

**DIVISION 800. ELECTRICAL****GENERAL ELECTRICAL REQUIREMENTS****SECTION 801. ELECTRICAL REQUIREMENTS**

**801.01 Definition.** Codes, standards, and industry specifications cited for electrical work shall be by definition the latest adopted version thereof, unless indicated otherwise.

Materials by definition shall include electrical equipment, fittings, devices, motors, appliances, fixtures, apparatus, all hardware and appurtenances, and the like, used as part of, or in connection with, electrical installation.

**801.02 Standards of Installation.** Materials shall be installed according to the manufacturer's recommendations, the NEC, OSHA, the NESC, and AASHTO's Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

All like materials shall be from the same manufacturer. Listed and labeled materials shall be used whenever possible. The listing shall be according to UL or an approved equivalent.

**801.03 Safety and Protection.** Safety and protection requirements shall be as follows.

- (a) **Safety.** Electrical systems shall not be left in an exposed or otherwise hazardous condition. All electrical boxes, cabinets, pole handholes, etc. which contain wiring, either energized or nonenergized, shall be closed or shall have covers in place and be locked when possible, during nonworking hours.
- (b) **Protection.** Electrical raceway or duct openings shall be capped or otherwise sealed from the entrance of water and dirt. Wiring shall be protected from mechanical injury.

**801.04 Equipment Grounding Conductor.** All electrical systems, materials, and appurtenances shall be grounded. Good ground continuity throughout the electrical system shall be assured, even though every detail of the requirements is not specified or shown. Electrical circuits shall have a continuous insulated equipment grounding conductor. When metallic conduit is used, it shall be bonded to the equipment grounding conductor, but shall not be used as the equipment grounding conductor.

Detector loop lead-in circuits, circuits under 50 volts, and runs of fiber optic cable will not require an equipment grounding conductor.

Where connections are made to painted surfaces, the paint shall be scraped to fully expose metal at the connection point. After the connection is completed, the paint system shall be repaired to the satisfaction of the Engineer.

Bonding of all boxes and other metallic enclosures throughout the wiring system to the equipment grounding conductor shall be made using a splice and pigtail connection. Mechanical connectors shall have a serrated washer at the contact surface.

All connections to structural steel or fencing shall be made with exothermic welds. Care shall be taken not to weaken load carrying members. Where connections are made to epoxy coated reinforcing steel, the epoxy coating shall be sufficiently removed to facilitate a mechanical connection. The epoxy coating shall be repaired to the satisfaction of the Engineer. Where connections are made to insulated conductors, the connection shall be wrapped with at least four layers of electrical tape extended 6 in. (150 mm) onto the conductor insulation.

**801.05 Submittals.** At the preconstruction meeting, the Contractor shall submit a written listing of manufacturers for all major electrical and mechanical items. The list of manufacturers shall be binding, except by written request from the Contractor and approval by the Engineer. The request shall include acceptable reasons and documentation for the change.

Major items shall include, but not limited to the following.

Type of Work	Item
All Electrical Work	Electric Service Metering Emergency Standby System Transformers Cable Unit Duct Splices Conduit Surge Suppression System
Lighting	Tower Pole Luminaire Foundation Breakaway Device Controllers Control Cabinet and Peripherals
Traffic Signals	Signal Controller Master Controller Controller Cabinet and Peripherals Mast Arm Assembly Signal Head Detector Loop Fiber Optic Cable
Pump Stations	Pump Motor Motor Control System HVAC Level Control System SCADA Fire Alarm and Gas Detection System Effluent Screening and Mixing System Overhead Crane Security System

- (a) Non-Traffic Signal Installations. Within 30 calendar days after contract execution, the Contractor shall submit, for approval, one copy each of the manufacturer's product data (for standard products and components) and detailed shop drawings (for fabricated items). Submittals for the materials for each individual pay item shall be complete in every respect. Submittals which include multiple pay items shall have all submittal material for each item or group of items covered by a particular specification, grouped together and the applicable pay item identified. Various submittals shall, when taken together, form a complete coordinated package. A partial submittal will be returned without review unless prior written permission is obtained from the Engineer.

The submittal shall be properly identified by route, section, county, and contract number.

The Contractor shall have reviewed the submittal material and affixed his/her stamp of approval, with date and signature, for each individual item. In case of subcontractor submittal, both the subcontractor and the Contractor shall review, sign, and stamp their approval on the submittal.

Illegible print, incompleteness, inaccuracy, or lack of coordination will be grounds for rejection.

The Engineer will review the submittals for conformance with the design concept of the project according to Article 105.04 and the following. The Engineer will stamp the drawings indicating their status as "Approved", "Approved as Noted", "Disapproved", or "Information Only". Since the Engineer's review is for conformance with the design concept only, it shall be the Contractor's responsibility to coordinate the various items into a working system as specified. The Contractor shall not be relieved from responsibility for errors or omissions in the shop, working, or layout drawings by the Engineer's approval thereof. The Contractor shall still be in full compliance with contract and specification requirements.

All submitted items reviewed and marked "Disapproved" shall be resubmitted by the Contractor in their entirety, unless otherwise indicated within the submittal comments.

Work shall not begin until the Engineer has approved the submittal. Material installed prior to approval by the Engineer, will be subject to removal and replacement at no additional cost to the Department.

- (b) Traffic Signal Installations. At the preconstruction meeting, the Contractor shall submit the following items for materials used in construction of traffic signals for approval by the Engineer.
- (1) Five complete copies of the manufacturer's descriptive literatures and technical data for the traffic signal materials. The descriptive literatures and technical data shall be adequate for determining whether the materials meet the requirements of the plans and specifications. If the

literature contains more than one item, the Contractor shall indicate which item or items will be furnished.

- (2) Five complete copies of the shop drawings for the mast arm assemblies and poles, and the combination mast arm assemblies and poles showing, in detail, the fabrication thereof and the certified mill analyses of the materials used in the fabrication, anchor rods, and reinforcing materials.
- (3) Samples of all conduit and cable, and samples of each type of cable splice that will be used in the work.

Unless otherwise approved by the Engineer, all of the above items shall be submitted to the Engineer at the same time. Each item shall be properly identified by route, section, and contract number.

The Engineer will review the literature and furnish written approval or disapproval to the Contractor within 30 calendar days after receipt of the literature. If the literature is disapproved, the Contractor shall resubmit corrected literature within 15 calendar days of receipt of disapproval. Within ten calendar days after receipt of written approval of any signal material, the Contractor shall order such signal material and shall furnish a copy of such order to the Engineer.

**801.06 Certifications.** When certifications are specified and are available prior to material manufacture, the certification shall be included in the submittal information. When specified and only available after manufacture, the submittal shall include a statement of intent to furnish certification. All certificates shall be complete with all appropriate test dates and data.

**801.07 Documentation for Electronic Materials.** The Contractor shall furnish three copies of the manufacturer's documentation, to the Engineer, for the following items:

- Signal controllers and master controllers.
- Inductive loop detectors and light detector amplifiers.
- Preemptors.
- Tranceivers.
- Load switches.
- Conflict monitors/malfunction management unit.
- High mast tower lowering devices.
- Pump station controls, communications, and backup systems.
- Any other item providing a logic, timing, or communication function.

The documentation shall include:

- Operations manual (including installation, start-up, and testing procedures)
- Service manuals.
- Circuit board schematics.
- Pictorial layout of circuit board components.
- Parts list.

The Contractor shall also furnish, to the Engineer, five copies of the controller cabinet wiring diagrams.

When approved by the Engineer, electronic copies of the documentation may be submitted in PDF format in lieu of paper copies.

**801.08 Authorized Project Delay.** For working day contracts, the Contractor may request to delay the start of work for a period of up to 120 consecutive calendar days after the execution of the contract for the delivery of long lead time electrical materials. This delay shall be requested by the Contractor at or prior to the time of the preconstruction meeting.

When approved, the delay shall not be construed as requiring the Contractor to actually have the material on hand within such period, only that charging of working days will begin at the termination of the delay.

**801.09 Marking Proposed Locations for Highway Lighting System.** The Contractor shall mark or stake the proposed locations of all poles, cabinets, junction boxes, pull boxes, handholes, cable routes, pavement crossings, and other items pertinent to the work. A proposed location inspection by the Engineer shall be requested prior to any excavation, construction, or installation work after all proposed installation locations are marked. Any work installed without location approval is subject to corrective action at no additional cost to the Department.

**801.10 Inspection of Work.** Inspection of electrical work shall be according to Article 105.12 and the following.

- (a) Before any splice, tap, or electrical connection is covered in handholes, junction boxes, light poles, or other enclosures, the Contractor shall notify and make available such wiring for the Engineer's inspection.
- (b) The Contractor shall prepare traffic signal materials at a suitable location, meeting the approval of the Engineer, so it may be readily inspected and tested by the Engineer. Prior to testing, all components shall be identified as to the vehicle movements. The inspector will tag the material that has been inspected and it may then be delivered to the job site. No materials will be inspected unless a written request for inspection is delivered to the Engineer at least one week in advance. Materials not complying with this requirement that have been installed on the job will be done at the Contractor's own risk and may be subject to removal and replacement at no additional cost to the Department.

**801.11 Maintenance and Responsibility During Construction.** Lighting and traffic signals shall be maintained during construction as follows.

- (a) Lighting. Roadway lighting systems which are being replaced, including sign and navigation lighting, must remain operational throughout the project according to Coast Guard requirements and as directed by the Engineer. No lighting circuit or portion thereof shall be removed from nighttime operation without the approval of the Engineer.

- (b) Traffic Signals. The Contractor shall be responsible for maintaining the traffic signal installation in proper operating condition.

The Contractor shall perform the following maintenance procedures.

- (1) Inspection. Patrol and inspect the signal installation at least once every two weeks for proper alignment of signal heads, lamp outages, and general operation of the traffic signals.
- (2) Correction. Provide immediate corrective action to replace burned-out lamps or damaged sockets with new approved lamps or sockets. At the time of replacement, the reflector and lens shall be cleaned.
- (3) Emergency Calls. Respond to emergency calls, including but not limited to dark signals and unprogrammed flashing signals, within two hours after notification and provide immediate corrective action. The Contractor shall maintain, in stock, a sufficient amount of materials to provide temporary and permanent repairs. Any damage to the signal installation from any cause whatsoever shall be repaired or replaced by the Contractor at no additional cost to the Department.

The Contractor shall install "STOP" (R1-1-3636) signs on all approaches to the intersection as a temporary means of regulating traffic during the time of repair, when required by the Engineer.

- (4) Personnel. The Contractor shall provide the Engineer the names and telephone numbers of two persons who will be available 24 hours a day, seven days a week, to perform any necessary work on the signal installation.
- (5) The Contractor's signal responsibilities of maintenance, energy charge, and damage repair shall begin and end as follows.
  - a. New Signal Installation. The signal responsibility shall begin at the start of signal construction and shall end upon issuance of Signal Acceptance Notice by the Engineer.
  - b. Modify Existing Signals. The signal responsibility shall begin at a date mutually agreed upon between the Contractor, Engineer, and the signal maintaining agency representative, but no later than the beginning of construction by the Contractor within 400 ft (125 m) of the intersection. The signal responsibility shall end upon issuance of Signal Acceptance Notice by the Engineer. The Contractor shall not be responsible for energy charges when modifying an existing installation.
  - c. Temporary Signals Used During Construction. The signal responsibility shall begin at the start of temporary signal construction and shall end with the removal of the signal as directed by the Engineer.

If, at any time, the Contractor fails to perform any work deemed necessary by the Engineer to keep the traffic signals in proper operating condition, or if the Engineer finds it impossible to contact the designated persons to perform any work, the Department reserves the right to perform the work. The cost of such work will be deducted from the amount due the Contractor.

**801.12 Damage to Electrical Systems.** Should damage occur to any existing electrical systems through the Contractor's operations, the Engineer will designate the repairs as emergency or non-emergency in nature.

Emergency repairs shall be made by the Contractor, or as determined by the Engineer, the Department, or its agent. Non-emergency repairs shall be performed by the Contractor within six working days following discovery or notification. All repairs shall be performed in an expeditious manner to assure all electrical systems are operational as soon as possible. The repairs shall be performed at no additional cost to the Department.

- (a) Lighting. An outage will be considered an emergency when three or more lights on a circuit or three successive lights are not operational. Knocked down materials, which result in a danger to the motoring public, will be considered an emergency repair.

Temporary aerial multi-conductor cable, with grounded messenger cable, will be permitted if it does not interfere with traffic or other operations, and if the Engineer determines it does not require unacceptable modification to existing installations.

- (b) Traffic Signals. Dark or unprogrammed flashing traffic signals will be considered an emergency. In the event that a traffic signal system is not functioning, the Contractor shall install "STOP" (R1-1-3636) signs on the approaches to the intersection as a temporary means of regulating traffic during the time of repair.
- (c) Pump Stations. Work shall be done in a manner such that the roadway served by the pump station is adequately protected from storm water and ground water at all times. If necessary, the Contractor may be required to provide alternate means of pumping to ensure that the roadway remains open.

**801.13 Testing.** Before final inspection, the electrical work shall be tested. Tests may be made progressively as parts of the work are completed, or may be made when the work is complete. Tests shall be made in the presence of the Engineer. Items which fail to test satisfactorily shall be repaired or replaced. Tests shall include checks of control operation, system voltages, cable insulation, and ground resistance and continuity.

The forms for recording test readings will be available from the Engineer. The Contractor shall provide the Engineer with a written report of all test data including the following:

- Date of test.
- Name of person performing the test.

Number of days since last rain.

Soil condition at the time of the test.

Diagram of test set-up showing distances between test equipment and grounding electrode(s).

Make and model of test equipment.

Tabulation of measurements taken and calculations made.

(a) Lighting. The following tests shall be made.

- (1) Voltage Measurements. Voltages in the cabinet from phase to phase and phase to neutral, at no load and at full load, shall be measured and recorded. Voltage readings at the last termination of each circuit shall be measured and recorded.
- (2) Insulation Resistance. Insulation resistance to ground of each circuit at the cabinet, with all loads connected, shall be measured and recorded.

On tests of new cable runs, the readings shall exceed 50 megohms for phase and neutral conductors with a connected load over 20 A, and shall exceed 100 megohms for conductors with a connected load of 20 A or less.

On tests of cable runs which include cables which were existing in service prior to this contract, the resistance readings shall be the same or better than the readings recorded at the maintenance transfer at the beginning of the contract. Measurements shall be taken with a megohm meter approved by the Engineer.

- (3) Loads. The current of each circuit, phase main, and neutral shall be measured and recorded. The Engineer may direct reasonable circuit rearrangement. The current readings shall be within ten percent of the connected load based on material ratings.
- (4) Ground Continuity. Resistance of the system ground as taken from the farthest extension of each circuit run from the controller (i.e. check of equipment ground continuity for each circuit) shall be measured and recorded. Readings shall not exceed 2.0 ohms, regardless of the length of the circuit.
- (5) Resistance of Grounding Electrodes. Resistance to ground of all grounding electrodes shall be measured and recorded. Measurements shall be made with a ground tester during dry soil conditions as approved by the Engineer. Resistance to ground shall not exceed 10 ohms.

(b) Traffic Signals. The following tests shall be made.

- (1) Testing as required by Articles 801.13(a)(4) and (5).
- (2) Detector Loops. Before and after permanently securing the loop in the pavement, the resistance, inductance, resistance to ground, and quality factor for each loop and lead-in circuit shall be tested. The loop and

lead-in circuit shall have an inductance between 20 and 2500 microhenries. The resistance to ground shall be a minimum of 50 megohms under any conditions of weather or moisture. The quality factor (Q) shall be 5 or greater.

- (c) Pump Stations. Testing shall be made as required by Articles 801.13(a)(1) through (5).
- (d) Fiber Optic Communication System. The Contractor shall provide all personnel, materials, instrumentation, and supplies necessary to perform all testing.

The testing shall be performed in an accepted manner and according to the testing equipment manufacturer's recommendations.

- (1) Pre-installation Testing. An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and the length of each fiber on cable reels prior to their use on the project. The fiber loss in dB/km and the length of each strand shall be recorded in the documentation. The attenuation of each fiber shall not exceed 3.5 dB/km nominal, measured at room temperature at 850 nm, and the attenuation measured shall be compared against that recorded by the manufacturer.

A hard copy of OTDR signature traces for all fibers on each cable reel shall be printed and provided in the documentation to the Engineer.

- (2) Post-Installation Testing. Each section of the cable shall be tested for the continuity and the attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an OTDR to locate points of localized loss caused by bends or kinks, and try to relax these bends or kinks. If this is not successful, the Contractor shall replace the damaged section of the cable at no additional cost to the Department. Splices shall not be allowed to repair the damaged section.

- a. Attenuation Test. After installation, the end-to-end attenuation shall be measured for each link by insertion loss testing.

The launch reference cable and the receive reference cable shall provide for the attachments to the light source and to the power meter, respectively. The fiber strand in the launch cable and in the receive cable shall be of the same size and type as the fiber under test.

The launch reference cable shall be connected to the light source and the receive reference cable to the power meter. The two reference cables shall then be connected via a patch panel. A reference power reading (P1) shall then be taken and recorded.

The system link to be tested shall then be inserted between the launch and the receive reference cables using two patch panels. A test power reading (P2) shall then be taken and recorded.

The link attenuation (A) in dB shall be recorded as the difference between the reference power (P1) and the test power (P2).

Link Attenuation,  $A = P1 - P2$

Where P1 = Reference Power  
P2 = Test Power

This test shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation.

- b. Transmitter/Receiver Power Level Tests. The output levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation.

The power meter shall be connected to the transmitter side with a system jumper. The transmit power level shall then be read and recorded. The transmitter is then reconnected to the cable link and the power meter connected to the receiver side. The receiver power level shall then be read and recorded.

- c. Continuity Test. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure that the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receive fiber.

To perform continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

**801.14 Contract Guarantee.** The Contractor shall provide a written guarantee for all electrical work provided under the contract for a period of six months after the date of acceptance according to Article 801.15.

All instruction sheets required to be furnished by the manufacturer for materials and supplies and for operation of the installation shall be delivered to the Engineer prior to acceptance of the project, with the following warranties and guarantees.

- (a) The manufacturer's standard written warranty for each piece of electrical material or apparatus furnished under the contract. The warranty for light emitting diode (LED) modules, including the maintained minimum luminance, shall cover a minimum of 60 months from the date of delivery.
- (b) The Contractor's written guarantee that, for a period of six months after the date of final acceptance of the work, all necessary repairs to or replacement of said warranted material or apparatus for reasons not proven to have been

caused by negligence on the part of the user or acts of a third party shall be made by the Contractor at no additional cost to the Department.

- (c) The Contractor's written guarantee for satisfactory operation of all electrical systems furnished and constructed under the contract for a period of six months after final acceptance of the work.

**801.15 Acceptance.** Acceptance of electrical work will be given at the time when the Department assumes the responsibility to protect and maintain the work according to Article 107.30 or at the time of final inspection.

When the electrical work is complete, tested, and fully operational, the Contractor shall schedule an inspection for acceptance with the Engineer no less than seven working days prior to the desired inspection date. The Contractor shall furnish the necessary labor and equipment to make the inspection.

A written record of the test readings taken by the Contractor according to Article 801.13 shall be furnished to the Engineer seven working days before the date the inspection is scheduled. Inspection will not be made until after the delivery of acceptable record drawings, specified certifications, and the required guarantees.

**Traffic Signals.** The following additional requirements shall also apply for the acceptance of traffic signals.

- (a) **Acceptance of Traffic Signal Installations.** A signal, whether a new installation or an existing modified, will be accepted with the issuance of a written Signal Acceptance Notice by the Engineer.

For interconnected signals, the Signal System Acceptance Notice covering interconnection and system operation will be issued only after the compliance with the requirements on all signals, interconnection, and system operation. The Signal Acceptance Notice may be issued for individual signals under system control that meet all the non-system requirements.

- (b) **Turn-on or Actuated Operation Inspection of Traffic Signals.** The Contractor shall request a Turn-on Inspection of a new signal installation and an Actuated Operation Inspection of an existing modified signal after the signal system has been completely installed and fully operational and when the roadway is open to traffic. For the interconnected signals (hardwire, fiber optic, or radio interconnect), all required system hardware and software including but not limited to internal and external modems, telephone drop, master controller, interconnect cable, and Closed Loop software, shall be completely installed and fully operational prior to the system inspection request.

The inspection request shall be made to the Engineer a minimum of three working days prior to the time of the requested inspection. During the inspection, all the traffic control items will be tested for proper operation according to the contract and to the satisfaction of the Engineer. The Contractor shall be provided with a punch list indicating the items that failed the inspection and require corrective measures. Upon the Turn-on

Inspection, the Engineer may allow the Contractor to activate the signal in continuous operation, but this shall not relieve the Contractor from correcting the failed items. The Contractor shall notify the Engineer when all the failed items on the punch list have been corrected and shall request an inspection. A Turn-on or Actuated Operation Inspection shall not be considered successful until each failed item on the punch list has been corrected by the Contractor to operate according to the contract and to the satisfaction of the Engineer. Only after a successful Turn-on or Actuated Operation Inspection shall the signals be considered ready for the final inspection and a 30-day on-site acceptance period shall start.

- (c) **Monitoring of Traffic Signal Installations (Thirty-day On-site Acceptance).** After a successful Turn-on or Actuated Operation Inspection, the signals shall enter a 30 calendar day minimum on-site monitoring phase. During this phase, the Contractor shall continuously monitor the operation of the traffic signal items including but not limited to controllers, master controller, inductive loop detectors, detector loop, transceivers, modems, conflict monitors, and controller cabinets with peripheral materials. If a Closed Loop system is being installed or being modified, the Contractor shall utilize the system software capabilities to monitor the traffic control items. Failure of any component during the monitoring period, with the exception of expendable items such as light bulbs and fuses, shall be reported to the Engineer and corrective measures shall be taken by the Contractor to the satisfaction of the Engineer. A failed item shall necessitate restarting the 30-day monitoring period for its full 30-day duration beginning at the time when the failed item was corrected by the Contractor to the satisfaction of the Engineer.

At the end of a successful 30-day monitoring period, the Contractor shall provide the Engineer with a monitoring log for the items covering the 30-day period. The Contractor shall utilize the system software capabilities to store and generate monitoring logs, if a Closed Loop system is being installed or modified. Upon review of the logs and further performance testing to the satisfaction of the Engineer, he/she will issue a Signal Acceptance Notice/Signal System Acceptance Notice or notify the Contractor in writing of the deficiencies.

**801.16 Record Drawings.** Alterations and additions to the electrical installation made during the execution of the work shall be neatly and plainly marked in red by the Contractor on the full-size set of record drawings kept at the Engineer's field office for the project. These drawings shall be updated on a daily basis and shall be available for inspection by the Engineer during the course of the work. The record drawings shall include all plans, details, notes, schedules, single line diagrams, etc., applicable to the electrical work and other information useful to locate and maintain the electrical system. As part of the record drawings, the Contractor shall inventory all materials, new or existing, on the project and record information on inventory sheets provided by the Engineer. Upon request, a full-size set of reproducible drawings of the lighting work will be made available to the Contractor for the purpose of compliance with these requirements.

When the work is complete, and seven days before the request for a final inspection, the full-size set of contract drawings, stamped "RECORD DRAWINGS",

shall be submitted to the Engineer for review and approval and shall be stamped with the date and the signature of the Contractor's supervising Engineer or electrician.

The Contractor shall provide two sets of electronically produced drawings in a moisture proof pouch to be kept on the inside door of the controller cabinet or other location approved by the Engineer. These drawings shall show the final as-built circuit orientation(s) of the project in the form of a single line diagram with all luminaires numbered and clearly identified for each circuit.

## **SECTION 802. RESERVED**

### **SECTION 803. LOCATING UNDERGROUND CABLE**

**803.01 Description.** This work shall consist of determining the exact locations of all underground electric cable and electric conductors in conduit owned and maintained by the Department, which are in possible conflict with construction operations, to protect them from damage.

#### **CONSTRUCTION REQUIREMENTS**

**803.02 General.** Any prints from microfilm or any information shown on the plans for existing underground electrical facilities owned and operated by the Department are intended to show electrical circuitry only, and are not intended to show exact locations of cable or conduits. The Contractor shall be responsible for determining the exact location of any such existing underground electric cable or electric conductors in conduit that are within 5 ft (1.5 m) of the limits of any excavation or penetration relative to the construction work that could interfere with the underground facilities.

Plans of existing Department owned electrical facilities may be available in the District Office in which the construction is located. Prints of applicable plans will be provided to the Contractor upon request, if available.

The Contractor shall take whatever precautions to protect the electric cable or electric conductors in conduit from damage during location and construction operations. In the event that the wiring is damaged, the Contractor shall replace the entire length of cable or conductors in conduit, in a manner satisfactory to the Engineer. Splicing below grade will not be permitted.

In the event the repairs are not made by the Contractor, the Contractor shall reimburse the Department for such repairs within 60 days of receiving written notification of said damage. Otherwise, the cost of such repairs will be deducted from monies due or which will become due the Contractor under the terms of the contract.

If, in the opinion of the Engineer, it is determined prior to any construction that existing electrical wiring at a particular location is such that damage to said wiring is impossible to avoid, the Contractor shall relocate that segment of the existing wiring to avoid his/her operations as directed by the Engineer.

**803.03 Method of Measurement.** This work will be measured for payment in feet (meters) in place for each single buried insulated cable containing multiple conductors, or for each single buried conduit containing multiple cables located within an area extending 5 ft (1.5 m) outside the limits of excavation or penetration in each direction. This work will be measured for payment at a specific work location only one time.

**803.04 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for LOCATING UNDERGROUND CABLE, which price shall include locating each cable, or conduit and protecting it from damage during location and construction operations.

If the Contractor is requested to relocate a segment of cable or conduit at a specific work location to avoid construction operations, this work will be paid for according to Article 109.04. Only that work requested in writing by the Engineer will be paid for.

**SECTION 804. ELECTRICAL SERVICE INSTALLATION - LIGHTING**

**804.01 Description.** This work shall consist of installing, modifying, or extending an electric service installation.

**804.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Conductors .....	1066.02
(b) Cable Insulation .....	1066.03
(c) Wood Pole (Note 1) .....	1069.04
(d) Electric Service Installation - Lighting .....	1086.01
(e) Electrical Raceway Materials .....	1088.01

Note 1. The pole shall be Class 5.

**CONSTRUCTION REQUIREMENTS**

**804.03 Utility Coordination.** The Contractor shall contact and coordinate both the work required and the timing of the installation with the electric utility.

In the event of delay by the utility, no extension of time will be considered applicable for the delay unless the Contractor can produce evidence that a written request(s) for electric service has been sent to the utility. The initial written request must be dated no later than 30 days from contract execution.

**804.04 Installation.** The electric service installation shall extend beyond utility owned facilities to the point of cable termination of the incoming power to the controller cabinet. It shall be installed according to the phasing, ampere rating, and voltage shown on the plans.

The Contractor shall ascertain the work being provided by the electric utility and shall provide all additional material and work required to complete the electric service

work in compliance with the requirements of the utility. All material and work, even if not specifically shown, shall be provided and included as part of the work.

The electric service installation shall include an appropriate service disconnect and when required, metering. Metering shall include all metering material including potential and current transformers. The metering and service disconnect shall be installed remote to the controller cabinet where possible.

The total length of aerial and underground service between the controller and primary transformer shall not exceed 250 ft (76 m). The service pole or above ground pedestal and controller shall be located adjacent to the right-of-way line or a minimum distance of 30 ft (9 m) from edge of pavement. The exact location will be established by the Engineer.

Raceways shall be installed according to Article 810.03 and the details shown on the plans.

Conductors shall be installed according to Article 817.03.

Grounding shall be according to Section 806.

Specific requirements for aerial and underground electric service installations shall be as follows.

- (a) Aerial Electric Service. The aerial service shall be mounted on a wood pole, along with a weatherhead, disconnect switch, meter base (if required), and all appurtenances to complete the installation as shown on the plans.

The wood pole shall be installed according to Article 830.03(c), except the pole shall be a minimum of 25 ft (7.5 m) in length and shall be increased as necessary to maintain ground clearance.

- (b) Underground Electric Service.

(1) Ground Mounted Service. The ground mounted service shall be installed on a service pedestal with a cabinet, disconnect switch, metering base (if required), and all appurtenances to complete the installation as shown on the plans.

(2) Pole Mounted Service. The service shall extend to a 12 ft (3.7 m) wood pole on which the metering base (if required) and service disconnect switch shall be channel mounted according to the utility guidelines and as shown on the plans.

The wood pole shall be installed according to Article 830.03(c).

Underground cable coming up the wood pole from the utility transformer and back down the pole to the controller cabinet shall be protected in conduit protected by galvanized steel "U" guard. The "U" guard shall be attached to the pole with 3/8 x 3 in. galvanized steel lag bolts.

**804.05 Basis of Payment.** This work will be paid for at the contract unit price per each for ELECTRIC SERVICE INSTALLATION.

Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

**SECTION 805. ELECTRICAL SERVICE INSTALLATION - TRAFFIC SIGNALS**

**805.01 Description.** This work shall consist of furnishing and installing an electrical service installation.

Type A service installation shall include one weather-head, one ground rod, one meter pan, one circuit breaker, one weatherproof enclosure, galvanized steel conduit, nonmetallic conduit, conduit clamps, lag screws, electric cables of the type and size specified by local utility company, and other miscellaneous items. The meter will be furnished by the utility company.

Type B service installation shall be according to the Type A service installation, except no meter will be installed.

Type C service installation shall include one weatherproof enclosure, one circuit breaker, one weather-head, one ground rod, galvanized steel conduit, conduit clamps, lag screws, electric cables of the type and size specified by a local utility company, and other miscellaneous items. The Contractor shall make connections to the line side of the circuit breaker, and coil the remainder above the junction box for installation by the utility company. No separate grounding of weatherproof enclosure will be installed, unless it is required by the utility company.

**805.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Weatherhead .....	1086.02(a)
(b) Circuit Breaker and Weatherproof Enclosure .....	1086.02(b)
(c) Grounding .....	1086.02(c)

**CONSTRUCTION REQUIREMENTS**

**805.03 Installation.** The service installation shall be installed according to the details shown on the plans. Exceptions will be made to comply with the local utility company's standard practices.

**805.04 Basis of Payment.** This work will be paid for at the contract unit price per each for SERVICE INSTALLATION, of the type specified.

Any changes by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

**SECTION 806. GROUNDING**

**806.01 Description.** This work shall consist of furnishing and installing a grounding electrode(s) and connecting the grounding electrode(s) by means of a grounding electrode conductor.

**806.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Grounding Electrode Conductors .....	1087.01(a)
(b) Grounding Electrodes .....	1087.01(b)
(c) Access Wells .....	1087.01(c)

**CONSTRUCTION REQUIREMENTS**

**806.03 Grounding Electrodes.** Cast-in-place concrete foundations shall have a grounding electrode installed at the bottom of the foundation hole, or through the concrete foundation, as shown on the plans. Other grounding applications shall have a grounding electrode installed 18 in. (450 mm) below grade. The grounding electrode conductor shall be attached to the grounding electrode by a mechanical ground clamp, except in an access well where an exothermic weld connection shall be made. Access well installed grounding electrodes shall be installed 12 in. (300 mm) below grade and filled with crushed stone from 4 in. (100 mm) below the exothermic connection to a point 20 in. (500 mm) below grade.

Testing resistance to ground shall be according to Article 801.13(a)(5). If the measured resistance to ground exceeds 10 ohms, additional rods shall be added to the grounding electrode. A maximum number of three rods shall be coupled together. If coupling three rods together does not lower the resistance to 10 ohms, then additional grounding electrodes shall be installed, a minimum of 24 in. (600 mm) from the initial installation and connected by a grounding electrode conductor to form a ground field. If the resistance to ground still exceeds 10 ohms after three sets of three coupled electrodes have been installed in the ground field or where sub-surface conditions limit the depth to which the grounding electrode(s) can be installed, the Contractor shall contact the Engineer for further instructions.

**806.04 Basis of Payment.** Installation and testing of the first rod for the grounding electrode will not be paid for separately, but shall be included in the cost of the item for which it is installed. If additional rods are needed, their installation and testing will be paid for according to Article 109.04.

**WIREWAY AND CONDUIT SYSTEMS**

**SECTION 810. UNDERGROUND RACEWAYS**

**810.01 Description.** This work shall consist of furnishing and installing raceways, fittings and accessories, either laid in trench, pushed in place, bored and pulled, or encased in concrete.

**810.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit .....	1088.01(a)
(b) Rigid Nonmetallic Conduit .....	1088.01(b)
(c) Coilable Nonmetallic Conduit.....	1088.01(c)
(d) Portland Cement Concrete (Note 1) .....	1020

Note 1. Class SI concrete shall be used for encased conduit.

**CONSTRUCTION REQUIREMENTS**

**810.03 Installation.** All underground conduit shall have a minimum depth of 2 1/2 or 2 ft (750 or 600 mm) below the finished grade as indicated on the plans.

(a) Rigid Metal Conduit (Steel, Intermediate Metal, Aluminum). The ends of the conduit shall be cut square and thoroughly reamed before installation. All burrs and rough edges shall be removed.

Bends shall be made with a standard pipe bender. Bends shall be made so the conduit is not injured and the internal diameter of the conduit is not effectively reduced.

Conduit joints shall be threaded. All joints before assembly and exposed threads after assembly shall be coated with low resistance, conductive, joint compound. Running threads in conduit runs will not be permitted. Conduits shall not be over-threaded. The protective coatings on all threads must be sufficient to prevent corrosion before installation is made. If threads become corroded before installation, the material shall be replaced with new material or the corroded parts thoroughly cleaned and recoated as directed by the Engineer.

Ends of conduits shall be equipped with insulating bushings. Rigid metal conduits terminating in the base of lighting controllers, pedestal bases, transformer bases, and other open enclosures shall be equipped with insulating bushings with ground lugs. The ground lugs shall be used to bond the conduits to the enclosure via a copper grounding conductor.

Conduits terminating at cast or malleable iron boxes shall be terminated in conduit hubs. Hubs shall be integral to the box or installed separately. Non-integral hubs or integral hubs which do not provide a flared, smooth entry

shall not be used where conductors are No. 4 or larger, and in these cases two locknuts and an insulating bushing shall be used.

Threaded conduits shall terminate with two locknuts and an insulating bushing for sheet metal enclosures above grade.

Conduit connections shall be made tight to assure good grounding continuity.

Conduit below pavement, used as sleeves, shall extend a minimum of 2 ft (600 mm) beyond the shoulder, curb, and/or guardrail.

The conduit shall be cleaned by rodding and swabbing to remove all dirt and other foreign materials and capped until conductors are installed.

When rigid metal conduit is pushed, it shall extend 2 ft (600 mm) beyond the edge of the paved shoulder surface. The Contractor shall be responsible for damage from work performed on any component of the roadway such as pavement, backslope, driveway, sidewalk, signs, wiring, etc., and shall restore them to their original condition as directed by the Engineer. Where rock or other obstructions such as broken concrete are encountered at push locations, alternate locations and/or methods may be approved by the Engineer for securing the conduit under the pavement as specified. Costs for moving push locations and restoration shall be considered included in the contract unit prices for the construction items involved and no additional compensation will be allowed.

Directional boring or augering may be considered as an alternate to pushed conduit.

- (b) Rigid Nonmetallic Conduit. The conduit shall be cut square. All burrs shall be removed from the inside and outside of the conduit.

Bending of the conduit shall be made so the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced. Bends shall be made with standard pipe bending equipment for nonmetallic conduit.

The conduit section shall be heated evenly over the entire length of the bend. The use of torches or other flame-type devices will not be allowed. Sections showing evidence of scorching or discoloration will not be acceptable.

All joints shall be test mated without forcing, then cemented. The socket depth of the fitting shall be marked on the outside of the conduit without scratching or damaging the surface. The conduit shall enter the fitting for the full depth of the socket.

Before applying cement, the surfaces to be joined shall be wiped clean and free of dirt, oil, grease, or moisture. The solvent cement shall be applied according to manufacturer's recommendations.

Immediately after applying the coat of cement to the conduit and fittings, the conduit shall be inserted into the fitting socket until it bottoms at the fitting shoulder. The conduit shall be turned 1/4 turn during insertion to distribute the cement evenly. Excess cement shall be wiped away from the outside of the joint.

Newly assembled joints shall set a minimum of ten minutes before handling.

Rigid Nonmetallic Conduit Pushed. Conduit shall be pushed according to Article 810.03(a).

- (c) Coilable Nonmetallic Conduit. Coilable Nonmetallic Conduit shall be installed in continuous lengths, without splicing.

Conduit extended to lighting, traffic, and sign structures shall extend 12 in. (300 mm) above the base of the structure.

Bends of conduit shall be made manually so the duct will not be damaged and the internal diameter of the duct will not be effectively reduced. No more than the equivalent of four quarter bends (360 degrees total) shall be made between termination/pull points.

Coilable Nonmetallic Conduit, Bored and Pulled. When the conduit is bored and pulled into place, a remotely steerable, fluid cutting tunneling system shall be used to install it. The tunneling system shall be electronically detectable and shall line the tunnel with a clay lining as it tunnels. The tunneling system shall be approved by the Engineer prior to its use.

- (d) Concrete-Encased Conduit. Multiple conduit runs grouped together in a duct bank shall be encased in concrete and shall be supported on interlocking plastic spacers designed for the purpose, spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common duct bank shall be a minimum of 2 in. (50 mm). The interlocking spacers shall be used at a maximum interval of 5 ft (15 m).

Concrete cover overall shall be a minimum of 3 in. (75 mm) all around the encased run. During concrete placement there shall be no voids, the spacers shall be undisturbed, and the conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to or movement of the conduits.

Conduit encased in concrete shall have steel reinforcing when installed below roadway or other paved vehicle areas (including shoulder) and the reinforcement shall extend a minimum of 5 ft (1.5 m) additional from the edge of pavement. Steel reinforcement shall be a minimum of No. 4 (No. 15) bars at corners and otherwise spaced on 12 in. (300 mm) centers, tied with No. 4 (No. 15) bars on 12 in. (300 mm) centers.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

**810.04 Method of Measurement.** This work will be measured for payment in feet (meters) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction.

Vertical conduit will be measured for payment. The vertical distance required for breakaway devices, barrier wall, concrete pedestals, etc., and the depth of any burial will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

Coilable nonmetallic conduit installed in excess of the limits described will not be measured for payment.

**810.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for CONDUIT IN TRENCH or CONDUIT PUSHED, of the type and size specified, or CONDUIT, BORED AND PULLED, of the type and size specified, or CONDUIT ENCASED, of the type, diameter, and number of raceways wide by the number of raceways high specified.

**SECTION 811. EXPOSED RACEWAYS**

**811.01 Description.** This work shall consist of furnishing and installing raceways, fittings, and accessories attached to supports.

**811.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit .....	1088.01(a)
(b) Expansion Fittings for Raceways .....	1088.02
(c) Stainless Steel Junction Box .....	1088.04(a)
(d) Fasteners and Hardware .....	1088.03

**CONSTRUCTION REQUIREMENTS**

**811.03 Installation.** Installation of exposed raceways shall be as follows.

(a) Rigid Metal Conduit. Rigid metal conduit installation shall be according to Article 810.03(a). Conduits terminating in junction and pull boxes shall be terminated with hubs, integral box hubs, or integral box bosses.

Supports. Surface-mounted conduits shall be held in place by one-hole clamps and clamp backs. Conduits mounted to steel beams or columns shall be held in place by suitable beam clamps. Clamps, clamp backs, and beam clamps shall be of hot-dipped galvanized steel or stainless steel.

Raceways suspended from the structure shall be supported by trapeze or other hangers approved by the Engineer. Trapeze hangers shall be hot-dip galvanized steel channels or angle irons with conduits held in place by heavy-duty stainless steel U-bolts, nuts, and lock washers. Trapeze hangers shall be hung using threaded hot-dipped galvanized or stainless

steel rods not less than 1/2 in. (13 mm) diameter and appropriate anchors or by other means approved by the Engineer.

Raceway supports shall be installed with a support within 3 ft (900 mm) of each cabinet, box, or fitting, except the maximum distance between supports shall be as indicated below.

#### Conduit Supports

Conduit Diameter		Maximum Distance Between Rigid Metal Conduit Supports	
in.	(mm)	ft	(m)
1/2-3/4	(13-20)	5	(1.5)
1	(25)	6	(1.8)
1 1/4-1 1/2	(30-40)	7	(2.1)
2-2 1/2	(50-65)	8	(2.4)
3 and larger	(75)	10	(3)

- (b) PVC Coated Rigid Steel Conduit. In addition to the methods described in Article 810.03(a) the following methods shall be observed when installing PVC coated conduit.

PVC coated conduit pipe vise jaw adapters shall be used when the conduit is being clamped to avoid damaging the PVC coating.

PVC coated conduit shall be cut with a roller cutter or by other means approved by the conduit manufacturer.

After any cutting or threading operations are completed, the bare steel shall be touched up with the conduit manufacturer's touch up compound.

- (c) Expansion Joints. Expansion joints shall be installed as follows.

- (1) Liquid Tight Flexible Metal Conduit (LTFMC). LTFMC shall not be used in lieu of bending conduit. LTFMC shall only be used to isolate structure to structure movement or to isolate vibration as shown on the plans.

LTFMC shall not exceed 36 in. (900 mm) in length unless approved by the Engineer. All LTFMC shall terminate in a stainless steel junction box installed according to Section 813. Fittings designed for use with liquid-tight flexible conduit shall be used at all connections.

- (2) Expansion Fittings. The fittings shall be precisely aligned with the conduit run to assure proper expansion and deflection operation and prevent binding.

For vertical conduit runs, the fitting shall be installed close to the top of the structure to prevent water running across the fitting and entering the conduit.

The fitting's deflection sleeve coupling, and pressure bushing at the barrel of the expansion body, shall be installed flush with the structure ends so that only the connecting expansion nipple crosses the opening between structures.

The fitting shall be supported by points on the conduit immediately adjacent to the fitting. The fitting shall have an external bonding jumper.

**811.04 Method of Measurement.** This work will be measured for payment in feet (meters) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction.

Expansion fittings or LTFMC and stainless steel junction boxes will not be measured for payment.

**811.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for CONDUIT ATTACHED TO STRUCTURE, of the type and diameter specified.

**SECTION 812. RACEWAYS EMBEDDED IN STRUCTURE**

**812.01 Description.** This work shall consist of furnishing and installing rigid conduit, fittings, and accessories embedded in concrete structures.

**812.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Rigid Metal Conduit .....	1088.01(a)
(b) Rigid Nonmetallic Conduit .....	1088.01(b)
(c) Expansion Fittings for Raceways .....	1088.02
(d) Stainless Steel Junction Box .....	1088.04(a)

**CONSTRUCTION REQUIREMENTS**

**812.03 Installation.** Conduit embedded in a structure shall be supported on interlocking plastic spacers specifically designed for that purpose and spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common structure shall be not less than 2 in. (50 mm). The interlocking spacers shall be used at a maximum interval of 5 ft (1.5 m). When approved by the Engineer, the conduit may be tied to the reinforcement where the reinforcement precludes the use of the supports.

Concrete cover shall not be less than 3 in. (75 mm) all around the embedded encased run. During concrete placement, spacers and conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to, or movement of, the conduits.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

Raceways shall be protected from mechanical and physical damage during construction. Open raceway ends shall be capped in accordance with manufacturer's recommendations. Raceways shall be cleared of all dirt, water, excess concrete, and other foreign materials with a dry swab and mandrel. Internal obstructions shall be repaired to the satisfaction of the Engineer.

The embedded conduit shall be continuous as shown on the plans, with no break or obstruction between junction boxes and through the entire raceway system. A 3/8 in. (9 mm) nylon rope shall be blown through following a mandrel being pulled through the conduit to demonstrate continuity between junction boxes and through the entire raceway system. The size(s) of the mandrel shall be in accordance with the size(s) of the conduit as shown on the plans. The rope shall be left in the conduit, and shall be continuous between junction boxes and between all conduit terminal points. Each rope end shall be securely fitted with a washer or other approved device, of a diameter larger than the conduit diameter, to prevent the rope from coiling back inside the conduit and to insure accessibility for the installation of cables.

- (a) Rigid Metal Conduit. Conduit installation shall be according to Article 810.03(a).
- (b) Rigid Nonmetallic Conduit. Conduit installation shall be according to Article 810.03(a).
- (c) Expansion Joints. Expansion joints shall be installed as follows.
  - (1) Expansion Fittings. Expansion fittings shall be installed according to Article 811.03(c)(2).
  - (2) Liquid Tight Flexible Metal Conduit (LTFMC). With the approval of the Engineer, LTFMC with stainless steel junction boxes may be used in lieu of an expansion fitting. The LTFMC shall be installed according to Article 811.03(c)(1). Stainless steel junction boxes shall be installed according to Section 813.

**812.04 Method of Measurement.** This work will be measured for payment in feet (meters) in place. Measurements will be made in a straight line along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment according to Article 810.04.

Expansion fittings or LTFMC and stainless steel junction boxes will not be measured for payment.

**812.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for CONDUIT EMBEDDED IN STRUCTURE, of the type and diameter specified.

**SECTION 813. JUNCTION BOXES**

**813.01 Description.** This work shall consist of furnishing and installing a junction box.

**813.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Junction Box .....	1088.04
(b) Electrical Raceway Materials .....	1088.01

**CONSTRUCTION REQUIREMENTS**

**813.03 Installation.** Exposed junction boxes on structures shall be installed on 1/2 in. (13 mm) long stainless steel or brass spacers with the hinge on top of the box and the cover lying in the vertical plane when closed. The exact orientation shall be as shown on the plans or as directed by the Engineer. Care shall be taken to assure proper orientation of mounting lugs.

The embedded junction box shall be set flush with the adjoining surface and shall be properly supported during concrete placement.

Field cut conduit openings shall be uniform and smooth. All burrs and rough edges shall be filed smooth prior to the installation of conduit(s) into the junction box. Field cut conduit openings shall be fitted with the appropriate conduit fittings and accessories.

**813.04 Basis of Payment.** This work will be paid for at the contract unit price per each for JUNCTION BOX ATTACHED TO STRUCTURE; or JUNCTION BOX EMBEDDED IN STRUCTURE, of the type and size when specified.

**SECTION 814. HANDHOLE**

**814.01 Description.** This work shall consist of furnishing and installing or constructing a handhole, a heavy-duty handhole, or a double handhole.

**814.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate for French Drains (Note 1) .....	1004.05
(b) Portland Cement Concrete (Note 2) .....	1020
(c) Composite Concrete Handhole (Note 3) .....	1088.05
(d) Handhole Frame and Cover .....	1088.06

Note 1. Gradation CA 5 or CA 7 shall be used.

Note 2. Class Sl concrete shall be used.

Note 3. All hardware used for assembling a composite concrete handhole shall be galvanized or stainless steel.

## CONSTRUCTION REQUIREMENTS

**814.03 Construction.** The location of the handhole shall be excavated so that the top of the handhole is set flush with the sidewalk or paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the handhole shall be 1 in. (25 mm) above the finished grade. The excavation shall be deep enough to accommodate the depth of the box and french drain.

The french drain shall be constructed underneath the proposed handhole according to Article 601.06.

Handholes shall be constructed of cast-in-place portland cement concrete with a frame and cover, or composite concrete. Heavy duty handholes shall be cast-in-place only.

- (a) **Cast-in-Place.** The method of forming the handhole and placing the concrete shall be approved by the Engineer.

The handhole frame and cover shall be set accurately to the finished elevation so no subsequent adjustment will be necessary.

Where a handhole is contiguous to a sidewalk, preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between the handhole and the sidewalk.

- (b) **Composite Concrete.** If located in sidewalk or other paved surface, the handhole shall be constructed with a portland cement concrete collar around the perimeter of the handhole. The collar shall be 3 in. (75 mm) wide and the depth shall be equal to the adjacent paved surface. Preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between new concrete and existing concrete.

**814.04 Backfilling.** Backfill shall be placed and compacted in 6 in. (150 mm) lifts.

Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 2 ft (600 mm) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.

**814.05 Cleaning.** The handhole shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind.

**814.06 Basis of Payment.** This work will be paid for at the contract unit price per each for HANDHOLE, HEAVY-DUTY HANDHOLE, or DOUBLE HANDHOLE, of the material type when specified.

**SECTION 815. GULFBOX JUNCTION**

**815.01 Description.** This work shall consist of furnishing and installing a gulfbox junction.

**815.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate (Note 1) .....	1004.01
(b) Portland Cement Concrete (Note 2) .....	1020
(c) Gulfbox Junction .....	1088.07

Note 1. Gradation CA 6 shall be used.

Note 2. Class SI concrete shall be used.

**CONSTRUCTION REQUIREMENTS**

**815.03 Installation.** The location of the gulfbox junction shall be excavated so that the top of the gulfbox is set flush with the sidewalk or paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the gulfbox shall be 1 in. (25 mm) above the finished grade. The excavation shall be deep enough to accommodate the depth of the box and the base.

When the gulfbox is to be constructed over existing conduit, the conduit shall be cut, 90 degree elbows installed, and the box constructed as shown on the plans.

- (a) Cast Iron Gulfbox. The base shall be constructed of 6 in. (150 mm) of concrete placed at the bottom of the excavation. The concrete shall be placed around the conduits and the conduits shall protrude approximately 1/2 in. (13 mm) above the concrete surface.

The casting shall be secured by setting the bottom flange into the concrete surface 1/2 to 3/4 in. (13 to 20 mm) while the concrete is still plastic and then trowel the surface smooth. Any piping slots in the sides shall be plugged.

The remaining excavation shall be backfilled with suitable material.

- (b) Composite Concrete Gulfbox. The base shall be constructed of 6 in. (150 mm) of coarse aggregate placed at the bottom of the excavation. The conduits shall protrude approximately 1 in. (25 mm) above the coarse aggregate.

The gulfbox shall be set on this base.

The remaining excavation shall be backfilled with coarse aggregate.

If located in sidewalk or other paved surface, the gulfbox shall be set with a minimum of 3 in. (75 mm) of concrete placed on each side of the gulfbox.

Preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between new concrete and existing concrete.

**815.04 Basis of Payment.** This work will be paid for at the contract unit price per each for GULFBOX JUNCTION, of the kind of material when specified.

**LIGHTING**

**WIRE AND CABLE**

**SECTION 816. UNIT DUCT**

**816.01 Description.** This work shall consist of furnishing and installing preassembled cable in coilable nonmetallic conduit (unit duct), complete with all splicing, identifications, and terminations.

**816.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Unit Duct .....	1066.01
(b) Coilable Nonmetal Conduit .....	1088.01(c)
(c) Conductors (Note 1) .....	1066.02
(d) Cable Insulation .....	1066.03
(e) Splicing and Termination of Electric Cable .....	1066.06

Note 1. Copper conductors shall be used.

**CONSTRUCTION REQUIREMENTS**

**816.03 Installation.** The unit duct shall be installed directly from the reels on which the unit duct was shipped, in continuous spans from terminal to terminal without splicing the duct or cables.

Where unit duct passes through handholes or pull boxes, the polyethylene duct shall be cut open and the continuous, uncut and unspliced conductors exposed and looped within the handhole or pull box. The ends of the polyethylene duct must be sealed with duct sealant and mounted in the handhole to prevent entrance of moisture or contaminants.

When the unit duct is to be pulled, the pulling apparatus shall be attached to the duct and not to the cables. The pulling tension on the duct shall not exceed 550 lb (2.4 kN).

Unit duct extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes. The duct of the unit duct assembly shall extend a minimum of 12 in. (300 mm) into pole shafts or transformer bases.

Minimum bending radius for the installed unit duct assembly shall be no smaller than the manufacturer's recommended radius. Bends shall be made so that the duct will not be damaged or kinked and the internal diameter of the duct will not be effectively reduced. There shall not be more than the equivalent of four quarter bends between pull points and no bend greater than 90 degrees.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

- (a) In Trench. The unit duct shall be placed in the bottom of the trench after all loose or protruding stones have been removed or covered with backfill material as directed by the Engineer. The installation, after inspection by the Engineer, shall be backfilled according to Article 819.04.

The unit duct shall be installed at a minimum depth of 2 ft (600 mm) unless otherwise directed by the Engineer.

Where plowed, the unit duct shall be laid in place and the duct shall not be pulled through the length of the cut behind a bullet-nose mandrel or similar apparatus. Plowing operations shall be non-injurious to the duct.

- (b) In Raceway. Lubricating compounds shall be used where necessary to assure smooth installation.
- (c) Bored and Pulled. A remotely steerable, fluid cutting tunneling system is to be used to install the unit duct assembly. The tunneling system shall be electronically detectable and shall line the tunnel with a clay lining as it tunnels. The tunneling system shall be approved by the Engineer prior to its use.

**816.04 Method of Measurement.** The unit duct will be measured for payment in feet (meters) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points. 10 ft (3 m) of extra unit duct will be allowed when terminating at a controller. 3 ft (1 m) of extra unit duct will be allowed at light pole, handholes, pull boxes, junction boxes, and similar locations.

The vertical distance of unit duct required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured in feet (meters). Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

**816.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) installed for UNIT DUCT, 600V, of the number, size and type of conductors, and the size and type of duct specified.

## SECTION 817. CABLE IN RACEWAY

**817.01 Description.** This work shall consist of furnishing and installing electric cables in conduit, complete with all splicing, identifications, and terminations.

**817.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Conductors (Note 1) .....	1066.02
(b) Cable Insulation .....	1066.03
(c) Splicing and Termination of Electric Cable .....	1066.06

Note 1. Copper conductors shall be used.

## CONSTRUCTION REQUIREMENTS

**817.03 Installation.** Cable shall be installed without damaging the insulation.

Cable lubricant shall be used when pulling cables into conduits. The lubricant shall be non-injurious to conduits, conductors, insulations, or jackets.

Where a number of cables are trained through a box, manhole, or handhole, the cables shall be grouped by circuit where applicable and bundled using appropriate cable ties and supported to minimize pressure or strain on cable insulation.

Wire and cable extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes.

Wire and cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. The cable shall be installed in continuous spans between terminal points and splicing will only be permitted in pole handholes or junction boxes on bridge structures above grade.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminants, unless splicing or termination work is performed concurrently.

**817.04 Method of Measurement.** The cable will be measured for payment in feet (meters) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points. 10 ft (3 m) of extra cable will be allowed when terminating at a controller. 5 ft (1.5 m) of extra cable will be allowed at light pole, handholes, pull boxes, junction boxes, and similar locations.

The vertical distance of cable required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured in feet (meters). Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

**817.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) installed for ELECTRIC CABLE IN CONDUIT, 600 V of the type, size, and number of conductors indicated.

**SECTION 818. AERIAL CABLE FOR LIGHTING**

**818.01 Description.** This work shall consist of furnishing, installing and connecting aerial cable complete with all splicing, identifications, and terminations.

**818.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Conductors (Note 1) .....	1066.02
(b) Aerial Cable Insulation .....	1066.03(a)(3)
(c) Aerial Cable Assembly .....	1066.04

Note 1. Aluminum conductors shall be used.

**CONSTRUCTION REQUIREMENTS**

**818.03 Installation.** The luminaire connections to the aerial cable shall be made with listed parallel tap insulation piercing connectors. The connector shall be rated for 600 V.

When the installation is temporary, upon written request of the Contractor, the Engineer may permit temporary portions of the work to be wired with previously-installed (used) aerial cable of ampacity equivalent to the specified cable and of a type and condition approved by the Engineer. The cable shall be left in place for the duration of the need for temporary wiring.

In addition to the wiring of temporary equipment indicated, the Contractor shall furnish and install electric feeders and make necessary equipment modifications to connect the existing system(s) to the temporary system(s). Buck-Boost Transformer(s), when indicated on the plans, shall be of the voltage and KVA indicated (or otherwise as applicable for the circuit), dry type, suitable for outdoor installation.

**818.04 Method of Measurement.** The aerial cable will be measured in feet (meters) in place and will be taken as the length of the messenger wire. Measurements will be made in a straight line between changes in direction and to the centers of light standards and control cabinets. Sag of the aerial cable or vertical cable will not be measured for payment. When the Engineer requests the used temporary cable be replaced with new, the new cable will be measured for payment.

Used aerial cable will not be measured for payment.

The rewiring to facilitate relocation of the cable due to staging or other construction requirements will not be measured for payment.

**818.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for AERIAL CABLE WITH MESSENGER WIRE, of the number and size of conductors specified.

## SECTION 819. TRENCH AND BACKFILL FOR ELECTRICAL WORK

**819.01 Description.** This work shall consist of constructing and backfilling a trench for the accommodation of raceways, unit duct, and cables.

**819.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Fine Aggregate .....	1003.04
(b) Underground Cable Marking Tape .....	1066.05

### CONSTRUCTION REQUIREMENTS

**819.03 Trench.** Trenching shall be as follows.

- (a) Trenches shall have a minimum depth of 2 ft (600 mm) or as otherwise indicated on the plans, and shall not exceed 1 ft (300 mm) in width without prior approval of the Engineer. The trenches shall be constructed to permit easy installation of cable or unit duct without twisting kinks, or sharp bends. The bottom of the trench shall be built up with suitable compacted backfill material so the raceway, unit duct or cable will have a smooth bed.

If the trench depth is less than 1 ft (300 mm) because of rock or concrete, the Contractor shall cut a groove in the obstructing material so the trench is 1 ft (300 mm) deep. The unit duct shall be laid in this groove and covered to grade with Class SI concrete.

Where the trench depth exceeds 1 ft (300 mm), but less than 2 ft (600 mm), because of rock, the bottom shall be made smooth and free of short radius dips by filling low sections with fine aggregate.

Where separate circuit runs are to be installed parallel with each other, one common trench shall be used. At the locations where a trench crosses other existing cable systems, the trench shall be hand dug 6.5 ft (2 m) to either side of the crossing.

The Contractor shall be responsible for damage incurred in any area of the project such as medians, pavement, shoulders, backslopes, driveways, and sidewalks and shall restore them to their original condition as directed by the Engineer.

- (b) Except where trenching is specifically indicated on the plans, the Contractor shall have the option to plow coilable nonmetallic conduit, unit duct, or cable by lay-in plow-feeding. The installation depth shall be 2 ft (600 mm) below the finished grade or as shown on the plans.

The coilable nonmetallic conduit, duct, or cable shall be round and free of kinks when fed into the plow. When more than one coilable nonmetallic conduit, duct, or cable is placed into a single plowed cavity, they shall be free of twists. Before final wire and cable connections are made, the Contractor shall demonstrate that all conductors within the coilable nonmetallic conduit or duct are free to move.

Where another circuit is plowed in parallel to the first, the distance between the two shall be not less than 1 ft (300 mm) nor more than 2 ft (600 mm).

**819.04 Backfill.** Backfill material shall be free of brick, rock, or any material that could damage the cable, duct, or conduit.

Backfill material for trenches in the subgrade of the proposed improvement, and for trenches outside of the subgrade where the inner edge of the trench is within 2 ft (600 mm) of the edge of the proposed pavement, curb, gutter, curb and gutter, stabilized shoulder or sidewalk shall be fine aggregate, gradation FA 6.

Backfill shall be deposited in uniform lifts not exceeding 6 in. (150 mm) thick loose measure. The material in each lift shall be mechanically compacted by tamping with power tools approved by the Engineer in such a manner as not to disturb, kink, or crush the cables, conductor, duct, or conduit.

Disposal of surplus material shall be according to Article 202.03.

**819.05 Cable Marking Tape.** Underground cable marking tape shall be installed a minimum of 6 in. (150 mm) and not more than 1 ft (300 mm) below finished grade for all underground cable and raceway runs.

Underground cable marking tape with a reinforced metallic detection strip shall be used when specified. Splicing of the underground cable marking tape shall be accomplished with metal clips to maintain electrical continuity along the entire length of the tape. In addition to metal clips, all splices must be wrapped with a waterproof adhesive tape to prevent corrosion of the metal core.

**819.06 Method of Measurement.** Trench and backfill, and trench and backfill in subgrade will be measured for payment in feet (meters) along the centerline of the trench.

Measurement will not be made for conduit which is pushed.

Where separate circuit runs are placed in a common trench or plowed cavity, the trench will only be measured once for payment.

Cable marking tape will not be measured for payment.

Excavation in rock will be measured for payment according to Article 502.12

**819.07 Basis of Payment.** Trench and backfill will be paid for at the contract unit price per foot (meter) for TRENCH AND BACKFILL FOR ELECTRICAL WORK.

Trench and backfill in subgrade will be paid for at the contract unit price per foot (meter) for TRENCH AND BACKFILL WITH SCREENINGS OR SAND.

Excavation in rock will be paid for according to Article 502.13.

## LUMINAIRES

### SECTION 821. ROADWAY LUMINAIRES

**821.01 Description.** This work shall consist of furnishing and installing a luminaire.

**821.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Luminaire .....	1067
(b) Wire in the Pole .....	1066.09
(c) Fuseholders and Fuses .....	1065.01
(d) Lamps .....	1067.06
(e) Fasteners and Hardware .....	1088.03
(f) Lightning Protection .....	1065.02

### CONSTRUCTION REQUIREMENTS

**821.03 General.** Each luminaire shall be installed according to the luminaire manufacturer's recommendations.

Luminaires which are pole mounted shall be mounted on site such that poles and arms are not left unloaded. Pole mounted luminaires shall be leveled/adjusted after poles are set and vertically aligned before being energized. When mounted on a tenon, care shall be exercised to assure maximum insertion of the mounting tenon.

Each luminaire ballast and/or ballast arrangement shall be checked to assure compatibility with the project power system. When the luminaire has a multi-tap ballast, the tap shall be adjusted as necessary to assure a voltage match.

When the night-time check of the lighting system by the Engineer indicates that any luminaires are mis-aligned, the mis-aligned luminaires shall be corrected at no additional cost. Should the photometric results of the luminaire indicate, in the judgement of the Engineer, a tilt adjustment is warranted, the adjustment shall be made at no additional cost.

No luminaire shall be installed before it is approved. Where independent testing is required, full approval will not be given until complete test results, demonstrating

compliance with the specifications, have been reviewed and accepted by the Engineer.

Pole wiring shall be provided with the luminaire. Included with the pole wiring shall be a surge protector and fusing located in the handhole. Wire shall be trained within the pole or sign structure so as to avoid abrasion or damage to the insulation.

Pole wire shall be extended through the pole, pole grommet, luminaire ring, and any associated arm and tenon. The pole wire shall be terminated in a manner that avoids sharp kinks, pinching, pressure on the insulation, or any other arrangement prone to damaging insulation value and producing poor megger test results. Wires shall be trained away from heat sources within the luminaire. Wires shall be terminated so all strands are extended to the full depth of the terminal lug with the insulation removed far enough so it abuts against the shoulder of the lug, but is not compressed as the lug is tightened.

When installing the lamp or performing any other activity that requires opening of the optical assembly, care shall be exercised to avoid touching the reflector or allowing contaminants to enter the assembly. Each lamp and lens shall be free of all dirt, smudges, etc. Should the reflector or refractor require cleaning, a mild soap or non-abrasive detergent, containing no chlorinated or aromatic hydrocarbons, shall be used and then rinsed clean with cold water and wiped dry.

**821.04 Conventional Pole Installation.** Horizontal mount luminaires shall be installed in a level, horizontal plane, with adjustments as needed to insure the optics are set perpendicular to the traveled roadway.

When the pole is bridge mounted, a minimum size stainless steel 1/4-20NC set screw shall be provided to secure the luminaire to the mast arm tenon. A hole shall be drilled and tapped through the tenon and luminaire mounting bracket and then fitted with the screw.

**821.05 Highmast Installation.** Luminaires having asymmetrical photometric distributions shall be carefully oriented with respect to the roadway as indicated on the plans and as directed by the Engineer. The Contractor shall confirm all luminaire orientations with the Engineer prior to installation.

For horizontal mounts having rotating optical assemblies, after the orientation of each mast arm tenon is inspected and approved by the Engineer, the position shall be permanently marked in a manner acceptable to the Engineer. The luminaire shall then be leveled to the plane of the luminaire ring.

When the luminaire position and orientation has been confirmed and approved by the Engineer, the luminaire shall be anchored with a minimum size 1/4-20NC stainless steel set screw installed through tapped holes in the tenon and mounting bracket of the luminaire. Counterweights on un-used tenons shall be mounted in a similar manner.

Pre-installed wire on the tower ring shall have the ends of each wire capped at the tenon with butt type crimp-connectors for un-used tenons. The wires shall then be re-inserted into the tenon end and the tenon end shall be capped.

**821.06 Underpass Installation.** When attached directly to a structure, the underpass luminaire shall have 1 in. (25 mm) stainless steel spacers installed between the luminaire and the structure.

When specified, an aluminum underpass luminaire numbering decal bracket for each underpass luminaire shall be installed as shown on the plan. The bracket shall be large enough to accommodate the identification and shall be mounted on the pier or retaining wall from which the luminaires are electrically fed as directed by the Engineer.

When suspended, the underpass luminaire shall be installed 1 in. (25 mm) above the lowest underpass beam and shall be mounted parallel to the plane of the roadway, taking into consideration the applicable grade and superelevation of the traveled lanes. Vibration dampening assemblies shall be used and sized to the weight and shape of the underpass luminaire. All mounting hardware, except the vibration dampers, shall be stainless steel.

The underpass luminaire shall include, from the junction box mounted on the structure to the luminaire, all aluminum conduit, fittings, attachment hardware, cable, and a disconnect switch with lockable exterior handle mounted within reach from the walkway.

**821.07 Sign Lighting Installation.** Each luminaire shall be mounted on the sign walkway structure with stainless steel hardware and with at least three points of attachment. The mounted luminaire or mounting hardware shall not extend above the bottom of the sign or below the bottom of the walkway support.

The center-to-center spacing of the luminaires will be determined by the Engineer. The end sections shall not exceed one-half the spacing between luminaires.

The mounting shall provide the correct position of the luminaire as recommended by the manufacturer and shall be able to withstand assigned loading according to AASHTO. The sign lighting installation shall include, from the sign truss handhole to the luminaire, all aluminum conduit, fittings, attachment hardware, cable, and a disconnect switch with lockable exterior handle mounted within reach from the walkway.

Disabling brightness shall be shielded from traffic approaching either the front or back of the sign.

**821.08 Basis of Payment.** This work will be paid for at the contract unit price per each for LUMINAIRE, of the lamp type, mount type, and wattage specified, UNDERPASS LUMINAIRE, of the wattage and lamp type indicated; or SIGN LIGHTING, of the lamp type specified.

**SECTION 822. NAVIGATION OBSTRUCTION WARNING LUMINAIRES**

**822.01 Description.** This work shall consist of furnishing and installing a navigation obstruction warning fixture complete with all supports, hardware, wiring, and connections to the structure or pole, and appurtenant mounting accessories.

**822.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Waterway Obstruction Warning Luminaire .....	1067.07(a)
(b) Aviation Obstruction Warning Luminaire .....	1067.07(b)
(c) Fuseholders and Fuses .....	1065.01
(d) Lamps .....	1067.06
(e) Transformer, General Purpose .....	1068.02

**CONSTRUCTION REQUIREMENTS**

**822.03 Installation.** Mounting of the luminaire shall be as recommended by the luminaire manufacturer in such a manner that they clear all obstacles when retrieved for maintenance and relamping.

**822.04 Basis of Payment.** This work will be paid for at the contract unit price per each for WATERWAY OBSTRUCTION WARNING LUMINAIRE or AVIATION OBSTRUCTION WARNING LUMINAIRE, of the type indicated.

**CONTROLLERS**

**SECTION 825. LIGHTING CONTROLLER**

**825.01 Description.** This work shall consist of furnishing and installing an electrical controller.

**825.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1) .....	1020
(b) Lighting Controller .....	1068.01
(c) Transformer, General Purpose .....	1068.02
(d) Lightning Protection .....	1065.02

Note 1. Class SI concrete shall be used.

**CONSTRUCTION REQUIREMENTS**

**825.03 Installation.** The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

A 4 in. (100 mm) thick portland cement concrete work pad, not less than 48 x 48 in. (1.2 x 1.2 m) shall be provided in front of the cabinet, except where the cabinet faces an adjacent sidewalk.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

- (a) **Controller Mounted on Concrete Foundation.** The Contractor shall confirm the orientation of the lighting controller, and its door side, with the Engineer, prior to installing the foundation. A portland cement concrete foundation shall be constructed to the details shown on the plans.

The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor rods with hot-dipped galvanized or stainless steel nuts and washers. Foundation mounted lighting controllers shall be caulked at the base with silicone.

Where the controller has a metal bottom plate, the plate shall be sealed with a rodent and dust/moisture barrier.

- (b) **Controller Mounted on Pole.** The lighting controller enclosure shall be mounted to the pole as shown on the plans. Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 26 in. (650 mm) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All mounting hardware shall be stainless steel.
- (c) **Controller Mounted on Wall.** The lighting controller enclosure shall be mounted to the wall with stainless steel fasteners as indicated in the plans. Stainless steel mounting brackets designed for wall mounting shall be used.

**825.04 Grounding.** Grounding shall be according to Section 806.

**825.05 Basis of Payment.** This work will be paid for at the contract unit price per each for LIGHTING CONTROLLER, of the enclosure and control type specified.

**SECTION 826. NAVIGATION OBSTRUCTION LIGHTING CONTROLLER**

**826.01 Description.** This work shall consist of furnishing and installing an electrical controller for navigation obstruction lighting.

**826.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1) .....	1020
(b) Navigation Obstruction Lighting Controller .....	1068.03
(c) Transformer, General Purpose .....	1068.02
(d) Lightning Protection .....	1065.02

Note 1. Class Sl concrete shall be used.

**CONSTRUCTION REQUIREMENTS**

**826.03 Installation.** Installation shall be according to Article 825.03.

**826.04 Basis of Payment.** This work will be paid for at the contract unit price per each for NAVIGATION OBSTRUCTION LIGHTING CONTROLLER, of the enclosure and control type specified.

**SECTION 827. TRANSFORMER, GENERAL PURPOSE**

**827.01 Description.** This work shall consist of furnishing a dry type transformer, wiring, conduit and mounting hardware, and installing it at the location shown on the plans or as designated by the Engineer.

**827.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Transformer, General Purpose .....	1068.02
(b) Electrical Raceway Materials .....	1088.01
(c) Wire and Cable .....	1066
(d) Splicing and Termination of Electric Cable .....	1066.06
(e) Fasteners and Hardware .....	1088.03

**CONSTRUCTION REQUIREMENTS**

**827.03 Installation.** General purpose transformers may be mounted inside a control cabinet, on a sign truss, and on a bridge structure requiring different mounting hardware. All material required to complete the installation shall be included. The transformer enclosure shall be NEMA 3R or 4X and may be stainless steel as shown on the plans. It shall be solid dielectric, air cooled, and of a type (i.e., buck/boost) as specified. The plans shall identify size in KVA as well as primary and secondary voltages. Air movement must be considered for mounting inside a junction box or other confined space.

**827.04 Basis of Payment.** This work will be paid for at the contract unit price per each for TRANSFORMER, GENERAL PURPOSE, of the size and type specified.

**POLES AND TOWERS**

**SECTION 830. LIGHT POLES**

**830.01 Description.** This work shall consist of furnishing and installing a light pole complete with an arm(s), when specified, and all hardware and accessories required for the intended temporary or permanent use of the pole.

**830.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Light Poles .....	1069.01
(b) Mounting Pad .....	1069.07
(c) Pole/Unit Identification .....	1069.06

**CONSTRUCTION REQUIREMENTS**

**830.03 Installation.** The light pole shall be set plumb on the foundation without the use of shims, or washers for leveling. On bridge parapet walls, a vibration mounting pad shall be installed between the foundation leveling plate and the light pole.

The handhole shall be located such that workers accessing the handhole shall face oncoming traffic directly or located on the back side of the pole facing the roadway. On bridge parapet walls, the access handhole shall be oriented facing the roadway.

Arms shall be set at right angles to the centerline of the pavement. Poles shall not be left in place without arm(s) and luminaire(s).

The Contractor shall be responsible to furnish pole mounting equipment that is of adequate strength and compatible for the pole it supports. This shall include, but not be limited to, the foundation, breakaway device (when specified), anchor rods, and hardware.

Lighting unit identification numbers shall be installed before the lighting unit is energized.

- (a) **Foundation Mounted Poles.** The Contractor shall avoid contact of dissimilar metals in erecting the pole on its foundation and/or breakaway device. Any concern of trapped moisture or potential corrosion cell shall be resolved to the satisfaction of the Engineer.
- (b) **Direct Embed Fiberglass Pole.** The depth of a direct embed fiberglass pole in the ground shall not be less than ten percent of the pole length plus 2 ft (600 mm) with a minimum of 6 ft (1.8 m). Direct embed poles shall be raked 1 ft (300 mm). Care shall be taken to get the shear plane of the pole at groundline for breakaway poles. Backfill shall be tamped and compacted around the pole in 6 in. (150 mm) lifts.
- (c) **Wood Pole.** Poles shall be stored and handled according to ANSI 05.1.

The depth of the pole in the ground shall not be less than ten percent of the pole length plus 2 ft (600 mm) with a minimum of 6 ft (1.8 m). The poles shall be raked 1 ft (300 mm). Backfill shall be tamped and compacted around the pole in 6 in. (150 mm) lifts.

Pole guying shall be provided where indicated on the plans, at every dead end pole, and at any pole having non-offsetting cable support stresses.

**830.04 Temporary Installation.** Wood poles used for a temporary lighting installation may be previously used poles as approved by the Engineer. The poles shall be in good condition and shall be according to the applicable ANSI requirements for sweep, crook, defects, and mechanical damage. Poles deemed unacceptable by the Engineer shall be removed from the jobsite.

**830.05 Basis of Payment.** This work will be paid for as follows.

- (a) Wood poles will be paid for at the contract unit price per each for LIGHT POLE, WOOD, of the length, class and arm (quantity and length) type specified.
- (b) All other light poles will be paid for at the contract unit price per each for LIGHT POLE, of the material type, mounting height, and arm (quantity and length) type specified.

When breakaway devices are specified, the devices will be measured and paid for separately according to Articles 838.04 and 838.05.

**SECTION 831. RESERVED**

**SECTION 832. RESERVED**

**SECTION 833. RESERVED**

**SECTION 834. RESERVED**

**SECTION 835. LIGHT TOWER**

**835.01 Description.** This work shall consist of furnishing and installing a light tower complete with lowering device, and all hardware and accessories required for a complete operating unit.

**835.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Light Tower .....	1069.08
(b) Pole/Unit Identification .....	1069.06

**CONSTRUCTION REQUIREMENTS**

**835.03 Submittals and Certifications.** Shop drawings, product data, and certifications shall be submitted to the Engineer for approval. The submitted information shall be complete and shall include information relative to all specified requirements suitable for verification of compliance.

In general, light tower submittal information shall be dated, current, project specific, identified as to the project, and shall include the following.

- (a) Dimensioned shaft drawings and details.
- (b) Shaft design calculations, including Registered Engineer Certification.
- (c) Shaft material data, including finish information.
- (d) Welding details and procedures.
- (e) Letter of intent to provide specified weld inspection reports.
- (f) Confirmation of coordination between anchor rod supplier and tower manufacturer for adequacy of anchor rod assembly.
- (g) Manufacturer's recommended installation procedures.
- (h) Letter of intent to provide manufacturer's representative during installation and to provide specified installation certification.

**835.04 Shipment and Installation.** The light tower, luminaire ring, etc., and hardware shall be packaged during shipment to protect all surfaces from being scratched, marred, chipped, or damaged in any way. Prior to installation, the tower and all its components will be inspected by the Engineer and any parts found to be damaged or defective shall be replaced. Any minor damage to a completely painted light tower surface shall be touched up in a professional manner as approved by the paint manufacturer.

The tower shall be set plumb on the foundation and fastened to the anchor rods with double nuts and washers. Flat washers shall be installed below and above the base plate of the pole. Locknuts with nylon or steel inserts shall be installed on top of the top nut. The nuts shall be tightened in compliance with torque specifications recommended by the manufacturer of the lighting unit.

The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The size of the mesh of the screen shall be 1/4 in. (6 mm) or less and #18 gauge (1.22 mm) thick, or heavier as approved by the Engineer. The screen shall be held in place with a stainless steel band installed around the tower base plate. The band shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

The light tower shall be straight and centered on its longitudinal axis, under no-wind conditions, so, when examined with a transit from any direction, the deviation from the normal shall not exceed 1/8 in. in 3 ft (3 mm in 1 m) within any 5 ft (1.5 m) of height, with total deviation not to exceed 3 in. (75 mm) from the vertical axis through the center of the pole base.

**835.05 Basis of Payment.** This work will be paid for at the contract unit price per each for LIGHT TOWER, of the mounting heights, luminaire mounting positions, and finish specified.

The concrete foundation and luminaires will be paid for according to Sections 837 and 821, respectively.

**FOUNDATIONS AND BREAKAWAY DEVICES**

**SECTION 836. POLE FOUNDATION**

**836.01 Description.** This work shall consist of constructing or furnishing and installing a light pole foundation.

**836.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete .....	1020
(b) Anchor Rods .....	1070.02
(c) Light Pole Foundation, Metal .....	1070.01
(d) Fine Aggregate .....	1003.04

**CONSTRUCTION REQUIREMENTS**

**836.03 Installation.** Foundations installed within the clear zone (unless behind guardrail) shall not protrude more than 4 in. (100 mm) above the finished grade within a 5 ft (1.5 m) chord across the foundation, with anchor rods and breakaway device included. If foundation heights, including anchor rods and fractured breakaway device extend beyond these specified limits, the foundation shall be replaced.

- (a) Drilled Shaft Foundations. Drilled shaft foundations shall be constructed according to Section 516 and the following.

The submittal requirements as stated in Article 516.04 shall not apply.

Grounding electrodes shall be according to Section 806.

The raceway and full length anchor rods shall be properly positioned and secured in the augered hole prior to placing the concrete. The bend radius of the anchor rods shall be at least four times the rod diameter.

The wiring window shall be perpendicular to the roadway. After installation of cable, voids within the wiring window shall be filled with fine aggregate.

The top of the foundation shall be constructed level. A liner or form shall be used to produce a uniform smooth side to the top of the foundation. The depth of the form shall be as shown on the plans.

The foundation form shall remain undisturbed for at least 24 hours after the concrete has been poured.

Concrete shall be cured before poles are installed.

When obstructions are encountered, the Contractor shall request to relocate the foundation. Any abandoned holes shall be backfilled to the satisfaction of the Engineer.

When rock is encountered, the foundation depth may be reduced 6 in. (150 mm) for every 12 in. (300 mm) of embedment in rock. The minimum depth of any foundation shall be 4.5 ft (1.4 m).

When the foundation depth is reduced to less than 6 ft (1.8 m), the anchor rods shall be cut, threaded, and a steel plate 20 X 20 X 1/4 in. (500 X 500 X 5 mm) shall be installed on the bottom of the anchor rods 6 in. (150 mm) above the bottom of the excavated hole with 1 in. (25 mm) nuts.

(b) **Metal Foundations.** Metal foundations shall be installed in undisturbed soil.

The foundation shall be installed with its axis plumb. The light pole shall be installed plumb without the use of shims, grout, or other leveling devices.

Any voids within the metal screw-in foundation shall be filled with fine aggregate.

Wiring windows shall be oriented to be parallel to the roadway unless otherwise directed by the Engineer to achieve alignment with grade or to minimize bends in the feeder wiring into the foundation.

The Contractor shall use a torque indicating device to install metal foundations. A shear pin indicator or other Engineer approved method shall be used to insure the foundation is installed properly. A metal foundation shall not be installed to a torque which exceeds the manufacturer's maximum torque rating nor shall it be installed to an installation torque value of less than 3,500 ft lb (5,000 N m). Metal foundations that are not installed to full installation depth or do not achieve the minimum installation torque shall be removed and replaced with a concrete foundation at no additional cost to the Department.

Driven grounding electrodes will not be required when metal foundations are specified.

**836.04 Method of Measurement.** Concrete foundations will be measured for payment in place in feet (meters). The length measured will be limited to that shown on the plans or authorized by the Engineer. Any offsets in the foundation will be measured along the vertical and horizontal centerlines of the foundation without overlap.

Relocation of a foundation due to an obstruction and any shaft excavation to that point will not be measured for payment.

Excavation in rock will be measured for payment according to Article 502.12.

**836.05 Basis of Payment.** Concrete foundations will be paid for at the contract unit price per foot (meter) for LIGHT POLE FOUNDATION, of the diameter specified.

Metal foundations will be paid for at the contract unit price per each for LIGHT POLE FOUNDATION, METAL, of the diameter, length, and bolt circle specified.

Excavation in rock will be paid for according to Article 502.13.

**SECTION 837. LIGHT TOWER FOUNDATION**

**837.01 Description.** This work shall consist of constructing a drilled shaft foundation for a light tower.

**837.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1) .....	1020
(b) Light Tower Anchor Rod Assembly .....	1070.03
(c) Fine Aggregate .....	1003.04
(d) Reinforcement Bars .....	1006.10(a)

Note 1. Class SI concrete shall be used for the concrete work pad and shall be cured according to Article 1020.13 under other incidental concrete.

**CONSTRUCTION REQUIREMENTS**

**837.03 Installation.** Drilled shaft foundations shall be constructed according to Section 516 and the following.

When obstructions are encountered, the Contractor shall request to relocate the foundation. Any abandoned holes shall be backfilled to the satisfaction of the Engineer.

Grounding electrodes shall be according to Section 806.

The anchor rod assembly may be factory fabricated with the reinforcing cage or it may be field assembled. The cage shall be hand tied, no tack welding will be allowed. Anchor rods shall sufficiently overlap with the rebar cage to develop their full holding strength. Full length anchor rods shall not be used unless approved by the Engineer.

The top of the foundation to 18 in. (450 mm) below grade shall be formed. The reinforcing cage, anchor rods, and wireway shall be accurately held in place by the form. The anchor rods shall be held plumb above the top of the foundation during concrete placement.

A permanent, concrete work pad shall be constructed as shown on the plans. This 36 x 36 x 8 in. (900 x 900 x 200 mm) pad shall be centered in front of the handhole and finished level.

After installation of cable, voids within the wiring window shall be filled with fine aggregate.

Concrete shall be cured before light towers are installed.

**837.04 Method of Measurement.** This work will be measured for payment in feet (meters) in place. The length measured will be limited to that shown on the plans or authorized by the Engineer.

Excavation in rock will be measured for payment according to Article 502.12.

**837.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for LIGHT TOWER FOUNDATION of the diameter specified.

Excavation in rock will be paid for according to Article 502.13.

Obstruction mitigation or abandoned foundation excavations and backfill will be paid for according to Article 109.04.

**SECTION 838. BREAKAWAY DEVICES**

**838.01 Description.** This work shall consist of furnishing and installing a breakaway device on a pole foundation.

**838.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Breakaway Devices .....	1070.04

**CONSTRUCTION REQUIREMENTS**

**838.03 Installation.** All entryway points created by the use of breakaway devices shall be permanently and completely sealed against rodent entry. This includes base plate and foundation plate openings, elongated holes for anchor rods, the opening below the pole base plate, and the wireway slots in the foundation. Where breakaway couplings are used in conjunction with steel foundations, the Contractor shall match the plate sizes in order to seal out rodents between the foundation and pole base. Breakaway devices are not allowed on bridge parapets, barrier walls, or pedestrian conflict areas, and are not required behind guardrail.

(a) Transformer Base. The transformer base shall be installed level and flush with the foundation without the use of washers or shims according to the manufacturer's installation procedures. All nuts, bolts, washers, and lock washers required to complete the installation of the transformer base shall be included.

- (b) Breakaway Couplings. The breakaway couplings shall be coordinated to match anchor rod size. The breakaway coupling shall be installed on the anchor rod according to the manufacturer's recommendations. The coupling installation shall not be used to level the pole base in lieu of a level foundation.

**838.04 Method of Measurement.** Transformer bases used for breakaway devices will be measured for payment as each, for each transformer base used.

Breakaway couplings used for breakaway devices will be measured for payment as each, for each individual coupling used, not as a set of four.

**838.05 Basis of Payment.** This work will be paid at the contract unit price per each for BREAKAWAY DEVICE, TRANSFORMER BASE, of the bolt circle indicated; or BREAKAWAY DEVICE, COUPLING WITH ALUMINUM SKIRT, WITH FIBERGLASS SHROUD, or WITH STAINLESS STEEL SCREEN.

## REMOVAL, RELOCATION, AND TEMPORARY LIGHTING

### SECTION 841. TEMPORARY LIGHTING REMOVAL

**841.01 Description.** This work shall consist of the disconnection and removal of the temporary lighting system.

### CONSTRUCTION REQUIREMENTS

**841.02 Removal.** Removal shall include the removal of temporary poles (which may be wood, concrete, steel, or aluminum), aerial cable, and all associated apparatus and connections. This removal shall also include removal of all wiring and connections to the associated lighting controller. All equipment and material, except for luminaires removed as part of this item, shall become property of the Contractor and shall be removed from the site.

All luminaires will be inspected by the Engineer. Non-operating or damaged luminaires shall be repaired or replaced in kind.

Luminaires shall be removed, boxed in new containers approved by the Engineer, and delivered and unloaded at a storage facility of the Department, as designated by the Engineer.

Pole holes shall be backfilled according to Article 819.04.

With the approval of the Engineer, the Contractor may partially remove the temporary lighting system after parts of the permanent lighting system are operational. Any modifications to the temporary system to keep the temporary lighting system and permanent lighting system operational shall be performed at no additional cost to the Department.

**841.03 Method of Measurement.** Units will be measured for payment as each on a per pole basis, regardless of pole material, mounting height, the number and type of mast arm(s), luminaires and other appurtenant items attached thereto.

**841.04 Basis of Payment.** This work will be paid for at the contract unit price per each for REMOVAL OF TEMPORARY LIGHTING UNIT.

## SECTION 842. REMOVAL OF LIGHTING UNITS

**842.01 Description.** This work shall consist of the removal and disposal of existing light units and their foundations.

### CONSTRUCTION REQUIREMENTS

**842.02 General.** No removal work will be permitted without approval from the Engineer. Removal shall start as soon as the temporary lighting or permanent lighting, as applicable, is placed in approved operation. An inspection and approval by the Engineer will take place before any associated proposed permanent or temporary lighting is approved for operation.

**842.03 Removal of Lighting Units.** Any damage resulting from the removal and/or transportation of the lighting luminaire and associated hardware, shall be repaired or replaced in kind. The Engineer will be the sole judge to determine the extent of damage and the suitability of repair and/or replacement.

The removal of pole mounted luminaries shall include the pole, breakaway device, arms, luminaries, and associated hardware and appurtenances.

Abandoned underground electric cables shall be removed with conduit and duct to a depth of 1 ft (300 mm) below ground level and the hole shall be backfilled. Cables in a unit duct may be removed from the duct and become the property of the Contractor. The empty duct shall be removed to 1 ft (300 mm) below ground level and the hole backfilled.

The removal of underpass and sign luminaries shall include all associated conduit, wire, junction boxes, hardware, and appurtenant materials.

Conduit hangers, straps, and supports shall be removed from bridge steel as directed by the Engineer. All open conductors and porcelain insulators shall be removed with the conduit system. Where the conduit system is removed from parapet walls and other concrete surfaces, the Contractor shall cut off the anchor device 1 in. (25 mm) below the surface of the concrete, and fill all voids with portland cement concrete mortar, making a smooth finish to the concrete surface.

Unprotected bridge steel which is exposed by the removal of the conduit system shall be touched up using a paint and procedure approved by the Engineer.

- (a) Removal of Lighting Unit, No Salvage. When indicated, poles, mast arms, luminaries, and all associated hardware and appurtenances shall become

the property of the Contractor and shall be disposed of according to Article 202.03.

- (b) **Removal of Lighting Unit, Salvage.** When indicated, poles, mast arms, luminaires, and all associated hardware and appurtenances shall remain the property of the Department and shall be delivered to a Department facility within the District and unloaded and stacked there, as directed by the Engineer. Wood blocking, banding, or other appurtenant items required for proper stacking and protection shall be included.

Luminaires shall be removed, boxed in new containers, approved by the Engineer, and delivered to a Department facility, as designated by the Engineer.

**842.04 Removal of Pole Foundation.** Concrete foundations shall be removed to at least 2 ft (600 mm) below grade, with removed material disposed of according to Article 202.03. The removal shall extend deeper where required to facilitate roadway construction at no additional cost to the Department. Underground conduits and cables shall be separated from the foundation at 2.5 ft (750 mm) below grade and shall be abandoned or re-used as indicated.

Where light poles are removed from retaining or parapet walls, the Contractor shall cut off the anchor rods and conduit stub-ups 1 in. (25 mm) below the wall surface and fill all voids with portland cement concrete mortar making a smooth surface to match the shape of the wall.

Existing steel helix foundations shall be removed and cleaned to expose the foundation for inspection by the Engineer. Those foundations deemed not reusable by the Engineer shall become the property of the Contractor and shall be disposed of according to Article 202.03. Those foundations deemed re-usable by the Engineer shall be thoroughly cleaned (inside and outside) and delivered to a Department storage facility and unloaded and stacked there as directed by the Engineer.

The void caused by the removal of the foundations shall be backfilled according to Article 819.04.

**842.05 Method of Measurement.** Each lighting unit which is removed and delivered to a Department storage facility, or disposed of as indicated, will be counted as a unit for payment.

**842.06 Basis of Payment.** Removal of lighting units will be paid for at the contract unit price per each for REMOVAL OF LIGHTING UNIT, SALVAGE or REMOVAL OF LIGHTING UNIT, NO SALVAGE.

Foundation removal will be paid for at the contract unit price per each for REMOVAL OF POLE FOUNDATION.

## **SECTION 843. REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING SYSTEM**

**843.01 Description.** This work shall consist of removing the existing bridge navigation obstruction lighting system. This navigation lighting system shall include fixtures installed for river navigation and, where applicable fixtures installed for air navigation.

### **CONSTRUCTION REQUIREMENTS**

**843.02 Removal of Navigation Obstruction Fixtures.** No removal work will be permitted without approval from the Engineer. Navigation lighting must remain operational throughout the project according to the FAA and Coast Guard requirements and as directed by the Engineer. An inspection and approval by the Engineer will take place before any proposed permanent or temporary lighting is approved for operation.

Existing fixtures to be removed shall include the fixture, fixture housing, mounting devices, flanges, nipples, relay boxes, junction boxes, support arms and arm lifting devices, counter balance and weights, wiring, conduit, electrical devices, and all other fixture appurtenances as directed by the Engineer.

Removal of abandoned electric cables and conduit shall be according to Article 842.03.

Any fixtures or fixture components which the Engineer designates as salvage shall be removed, boxed in new containers, approved by the Engineer, and delivered and unloaded at a storage facility of the Department, as designated by the Engineer. Wood blocking, banding, or other appurtenant items required for proper staking shall be included. Materials that are not salvaged shall become the property of the Contractor and shall be disposed of according to Article 202.03.

Any damage resulting from the removal and/or transportation of the lighting fixtures and associated hardware that are to be salvaged, shall be repaired or replaced in kind. The Engineer will determine the extent of damage and the suitability of repair of repair and/or replacement.

**843.03 Basis of Payment.** This work will be paid for at the contract lump sum price for REMOVAL OF NAVIGATION OBSTRUCTION WARNING LIGHTING SYSTEM.

**SECTION 844. RELOCATE LIGHTING UNITS**

**844.01 Description.** This work shall consist of removing an existing lighting unit and reinstalling temporary pole and/or lighting unit on a proposed foundation in locations as designated by the Engineer.

**844.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Pole/Unit Identification .....	1069.06
(b) Fuseholders and Fuses .....	1065.01

**CONSTRUCTION REQUIREMENTS**

**844.03 Lighting Unit.** Lighting units shall be removed and reinstalled as follows.

- (a) Removal. The existing lighting unit shall be disconnected and removed from the existing foundation by removing the anchor rod nuts and lifting the lighting unit from the foundation.

Any damage sustained to the lighting unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer.

- (b) Reinstallation. The lighting unit shall be installed immediately on the proposed foundation. The electric cables shall be connected to power supply cables so the reinstalled lighting unit becomes operational the same evening without interruption. Temporary wiring will be permitted at the discretion of the Engineer.

When a conduit or duct extension is required, the conduit and/or duct may be spliced and a new span of cable shall be installed. The Engineer will inspect all conduit and/or duct splices before backfilling.

The existing pole wire shall be preserved and reconnected to the proposed underground wiring. The space between the finished top of the foundation and the base plate of the pole shall be enclosed to prevent the entry of rodents in a manner approved by the Engineer.

The anchor rod cover and handhole covers of the lighting unit shall be removed and reinstalled. If during removal, the screws holding the cover break, a hole in the pole base shall be drilled and threaded to accept a new screw. The screws shall be 1/4 in. (6 mm) 20 stainless steel with anti-seize compound applied.

The mast arm and/or luminaire may be removed and reinstalled as a unit, at the option of the Contractor, with the approval of the Engineer. No additional compensation will be paid for these operations.

Luminaire Circuit Identification. Each lighting unit which is to be relocated under this item shall be checked during the preconstruction inspection for complete circuit identification. Any damage to the identification occurring prior to final acceptance shall then be repaired or replaced under this item, in conformance with the specifications, at no additional cost to the Department. The existing circuit identification and the identification shown on the plans shall be compared and where the existing identification must be changed to conform with the plans, the removal and replacement of identification shall be included in this item.

**844.04 Light Towers.** This work shall be according to Article 844.03 and the following.

The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The mesh of the screen shall be 1/4 in. (6 mm) or less, as approved by the Engineer. The screen shall be held in place with bands made of stainless steel. The ends shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

The light pole shall be straight and centered according to Article 835.04.

**844.05 Wood Poles.** Wood pole removal, reinstallation, and luminaire circuit identification shall be as follows.

- (a) **Removal and Reinstallation.** The temporary lighting unit shall be installed immediately at the new location. The electric cables shall be connected to power supply cables so the reinstalled temporary light unit becomes operational the same evening without interruption. If the existing electric cables are not of sufficient length to make the new connection, a new continuous span of electric cables, of equal or better quality, shall be installed at no additional cost.

Any damage sustained to the temporary light unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer.

When a temporary lighting unit or pole is not in conflict with the proposed construction, but is in conflict with the Contractor's proposed sequence of operations, or the relocation is for the Contractor's convenience, relocation of said temporary lighting unit will be at the Contractor's option and expense. The Contractor shall obtain the Engineer's approval before any pole or unit is relocated.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary lighting unit shall be reset in or near the same location.

- (b) **Luminaire Circuit Identification.** Each pole which is to be relocated shall be checked during the preconstruction inspection for complete circuit identification and corrected according to Article 1069.06.

Any damage to the identification occurring prior to final acceptance shall be repaired or replaced by the Contractor according to the specifications.

**844.06 Method of Measurement.** Relocation of lighting units, light towers, or temporary wood poles will be measured for payment as each.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary lighting unit will be measured for payment as each. Resetting of the pole will not be paid for if the pole setting has been weakened by construction operations.

**844.07 Basis of Payment.** This work will be paid for at the contract unit price per each for RELOCATE EXISTING LIGHTING UNIT, of the type specified; RELOCATE EXISTING LIGHT TOWER; or RELOCATE EXISTING WOOD POLES.

## SECTION 845. REMOVAL OF LIGHTING CONTROLLER

**845.01 Description.** This work shall consist of the removal and disposal of existing electric service installation, lighting controller, and associated foundations.

### CONSTRUCTION REQUIREMENTS

**845.02 General.** No removal work shall be permitted without approval from the Engineer. Abandoned underground electric cables shall be removed with conduit and duct to a depth of 1 ft (300 mm) below ground level and the hole backfilled. Cables in unit duct may be removed from the duct and become property of the Contractor.

Any removal work involving facilities owned by the electric utility shall be coordinated by the Contractor to insure the utility is properly notified and (if necessary) present while the removal work is being done. The Contractor shall insure that the removal work is disconnected from the utility's service equipment in a manner which is in compliance with the requirements of the utility.

**845.03 Removal of Electric Service Installation.** This work shall consist of the removal and satisfactory disposal of the wood pole and weatherhead or underground pedestal, grounding electrode, meter base, disconnect, conduit, wiring, and other miscellaneous items associated with an electric service installation.

**845.04 Removal of Lighting Controller.** This work shall consist of the removal and satisfactory disposal of the lighting controller cabinet, enclosed electrical equipment, and all other miscellaneous items associated with a lighting controller.

**845.05 Removal of Lighting Controller Foundation.** Concrete foundations shall be removed to at least 2 ft (600 mm) below grade with removed material disposed of according to Article 202.03. The removal shall extend deeper where required to facilitate roadway construction. Underground conduits and cables shall be separated from the foundation at 2.5 ft (750 mm) below grade and shall be abandoned or reused as indicated. The grounding electrode shall be removed or cut off to the same depth as the concrete.

Existing steel helix foundations shall be removed and disposed of according to Article 842.04.

The void caused by the removal of the foundations shall be backfilled according to Article 819.04.

**845.06 Basis of Payment.** Removal of lighting controllers will be paid for at the contract unit price per each for REMOVAL OF LIGHTING CONTROLLER.

Removal of electric service installations will be paid for at the contract unit price per each for REMOVAL OF ELECTRIC SERVICE INSTALLATION.

Removal of lighting controller foundations will be paid for at the contract unit price per each for REMOVAL OF LIGHTING CONTROLLER FOUNDATION.

## TRAFFIC SIGNALS

### MAINTENANCE

#### SECTION 850. MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION

**850.01 Description.** This work shall consist of maintaining an existing traffic signal installation that has been designated to remain in operation during construction.

**850.02 Procedure.** The energy charges for the operation of the traffic signals will be paid for by the Department or the local agency.

At least one week prior to beginning construction within 400 ft (125 m) of the signalized intersection, the Contractor shall conduct a signal inspection with a representative of the agency responsible for the signal maintenance. The signal inspection shall reveal defective existing traffic signal items such as inductive loop detectors, lead-in cable, detector loop, interconnect cable, and so forth, and the Contractor shall not be held responsible for these items. In case the Contractor fails to contact the signal maintaining agency for the signal inspection, the Contractor shall be held responsible for all the signal items remaining defective at the completion of the construction.

The Contractor shall become responsible for the maintenance of the existing signalized intersection at a date mutually agreed upon between the Contractor and the signal maintaining agency representative, but no later than the beginning of construction by the Contractor within 400 ft (125 m) of the intersection. The Contractor's signal maintenance responsibility shall cease upon the issuance of a Signal Acceptance Notice by the Engineer.

**850.03 Maintenance.** The maintenance shall be according to Article 801.11 and the following.

The Contractor shall be responsible for the controller programming to provide for safe and efficient signal operation during construction. The Contractor may seek assistance from the maintaining agency personnel on the appropriate controller settings.

**850.04 Basis of Payment.** This work will be paid for at the contract unit price per each for MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

## **SECTION 851. PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT**

**851.01 Description.** This work shall consist of cleaning and painting the existing traffic signal equipment reused as part of the new traffic signal installation.

**851.02 Materials.** Materials shall be as specified in the contract.

### **CONSTRUCTION REQUIREMENTS**

**851.03 Cleaning.** Prior to painting, the surfaces shall be thoroughly cleaned of all surface irregularities and foreign materials, so the prime and paint coatings will have a smooth finish.

**851.04 Painting.** After cleaning, one coat of primer shall be applied to all areas where the old paint has been removed or damaged. On surfaces where small areas of metal at closely spaced intervals are exposed, the primer shall consist of a complete coating. The surface of the signal equipment shall be painted as follows.

- (a) The signal housings, controller cabinet, signal posts (except bright aluminum posts), and brackets shall be painted with two coats of yellow.
- (b) The signal doors, visors, and metal backplates (except polycarbonate materials) shall be painted with two coats of dull (matte) black paint.
- (c) The steel mast arm assemblies and poles shall be painted with two coats of aluminum paint.

**851.05 Method of Measurement.** This work will be measured for payment as each. Each intersection will be considered one each.

**851.06 Basis of Payment.** This work will be paid for at the contract unit price per each for PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT.

**CONTROLLERS AND EQUIPMENT****SECTION 857. TRAFFIC ACTUATED CONTROLLER**

**857.01 Description.** This work shall consist of furnishing and installing a traffic actuated solid state digital controller in the controller cabinet of the type specified with peripheral equipment.

**857.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Traffic Actuated Solid State Digital Controller .....	1073.01
(b) Controller Cabinet and Peripheral Equipment .....	1074.03

**CONSTRUCTION REQUIREMENTS**

**857.03 Installation.** The traffic actuated controller shall be installed in a completely wired cabinet, with necessary connections for proper operation. The model and serial number of the controller shall be permanently affixed on the front or top of the controller housing and readily visible.

All conduit entrances into the controller cabinet shall be sealed with a pliable waterproof material. Electrical cables inside the controller cabinet shall be neatly trained along the base and back of the cabinet. Each conductor shall be connected individually to the proper terminal, and the spare conductors shall be insulated and bound into a neat bundle. Each cable shall be marked with identification meeting the approval of the Engineer and recorded on a copy of the plans for the intersection and submitted to the Engineer.

The traffic actuated controller shall provide the NEMA eight phase dual ring operation for the phase designation diagram shown on the plans and the preemption sequence of operation, when shown on the plans. A print out of all controller settings including coordination and preemption shall be provided to the Engineer.

**857.04 Basis of Payment.** This work will be paid for at the contract unit price per each for FULL-ACTUATED CONTROLLER AND CABINET or RAILROAD, FULL-ACTUATED CONTROLLER AND CABINET, of the type specified. The transceiver shall be furnished with the controller only when specified as a separate pay item on the plans.

**SECTION 858. FLASHER CONTROLLER**

**858.01 Description.** This work shall consist of furnishing and installing a flasher controller and cabinet.

**858.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Flasher Controller .....	1073.02

**CONSTRUCTION REQUIREMENTS**

**858.03 Installation.** The flasher controller shall be installed according to the details shown on the plans.

**858.04 Basis of Payment.** This work will be paid for at the contract unit price per each for FLASHER CONTROLLER.

**SECTION 859. TRANSCEIVER**

**859.01 Description.** This work shall consist of furnishing and installing a transceiver with necessary connections for proper operation.

**859.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Transceiver .....	1073.03

**CONSTRUCTION REQUIREMENTS**

**859.03 Installation.** The transceiver shall be connected to the communication interface panel. The transceiver shall be assigned a unique address in the master controller.

**859.04 Basis of Payment.** This work will be paid for at the contract unit price per each for TRANSCEIVER.

The interface panel, all necessary harnesses, and the programming of the controller and the master controller shall be included in this item.

**SECTION 860. MASTER CONTROLLER**

**860.01 Description.** This work shall consist of furnishing and installing a master controller with the necessary connections for proper operation.

**860.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Master Controller .....	1073.04

**CONSTRUCTION REQUIREMENTS**

**860.03 Installation.** Installation of the master controller shall be as follows.

(a) Telephone Service. The Contractor shall arrange with the telephone company to install a standard voice-grade dial-up telephone line. Any

charges by the telephone company to provide initial service will be paid for according to Article 109.05.

- (b) System Set-up. The Contractor shall set up graphic displays and all software parameters, including compatible viewing and control capabilities from the remote monitor.
- (c) Housing and Cabinet. The model and serial numbers shall be affixed on the front of the housing and shall be readily visible. The master controller shall be installed in the same cabinet with a traffic signal controller. One circuit breaker rated at 10 A shall be provided.
- (d) Software. Based on the need, up to three complete sets of the latest edition of registered remote monitoring software with full manufacturer's support shall be furnished with each master controller. Each set shall consist of complete software on 3 1/2 in. (90 mm) floppy disks, and a bound set of manuals containing loading and operating instructions. The distribution of the software will be directed by the Engineer.

**860.04 Basis of Payment.** This work will be paid for at the contract unit price per each for MASTER CONTROLLER.

**SECTION 861. DIGITAL TIME SWITCH**

**861.01 Description.** This work shall consist of furnishing, installing, and setting a digital time switch, with necessary connections for proper operation.

**861.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Digital Time Switch .....	1074.01

**861.03 Basis of Payment.** This work will be paid for at the contract unit price per each for DIGITAL TIME SWITCH.

**SECTION 862. RESERVED**

**SECTION 863. CONTROLLER CABINET AND PERIPHERAL EQUIPMENT**

**863.01 Description.** This work shall consist of furnishing and installing a cabinet and peripheral equipment for an existing traffic signal controller.

**863.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Controller Cabinet and Peripheral Equipment .....	1074.03

**CONSTRUCTION REQUIREMENTS**

**863.03 General.** The cabinet shall be furnished with panel, terminal facilities, conflict monitor, load switches, and flasher relays complete with necessary connections for proper operation. The type of cabinet shall be as specified on the plans.

**863.04 Basis of Payment.** This work will be paid for at the contract unit price per each for CONTROLLER CABINET, of the type specified.

**SECTION 864. TRANSCIEVER-FIBER OPTIC**

**864.01 Description.** This work shall consist of furnishing and installing a fiber optic transceiver for a traffic signal controller.

**CONSTRUCTION REQUIREMENTS**

**864.02 General.** The fiber optic transceiver shall be installed according to Section 859 and the following.

All fiber optic components, except the interconnect cable itself, required to provide proper communication between local controllers and/or masters, shall be furnished and installed as part of this item.

**864.03 Transceiver Components.** The transceiver and all related components and connections shall be provided for the proper operation of the fiber optic interconnect communication system in each traffic signal cabinet. These items shall include but not be limited to the following.

- (a) Distribution Enclosure. Field cable shall terminate in the controller cabinet within a wall-mount distribution enclosure. The distribution enclosure shall seal out dust and moisture. The size shall be sufficient to store all fiber windings and splices. The location of the distribution enclosure shall not restrict access to other controller components. The field cable shall be firmly secured to the enclosure with hose clamps or similar clamping devices. The cabinet cable shall leave the enclosure through rubber grommets or similar devices to protect the cable against wear. The field cable jacket shall be removed and all protective gel cleaned from the loose tubes as recommended by the cable supplier. Sufficient lengths of every loose tube shall be coiled within the enclosure to reach the fiber interface panel or modem.
- (b) Connectors. Only ST type connectors of ceramic ferrule and Physical Contact (PC) end finish shall be used to terminate fibers to equipment. ST or mechanical connectors shall not be used to splice cables.
- (c) Splices. The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices will be allowed outside the controller cabinets. Only mechanical or fusion splices will be

allowed in the controller cabinet. The splices shall be secured in a splice organizer tray.

- (d) **Modems and Power Source.** Communication between local controllers and the system master controllers shall be facilitated by the use of fiber optic modems. The modems shall be capable of communications with NEMA traffic signal controllers in a coordinated closed loop system. Modems shall be active devices providing full-duplex communication via RS-232 connector and supporting daisy-chain wiring. The nominal operating wavelength shall be 850 nm. The modems shall be according to NEMA Standards for Traffic Control Systems, TS1, Section 2. A minimum of two fiber optic ports shall be provided on each modem. Each fiber optic port shall be ST-PC style and shall be identified as either transmitter or receptor of the optic signal. The other end of the modem shall have the male type RS-232 connector. The modems shall be installed on the interface panel on the side of the controller cabinet. The modems shall be powered from the controller telemetry module.
- (e) **Light Source.** An LED light source with a wavelength that is the system wavelength shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long enough to perform the measurement. The output of the LED shall overfill the input end of the launch fiber in both numerical aperture (NA) and core diameter.
- (f) **Power Meter.** The detector in the power meter shall have an effective NA and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 dBm to -40 dBm. The power meter shall have an accuracy of  $\pm 0.5$  dB through the operating temperature and minimum resolution of 0.1 dB.
- (g) **Breakout Kits.** Breakout kits shall provide for the separation and protection of individual fibers with buffer tubing and jacketing materials suitable for termination of the fiber with the fiber optic connectors as specified.
- (h) **Interface Panel.** This panel interfaces the controller telemetry to the fiber optic modems and provides terminal block tie points for the other telemetry signals. A terminal for each conductor in the cable shall be required.

**864.04 Testing and Product Information.** Field testing of the equipment shall be according to Article 801.13(d). All components of the fiber optic system shall have the manufacturer's name, address, type, style, model or serial number, and catalog number on a plate secured to the equipment. It is advised that the system be from the same manufacture to assure uniformity, interchangeability of components, single responsibility, and most satisfactory service.

**864.05 Basis of Payment.** This work will be paid for at the contract unit price per each for TRANSCEIVER - FIBER OPTIC, for each traffic signal cabinet.

**WIRE AND CABLE**

**SECTION 870. MULTI-CONDUCTOR POWER CABLE**

**870.01 Description.** This work shall consist of furnishing and installing multi-conductor direct burial power cable, complete with all splicing, identifications, and terminations.

**870.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Multi-Conductor Power Cable .....	1076.01
(b) Splicing and Termination of Electric Cable .....	1066.06

**CONSTRUCTION REQUIREMENTS**

**870.03 Installation.** The multi-conductor cable extended to equipment shall be of a length sufficient for cable splices to be withdrawn a minimum of 18 in. (450 mm) out of pole handholes, pull boxes, or junction boxes.

For preparation of cable termination or splicing, the multi-conductor cable jacket and any underlying tape, shall be removed for a distance of 8 in. (200 mm) from the end of the center conductor. The fillers shall be removed and cut at the end of the jacket. The assembly shall be taped tightly together at the end of the jacket before the conductors are spread apart.

Multi-conductor cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. No underground splicing of cable will be permitted.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminates, unless splicing or termination work is performed concurrently.

The multi-conductor cable assembly shall be terminated with a multi-leg heat-shrink boot. The end of the cable shall be wrapped with sealant tape recommended by the boot manufacturer around and between individual insulated conductors, with the boot overall. The boot shall meet military specification SAE-AS81765/1.

(a) In Trench. The cable shall be installed as indicated on the plans and according to the manufacturer's recommendations. Installation, after inspection by the Engineer, shall be backfilled according to Section 819, except plowing will not be allowed.

(b) In Raceway. Raceways shall be cleaned and freed of rough spots by reaming or other methods approved by the Engineer. All raceways shall be

swabbed and blown clean with compressed air. Lubricating compounds approved by the cable manufacturer shall be used to facilitate installation of the cable in raceways.

The manufacturer’s recommended allowable tension for the conductor or the allowable sidewall load, whichever is smaller, shall be used for maximum pulling tension. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

**870.04 Method of Measurement.** Cable will be measured for payment according to Article 817.04.

**870.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for ELECTRIC CABLE ASSEMBLY IN CONDUIT, or TRENCH, 600V of the type, size, and number of conductors specified.

**SECTION 871. FIBER OPTIC CABLE**

**871.01 Description.** This work shall consist of furnishing and installing all accessories required and the fiber optic cable of the type, size, and number of fibers specified.

**871.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Fiber Optic Cable .....	1076.02

**871.03 Contractor Qualifications.** The fiber optic cable installation shall be supervised by trained and experienced personnel. The cable terminations and splices shall be made by qualified technicians. Upon request by the Engineer, the Contractor shall provide documentation on qualifications and experience for fiber optic equipment installations. The Engineer will determine if the Contractor is qualified to perform the work.

**CONSTRUCTION REQUIREMENTS**

**871.04 Cable Installation.** The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices shall be allowed outside the controller cabinet. The cable end shall be secured inside the controller cabinet so no load is applied to the exposed fiber strands.

Cable Minimum Bend Radius. For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than 15 times the diameter of the cable outside diameter or as recommended by the manufacturer.

Extra Cable. Extra cable shall be left in each handhole and double handhole, at the top of each conduit riser, and at each wood support pole according to the following requirements. Storage of additional extra cable in each handhole shall be

coiled. These coils shall be bound at a minimum of three points around the coil perimeter and supported in their static storage positions. Storage of additional cable adjacent to conduit risers and support poles shall be as detailed on the plans. The minimum of extra cable amounts shall be as follows.

Location	Extra Cable Length	
	feet	(meters)
Gulfbox	1.5	0.5
Junction Box	1.5	0.5
Handhole	6.5	2.0
Double Handhole	13.0	4.0
Conduit Riser	13.0	4.0
Support Pole	13.0	4.0

Cable Termination. Field cable shall terminate in the controller cabinet within a wall-mounted distribution enclosure according to Article 864.03.

- (a) Installation in Conduits and Ducts. A suitable cable feeder guide shall be used between the cable reel and the face of the conduit/duct to protect the cable and to guide it into the conduit off the reel. The cable shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer shall be notified.

Precautions shall be taken during installation to prevent the cable from being kinked or crushed. A pulling eye shall be attached to the cable and used to pull the cable through the conduit. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be lubricated with a type of lubricant recommended by the cable manufacturer. The lubricant used shall be a water based type and approved by the cable manufacturer. Dynamometers or break away pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension specified by the cable manufacturer. Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of the cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked, or forced around a sharp corner. A sufficient length of cable shall be left at each end of the cable to allow proper cable termination. At the controller cabinet and at the handhole the cable shall be visibly marked/tagged as "CAUTION-FIBER OPTIC CABLE".

- (b) Installation on Aerial Spans. The fiber cable shall be lashed onto the aerial support span wire. The aerial support shall be existing span wire, or new span wire according to Section 872. When the existing interconnect is supported by messenger cable and hanger rings, the rings and interconnect cable shall be removed. Existing conduit risers designated for reuse with the fiber optic interconnect shall have the existing weatherhead removed. Removal of these items shall be included in the cost of the fiber optic cable. The fiber optic cable shall be secured to the support cable by lashing with a cable lasher. The lashing wire shall be a dielectric lashing filament to

prevent the conductance or attraction of lightning. The lashing wire shall be securely tied off when terminated near each support pole.

- (c) Cable Placement into Conduit Risers. Kellum grips and/or other hanger devices shall be used to support the vertical drop of the cable and to prevent any possible kinking of the cable after installation. The top of the risers shall have a hexnut type watertight service entrance connector with an oval shaped grommet. The grommet shall be either neoprene or rubber. The voids between the fiber optic cable(s) and the grommet shall be sealed with silicone.

The fiber optic cable shall be tested according to Article 801.13(d).

**871.05 Method of Measurement.** Cable will be measured for payment in feet (meters) in place. Cable will be measured horizontally and vertically between the changes in direction, including the cable in the vertical conduit riser and any extra cable as specified in Article 871.04. The cable length in the foundations of a controller cabinet and a vertical pole will be accounted as 3 ft (1 m) each.

**871.06 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for FIBER OPTIC CABLE of the method of installation (in conduit or on messenger), of the type, size, and number of fibers specified.

The cable warning tags will be included in the cost of the fiber optic cable.

## SECTION 872. SPAN WIRE AND TETHER WIRE

**872.01 Description.** This work shall consist of furnishing and installing span wire or tether wire and accessories.

**872.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Span Wire and Tether Wire .....	1076.03

## CONSTRUCTION REQUIREMENTS

**872.03 Installation.** The span wire or tether wire with accessories shall be installed according to the details shown on the plans.

**872.04 Method of Measurement.** Span wire and tether wire will be measured for payment in feet (meters) in place. Measurements will be along the horizontal distances between the supporting poles.

**872.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for SPAN WIRE or TETHER WIRE.

Any additional span wire or tether wire required for sag and wrap around shall be included in the cost of the wire specified.

**SECTION 873. ELECTRIC CABLE**

**873.01 Description.** This work shall consist of furnishing and installing an electric cable of the type, size, and number of conductors specified.

**873.02 Materials.** Materials shall be according to the following.

	Item	Article/Section
(a)	Electric Cable - Signal, Lead-in, Communication, and Service .....	1076.04
(b)	Electrical Raceway Materials .....	1088.01

**CONSTRUCTION REQUIREMENTS**

**873.03 Installation.** The electric cable may be installed in a trench, in a conduit, or aerially suspended, as indicated on the plans. When installed in a trench, the electric cable shall have a minimum depth of 2.5 or 2 ft (750 or 600 mm) as indicated on the plans.

The color coded conductor shall be connected according to the following schedule.

(a) Signal Cable - Signal Head (5 Conductor or 7 Conductor)

Conductor No.	Base Color	Tracer Color	Connection
1	Black		AC, Neutral Red Circle Indication (AC,Line) Green Circle Indication (AC,Line) Yellow Circle Indication (AC,Line) Yellow Arrow Indication (AC,Line) Green Arrow Indication (AC,Line)
2	White		
3	Red		
4	Green		
5	Orange		
6	Blue		
7	White	Black	

(b) Signal Cable - Pedestrian Signal Head

Conductor No.	Base Color	Tracer Color	Connection
1	Black		AC, Neutral Don't Walk (AC,Line) Walk (AC,Line)
2	White		
3	Red		
4	Green		

(c) Signal Cable - Pedestrian Push-Button

Conductor No.	Base Color	Tracer Color	Connection
1	Black		24 V DC
2	White		Cabinet Logic Ground

## (d) Lead-in Cable (Single-Pair)

Conductor No.	Color	Connection
1	Black	Loop Detector - Loop Signal
2	Non-Black	Loop Detector - Loop Neutral

## (e) Communication Cable or Lead-in Cable (Multipair)

Conductor No. (Each Pair)	Color	Connection
1	Black	Signal
2	Non-Black	Neutral/Logic Ground

## (f) Service Cable

Conductor No.	Color	Connection
1	Black	AC, Line
2	White	AC, Neutral

The length of extra cable shall be provided according to the following schedule.

Location	Length of Cable	
	feet	(meters)
Gulfbox	1.5	0.5
Junction Box	1.5	0.5
Handhole	6.5	2.0
Double Handhole	13.0	4.0

Cable splices shall be made only at connections to detector loops or at the locations specified on the plans. When making a cable splice, the following procedures shall be used.

- (a) Remove all outer cable coverings, leaving 4 in. (100 mm) of insulated wire exposed.
- (b) Remove insulation for 1 in. (25 mm) and scrape copper conductors.
- (c) Connect conductors by twisting and soldering together.
- (d) Wrap each conductor separately with rubber or vinyl electrical tape. The wrapping shall completely cover the twisted connection and the insulation 1 in. (25 mm) beyond all exposed copper wire on either end of the connection.
- (e) Scrape the cable sheath clean and place the cable in a rigid mold or a container. The mold or container shall be of a type acceptable to the Engineer.

- (f) Center all conductors in molds or containers.
- (g) Fill the mold or container with epoxy resin or polyurethane compound. The epoxy resin or polyurethane compound used shall be dielectric, waterproof, and approved by the Engineer.

All stranded conductors shall be terminated in the cabinet using crimp-on connectors.

Electric cables shall be pulled into conduit by training the cables at the entrance to the conduit to prevent twisting or overlapping. Detector lead-in cables shall be placed on top of signal cables. When three or more cables are pulled into a conduit, a fast-drying, water based lubricant recommended by the cable manufacturer shall be applied on the cables.

**873.04 Method of Measurement.** Electric cable will be measured for payment in feet (meters) in place. The length of measurement shall be the distance horizontally and vertically measured between the changes in direction, including cables in mast arms, mast arm poles, signal posts, and extra cable length as specified in Article 873.03. The vertical cable length shall be measured according to the following schedule.

Location	Cable Length
Foundation (signal post, mast arm pole, controller cabinet)	3 ft (1 m)
Mast Arm Pole (mast arm mounted signal head)	20 ft (6 m)
Mast Arm Pole (bracket mounted signal head attached to mast arm pole)	13 ft (4 m)
Signal Post (bracket or post mounted signal head)	13 ft (4 m)
Pedestrian Push Button	6 ft (2 m)

**873.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for ELECTRIC CABLE, of the method of installation (IN TRENCH, IN CONDUIT, or AERIAL SUSPENDED), of the type, size, and number of conductors specified.

The type specified will indicate the method of installation and whether the electric cable is Service, Signal, Lead-in or Communication.

**POSTS AND FOUNDATIONS**

**SECTION 875. TRAFFIC SIGNAL POST**

**875.01 Description.** This work shall consist of furnishing and installing a metal traffic signal post.

**875.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Traffic Signal Post .....	1077.01

**CONSTRUCTION REQUIREMENTS**

**875.03 Installation.** The traffic signal post shall be erected plumb, securely bolted to a concrete foundation, and grounded to a ground rod according to the details shown on the plans. No more than 3/4 in. (20 mm) of the post threads shall protrude above the base. The vertical clearance between the bottom of a bracket or post mounted signal head or pedestrian signal head and the crown of the pavement shall be between 8 and 15 ft (2.5 and 4.5 m).

When the signal head is not mounted on the top of the post, a pipe cap shall be furnished and installed on the top of the post. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

Prior to the assembly, the Contractor shall apply two additional coats of galvanized paint on the threads of the post and the base. The Contractor shall use a fabric post tightner to screw the post to the base.

**875.04 Basis of Payment.** This work will be paid for at the contract unit price per each for TRAFFIC SIGNAL POST, of the type and length specified.

When a particular kind of material is specified for the post and base assembly, the work will be paid for at the contract unit price per each for TRAFFIC SIGNAL POST, PAINTED STEEL; TRAFFIC SIGNAL POST, GALVANIZED STEEL; or TRAFFIC SIGNAL POST, ALUMINUM.

**SECTION 876. PEDESTRIAN PUSH-BUTTON POST**

**876.01 Description.** This work shall consist of constructing a concrete foundation, and furnishing and installing a pedestrian push-button post.

**876.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Pedestrian Push-Button Post .....	1077.02
(b) Traffic Signal Post.....	1077.01
(c) Portland Cement Concrete (Note 1) .....	1020

Note 1. Class SI concrete shall be used.

**CONSTRUCTION REQUIREMENTS**

**876.03 Installation.** The pedestrian push-button post shall be installed plumb on a concrete foundation according to the details shown on the plans. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

**876.04 Basis of Payment.** This work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON POST, TYPE I or PEDESTRIAN PUSH-BUTTON POST, TYPE II.

When a galvanized post is specified, the work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON POST, GALVANIZED STEEL, TYPE I or PEDESTRIAN PUSH-BUTTON POST, GALVANIZED STEEL, TYPE II.

**SECTION 877. MAST ARM ASSEMBLY AND POLE**

**877.01 Description.** This work shall consist of furnishing and installing a steel mast arm assembly and pole.

**877.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Mast Arm Assembly and Pole .....	1077.03

**CONSTRUCTION REQUIREMENTS**

**877.03 Installation.** The components of a mast arm assembly and pole shall be assembled and erected according to the details shown on the plans. The pole shall be erected vertically on a concrete foundation. The Contractor shall furnish and install the required nuts and washers for mounting and plumbing the pole on the anchor rods. After the entire assembly has been aligned and plumbed, a stainless steel mesh 1/4 in. (6 mm) maximum opening with a minimum wire diameter AWG No. 16 (1.5 mm) shall be stainless steel banded to the anchor rods with a minimum 2 in. (50 mm) lap to enclose the void between the mast arm base plate and the concrete foundation. The pole shall be grounded according to Section 806.

The Contractor shall take precautions to avoid scratching the galvanized coating on the mast arm pole and assembly during the transportation and erection. If it is scratched, the Contractor shall repair the galvanized coating according to ASTM A 780 and the manufacturer's recommendations. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

A combination mast arm assembly and pole shall not be installed without the luminaire.

**877.04 Basis of Payment.** This work will be paid for at the contract unit price per each for STEEL MAST ARM ASSEMBLY AND POLE or STEEL COMBINATION MAST ARM ASSEMBLY AND POLE, of the signal arm length specified.

**SECTION 878. TRAFFIC SIGNAL CONCRETE FOUNDATION**

**878.01 Description.** This work shall consist of constructing a concrete foundation for a traffic signal post, controller base, or mast arm pole.

**878.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete .....	1020
(b) Reinforcement Bars .....	1006.10(a)
(c) Anchor Rods .....	1006.09

**CONSTRUCTION REQUIREMENTS**

**878.03 Installation.** The top of the foundation shall be finished level. Shimming of the appurtenance to be attached will not be permitted. A form extending a minimum of 9 in. (225 mm) and a maximum of 24 in. (600 mm) below the top surface of the foundation is required. The form shall be set level, and means shall be provided for holding it rigidly in place while the concrete is being deposited. The form shall remain undisturbed for at least 24 hours after the concrete has been poured.

Where a concrete foundation is contiguous to a sidewalk, preformed joint filler of 1/2 in. (13 mm) thickness shall be placed between the foundation and the sidewalk.

All raceways in the foundation shall be installed rigidly in place before concrete is deposited in the form. Bushings shall be provided at the ends of conduit. Anchor rods and ground rod shall be set in place before the concrete is deposited by means of a template constructed to space the anchor rods according to the pattern of the bolt holes in the base of the appurtenance to be attached.

Grounding electrodes shall be according to Section 806.

- (a) Square or Rectangular Foundations. Whenever the excavation is irregular, a form shall be used to provide the proper dimension of the entire foundation below the ground surface.
- (b) Drilled Shaft Foundations. Drilled shaft foundations shall be constructed according to Section 516 and the following.

The submittal requirements as stated in Article 516.04 shall not apply.

Concrete shall be cured before poles are installed.

**878.04 Method of Measurement.** The foundation will be measured for payment in feet (meters) in place. The length measured will be limited to that shown on the plans or authorized by the Engineer.

Excavation in rock will be measured for payment according to Article 502.12.

**878.05 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) of depth of CONCRETE FOUNDATION, of the type specified.

Excavation in rock will be paid for according to Article 502.13.

Obstruction mitigation will be paid for according to Article 109.04.

**SECTION 879. DRILL EXISTING FOUNDATION OR HANDHOLE**

**879.01 Description.** This work shall consist of drilling a hole in an existing concrete foundation or handhole and for furnishing and installing a new conduit.

**CONSTRUCTION REQUIREMENTS**

**879.02 General.** The size of the hole shall be as close as possible to the size of the conduit. A conduit of the size required shall be installed in the drilled hole. A bushing shall be provided at the end of the conduit. The space between the conduit and the foundation shall be caulked with a waterproof grout.

**879.03 Basis of Payment.** This work will be paid for at the contract unit price per each for DRILL EXISTING FOUNDATION or DRILL EXISTING HANDHOLE, which price shall include all necessary excavation and backfilling outside of the foundation or handhole.

**SIGNAL HEADS**

**SECTION 880. SIGNAL HEAD, OPTICALLY PROGRAMMED SIGNAL HEAD, AND LIGHT EMITTING DIODE (LED) SIGNAL HEAD**

**880.01 Description.** This work shall consist of furnishing and installing a conventional signal head, optically programmed signal head, or light emitting diode (LED) signal head.

**880.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Signal Head, Optically Programmed Signal Head, and Light Emitting Diode (LED) Signal Head.....	1078.01

**CONSTRUCTION REQUIREMENTS**

**880.03 Installation.** The signal head shall be installed on a post, bracket, span wire, or mast arm as shown on the plans. Other methods of attaching the signal head to a post, a mast arm pole, or a mast arm may be used upon approval by the Engineer. Signal heads consisting of only one face and up to three sections may be post mounted.

Each signal face shall be pointed in the direction of the approaching traffic it is to control and be aimed to have maximum effectiveness for an approaching driver located at a distance from the stop line equal to the normal distance traversed while stopping. The optically programmed signal face shall be veiled according to the visibility requirements at the direction of the Engineer.

The size of each signal lens shall be 12 in. (300 mm).

During construction and until the installation is placed in operation, all signal faces shall be hooded. The hooding material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the hooding materials shall differentiate the signal as being hooded.

**880.04 Basis of Payment.** This work will be paid for at the contract unit price per each for SIGNAL HEAD, OPTICALLY PROGRAMMED SIGNAL HEAD, or SIGNAL HEAD, LED of the type specified, and of the particular kind of material, when specified.

If a signal head with both conventional and optically programmed signal faces is required, it will be paid for as a COMBINATION SIGNAL HEAD.

The type specified will indicate the number of signal faces, the number of signal sections in each signal face, and the method of mounting.

**SECTION 881. PEDESTRIAN SIGNAL HEAD**

**881.01 Description.** This work shall consist of furnishing and installing a conventional pedestrian signal head or light emitting diode (LED) pedestrian signal head.

**881.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Pedestrian Signal Head .....	1078.02

**CONSTRUCTION REQUIREMENTS**

**881.03 Installation.** The pedestrian signal head shall be installed on a post or bracket as shown on the plans. Other methods of attaching the pedestrian signal head to a post or a mast arm pole may be used upon approval by the Engineer.

Each pedestrian signal face shall be aimed to provide maximum visibility at the beginning of the controlled crossing.

The size of the pedestrian signal face shall be Class 2, 3, or 4 according to the ITE Standards. All pedestrian signal faces of one intersection shall be of the same Class and design.

During construction and until the installation is placed in operation, all pedestrian signal faces shall be hooded. The hooding material shall be securely fastened so it

will not be disturbed by normal inclement weather or wind. The color of the hooding material shall differentiate the pedestrian signal faces as being hooded.

**881.04 Basis of Payment.** This work will be paid for at the contract unit price per each for PEDESTRIAN SIGNAL HEAD or PEDESTRIAN SIGNAL HEAD, LED of the type specified, and of the particular kind of material, when specified.

The type specified will indicate the number of faces and the method of mounting.

**SECTION 882. TRAFFIC SIGNAL BACKPLATE**

**882.01 Description.** This work shall consist of furnishing a traffic signal backplate and attaching it to a traffic signal face.

**882.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Traffic Signal Backplate .....	1078.03

**CONSTRUCTION REQUIREMENTS**

**882.03 Installation.** The traffic signal backplate shall be securely attached to a traffic signal face with noncorrosive bolts, locknuts, and washers. At least one bolt shall be used on each side of a signal section in contact with the backplate.

**882.04 Basis of Payment.** This work will be paid for at the contract unit price per each for TRAFFIC SIGNAL BACKPLATE, of the type specified, and of the particular kind of material, when specified.

**SECTION 883. DIRECTIONAL LOUVER**

**883.01 Description.** This work shall consist of furnishing and installing a directional louver for a 12 in. (300 mm) signal lens in the signal heads.

**883.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Directional Louver .....	1078.04

**CONSTRUCTION REQUIREMENTS**

**883.03 Installation.** The directional louver shall provide an angle of cutoff on each side of the center axis of the light beam as follows.

Type A	0 to 6 degrees
Type B	7 to 10 degrees
Type C	11 to 14 degrees

The directional louver shall be installed inside the signal visor in front of the signal lens and secured in place with a minimum of two metal screws.

**883.04 Basis of Payment.** This work will be paid for at the contract unit price per each for DIRECTIONAL LOUVER, of the type specified.

When used with a 8 in. (200 mm) lens, this work will be paid for at the contract unit price per each for DIRECTIONAL LOUVER, of the type specified.

**DETECTION**

**SECTION 885. INDUCTIVE LOOP DETECTOR**

**885.01 Description.** This work shall consist of furnishing and installing an inductive loop detector.

**885.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Inductive Loop Detector .....	1079.01

**CONSTRUCTION REQUIREMENTS**

**885.03 Installation.** The inductive loop detector shall be installed inside a traffic signal controller cabinet. The detector shall be either card rack type or shelf-mounted type. The detector may be single-channel, two-channel, or four-channel.

**885.04 Basis of Payment.** This work will be paid for at the contract unit price per each for INDUCTIVE LOOP DETECTOR or INDUCTIVE LOOP DETECTOR WITH SYSTEM OUTPUT, which price shall include the necessary connections and adjustments for proper operation.

If the detector unit has more than one complete detection channel, each complete detection channel will be considered as a detector for payment.

**SECTION 886. DETECTOR LOOP**

**886.01 Description.** This work shall consist of furnishing and installing a detector loop in the pavement.

**886.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Detector Loop and Sealer .....	1079.02

The detector loop and sealer shall be according to the recommendations of the manufacturer of the related inductive loop detector as needed for proper operation.

**CONSTRUCTION REQUIREMENTS**

**886.03 Testing.** The detector loop shall be tested according to Article 801.13(b)(2).

**886.04 Installation.** The detector loop location, shape, size, and the number of turns shall be as shown on the plans or as recommended by the manufacturer of the related inductive loop detector. Multiple loops connected to the same detector channel shall be connected in series or as directed by the Engineer. The detector loop shall be installed in the pavement according to the details shown on the plans and the following requirements.

- (a) Type I detector loop shall consist of furnishing a detector loop wire enclosed in a flexible tubing and installing it in a sawed slot in the pavement.

The sawed slot shall be clean, dry, and have a smooth bottom. Diagonal saw cuts or drilled holes shall be made at all corners to prevent sharp bends in the wire. The saw cuts at the corners shall be overlapped so they have full depth. The slot shall be cleaned by air pressure removing any debris and water, if any present. Each tube containing the loop wire shall be pushed into the saw cut with a wooden stick and not with any metal tool.

Retainers shall be added to the sawed slot to prevent the loop wires from floating during the pouring of the loop sealant. These retainers shall be 1 in. (25 mm) pieces of the tubing bent in half. The loop wires not embedded in the pavement shall be evenly twisted approximately 5 turns per foot (16 turns per meter).

- (b) Type II detector loop shall consist of furnishing a mineral-insulated metal-sheathed cable, installing it on a HMA or portland cement concrete base course and covering it with a HMA surface course. The surface course shall be between 2 and 5 in. (50 and 125 mm) thick. The cable shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The leads shall be bound together with tie wraps or fish tape rope, inserted through the hole, and positioned in place to make splices in the junction box or handhole.

The end of the cable shall be stripped, insulated and installed in a sleeve assembly according to the manufacturer's instructions to prevent moisture from entering the cable. The sleeved conductors shall be spliced together to form one continuous length. As each splice is made, it shall be metered to ensure a proper connection. The conductors must be soldered together and each conductor completely wrapped with two layers of rubber or vinyl electrical tape.

- (c) Type III detector loop shall consist of one of the following.

- (1) Rigid Plastic Conduit. This detector loop shall consist of furnishing a detector loop wire sealed with asphalt rubber or waterproof flexible sealant inside a rigid plastic conduit, installing it on a HMA or portland cement concrete base course and covering it with a HMA surface

course. The surface course shall be between 2 and 5 in. (50 and 125 mm) thick. The conduit shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The plastic conduit shall be inserted through the hole toward the junction box or handhole.

- (2) Heavy Duty Reinforced Rubber Conduit. This detector loop shall consist of furnishing a detector wire sealed with asphalt rubber or waterproof flexible sealant inside a conduit made of heavy duty reinforced rubber hose.

When the detector loop is installed on a HMA or portland cement concrete base course, and covered by a HMA surface course, the surface course shall be between 2 and 5 in. (50 and 125 mm) thick.

When the detector loop is covered by portland cement concrete surface course, the surface course shall be between 2 and 16 in. (50 and 400 mm) thick. The conduit shall be secured to the base course by a method approved by the Engineer. The conduit shall be secured to reinforcing steel in the pavement, at each point the conduit crosses the reinforcing steel, in order to prevent shifting of the loop as the surface course is poured. When loops are secured to the top of reinforcing steel, care must be taken to prevent the steel from cutting into the conduit when the portland cement concrete surface course is poured over the top. In new roadways, the conduit may be placed directly on top of the gravel substrate.

**886.05 Method of Measurement.** This work will be measured for payment in feet (meters) in place. Type I detector loop will be measured along the sawed slot in the pavement containing the loop and lead-in, rather than the actual length of the wire. Type II and Type III detector loops will be measured along the detector loop and lead-in embedded in the pavement, rather than the actual length of the wire.

**886.06 Basis of Payment.** This work will be paid for at the contract unit price per foot (meter) for DETECTOR LOOP, of the type specified.

## SECTION 887. EMERGENCY VEHICLE PRIORITY SYSTEM

**887.01 Description.** This work shall consist of furnishing a light transmitter, furnishing and installing a light detector, or a light detector amplifier, for an emergency vehicle priority system.

**887.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Emergency Vehicle Priority System .....	1072

**CONSTRUCTION REQUIREMENTS**

**887.03 Installation.** The light transmitter shall be furnished to the user as directed by the Engineer.

The light detector shall be installed on or near a traffic signal head with necessary connections for proper operation, as indicated on the plans. The confirmation beacon shall be installed near the light detector or as indicated on the plans and shall face in the same direction as the corresponding light detector.

The light detector amplifier shall be installed inside a traffic signal controller cabinet or in the light detector housing.

**887.04 Basis of Payment.** This work will be paid for at the contract unit price per each for LIGHT TRANSMITTER, LIGHT DETECTOR, or LIGHT DETECTOR AMPLIFIER.

Furnishing and installing a confirmation beacon shall be included in the cost of the light detector.

**SECTION 888. PEDESTRIAN PUSH-BUTTON**

**888.01 Description.** This work shall consist of furnishing and installing a pedestrian push-button and an appropriate traffic signal instruction sign.

**888.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Pedestrian Push-Button .....	1074.02

**CONSTRUCTION REQUIREMENTS**

**888.03 Installation.** The pedestrian push-button shall be mounted approximately 42 in. (1050 mm) above the sidewalk level. The mounting saddle shall be completely in contact with the post or pole on which it is mounted. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly. The methods of mounting both the pedestrian push-button and the sign shall be approved by the Engineer.

The traffic signal instruction sign applicable to pedestrians shall be according to the National MUTCD, i.e., signs in series R 10-1 through R 10-4.

**888.04 Basis of Payment.** This work will be paid for at the contract unit price per each for PEDESTRIAN PUSH-BUTTON.

**MISCELLANEOUS**

**SECTION 890. TEMPORARY TRAFFIC SIGNAL**

**890.01 Description.** This work shall consist of furnishing, installing, maintaining, and removing a temporary traffic signal installation as shown on the plans.

**CONSTRUCTION REQUIREMENTS**

**890.02 Installation.** The Contractor shall notify the Engineer at least 48 hours in advance when the temporary signal installation is ready to be activated. The Engineer will then inspect the installation. After approval by the Department, the maintenance of the temporary signal installation, including all energy charges, shall become the responsibility of the Contractor until removal is directed by the Engineer.

After the removal of the temporary installation, the equipment and materials furnished by the Contractor shall remain the property of the Contractor.

**890.03 Maintenance.** The temporary traffic signal maintenance shall be according to Article 801.11(b).

**890.04 Basis of Payment.** This work will be paid for at the contract unit price per each for TEMPORARY TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

Following approval of each installation, 60 percent of the bid price will be paid. The remaining 40 percent will be paid following removal of each installation.

**SECTION 891. ILLUMINATED SIGN**

**891.01 Description.** This work shall consist of furnishing and installing an illuminated sign.

**891.02 Materials.** Materials shall be according to the following.

Item	Article/Section
(a) Illuminated Sign .....	1084.01

**891.03 Basis of Payment.** This work will be paid for at the contract unit price per each for ILLUMINATED SIGN, FIBER-OPTIC or ILLUMINATED SIGN, LED.

## REMOVAL AND RELOCATION

### SECTION 895. REMOVAL, RELOCATION, AND REBUILDING OF EXISTING SIGNAL AND APPURTENANCES

**895.01 Description.** This work shall consist of the removal, removal and relocation, and/or the rebuilding of existing signal items and appurtenances in the construction of signalized intersections.

### CONSTRUCTION REQUIREMENTS

**895.02 Relocation.** All existing signal items shall be removed and relocated as shown on the plans. The installation shall be done according to the specifications for the specific item. Any damage done to the existing signal items or appurtenances shall be repaired or replaced by the Contractor at his/her own expense, as directed by the Engineer.

Relocation of the existing traffic signal controller and its associated equipment shall also consist of reusing the controller cabinet. Anchor rods, nuts, and washers shall be new for the installation of an existing traffic controller. The controller shall be installed according to Article 857.03.

Relocation of an existing signal head shall consist of removing an existing signal head, optically programmed signal head, light emitting diode (LED) signal head, or combination signal head and installing it according to Article 880.03.

Installation of the pedestrian signal head shall be according to Article 881.03.

Installation of an existing illuminated sign shall be according to Section 891.

Relocation of an existing signal post, controller cabinet, or mast arm assembly and pole shall include the removal and installation on a new concrete foundation with new anchor rods, nuts, and washers, according to Article 878.03.

When removing an existing pedestrian push-button, the related sign shall be removed and installed at the new location. The push-button shall be installed according to Article 876.03.

**895.03 Rebuilding Signal Head.** The existing signal components shall be removed and altered by adding or removing signal faces and/or mounting hardware. The additional signal faces and/or sections shall be of the same type and make as the existing signals. All lenses and reflectors shall be cleaned, and the reassembled signal head shall be cleaned and repainted. Rebuilding an existing signal head may require removing old components and/or adding new components. All components removed from the existing signal head and not reused shall be disposed of as directed by the Engineer. The Contractor may, without additional compensation, furnish all new components, in lieu of rebuilding. Installation shall be according to Article 880.03.

**895.04 Modifying Existing Controller.** This work shall consist of modifying an existing controller to change the existing sequence of operation to the proposed sequence of operation. Both the existing and the proposed sequence of operation will be shown on the plans. Upon completion, the Contractor shall furnish the Engineer five copies of the cabinet wiring diagram.

**895.05 Removal.** Removal of existing signal and appurtenances shall be as follows.

- (a) Existing Traffic Signal Equipment. The existing traffic signal equipment at an intersection shall be removed and disposed of as listed on the plans and as directed by the Engineer. The Contractor shall be responsible for repairing or replacing any items of equipment damaged during the process to the satisfaction of the Engineer.

All equipment shall be stored off the job site at an approved location, and electrical components shall be stored indoors.

- (b) Handhole. The frame and cover of an existing handhole shall be broken off the top section of the handhole wall to a minimum depth of 3 ft (900 mm) below the surrounding grade, or as specified, backfilled with approved material, and the surface reconstructed to match the adjoining area. The concrete debris shall be disposed of outside the right-of-way, and the frame and cover disposed of as directed by the Engineer. If the handhole is located in the sidewalk area, the entire sidewalk square or squares where the handhole is located shall be replaced with new sidewalk.
- (c) Concrete Foundation. The concrete foundation shall be removed to a level at least 3 ft (900 mm) below the adjacent grade, backfilled with approved material, and the surface reconstructed to match the adjoining area. The foundation shall be disposed of outside the right-of-way. If the concrete foundation is located in the sidewalk area, the entire sidewalk square or squares where the concrete foundation is located shall be replaced with new sidewalk.
- (d) Electric Cable from Conduit. An existing electric cable shall be removed, as directed by the Engineer, from a conduit.

**895.06 Removal and Reinstallation.** This work shall consist of removing an existing electric cable from a conduit and then reinstalling it in an existing or a new conduit. The conduit shall be cleaned and swabbed prior to reinstallation of cable.

**895.07 Method of Measurement.** Removal, and removal and reinstallation of existing electric cable will be measured for payment in place in feet (meters). If two or more cables in a conduit are to be removed, or removed and reinstalled, each cable will be measured for payment separately.

Concrete foundations, when specified, will be measured for payment according to Article 878.04.

**895.08 Basis of Payment.** Removal and Relocation will be paid for at the contract unit price per each for RELOCATE EXISTING SIGNAL HEAD, RELOCATE EXISTING PEDESTRIAN SIGNAL HEAD, RELOCATE EXISTING ILLUMINATED SIGN, or RELOCATE EXISTING PEDESTRIAN PUSH-BUTTON.

Removal and reinstallation of existing traffic signal items will be paid for at the contract unit price per each for RELOCATE EXISTING TRAFFIC SIGNAL CONTROLLER, RELOCATE EXISTING TRAFFIC SIGNAL POST, or RELOCATE EXISTING MAST ARM ASSEMBLY AND POLE.

Concrete foundations, when specified, will be paid for according to Article 878.05.

Rebuilding an existing signal head will be paid for at the contract unit price per each for REBUILD EXISTING SIGNAL HEAD.

Modifying an existing controller will be paid for at the contract unit price per each for MODIFY EXISTING CONTROLLER. Some of the parts and equipment required for the completion of this work may be listed on the plans as separate pay items.

Removal of an existing electric cable will be paid for at the contract unit price per foot (meter) for REMOVE ELECTRIC CABLE FROM CONDUIT.

Removing and reinstalling the electric cable will be paid for at the contract unit price per foot (meter) for REMOVE AND REINSTALL ELECTRIC CABLE FROM CONDUIT.

Removal of existing traffic signal equipment will be paid for at the contract unit price per each for REMOVE EXISTING TRAFFIC SIGNAL EQUIPMENT. Removal of existing handholes will be paid for at the contract unit price per each for REMOVE EXISTING HANDHOLE. Removal of existing concrete foundations will be paid for at the contract unit price per each for REMOVE EXISTING CONCRETE FOUNDATION.