high tensile strength aramid yarn and/or fiber glass.
- i. Dielectric cables, without armoring, or armored cables with corrugated steel tape armor as specified in the contract documents. Outer jacket of medium density polyethylene applied directly over the tensile strength members and flooding compound. Jacket or sheath marked in a contrasting color with the manufacturer's name and the words "Optical Cable," the year of manufacture, and sequential meter or feet marks. Additionally, provide a durable weather proof label on the cable jacket showing the actual attenuation of each fiber expressed in dB/km.
- j. Cable fabricated to withstand a maximum pulling tension of 600 pounds during installation (short term) and 135 pounds upon installation (long term).
- k. Shipping, storing, and operating temperature range of the cable: -40° C to + 70° C. Installation temperature range of cable: -30° C to + 70° C.
- l. Each fiber of all fiber optic cable tested by manufacturer at the 100% level for the following tests:
 - Proof tested at a minimum load of 50 kpsi (350 Mpa)
 - Attenuation
- m. Meet the appropriate standard Fiber Optic Test Procedure for the following measurements:
 - Fluid Penetration
 - Compound Drip
 - Compressive Loading Resistance
 - Cyclic Flexing
 - Cyclic Impact
 - Tensile Loading and Bending
- n. Make cable ends available for testing. Seal cable ends to prevent moisture impregnation.
- o. Fiber Distribution Panel: Provide a fiber distribution panel capable of terminating the number of fibers as specified in the contract documents.
- p. Fiber Optic Connectors:
 - 1) ST type connectors of ceramic ferrule and physical contact end finish to terminate multi-mode fibers to equipment.
 - 2) SC type connectors of ceramic ferrule and physical contact end finish to terminate single-mode fibers to equipment.
 - 3) ST or mechanical connectors not allowed for cable splices.
 - 4) Maximum attenuation per connector: 0.75 dB.
- q. Fiber Optic Jumpers/Patch Cords: For connections in the cabinet, provide factory-assembled duplex pigtail jumpers with dielectric strength member, durable outer jacket and ST or SC compatible connectors. Provide adequate length for connections and 2 feet minimum slack.
- r. Fiber Optic Breakout Kits: Provide breakout kits for separation and protection of individual fibers, with buffering tube and jacketing materials suitable for termination of the fiber and fiber optic connector.

2.01 UNDERGROUND (Continued)

- s. Splices/ Splice Enclosures: Fusion splice continuous fiber runs or branch circuit connections in splice enclosures as allowed or specified in the contract documents. Provide environmentally protected outside plant splice enclosures with adequate number of trays to splice all fibers. Do not splice continuous fibers unless physical restraints require all fibers to be cut, unless approved by the Jurisdiction. Maximum attenuation per splice: 0.3 dB.

D. Footings and Foundations:

1. Use Class C structural concrete complying with [Iowa DOT Section 2403](#).
2. Use uncoated reinforcing steel complying with [Iowa DOT Section 4151](#).

E. Bonding and Grounding:

1. **Ground Rods:** Provide 5/8 inch by 8 foot copper clad, steel ground rod.
2. **Bonding Jumper or Connecting Wire:** Provide #6 AWG bare conductor, copper wire.

2.02 DETECTION

- A. Inductive Loop Vehicle Detector:** A detector consists of a conductor loop or series of loops installed in the roadway, lead-in (feeder) cable, and a sensor (amplifier) unit with power supply installed in a traffic signal controller cabinet.

1. Cables:

- a. **Tube Loop Detector Cable:** Comply with IMSA Specifications 51-5.
- b. **Preformed Loop Detector Cable:** As approved by the Engineer.
- c. **Loop Detector Lead-in Cable:** Comply with IMSA Specifications 50-2.

2. Detector Loop Sealant:

- a. Use a rapid cure, high viscosity, liquid epoxy sealant formulated for use in sealing inductive wire loops and leads embedded in pavement. Ensure the cured sealer is unaffected by oils, gasoline, grease, acids, and most alkalis.
- b. Use a sealant complying with [Iowa DOT Materials I.M. 491.18](#).

3. Sensor (Amplifier) Unit:

- a. Use a sensor unit that is solid state, digital, providing detection channel(s) with an inductance range of 0 to 2,000 micro-henries. Output circuits of the sensor unit will be provided by relays. Vehicle presence will result in a continuous call indication.
- b. Provide a sensor unit with the following qualities:
 - 1) Sensitivity adjustment to allow as a minimum the selection of high, medium, or low sensitivity.
 - 2) Be capable of providing reliable detection of all licensed motor vehicles.
 - 3) Provide an indicator light for visual indication of each vehicle detection.
 - 4) Will not require external equipment for tuning or adjustment.
 - 5) Provide operation in the pulse mode or presence mode. Ensure mode switch is readily accessible.
 - 6) Provide a self tuning system that is activated automatically with each application of power. Provide automatic and continuous fine tuning to correct for environmental drift of loop impedance.
 - 7) Provide for fail-safe operation (continuous call) in the event of detector loop failure.
 - 8) Ensure each detector channel will respond to a frequency shift in an increasing or decreasing value as occurs with temperature shifts in the pavement without requiring a locked call.

2.02 DETECTION (Continued)

- 9) Use detector units with delay and extension timing. The delay feature is selected and adjusted externally on the sensor unit housing. Digitally derived timing is selectable in 1 second increments from 0 to 30 seconds. Ensure delay timing inhibits detector output until presence has been maintained for the time selected. Restart delay timer at each new detection.
- 10) Use a sensor unit capable of normal operation without interference and false calls between sensor units ("crosstalk") when installed in the physical environment of the controller cabinet and the electrical environment of the associated electronic equipment installed therein, including other detectors.

B. Pedestrian Push Button Detectors:**1. Assembly:**

- a. Ensure the entire assembly is weather tight, secure against electrical shock, withstands continuous hard usage.
- b. Provide a removable contact assembly mounted in a die cast aluminum case.
- c. Ensure contacts are normally open with no current flowing except at the moment of actuation.
- d. Ensure the contacts are entirely insulated from the housing and operating button with terminals for making connections.
- e. Provide housing with one outlet for 1/2 inch pipe.

2. Accessible Pedestrian Signals (APS) Push Button Stations:

- a. **Housing:** Die cast aluminum, weather tight, secure against electrical shock and withstands continuous hard usage.
- b. **Audible and Vibrotactile Features:** Audible walk indication tone, vibrotactile arrow, and locator tone complying with MUTCD.
- c. **Voice Messages:** As specified in the contract documents and per MUTCD.
- d. **Speaker:** Weatherproof with automatic volume adjustment to 5 dBA over ambient sound. Maximum volume 100 dB at 3 feet.
- e. **Push Button:** Nonrusting metal alloy, ADA compliant, 2 inch diameter with tactile arrow and 3 pounds maximum operational force.
- f. **Switch:** Solid state rated at 20 million operations minimum.
- g. **Program and Audio File Updates:** USB or Ethernet.
- h. **Operating Temperature:** -30 to + 165°F.

3. Solid State Pedestrian Push Buttons (non-APS):

- a. **Housing:** Die cast aluminum, weather tight, secure against electrical shock and withstands continuous hard usage.
- b. **Push Button:** Nonrusting metal alloy, ADA compliant, 2 inch diameter with 3 pounds maximum operational force, with momentary LED visual confirmation and audible tone confirmation.
- c. **Switch:** Solid state piezo-driven, rated at 20 million operations minimum.
- d. **Operating Temperature:** -30 to + 165°F.

4. Signs: Furnish signs complying with MUTCD.**C. Video Detection Camera System:** Detects vehicles by processing video images and providing detection outputs to the traffic signal controller.**1. Video Detection System and Processors:**

- a. Processor to be card rack mounted, shelf mounted, or located within camera. Compatible with NEMA TS-1, TS-2, ITE ATC, and Type 170 and 2070 controllers and cabinets.

2.02 DETECTION (Continued)

- b. Must be capable of the following:
 - 1) Shadow rejection without special hardware.
 - 2) Non-impaired operation under light intensity changes.
 - 3) Maintained operation during various weather conditions (e.g. rain, fog, snow).
 - 4) Anti-vibration, 5% rejection based on image change.
 - 5) Ability to select direction of flow parameters.
 - 6) Ability to properly detect directionally.
 - 7) Operate in presence mode with less than 4% error.
- c. Provide user-defined detection zone programming via a graphical user interface (GUI) and any necessary equipment for future programming. Store detection zones in non-volatile memory.
- d. Comply with NEMA TS-1 and TS-2 environmental and physical standards with an operating temperature of -34°C to +60°C, and 0% to 95% relative humidity.
- e. Ensure a factory certified representative from the supplier provides on-site VDS programming and testing.

2. Video Cameras:

- a. Meet NEMA-4 or NEMA-6P environmental standards.
- b. Use camera cable(s) meeting the manufacturer's recommendations. Provide a continuous run, without splices, from the camera to the controller cabinet.
- c. Camera per Approach or Advance Detection Camera:
 - 1) Provide a charge-coupled device (CCD) image sensor with variable focus color or black and white lens providing a minimum of 4 to at least a 40 degree horizontal field of view.
 - 2) Equipped with internal thermostatically controlled heater and external sunshield.
- d. Single Stop Line Detection Camera:
 - 1) Provide a minimum 5 MP image sensor with power over ethernet and a fisheye lens capable of detecting multiple approaches from a single mounting location.
 - 2) Include the ability to count traffic.
 - 3) Provide necessary internal thermostatically controlled heater as needed.

D. Microwave/Radar Vehicle Detectors: Detects all vehicles moving within the field of detection at speeds from 2 to 80 mph.

- 1. Must be capable of the following:
 - a. Minimum detection range from 3 to 200 feet for all vehicles.
 - b. Pattern spread of the detection field no more than 16 degrees.
 - c. Self-tuning and capable of continuous operation over a temperature range of -35°F to 165°F.
 - d. Side-fire mount or overhead mount.
 - e. Detecting directional traffic and the direction user selectable.
- 2. Microprocessor based using Doppler microwave at an operating frequency of 10.525 GHz.
- 3. FCC certification and tested to the applicable FCC specifications.
- 4. Enclosure constructed of aluminum or stainless steel and water resistant.
- 5. All user operated controls and adjustments must be clearly marked and easily accessible.
- 6. Relay detection output to the controller with a minimum 5 amp rating and designed to place a constant call to the controller in the event of any failure.
- 7. Easily accessible indicator showing activation of detection relay.

2.02 DETECTION (Continued)

8. Required wiring as recommended by the manufacturer.
 9. Provide mounting hardware for the type of mounting specified in the contract documents and power supply equipment as recommended by the manufacturer.
- E. Wireless Magnetic Sensors (Pod/Puck):** Provide as specified in the contract documents in pavement sensors, access points, base stations, and repeaters, if necessary.

2.03 COMMUNICATIONS

- A. Traffic Monitoring System:** Provide as specified in the contract documents including, video camera in dome, dome mounting bracket and hardware, camera controller, cabling from camera to controller cabinet, and all accessories, software, and hardware necessary for a complete and operational system.
1. Pan/tilt/zoom (PTZ) color camera with automatic conversion to monochrome during low light levels, auto focus, auto-iris control, electronic image stabilization, privacy masking and progressive CMOS sensor. Minimum 1920 x 1080 maximum resolution. Minimum optical zoom: 25X. Minimum digital zoom: 12X.
 2. Camera system provided in a NEMA 4X or IP66 certified rugged weather-resistant package.
 3. Provide all required lightning protection for electronics control, power, and coax video outputs.
 4. Operating temperature range: -40°C to +50°C.
 5. Maximum cable length as specified by camera manufacturer.
 6. Provide full 360 degree endless pan and 220 degree tilt under PTZ control.
 7. Dome electronics capable of programming a minimum of 64 preset views and nine preprogrammed pattern sequences of preset views. All views selectable by the central office computer or a remote control device.
 8. Provide encoder and decoder devices as needed to transmit video over existing or proposed communication systems at 30 frames per second (or more).
 9. Provide all necessary rack support devices for video viewing and PTZ control.
 10. Provide ability to control PTZ and view video remotely. Includes installing necessary software/programming needed for agency to operate system.
- B. Fiber Optic Hub Cabinet:** As specified in the contract documents.
- C. Wireless Interconnect Network:** Provides two-way data communication between the system control software and local traffic signal controllers.
1. **Data Transceiver:**
 - a. Utilize a license-free spread spectrum radio frequency (902-928 MHz) with frequency hopping technology.
 - b. Completely programmable by software. Furnish software to the Jurisdiction.
 - c. Built-in diagnostics capabilities.
 - d. Configurable as master, slave, or repeater with store and forward capability.
 - e. Maintains user selectable power output levels between 0.1 and 1 watt.

2.03 COMMUNICATIONS (Continued)

- f. Operates with input voltages between 6 VDC and 30 VDC.
- g. RS-232 interface with 115.2 kbps capability.
- h. Operating temperature of -40°C to +75°C.
- i. Receiver sensitivity of -108 to -110 dBm at 10^{-6} BER.
- j. Protected from power surges.
- k. Rack or shelf mounted in controller cabinet and connections for antenna, power, and controller.

2. Antenna:

- a. Capable of transmitting and receiving data between intersections.
- b. Mount near the top of the signal pole nearest the controller cabinet or as specified in the contract documents. Provide engineer-approved mounting hardware.
- c. Connect to transceiver via appropriate cable from pole to signal cabinet in same conduit as traffic signal cable. Conceal cable within a watertight connection at antenna.

2.04 CABINET AND CONTROLLER

A. Controller, Cabinet, and Auxiliary Equipment: Comply with the latest edition of NEMA TS1 or TS2, CalTrans model 2070, or ITE advanced transportation controller (ATC) standards.

1. Controller:

- a. Solid state modular design with digital timing and capable of accommodating at least eight phases.
- b. Fully prompted, front panel keyboard with menu driven programmability.
- c. Local time base scheduler including automatic accommodation for daylight savings time.
- d. Local coordination control.
- e. Local preemption control with at least four programmable internal preemption sequences.
- f. Current software and documentation.
- g. Data retained in a memory medium that does not require battery backup.

2. Cabinet:

- a. Unpainted aluminum cabinet according to NEMA standards.
- b. Aluminum cabinet riser with same dimensions as cabinet and 12 to 18 inch height, as specified in the contract documents.
- c. ATC cabinet voltage category as specified in the contract documents.
- d. Police door with auto/flash switch, manual/stop time switch, and on/off power switch for signal heads only. Controller to remain in full operation regardless of switch positions.
- e. Maintenance panel on 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.
- f. Heavy-duty clear plastic envelope attached to inside wall of cabinet or cabinet door, for cabinet wiring diagrams, 12 inches by 18 inches minimum.
- g. GFI electrical outlet and lamp in accessible location near the front of the cabinet. GFI outlet fused separately from main AC circuit breaker. LED cabinet lamp connected and fused with GFI outlet.
- h. Back panel positions to accommodate phasing and expansibility specified in the contract documents.

2.04 CABINET AND CONTROLLER (Continued)

- i. Power protection devices including AC power circuit breakers, radio interference suppressors, and lightning and surge protectors.
 - 1) AC field service single pole, nonadjustable, magnetic breaker rated for 117 VAC operation, NEC approved.
 - 2) Radio interference suppressors (RIS) as required to minimize interference in all broadcast transmission and aircraft frequency bands.
 - 3) Lightning arrestor/surge protector capable of withstanding repeated (minimum of 25) 30,000 ampere surges.
 - j. Neatly train wiring throughout the cabinet and riser. Bundle and attach wiring to interior panels using nonconductive clamps or tie-wraps.
- 3. Auxiliary Equipment:** Conflict monitor/malfunction management unit, flasher, load switches, terminals and facilities, and miscellaneous equipment and materials according to NEMA standards. For ATC cabinets, use serial interface unit, high density switch pack/flasher unit, cabinet monitor unit, cabinet power supply requirements, auxiliary display unit, sensor unit, and miscellaneous equipment materials meeting ITE standards.
- B. Uninterruptible Power Supply Battery Backup System:** Monitors 120VAC input from the electric utility source and automatically switches to/from a system consisting of batteries and electronics.
1. Include a maintenance bypass switch to allow operation of the traffic signal system while repairs are made to the battery backup system.
 2. Designed to provide a minimum of 4 hours of normal operation.
 3. Use cabinet equipment that is plug connected and shelf mounted.
 4. Designed to cover a temperature range from -30°F to +165°F and include a surge suppressor.
- C. Emergency Vehicle Preemption System:** As specified in the contract documents.

2.05 POLES, HEADS, AND SIGNS

- A. Vehicle Traffic Signal Head Assembly:** Comply with current MUTCD and ITE standards.
- 1. Housing:**
 - a. Individual signal sections made of a durable polycarbonate. Use color specified in the contract documents. Color to be an integral part of the materials composition.
 - b. Self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together.
 - c. Equipped 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.
 - d. Doors and lenses with suitable watertight gaskets and doors that are suitably hinged and held securely to the body of the housing by simple locking devices of non-corrosive material. Doors are to be easily removed and reinstalled without use of special tools.
 - 2. Optical System:** Designed to prevent any objectionable reflection of sun rays even at times of the day when the sun may shine directly into the lens.
 - 3. Lenses:** 12 inch diameter polycarbonate. Do not use glass lenses.

2.05 POLES, HEADS, AND SIGNS (Continued)

- 4. Visors:**
 - a. Standard Installation:**
 - 1) Each signal lens is to have a visor with the bottom 25% open.
 - 2) Minimum 0.1 inch in thickness and black in color.
 - 3) Fits tightly against the housing door with no filtration of light between the visor and door.
 - 4) Minimum length of 9 1/2 inches. Ensure the visor angle is slightly downward.
 - b. Optically Programmed Sections:** Make sure the optical unit and visor are designed as a whole to eliminate the return of outside rays entering the unit from above the horizontal.
 - 5. Terminal Block:**
 - a. Three-section signal equipped with a six position terminal block.
 - b. Four- and five-section signal equipped with an eight position terminal block.
 - 6. Backplate:**
 - a. Manufactured one-piece, durable, black plastic or aluminum capable of withstanding 100 mph winds.
 - b. Provides 5 inches of black field around the assembly.
 - c. If specified, provide high visibility reflective tape with a minimum width of 1 inch.
 - 7. Mounting Hardware:**
 - a. Rigid:** 1 1/2 inch aluminum pipe and fittings, natural aluminum finish or match the pole color if specified in the contract documents. Secure to pole with a minimum 5/8 inch wide stainless steel banding material.
 - b. Universally Adjustable:** Rigid mounted, consisting of both top and bottom brackets and easily adjustable in both horizontal and vertical planes. Provide galvanized steel cable material per manufacturer's recommendation.
 - 8. LED Modules:** Comply with current ITE standards and consistent with cabinet voltage requirements.
- B. Pedestrian Traffic Signal Head Assembly:** Comply with current MUTCD and ITE standards.
- 1. Housing:**
 - a. Made of a durable polycarbonate. Use color specified in the contract documents. Color to be an integral part of the materials composition.
 - b. Self-contained unit capable of separate mounting or inclusion in a signal face containing one or more signal sections rigidly and securely fastened together.
 - c. Equipped 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.
 - d. Doors and lenses with suitable watertight gaskets and doors that are suitably hinged and held securely to the body of the housing by simple locking devices of non-corrosive material. Doors are to be easily removed and reinstalled without use of special tools.
 - 2. Visor:**
 - a. Egg crate or tunnel type visor, as specified in the contract documents, attached to the housing door by stainless steel screws or according to manufacturer's requirements.
 - b. Fit tightly against the housing door to prevent any filtration of light between the door and the visor.
 - c. Ensure the visor angle is slightly downward.

2.05 POLES, HEADS, AND SIGNS (Continued)**3. LED Module:**

- a. Provide a LED unit(s) for the filled upraised hand symbol, walking person symbol, and countdown timer.
- b. Ensure immediate blank out of the countdown timer display upon recognizing a shortened "Walk" or a shortened "Flashing Don't Walk" interval.
- c. Comply with current ITE standards and consistent with cabinet voltage requirements.

C. Traffic Signal Poles and Mast Arms:**1. General:**

- a. Use mast arm length and vertical pole height as specified in the contract documents.
- b. Ensure the mast arms, poles, and supporting bases are galvanized on both interior and exterior surfaces according to ASTM A 123.
- c. Use continuously tapered, round, steel poles of the transformer base type for poles with mast arms 60 feet or less. Fabricate poles from low carbon (maximum carbon 0.30%) steel of U.S. standard gauge.
- d. For poles with mast arms greater than 60 feet or when a transformer base is not specified, provide a 6 inch by 16 inch handhole in the pole shaft for cable access. Provide a cover for the handhole. Secure the cover to the base with simple tools. Use corrosion resistant hardware.
- e. Ensure minimum yield strength of 48,000 psi after manufacture. Supply base and flange plates of structural steel complying with ASTM A 36 and cast steel complying with ASTM A 27, Grade 65-35 or better.
- f. Where a combination street lighting/signal pole is specified in the contract documents, ensure the luminaire arm is mounted in the same vertical plane as the signal arm unless otherwise specified. Use a luminaire arm of the single member tapered type. Fabricate the pole with a minimum 4 inch by 6 inch handhole and cover located opposite the signal mast arm.
- g. If allowed by the Engineer, poles and mast arms may be fabricated by shop welding two sections together, resulting in a smooth joint as follows:
 - 1) Ensure a minimum of 60% penetration for longitudinal butt welds in plates 3/8 inch and less in thickness, except within 1 foot of a transverse butt-welded joint. Ensure a minimum of 80% penetration for longitudinal butt welds in plates over 3/8 inch in thickness.
 - 2) Ensure 100% penetration for longitudinal butt welds in poles and arms within 1 foot of a transverse butt-welded joint.
 - 3) Ensure 100% penetration for transverse butt welds by using a back-up ring or bar to connect the sections.
 - 4) Examine the full length of all transverse butt welds and 100% penetration longitudinal butt welds by ultrasonic inspection according to the requirements of ANSI/AWS D1.1.
 - 5) Comply with ANSI/AWS D1.1 except as modified by [Iowa DOT Article 2408.03, B.](#)
- h. For mast arms over 50 feet length, two-piece mast arms with a slip-fit and bolt connection are allowed.
- i. Provide non-shrink grout (complying with [Iowa DOT Materials I.M. 491.13](#)) or a rodent guard (complying with [Iowa DOT Materials I.M. 443.01](#)) for placement between the pole base and the foundation per the manufacturer's requirements.

2.05 POLES, HEADS, AND SIGNS (Continued)

- 2. Pole Design:** Comply with AASHTO 2013 Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Use a 90 mph basic wind speed with a 50 year mean recurrence interval for strength design. Use Category II for fatigue design. Apply only natural wind gust loads (i.e. do not apply galloping loads, vortex shedding loads, or truck-induced gust loads) for fatigue design. Install vibration mitigation devices that mechanically or statically minimize vibration on the mast arm caused by wind on all traffic signal pole mast arms over 60 feet in length as shown on [Figure 8010.105](#).
- 3. Hardware:**
 - a. General:**
 - 1) Equip poles and mast arms with all necessary hardware and anchor bolts to provide for a complete installation without additional parts.
 - 2) Furnish each anchor bolt with one leveling nut, one anchoring nut, and one jam nut (if required) on the exposed end and one of the following on the embedded end: nut, nut and plate, or nut and anchor bolt assembly ring plate. Use anchor bolts, nuts, and washers that comply with [Iowa DOT Materials I.M. 453.08](#).
 - b. Anchor Bolts:**
 - 1) Use straight full-length galvanized bolts.
 - 2) Comply with ASTM F 1554, Grade 105, S4 (-20°F).
 - 3) Threads are to comply with ANSI/ASME B1.1 for UNC thread series, Class 2A tolerance.
 - 4) The end of each anchor bolt intended to project from the concrete is to be color coded to identify the grade.
 - 5) Do not bend or weld anchor bolts.
 - c. Nuts:**
 - 1) Comply with ASTM A 563, Grade DH or ASTM A 194, Grade 2H.
 - 2) Use heavy hex.
 - 3) Use ANSI/ASME B1.1 for UNC thread series, Class 2B tolerance.
 - 4) Nuts may be over-tapped according to the allowance requirements of ASTM A 563.
 - 5) Refer to Section 8010, 3.05, B, 2 for tightening procedure and requirements.
 - d. Washers:** Comply with ASTM F 436 Type 1.
 - e. Galvanizing:** Galvanize entire anchor bolt assembly consisting of anchor bolts, nuts, and washers (and plates or anchor bolt assembly ring plate, if used) according to the requirements of ASTM B 695, Class 55 Type 1 or ASTM F 2329 with zinc bath temperature limited to 850°F. Galvanize entire assembly by the same zinc-coating process, with no mixed processes in a lot of fastener assemblies.

D. Traffic Signal Pedestal Poles:

- 1. Materials:**
 - a. Pedestal:** The height from the bottom of the base to the top of the shaft as specified in the contract documents.
 - b. Pedestal Shaft:** Schedule 80 with satin brush or spun finish aluminum tubing. Top of the shaft outer diameter to be 4 1/2 inches and provided with a pole cap. Supply base collar for poles with shaft lengths greater than 10 feet. Provide brackets to mount pedestrian signal on side of pole.
 - c. Pedestal Base:** Cast aluminum, square in shape, with a handhole.
 - 1) Handhole:** Minimum of 3 1/2 inches by 5 1/2 inches and equipped with a cast aluminum cover that can be securely fastened to the base with the use of simple tools.
 - 2) Base:** A breakaway base with a four bolt pattern uniformly spaced on a minimum of 6 inch diameter bolt circle. Meet or exceed AASHTO breakaway requirements.

2.05 POLES, HEADS, AND SIGNS (Continued)

2. **Anchor Bolts:** Four 5/8 inch by 7 1/2 inch steel (minimum), hot dip galvanized anchor bolts complying with ASTM F 1554, Grade 36, meeting pole manufacturer requirements for installation, complete with all hardware required for installation. For pedestal pole sidewalk mounting, provide anchor bolts and hardware per pole manufacturer requirements.

E. Traffic Signs:

1. Sheet aluminum and retroreflective sheeting complying with [Iowa DOT Section 4186](#).
2. Use a universally adjustable mast arm mounted sign bracket.
3. Comply with MUTCD and the contract documents for the street name sign dimensions, letter height, and font.

PART 3 - EXECUTION**3.01 UNDERGROUND****A. Handhole:****1. Locations:**

- a. Do not construct in ditch bottoms, low areas where ponding of water may occur, or where they will be subject to normal vehicular traffic.
- b. With Engineer approval, additional handholes may be placed, at no additional cost to the Contracting Authority, to facilitate the work.

2. Excavation: Excavate as necessary to accommodate the handhole and granular base.**3. Granular Base:** Install 8 inch thick granular base extending a minimum of 6 inches beyond the outside walls of the handhole.**4. Placement:**

- a. In paved areas, install the handhole at an elevation so the casting is level and flush with the pavement. In unpaved areas, install the handhole approximately 1 inch above the final grade.
- b. Verify ring placement. Invert rings when installed in paved areas.

5. Conduit:

- a. Remove knockouts as necessary to facilitate conduit entrance.
- b. Extend conduit into the handhole, through a knockout, approximately 2 inches beyond the inside wall. Conduit to slope down and away from the handhole.
- c. Place non-shrink grout (complying with [Iowa DOT Materials I.M. 491.13](#)) in the opening of the knockout area after placement of conduit.

6. Cable Hooks:

- a. Install cable hooks centered between the knockouts and the top of the handhole anchored within the handhole wall.
- b. Place non-shrink grout (complying with [Iowa DOT Materials I.M. 491.13](#)) in the opening around the hook after placement of the hook.

7. Backfill: Place suitable backfill material according to [Section 3010](#).**8. Casting:** Place the casting on the handhole. Ensure the final elevation meets the handhole placement requirements.**B. Conduit:****1. General:**

- a. Place conduit to a minimum depth of 30 inches and a maximum depth of 60 inches below the gutterline, unless utility conflicts require deeper placement. When conduit is placed behind the curb, place to a minimum depth of 24 inches and a maximum depth of 48 inches below top of curb.
- b. Change direction at handholes or by bending, such that the conduit will not be damaged or its internal diameter changed. Ensure bends are uniform in curvature and the inside radius of curvature of any bend is no less than six times the internal diameter of the conduit.
- c. On the exposed ends of conduit, place bell-end fittings on PVC or HDPE conduit and bushings on steel conduit prior to installing cable. Extend all conduits a minimum of 2 inches and a maximum of 4 inches above the finished surface of any foundation, footing, or structural base.

3.01 UNDERGROUND (Continued)

- d. When it is necessary to cut and thread steel conduit, do not allow exposed threads. Ensure conduits and fittings are free from burrs and rough places. Clean, swab, and ream conduit runs before cables are installed. Use nipples to eliminate cutting and threading where short lengths of conduit are required. Coat damaged galvanized finish on conduit with zinc rich paint. Use only galvanized steel fittings with steel conduit.
- e. Install duct plugs in conduit ends or pack conduit ends with a conduit sealing compound.
- f. Install pull tape in each conduit segment, including empty conduits, and secure to duct plugs at each end.

2. Trenched Installation:

- a. Place backfill in layers not to exceed 12 inches in depth with each layer thoroughly compacted before the next layer is placed. Ensure backfill material is free of cinders, broken concrete, or other hard or abrasive materials.
- b. Remove all surplus material from the public right-of-way as soon as possible.

3. Trenchless Installation:

- a. When placing conduit under pavements, use the trenchless installation methods described in [Section 3020](#).
- b. If trenchless methods that compact soils in the bore path are used, provide sufficient cover to prevent heaving of overlying paved surfaces.
- c. Do not allow pits for boring to be closer than 2 feet to the back of curb, unless otherwise specified in the contract documents.

C. Wiring and Cable:

1. Where practical, follow color codes so that the red insulated conductor connects to the red indication terminal, yellow to yellow, and green to green. Ensure cables are properly labeled at the controller by durable labels, or other appropriate methods, attached to the cables. Label home runs for cables as follows: northwest corner is red, southeast corner is blue, northeast corner is green, and southwest corner is orange.
2. Install continuous runs of vehicle and pedestrian signal cables from the vehicle or pedestrian signal head to the handhole compartment of the signal pole base. Install continuous runs of vehicle and pedestrian signal cables from the handhole compartment of the signal pole base to the terminal compartment in the controller cabinet. Do not splice signal cables in underground handholes.
3. Install continuous runs for video detection and emergency vehicle preemption cables from the unit to the controller cabinet.
4. Install continuous runs of power lead-in cables from the service point to the meter socket and from the meter socket to the controller cabinet.
5. Install continuous detector cable from each detector loop to the first handhole adjacent to the loop. Ensure cables are properly labeled at the controller by durable labels, or other appropriate methods, attached to the cables. Install continuous homerun cable from the splice made in the first handhole to the terminal compartment in the controller cabinet. Attach the drain wire of the shielded cable to the ground in the controller cabinet.
6. Provide a minimum of 4 feet of additional cable at each handhole and loosely coil the extra cable on the handhole cable hooks. Provide a minimum of 2 feet of additional cable at each signal pole (measured from the handhole compartment in the pole to the end of the cable). Provide a minimum of 10 feet of additional cable at each controller base. For fiber optic cable, coil the specified length in a wheel shape and hang vertically.

3.01 UNDERGROUND (Continued)

7. Pull cables through conduit using a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, and minimize dragging on the ground or pavement.
8. Install a tracer wire in all conduits with the exception of conduits between detector loops and handholes. Use a silicon-filled wire nut to splice the tracer wire in each handhole and at the controller to form a continuous run.
9. Fiber Optic Cable and Accessories:
 - a. Use a suitable cable feeder guide between the cable reel and the face of the conduit to protect the cable and guide the cable directly into the conduit off the reel. During the installation, carefully inspect cable jacket for defects. If defects are found, notify the Engineer prior to any additional cable being installed. Take care when pulling the cable to ensure the cable does not become kinked, crushed, twisted, snapped, etc.
 - b. Attach a pulling eye to the cable and use to pull the cable through the conduit. Use a pulling swivel to preclude twisting of the cable. Lubricate cable prior to entering the conduit with a lubricant recommended by the manufacturer. Use dynamometer or break away pulling swing to ensure the pulling tension does not exceed the specified force of 600 pounds or the cable manufacturer's recommendations, whichever is less. Do not allow the cable to twist, stretch, become crushed, or forced around sharp turns that exceed the bend radius or scar or damage the jacket. Manually assist the pulling of the cable at each pull point.
 - c. Do not pull cable through any intermediate junction box, handhole, pull box, pole base, or any other opening in the conduit unless specified in the contract documents. Install cable by pulling from handhole or controller cabinet to the immediate next downstream handhole or cabinet. Carefully store the remaining length of cable to be installed in the next conduit run(s) in a manner that is not hazardous to pedestrian or vehicular traffic, yet ensures that no damage to the cable occurs. Storage methods are subject to Engineer approval.
 - d. At each handhole, visibly mark or tag cable, "CITY (or COUNTY) FIBER OPTIC"
 - e. Secure cables inside controller cabinet so that no load is applied to exposed fiber strands.
 - f. Ensure the radius of the bend for static storage is no less than 10 times the outside diameter of the cable, or as recommended by the manufacturer. Ensure the radius of the bend during installation is no less than 15 times the outside diameter of the cable, or as recommended by the manufacturer.
 - g. Provide cable slack in each handhole, junction box, and cabinet as specified in the contract documents. Where handholes or junction boxes lack sufficient area for cable storage or bend radius requirements, provide equivalent additional slack in adjacent facilities. Coil and bind slack cable at three points around the cable perimeter and support in its static storage position.
 - h. Install fiber optic accessories according to the manufacturer's recommendations and as specified in the contract documents.
10. Fiber Optic Cable Field Testing: Provide for each fiber strand both on-reel testing prior to installation and final testing after installation using a high-resolution optical time domain reflectometer (OTDR). Conduct measurements for single-mode fibers at 1310 nanometer and 1550 nanometer wavelengths. Conduct measurements for multimode fibers at 850 nanometer wavelength. Record the identification, location, length, and attenuation measurements of each fiber, and furnish test reports to the Engineer. Replace any cable that fails testing, at no additional cost to the Contracting Authority.
 - a. On-reel Testing: Perform testing for attenuation and continuity using OTDR and a pigtail splice. Complete testing in one direction only. Acceptable test results will be within $\pm 3\%$ of factory-supplied attenuation measurements. Except for access to and test preparation of one end of the newly furnished cable, preserve the cable in its originally-shipped condition. Furnish test reports to the Engineer prior to installation.

3.01 UNDERGROUND (Continued)

- b. Post installation, test 100% of the new cables' fiber count bi-directionally with an optical time domain reflectometer (OTDR) at 1310 nm and 1550 nm; in addition, use an optical loss test set (OLTS) to test all fibers at both wavelengths. Also test existing fibers that are spliced to or re-spliced as part of this contract in both directions and at both wavelengths. Provide the Engineer with up to five copies of any software required for viewing electronic files of the OLTS and OTDR traces. Use test equipment equal to EXFO FTB-500 OTDR meter, and Fluke DTX-CLT OLTS meter.
- c. Ensure all test equipment has been factory certified within the last year. Provide copies of the certification 10 days prior to testing.
- d. Record test results through the meter manufacturer's software with data compiled in a PDF. Additional alteration using software beyond the meter manufacturer's software will not be allowed. Submit test results in a format approved by the Engineer. Provide completed test forms on each fiber to the Engineer. Also provide native test (electronic version) with no alterations and meter software for viewing of fiber traces. At a minimum, ensure test results show the following:
 - Cable and fiber identification (as approved by the Engineer)
 - Operator name
 - Date and time
 - Setup and test parameters including wavelength, pulse width, range, scale, and ambient temperature.
 - Test results for OTDR test in both directions for total fiber trace, splice loss/gain (dB), connector loss (dB), all events greater than 0.05 dB, measured length from cable markings, and total length from OTDR.
 - Test results for attenuation test including measured cable length (cable marking), total length (from OTDR test), number of splices (from as-built) and total link end-to-end attenuation in each direction, and the bidirectional average.
- e. Ensure OTDR testing uses launch and receiving cables minimum 3,300 feet or greater than the dead zone for the OTDR used for this test.
- f. Ensure all fiber connectors are cleaned and checked for dirt, scratches, or chips before installed in adapters and testing. Install all dust covers after testing is complete.
 - Ensure the fiber optic cable has a maximum attenuation of 0.4 dB/km at 1310 nm and 0.3 dB/km at 1550 nm when measured with an OLTS.
 - Ensure each connector has an averaged loss value of 0.25 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm.
 - Ensure each splice has an averaged loss value of 0.08 dB or less when measured bi-directionally with an OTDR at 1310 nm and 1550 nm.

D. Footings and Foundations:

1. **Excavation:** Excavate to the size, shape, and depth specified in the contract documents. Ensure the bottom of all foundations rest securely on firm undisturbed soil. Minimize over-excavation to ensure support and stability of the foundation. Notify the Jurisdiction and Engineer immediately if high water and/or poor soils are encountered during excavation. Provide circular forms if needed at no additional cost to the Contracting Authority.
2. **Foundation:** Provide a means for holding all of the following elements rigidly in place while the concrete is being placed.
 - a. **Forms:**
 - 1) Set the forms level or sloped to meet the adjacent paved areas.
 - 2) When adjacent to paved areas, shape the top 11 inches of the foundation to be square and flush with the surrounding paved area. Provide preformed expansion material between the foundation and paved areas.

3.01 UNDERGROUND (Continued)

3) When installed in an unpaved area, set the top of the foundation 2 inches above the surface of the ground.

b. Reinforcing Steel: Install reinforcing steel.

c. Conduit: Install conduit.

d. Anchor Bolts:

- 1) Set anchor bolts using a template constructed to accommodate the specified elevation, orientation, and spacing according to the pole and controller manufacturer's requirements.
- 2) Center the pole anchor bolts within the concrete foundation.
- 3) Protect the anchor bolts until poles are erected.
- 4) Orient controller footing 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 Engineer.

e. Concrete:

- 1) Place concrete to form a monolithic foundation. Consolidate concrete by vibration methods.
- 2) Finish the top of the base level and round the top edges with an edging tool having a radius of 1/2 inch. Provide a rubbed surface finish on the exposed surface of the footing or foundation.
- 3) Allow the foundation to cure a minimum of 4 days prior to erecting the poles and 7 days prior to installing the mast arms. Times may be shortened if supported by strength test results.

3. Backfill: Place suitable backfill material according to [Section 3010](#).

E. Bonding and Grounding:

1. Ensure the traffic signal installation is grounded as required by the National Electric Safety Code.
2. Install a ground rod at each signal pole foundation and controller footing.
3. Use PVC conduit within the foundation or footing to accommodate the connection between the top of the concrete and the ground rod.
4. Bond poles to ground rods with copper wire. Connect ground wires to ground rods with approved mechanical connectors.
5. Bond rigid steel conduit ends in handholes with copper wire and approved fittings.

3.02 DETECTION**A. Detector Loop Cable Installation:**

1. Coordinate the location of the detector loop with the Engineer. Obtain the Engineer's approval prior to cutting the pavement.
2. Saw to ensure proper depth and alignment of the slot. Make a 2 inch deep clean, straight, well-defined 3/8 inch wide saw cut without damage to adjacent areas. Overlap the saw cuts where the detector loop changes direction to provide full depth at all corners. Do not use right angle or corners less than 90 degrees. Minimize crossing the number of pavement joints where possible. Route the sawcut from the loop to the edge of pavement perpendicular to the flow of traffic, maintaining at least 1 foot of clearance from parallel joints.

3.02 DETECTION (Continued)

3. Before installing the detector loop cable, check the saw cuts for the presence of jagged edges or protrusions and remove if present. Clean and dry the saw cuts to remove cutting dust, grit, oil, moisture, or other contaminants. Clean by flushing with a stream of water under pressure. Use oil-free compressed air to dry the saw cuts.
4. Install detector loop cable without damage. Place three turns of the detector loop cable into the saw cut. Seal the ends of the tubing at the time of placement to prevent entrance of moisture.
5. Ensure the detector loop cables are in the bottom of the saw cut. Place detector loop sealant within the saw cut area. Comply with the manufacturer's instructions for mixing and using the detector loop sealant.
6. Install preformed loop detector according to the manufacturer's recommendations.
7. Identify each detector loop cable in the handhole by phase and location. Wind loops that are physically adjacent in an individual lane or adjacent lanes with opposite rotation (i.e. #1 clockwise, #2 counter-clockwise, #3 clockwise, etc.). Rotation reversal can be accomplished by reversing leads at the handhole.
8. Twist, with at least five turns per foot, all lengths of loop wires and tubing that are not embedded in the pavement.
9. Identify all detector loop lead-in cables with appropriate detector numbers.
10. Use a detector loop cable splice kit for the electrical splice between the detector loop cable and the detector loop lead-in cable to the controller.
 - a. Ensure splice kit provides a watertight protective covering for the spliced wire, the shielding on the detector loop lead-in cable, and the end of the tubing containing the detector loop cable.
 - b. Use a manufactured electrical splice kit approved by the Engineer.
11. Test all loops and document by using the following procedures:
 - a. Determine the insulation resistance of the loop wire using a "megger" with 500V applied to either loop wire to earth ground. The resistance is to be greater than 100 megohms.
 - b. Determine the inductance of the loop using a loop inductance meter.

B. Pedestrian Push Button Detectors:

1. Install according to the manufacturer's recommendations.
2. Seal the wire entrance into the pedestrian push button assembly.

C. Video Detection Camera System: Install according to the manufacturer's recommendations and as specified in the contract documents.**D. Wireless Magnetic Sensors (Pod/Puck):** Install according to the manufacturer's recommendations.

3.03 COMMUNICATIONS

A. Traffic Monitoring System: Install according to the manufacturer's recommendations and as specified in the contract documents, as well as the following:

1. Position camera dome on the pole as directed by the Engineer.
2. Test installed system under the supervision of the Engineer, and certify as fully-functional.

B. Fiber Optic Hub Cabinet: Install according to the manufacturer's recommendations and as specified in the contract documents.

3.04 CABINET AND CONTROLLER

A. Cabinet:

1. Install according to the manufacturer's recommendations and as specified in the contract documents.
2. Install on pre-placed caulking material on the concrete base. After the cabinet is installed in place, place caulking material around the base of the cabinet.

B. Controller and Auxiliary Equipment: Install according to the manufacturer's recommendations and as specified in the contract documents.

C. UPS Battery Backup System: Install according to the manufacturer's recommendations and as specified in the contract documents. Provide service outlet that is not connected to the battery backup system.

D. Emergency Vehicle Preemption System: Install according to the manufacturer's recommendations and as specified in the contract documents.

3.05 POLES, HEADS, AND SIGNS

A. Vehicle and Pedestrian Traffic Signal Heads:

1. Inspect each signal head assembly while still on the ground for the following:
 - a. Physical defects
 - b. Visor type
 - c. LED wattage
 - d. Lens orientation
 - e. Wiring connections
2. Attach signal head mounting hardware according to the manufacturer's recommendations. Apply anti-seize compound to all mechanical fasteners.
3. Adjust each signal head both vertically and horizontally to approximate a uniform grade of all like signal heads.
4. During the course of construction and until the signals are placed in operation, cover signal faces or turn away from approaching traffic. Plumb and aim the heads. Confirm placement of signal heads with the Engineer.

3.05 POLES, HEADS, AND SIGNS (Continued)**B. Traffic Signal and Pedestal Poles:**

1. Erect all poles vertically under normal load.
2. Securely bolt the bases to the cast-in-place concrete foundations using the following procedures. Perform this work only on days with winds less than 15 mph. Tighten all of the nuts. Once the tightening procedure is started, complete on all of the base plate nuts without pause or delay.
 - a. Use properly sized wrenches or sockets, or both, designed for tightening nuts or bolts, or both, to avoid rounding or other damage to the nuts. Do not use adjustable end or pipe wrenches.
 - b. Ensure base plates, anchor rods, and nuts are free of all dirt or debris.
 - c. Apply stick wax or bees wax to the threads and bearing surfaces of the anchor bolt, nuts, and washers.
 - d. Tighten top nuts so they fully contact the base plate. Tighten leveling nuts to snug tight condition. Snug tight is defined as the full effort of one person on a wrench with a length equal to 14 times the bolt diameter but not less than 18 inches. Apply full effort as close to the end of the wrench as possible. Perform tightening by leaning back and using entire body weight to pull firmly on the end of the wrench until the nut stops rotating. Perform a minimum of two separate passes of tightening. Sequence tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all of the nuts in that pass have been tightened.
 - e. Tighten top nuts to snug tight as described for the leveling nuts.
 - f. Match-mark the top nuts and base plate using paint, crayon, or other approved means to provide a reference for determining the relative rotation of the nut and base plate during tightening. Further tighten the top nuts tightened in two passes, as listed in Table 8010.01, using a striking or hydraulic wrench. Follow a sequence of tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all nuts in that pass have been turned. Do not allow the leveling nut to rotate during the top nut tightening.
 - g. Lubricate the jam nuts, place, and tighten to snug tight.

Table 8010.01: Bolt Tightening

Anchor Bolt Size	First Pass	Second Pass	Total Rotation
Less than or equal to 1 1/2 inch diameter	1/6 turn	1/6 turn	1/3 turn
Greater than 1 1/2 inch diameter	1/12 turn	1/12 turn	1/6 turn

3. A torque wrench should be used to verify that a torque at least equal to the computed verification torque, T_v , according to paragraph 6.9 of FHWA *Guidelines for the Installation, Inspection, Maintenance, and Repair of Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, is required to additionally tighten the top nuts. An inability to achieve this torque should be interpreted to indicate that the threads have stripped and should be reported to the Engineer.
 4. After leveling the poles, use non-shrink grout or a rodent guard between the pole base and the foundation. When non-shrink grout is used, neatly finish exposed edges of grout to present a pleasing appearance, and place a weep hole in the grout.
 5. Apply anti-seize compound to all mechanical fasteners on pole access doors.
 6. Install pedestrian push button post caps with tamper-proof set screws per manufacturer's direction or by driving the cap a minimum of 1/2 inch onto the post.
- C. Traffic Signs:** Install signs using universally adjustable sign brackets banded to the pole. Apply anti-seize compound to all mechanical fasteners.

3.06 TEMPORARY TRAFFIC SIGNAL

Construct according to [Figure 8010.107](#) and to the configuration specified in the contract documents. Remove the temporary traffic signal as directed by the Engineer.

3.07 SURFACE RESTORATION

- A. Replace or reconstruct features removed as a part of the work, such as sidewalks, driveways, curbs, roadway pavement, unpaved areas, or any other items.
- B. Complete restoration according the applicable sections of the SUDAS Standard Specifications or as directed by the Engineer.

3.08 SIGNAL TURN ON

Six days in advance of the scheduled signal turn on, place static signs or portable dynamic message signs (PDMS) on at least each of the major street approaches indicating day of week when the traffic signals will be active. If required, special Traffic Signal Ahead signs or PDMS with "Signal Active" message may be left in place for up to 7 days following activation.

3.09 TESTING

- A. Notify the Engineer 2 working days in advance of the time and date the signal or signal system will be ready for turn on. Do not turn on the signal or signal system without authorization of the Engineer.
- B. Ensure a representative from the manufacturer and/or supplier of signal controller or other authorized person is at the project site when the signal controllers are ready to be turned on to provide technical assistance including, as a minimum, programming of all necessary input data.
- C. All required signal timing data will be provided by the Engineer.
- D. A test period of 30 calendar days will start upon confirmation from the Engineer that the signal or signal system is operating consistent with the project requirements. Any failure or malfunction of the equipment furnished by the Contractor, occurring during the test period will be corrected by the Contractor at no additional cost to the Contracting Authority. Upon confirmation by the Engineer that any failure or malfunction has been corrected, a new test period of 30 calendar days will start, exclusive of minor malfunctions such as lamp burnouts. Repeat this procedure until the signal equipment has operated satisfactorily for 30 consecutive calendar days.
- E. After signal turn on and prior to completion of the 30 calendar day test period, respond, within 24 hours, to perform maintenance or repair of any failure or malfunction reported.

3.10 DOCUMENTATION

- A. Provide file documentation packages with each signal system, consisting of the following:
 - 1. Complete cabinet wiring diagram.
 - 2. Complete physical description of the equipment.
 - 3. Controller printout or equal documentation of initial controller settings installed in the field or in the office.

3.10 DOCUMENTATION (Continued)

4. Product manuals for all cabinet equipment.
 5. Standard industry warranties on equipment supplied.
 6. Documentation of field cable labeling scheme.
 7. Diagram of phasing and detector locations.
 8. One set of as-built construction plans indicating changes from the original contract documents.
- B. Supply two complete sets of documentation. One set to be placed in the controller cabinet and the other set (less construction plan) to be delivered to the Engineer. Electronic (PDF) submittal of the documentation is acceptable, if allowed by the Engineer.

3.11 TRAFFIC SIGNAL REMOVAL

- A. Remove and salvage traffic signal and pedestrian poles and posts, including mast arms, signal heads, wiring, mounting hardware, and associated equipment.
- B. Remove and salvage controller cabinet and controller, including associated equipment.
- C. Remove and dispose of handholes and abandoned conduit as specified in the contract documents.
- D. Remove concrete pads and foundations, including reinforcing steel to a depth of 4 feet below established grade. Furnish, place, and compact backfill according to [Section 3010](#).
- E. Restore disturbed surfaces to match adjacent areas.
- F. Deliver salvaged materials to the location specified in the contract documents.

END OF SECTION