

ROADWAY LIGHTING

1. **GENERAL REQUIREMENTS**

Scope of Work: Furnish all necessary supervision, labor, material, tools and equipment, including materials and equipment not specifically mentioned but necessary to complete the work in a neat, correct, and workmanlike manner, to include:

- 1) Electrical services complete to the point of connection with the utility company's facilities.
- 2) Service entrance equipment, including control panels.
- 3) Complete grounding system for lighting and equipment, including grounding conductors, ground rods, and grounding connections.
- 4) Complete branch circuit wiring system for lighting and equipment, including conduit, trenching and backfill, jacking and boring, concrete encasement, pull boxes, and wiring.
- 5) Lighting fixtures, poles and foundations for roadway lighting.

Design of Lighting Systems: The Contractor will be responsible for designing the lighting systems to include length of circuit runs and conduit and conductor requirements and designing of lighting cabinets and controls and components required. The contractor shall provide a schematic of the systems as well as the control cabinets and circuitry. The finished plan shall be submitted to the Director of Traffic Engineering's office for review and acceptance before work can begin. This submittal may be made by hard copies of the documents or provided electronically in an Adobe Acrobat (pdf) format.

Existing Conditions: The Contractor will be held responsible for having visited the site and having familiarized himself with the existing conditions prior to submitting his bid. No adjustment in the contract unit prices will be allowed for field conditions with which the Contractor did not appraise during his field visit.

The Contractor shall be responsible for consulting with the various utilities and local underground utility location services to determine the exact locations of utilities and will bear all costs thereof. Any damages to existing underground utilities caused by the Contractor's workmen or subcontractors will be repaired by the owner of the damaged utility and paid for by the Contractor.

Coordination: All work under this Section shall be coordinated with other trades to insure proper location of outlets and equipment connections, and to minimize conflicts with structural members, piping, grading, etc. Conflicts between equipment and/or material locations shall be resolved as directed by the Engineer at no additional cost to the Department.

Utilities: The service locations, arrangement and metering for electrical service entrances shall be coordinated in detail with the service provider. All provisions necessary for the services shall be provided in the Electrical Contractor's bid, unless otherwise indicated.

Codes and Permits: Installation and materials shall be in accordance with the current editions of NFPA-70 National Electrical Code, ANSI C2 National Electrical Safety Code, and all local codes. The Contractor shall apply and pay for all permits and inspection required by local and state governments for this construction.

Drawings: The drawings and specifications shall be considered as complementary, one to the other, so that materials and labor indicated, called for, or implied by either shall be furnished and installed as if required by both. Where a disagreement exists between the plans and specifications, the item or arrangements of better quality, greater quantity, or higher cost shall be included in the base bid. Any discrepancies between the drawings, specifications, and field conditions shall be resolved with the Engineer prior to commencing work. All agreements shall be verified in writing.

As-Built Drawings: The Contractor shall maintain one set of clean blueprints for "As-Built" drawings. All changes, revisions, or modifications to the project shall be recorded daily on these drawings as well as final locations of conduits, pull boxes, luminaires, etc. with red-line pencil. Upon completion of the project, these red-line drawings shall be turned over to the Engineer for preparation of final "As-Built" drawings. The drawings shall include:

- Final locations of service panels, meters, etc.
- Final routing of conduit runs
- Final locations of light poles
- Final locations of junction boxes
- Final locations and number of jacked and bored conduits

Maintenance and Operating Manual: The Contractor shall furnish the Department eight (8) complete maintenance and operating manuals for each piece of equipment and material furnished under this project. These manuals shall be bound in hard cover binders with tabs for each item or piece of equipment. The manuals shall be furnished prior to the final inspection, and final acceptance shall not be given until the system maintenance personnel are instructed in maintenance and operation of all systems.

Guarantee: All materials and labor furnished under this Section of the specifications shall be guaranteed by the Contractor to be free from defects for a period of six months from the date of acceptance. The Contractor shall repair or replace any deficiencies reported in the guarantee period promptly after notification, without any additional compensation from the Owner.

Submittals and Approvals: At least 30 days prior to ordering any materials or equipment or beginning work on lighting system, submit three (3) sets of shop

drawings and equipment specifications to the Director of Traffic Engineering for approval on the following materials:

- 1) Control Panels, including all devices and Equipment.
- 2) Lighting Fixtures, Poles, Lowering Systems, Lamps, and Ballasts.
- 3) Wire and Cable.
- 4) Raceways and Fittings.
- 5) Pull boxes, Pull Boxes, and Junction Boxes.

2. **MATERIALS**

General: All materials shall be listed by Underwriter's Laboratories, and shall bear the "UL" Label, where applicable.

Substitutions: Specific reference in the specifications to any article, device, product, material, fixture, form or type of construction, etc., by name, make or catalog number, with or without the words "or equal" shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. The Contractor may, at his option, propose for consideration any article, device, product, material, fixture, form or type of construction, which in his opinion is equal to that herein named.

Requests for written approval to substitute materials or equipment to those specified shall be submitted for approval to the Engineer ten (10) days before bids are taken. Requests shall be accompanied by samples, descriptive literature, and engineering information, as necessary too fully identify and appraise the product. No increase in the contract sum will be considered when requests are not approved. If the item is found to be equal, the Engineer will issue an Addendum making it a part of the Contract Documents prior to bidding.

Cable: Underground cable for low voltage parallel circuits shall conform to the requirements of Underwriter's Laboratories UL-83 for copper conductor with Type RHH-RHW-USE, 600 volt, 75 C, cross linked polyethylene insulation.

All cable shall be 7 or 19 strand in accordance with ASTM B8. For power cable, conductor size shall not be smaller than No. 8 AWG. Control cable conductor size shall not be less than No. 14 AWG. These limits on conductor sizes shall not apply to leads furnished by manufacturers on fixtures and equipment.

Cable type, size, number of conductors, strand and service voltage shall be determined by the Contractor.

Cable Connections: In-line connections for roadway lighting circuits which are located in the base of each pole shall be fused molded rubber connector kits, Elastimold Style 82S, or approved equal of Bussman or Gould. One kit shall be used for each conductor.

Fuses shall be dual element, current limiting type rated 600 volt and shall conform to the requirements of UL 168.

Plastic Conduit and Fittings: Plastic conduit shall be sunlight resistant polyvinyl chloride (PVC), SCHEDULE 80, meeting the requirements of National Electrical Manufacturing Association (NEMA) Specification TC-2 and Underwriter Laboratory (UL) Standard UL-514, and/or ASTM-D1784. Fittings shall meet NEMA TC-3 and UL-514. No half or quarter size conduit shall be used. Conduit sizes shall be as follows: 1 inch, 2 inch, 3 inch and so on.

Galvanized Rigid Conduit and Fittings: Galvanized rigid conduit shall conform to the requirements of Federal Specification WW-C-581, American Standards Association Specification USAS C80.1-1996 and Underwriter's Laboratories UL 6, with full weight screwed fittings. Bushings for conduits 1.5" and larger shall be grounding type with insulated throat.

Expansion fittings shall be provided in conduit systems at all structural expansion joints. Expansion fittings shall be linear sleeve type, constructed from conduit sleeves and reducing fittings. A braided copper grounding jumper shall be provided with each expansion fitting. Expansion fittings shall provide for 8 inches maximum movement. Fittings shall be O-Z type EXPB, or equal of Crouse Hinds, Appleton, Killark or Spring City.

HDPE Rolled Conduit: Under ground conductors may be installed in HDPE rolled conduit, plowed or directional bored in. The conduit shall be a minimum of schedule 80 or SDR 11 HDPE and shall be red in color. HDPE shall not be used where the conduit is exposed. If splicing of the HDPE conduit is required, comfit fittings shall be used.

Pull boxes: Pull boxes shall be Armorcast A6001640TAPCX28, 17"x30"x28", or approved equal. All pull boxes shall have SCDOT ELECTRIC logo cast on the lid. There shall be a red passive marking ball, operating at a frequency of 169.8KHZ installed in each pull box. The red passive marker ball shall be compatible with a Metro Mark passive marker locator 760 Dx or approved equal.

Marking Posts: Marking Posts shall be round dome type, ProMark PM303 or approved equal, red in color with the word "WARNING ELECTRIC" on them.

Concrete and Reinforcement: Concrete for light pole foundations and concrete encasement of conduits shall conform to the requirements of ASTM C-387 and shall be rated for 3000 psi minimum compressive strength at 28 days.

Reinforcing steel shall be deformed steel reinforcement bars conforming to the requirements of ASTM A-615, Grade 60. Anchor bolts shall be provided as recommended by the pole manufacturer. Anchor bolts shall be in accordance

with ASTM A-687 and anchor bolt nuts shall be in accordance with ASTM A-563. Bolts and nuts shall be galvanized in accordance with ASTM A-123.

Roadway Luminaires: . Luminaires shall be Holophane Mongoose Series or approved equal meeting the following requirements. Roadway luminaires shall be 250 watt, high pressure sodium. Luminaires shall be top, vertical tenon mounted, directional with adjustable tilt from 0 to 18 degrees, complete, including integral ballast, reflector, refractor, and housing with all stainless steel hardware. All mating surfaces shall be gasketed, and secured with standard threaded machine screws. Luminaires shall be equipped with a narrow roadway prismatic refractor. Luminaires shall have light gray painted finish, terminal block and NEMA decal, 6 foot pigtail and Sylvania 250 watt clear Mogul base "O" TCLP compliant lamp.

Ballasts shall be 480 volt high power factor autoregulator type mounted internally in the fixture. The HPS starter shall be totally encapsulated with a material that electrically and thermally insulates all components from lamp and ballast heat. The starter shall sense an inoperative lamp and shut down automatically to prevent continuous pulsing and damage to itself and the ballast. Lamp leads shall be provided with quick disconnect so that ballast assembly is readily removed.

High Mast Luminaires: Luminaires shall be Holophane HMST Series, or approved equal. High mast luminaires shall be 1000 watt, high pressure sodium. Luminaires shall be high mast type, with vertical lamp, cast aluminum ballast housing, Alzak aluminum reflector, heavy duty glass refractor assembly, and all stainless steel hardware. All mating surfaces shall be gasketed. Luminaires within the interchanges shall be designed with IES Type V, symmetrical light distribution. Luminaires along the mainline shall be designed with IES Type III, asymmetrical light distribution. Luminaires shall have light gray painted finish.

Ballasts shall be 480 volt high power factor autoregulator type. The HPS starter shall be totally encapsulated with a material that electrically and thermally insulates all components from lamp and ballast heat. The starter shall sense an inoperative lamp and shut down automatically to prevent continuous pulsing and damage to itself and the ballast. Lamp leads shall be provided with quick disconnect so that ballast assembly is readily removed.

Light Poles (General): Equipment and materials covered by other referenced specifications shall be subject to acceptance through the manufacturer's certification of compliance with the applicable specifications.

Poles shall be as specified on the drawings and in the proposal and shall be manufactured in accordance with AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals". Poles shall be rated for 90 MPH wind load using effective projected area of the proposed luminaire(s) and luminaire mounting bracket(s) for the wind load.

Roadway Lighting Poles: Poles and accessories shall be spun brushed aluminum. Each pole shall be provided with a top mounted vertical mounting tenon. Aluminum poles shall be provided with a cast aluminum base welded to the lower end. After bonding or welding, the base shall develop the full strength of the adjacent shaft to resist bending action. Poles shall be 35 feet or as specified in the plans.

Removable anchor bolt covers shall be provided with each pole. Covers shall be secured to the base plate with tamperproof, stainless steel screws.

Anchor bolts shall be sized as recommended by the pole manufacturer and shall be provided with frangible breakaway couplings as well as a breakaway electrical coupling. Anchor bolts shall meet the requirements of ASTM A-576, Grades 1025 to 1055 inclusive, with minimum yield strength of 50,000 psi. Anchor bolts and hardware shall be hot dipped galvanized in accordance with ASTM A-153. Two nuts, two lock washers, and one flat washer shall be furnished with each anchor bolt.

High Mast Lighting Poles and Lowering System: High mast poles and lowering device shall be manufactured by Holophane, or approved equal.

High Mast Lighting Poles: Poles shall be round tapered galvanized steel designed for support of the number and type of luminaires, support ring, and lowering device as specified. Pole shall be fabricated from ASTM-A595 Grade A high strength steel, hot dipped galvanized in accordance with ASTM A-123. Sectional poles will be permitted.

Shaft shall be furnished with handhole(s) for access to the circuit breaker and the lowering system winch and mechanism. The handhole(s) shall be secured to the pole with tamperproof stainless steel screws. Handholes shall be reinforced to provide the equivalent strength of the pole section lost in the opening. A mounting bracket for attaching the portable lowering device shall be provided.

Fabrication and welding of the poles shall be in accordance with the requirements of AWS D1.1 Specification. All welds shall be inspected according to the AWS standards, using dye penetrant or magnetic particle inspections. The first welded joint of each full penetration transverse weld for each order shall be nondestructively examined to certify that the weld is of required quality. Longitudinal seam welds shall have a minimum of 60% penetration and shall be verified by polishing, etching, and examining a trimming cut-off from selected male tube ends. The female tube ends in the area of telescoping joints shall be welded both inside and outside to insure the integrity of the weld. No transverse welding shall be permitted to secure telescoping joints.

Anchor bolts shall be sized as recommended by the manufacturer of ASTM A-687 steel and shall be provided with a bearing plate of ASTM A-36 steel. Threaded ends of anchor bolts shall be galvanized per ASTM-A-153. Each anchor bolt shall be supplied with two anchor nuts and two flat washers.

High Mast Lowering System (Top Latching Type): The lowering system shall be Holophane LD5, or approved equal. It shall consist of 1) head frame; 2) luminaire ring; 3) circuit breaker assembly. The head frame structure shall be zinc coated steel.

The head frame shall encompass cable sheaves. The sheave shall be zinc-electroplated per ASTM A-164 and yellow chromate dipped for corrosion resistance. Oil-impregnated sintered bronze bushings shall be pressed into the steel sheave hub and shall ride on stainless steel shafts.

The hoisting cables shall be stainless steel 7 x 19 aircraft cable of 3/16" diameter manufactured per MIL Spec W-5424.

The power cord roller assembly shall consist of rollers mounted between two cold-rolled steel plates. The plates shall be zinc-electroplated per ASTM A-164 and yellow chromate dipped. The power cord shall ride on rollers mounted on AISI 304 stainless steel shafts. Six rollers shall be located on a radius on either end of the plates to support the power cord in a seven inch bending radius. At either end of the plates, a keeper bar shall be provided over the power cord between the plates to keep the cord in its track during pole erection and during normal operation. The head frame shall be covered with an aluminum cover.

The head frame shall also include three latch barrels which support the luminaire ring assembly. Latching shall be accomplished by the alternate raising and lowering of the luminaire ring assembly by the winch and hoisting assembly. There shall be no moving latch parts or springs attached to the head frame assembly. The latching and locking of each latching mechanism shall be signaled by retro-reflecting indicator flags visible from the ground. The latching mechanism shall not be impaired by formation of ice and shall not require adjustment after the original installation.

The luminaire ring shall be fabricated of steel C-channel, hot dip galvanized per ASTM A-386 Class B with the appropriate number of 2" nominal galvanized steel pipe mounting arms. The luminaire ring shall be wired with a power cord of a suitable number of conductors and current carrying capacity for the total load, with 2% maximum voltage drop.

Electrical cords shall be attached to weather-tight wiring chamber through weather-tight cable connections. A prewired 600 volt terminal block shall be provided in the weather-tight chamber. A weather-tight twistlock power inlet shall be provided on the chamber to allow testing of the luminaires while in the lowered position.

Roller-contact, spring-loaded centering arms shall be provided which will center the luminaire ring while ascending and descending the pole. The arm system shall be capable of keeping the ring concentric with the pole in winds up to 30

MPH. Ultimate support of the luminaire ring shall be sacrificed by individual or total spring failure.

The winch shall have an ultimate strength of five times the lifted load with the number of layers of cable with which it will be used. The winch shall have a worm gear reduction ratio, and include an integral friction drag brake on the worm shaft to prevent free spooling of the winch.

The winch shall be prewound with stainless steel 7 x 19 aircraft cable manufactured per MIL W-5424 of 1/4" diameter. The drum shall be supported at both ends and keepers shall be provided to insure that uncoiled cable will rewrap onto the drum.

Portable Drive Motor for High Mast Lowering Device: The portable power unit shall contain the drive motor, torque limiter, and cable wound winch. The power unit shall have the capability of installation, operation, and removal by one person. Two (2) portable power units shall be turned over to the Department upon completion of the project.

The drill motor shall be the heavy-duty reversing type with a stalling torque at least twice that required to operate the device. The drill shall drive the winch through the torque limiter coupling to limit the lifting force. There shall be a back-up shear pin designed to shear at a torque level between 35% and 70% over the torque limiter setting. The drill shall be controlled by a reversing switch connected by a 20 foot remote cord.

Control Panels: Control panels for the lighting shall be installed at locations as suggested on the plans with final locations determined by the contractor and approved by the Engineer.

Panelboards, contactors, and control switches for control of lighting shall be mounted inside a weatherproof NEMA 4X stainless steel enclosure, as manufactured by Electromate, Bee-Line, Hoffman Engineering, or Austin Berryhill. Panel shall be equipped with 3-point latching door with provision for padlocking and 120 volt NEMA 5-15R-GFI duplex receptacle. Panel shall be equipped with an approved 650 volt, three pole lightning surge protector, as manufactured by General Electric, Square D, Deltrol, or approved equal.

Panelboards shall be as manufactured by General Electric, Square D, Westinghouse, or I-T-E. Type and rating shall be determined by the Contractor. Busses shall be copper for bolt-in type circuit breakers. Circuit breakers shall be molded case type, as specified on the drawings.

Lighting contactors shall be mechanically held type. A Hand-Off-Auto selector switch shall be provided to override the photocell. Contactors shall be manufactured by General Electric, Square D, Westinghouse, or I-T-E.

Photocell shall be a locking type photocell furnished and installed with twist lock receptacle conforming to EEI-NEMA standards. Photocell shall be rated 1800 watts at 120 volts. Photocell and base shall be Precision "P" series, or approved equal.

The contractor is responsible for sizing all equipment including panels, boxes, breakers, contactors to handle the loads required to operate the system,

3. CONSTRUCTION METHODS

General Requirements: All work shall be installed in a neat and orderly manner. Devices, cabinets, covers, fixtures, exposed raceways, etc., shall be aligned plumb and parallel or perpendicular to the curb lines, and or structure or ground lines. Wiring in panel boards and cabinets shall be neatly looped and laced with nylon cable ties, and not wadded. Wires shall be identified at each terminal or junction with adhesive backed permanent plastic wire markers. The Owner reserves the right to require repair or replacement of defective or inferior workmanship and material without additional compensation to the Contractor.

Supports: Conduits, boxes, cabinets, enclosures, lighting fixtures, poles, etc., shall be securely supported by structural members or structural walls at intervals required by the NEC or as recommended by the manufacturer.

Cutting and Patching: The electrical contractor shall perform all boring, drilling, and cutting of sidewalks and roadways as required to install and support his raceways and equipment. Provide finished patching to match existing surfaces and conditions.

Trenching and Backfill: The electrical contractor shall perform all excavation, trenching, and backfilling necessary to install his work. Trenches shall be run at 36 inches minimum depth from finished grades. Contact all underground utilities (electric, telephone, cable TV, gas, water, sewer) and establish locations of underground utilities prior to digging. Damages to underground utilities will be repaired by the Owner of the line, and the Contractor responsible for the damage will pay all costs of repairs. After completion of backfilling operations, restore the disturbed areas to their original condition by leveling, raking, seeding and mulching.

The Contractor shall excavate all cable trenches to a width not less than 6 inches. The trench shall be deepened or widened, where more than two conduits are to be installed in the same trench. Unless otherwise specified in the plans, all conduits in the same location and running in the same general direction shall be installed in the same trench.

When rock excavation is encountered, the rock shall be removed to a depth of at least 3 inches below the required trench depth and it shall be replaced with bedding material of earth or sand containing no mineral aggregate particles that

would be retained on a ¼-inch sieve. The Contractor shall ascertain the type of soil or rock to be excavated before bidding.

After the conduit has been installed, the trench shall be backfilled 3 inches deep, loose measurement, and shall be either earth or sand containing no mineral aggregate particles that would be retained on a ¼-inch sieve. This layer shall not be compacted. The second layer shall be 5 inches deep, loose measurement, and shall contain no particles that would be retained on a 1-inch sieve. The remainder of the backfill shall be excavated or imported mineral and shall not contain stone or aggregate larger than 4 inches maximum diameter. The third and subsequent layers of the backfill shall not exceed 8 inches in maximum depth, loose measurement.

The second, and subsequent layers shall be thoroughly tamped and compacted to at least the density of the adjacent undisturbed soil, and to the satisfaction of the engineer. If necessary to obtain the desired compaction, the backfill material shall be moistened or aerated as required.

Trenches shall not be excessively wet and shall not contain pools of water during backfilling operations. The trench shall be completely backfilled and tamped level with the adjacent surface, except that when sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement. Any excess excavated material shall be removed and disposed of in accordance with instructions issued by the engineer.

Bored and Jacked Conduit (Pushing): Where necessary to cross existing roadway and steel galvanized conduit is to be used, the contractor shall bore under the roadway and the conduit jacked into the bore. The method of boring and jacking will be approved by the Engineer prior to beginning work. Maximum conduit size is limited to four (4) inches.

Bored and Jacked Conduit (Pulled): When HDPE conduit is used under existing roadway, the contractor shall bore under the roadway and the conduit pulled through the bore. The method of boring and pulling the conduit will be approved by the Engineer prior to beginning work. Maximum conduit size is limited to four (4) inches.

Restoration: Where sod has been removed, it shall be replaced as soon as possible after the backfilling is completed. All areas disturbed by the trenching, storing of dirt, cable laying, pad construction, and other work shall be restored to its original condition. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging or mulching. All such work shall be performed in accordance with Section 810 of the Standard Specifications. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance.

Marking Posts: Marking Posts shall be placed at 500' intervals along conduit runs and everywhere the conduit makes a turn. All junction boxes should be marked as well as the ends of jacked and bored conduits under the roadway. In addition, red marking tapes should be placed in the trench.

Grounding: Entire system shall be grounded and bonded in accordance with the requirements of the National Electrical Code.

Electrical service shall be grounded to driven ground rods as required by the National Electrical Code. Grounding point shall be inside the Main service equipment.

Each raceway shall be bonded to every cabinet, pull box, etc., to which it is connected by grounding bushings and bonding jumpers sized per NEC Table 250-95, even when separate grounding conductors are specified. An insulated stranded copper wire, No. 8 AWG minimum size, shall be installed for grounding in all circuit runs. The grounding wire shall be securely attached to each light base.

Conduit: The Contractor shall install direct burial conduits as necessary to provide electrical service to the lighting. The Engineer shall approve specific locations as the work progresses. Conduits shall be sized to accommodate the size and number of conductors by the contractor.

The Contractor shall mandrel each conduit. An iron-shod mandrel, not more than ¼-inch smaller than the bore of the conduit shall be pushed through each conduit by means of jointed conduit rods. The mandrel shall have a leather or rubber gasket slightly larger than the conduit diameter.

All spare conduits shall be provided with a No. 10 gage galvanized iron or steel drag wire or equivalent plastic cord with 200 lb. Tensile strength for pulling the permanent wiring. Sufficient length shall be left in manholes or pull boxes to bend the drag wire back to prevent it from slipping back into the conduit. Where spare conduits are installed the open ends shall be plugged with removable tapered plugs, designed by the manufacturers, or with hardwood plugs conforming accurately to the shape of the conduit and having the larger end of the plug at least ¼-inch greater in diameter than the conduit.

All conduits shall be securely fastened in place during construction and progress of the work and shall be plugged to prevent seepage of grout, water, or dirt. Any conduit section having a defective joint shall not be installed.

Pull Boxes: Pull boxes shall be placed at intervals of 250' along conduit runs and at turns in the runs, at all junction boxes and at the ends of jacked or bored conduit. Final locations of the pull boxes shall be staked by the contractor and approved by the engineer prior to construction. Pull boxes shall be placed in excavated holes over pea gravel or crushed stone for drainage. The top of the

pull box shall lie flush inside the pull box. The top of the pull box shall be placed 1-inch above the finished grade, then 4 inches of concrete backfill placed on all sides of the pull box.

Each pull box shall be located using the Global Positioning System (GPS) with the coordinates shown on the as built plans.

Wiring: The Contractor shall install cable at the approximate locations indicated in the lighting layout plans. The contractor and Engineer shall determine specific locations.

Cable connections will be permitted only at the light base locations for connecting the underground cable to the leads of the individual luminaires. Splices will be permitted for cables in pull boxes and manholes, where approved by the engineer or shown in the plans.

Field cable splices and taps shall be made with copper sleeve compression type connectors only. Compression tool shall be the type which will release only after full compression to sleeve is made. After the compression is complete the splice shall be insulated with two wraps, half lapped, of insulating rubber tape, Scotch No. 33, or equal, shall be applied over the rubber tape. Tape shall be applied to at least 3 inches beyond the sleeve on each conductor entering the splice. All sharp points and edges shall be padded, and all voids filled with rubber and plastic tape. The tape shall not be stretched excessively in a manner to cause creeping. Where approved by the engineer, a heat shrinkable, self-sealing, splice insulator kit may be used in lieu of the taping above for splices in pole bases and in structure boxes (above ground). All spliced joints shall be watertight.

Cable splices in pull boxes shall be made with pressed sleeve connector or equivalent, and a protective plastic case installed around the cable. Ends of the cases shall be sealed with plastic tape, following which the case shall be poured full of a 2-part, field mixed hardening insulation compound, in accordance with the manufacturer's instructions. Splices shall be watertight and capable of continuous submersion in water.

Installation of Wire in Conduit: The maximum number and voltage ratings of cables installed in each single conduit, and the current-carrying capacity of each cable shall be in accordance with the latest National Electric Code, or the local agency having jurisdiction.

The Contractor shall make no connections or joints of any kind in cables installed in conduits.

The Contractor shall make sure that the conduit is open, continuous, and clear of debris before installing cable. The cable shall be installed in a manner to prevent harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. The ends of all cables shall be sealed with moisture-

seal tape before pulling into the conduit and it shall be left sealed until connections are made. Where more than one cable is to be installed in a conduit under the same contract, all cable shall be pulled in the conduit at the same time. The pulling of a cable through conduits may be accomplished by hand winch or power winch with the use of cable grips or pulling eyes. Pulling tensions should be governed by recommended standard practices for straight pulls or bends. A lubricant recommended for the type of cable being installed shall be used where pulling lubricant is required. Upon completion of installation of wiring in conduits, ends of conduit shall be sealed with untreated oakum, or other sealer as approved by the engineer. Conduit markers temporarily removed for excavations shall be replaced as required.

Placing Foundations: The poles shall be installed at the approximate locations indicated in the plans. The Contractor shall stake out the exact locations and obtain approval from the Engineer prior to commencing construction. High mast foundations shall not be installed within 30' of the roadway.

Foundation: Stake each pole location and obtain approval from Engineer prior to commencing work. Excavate holes for pole foundations in undisturbed earth to the dimensions indicated on the accepted shop drawings. The Contractor shall perform a soil analysis after compaction at each pole location to verify footing designs and to submit to the engineer a shop drawing of the footing and design calculations, certified by a professional structural engineer registered in South Carolina.

Erect foundation reinforcement, anchor bolts, and conduits as indicated on the drawings and secure in place for the placement of concrete. Insure that all reinforcement and anchor bolts have 3-inch minimum clearance from the outside edge of the concrete. Insure that anchor bolts extend high enough to permit double nuts and bearing plate in accordance with the manufacturer's recommendations. Place concrete in excavated hole against undisturbed earth. Vibrate concrete per ACI recommendations to insure there are no voids in the foundation. Allow 28 days for curing prior to placing poles on foundation.

Poles: Assemble poles, luminaires, wiring, and other components and allow for observation by Engineer prior to erecting pole. Place and adjust leveling nuts and bearing plate so that the pole will have a level-bearing surface to rest on. Erect pole in accordance with manufacturer's recommendation, using lifting equipment which will not damage the finish surfaces of the poles. Use transit to check and level pole. Tension nuts per the manufacturer's instruction and **Section 709** of the **Standard Specifications**. Install bolt covers with stainless steel security screws over each anchor bolt.

Do not place grout under the base plate between the base plate and the top of the footing.

Luminaires: Luminaires shall be installed, leveled, and aimed in accordance with the recommendations of the manufacturer and as indicated on the drawings.

Contractor shall take particular care to prevent spill light and glare. Wiring within the poles shall be supported at the top of the pole with a cable clamp or attachment clip to prevent tension on the cable splices or connections to the luminaires. Luminaires shall be connected to balance the loading between all phases on the supply circuit. Luminaires shall be thoroughly cleaned after completion of installation, and all aiming devices and clamps securely tightened.

Testing: Prior to connecting ground rods to grounding conductor, each ground rod shall be tested for earth resistance. Test method shall be Biddle fall of potential method, or approved equivalent method. Notify Engineer seven (7) calendar days prior to performing testing. Tests shall not be performed within seven (7) days of measurable rainfall (greater than 0.01 inches). Should the resistance of any ground rod exceed 25 ohms, notify Engineer for further action.

Furnish to the Engineer a written certification of the testing, listing each ground rod as identified in the Drawings, and the resulting value of resistance, and any further corrective action taken.

Completion of Work: Poles shall be erected, leveled, and connected to power and control systems. Repair and/or refinish any damaged surfaces. Test lowering system and latching mechanism at least three times for each pole. Insure that all equipment and luminaires are operational. Instruct Owner's maintenance personnel in the operation and maintenance of the system.

Tests: Upon completion of work, the entire system shall be completely operational and tested to conform to these specifications and drawings, and inspected and approved by the Engineer. All defects in workmanship and material shall be immediately corrected by the Contractor without additional compensation to the Contractor.

Upon completion of all installations and prior to final acceptance by the Owner, remove all debris from the site. Clean and touch up paint on fixture lenses and trims, cabinets, enclosures, cover plates, etc.