

December 6, 2018

SUPPLEMENTAL SPECIFICATIONS – ROADWAY LIGHTING

1. **GENERAL REQUIREMENTS**

1.1 Scope of Work:

This work shall consist of designing, furnishing, and installing roadway lighting systems and shall include but not be limited to all necessary plans, design documents, materials, supervision, labor, tools, and equipment necessary to complete the work in a professional manner and in accordance with all national and state codes and standards to include:

- Complete plans, design basis documentation, and cut sheets for all aspects of the lighting system including photometric study, electrical schematics, foundations, poles, system controllers, controller cabinets, and luminaries.
- Electrical services, complete to the point of connection with the utility company's facilities.
- Service entrance equipment, including system luminaire control panels.
- Complete grounding system for lighting and equipment sufficient for lightning protection, including grounding conductors, ground rods, and grounding connections.
- Complete branch circuit wiring system for lighting and equipment, including conduit, trenching and backfill, jacking and boring, concrete encasement, pull boxes, and wiring.
- Luminaries, poles, and foundations for roadway lighting.

1.2 Design of Lighting Systems:

The contractor will be responsible for providing a lighting system that conforms to the design/installation requirements of Table 1 and operates per the conditions of Table 2 below. Additional component manufacturing standards are listed in the **MATERIALS (3)** section.

The Contractor will be responsible for designing the lighting systems to include:

- Voltage drop calculations (see Table 1)
- Conduit and conductor size requirements
- Designing of lighting controller cabinets including all components
- Determining length of cable runs

The contractor is responsible for the compatibility of all components of the system as well as providing for sufficient lightning protection. The contractor shall provide a schematic of the systems as well as the control cabinets and

circuitry. Before materials are ordered, submit the finished plans, including the photometric study, to the Director of Traffic Engineering's office for review and acceptance. This submittal may be made by hard copies of the documents or provided electronically in an Adobe Acrobat (pdf) format.

TABLE 1: DESIGN STANDARDS

SYSTEM ID	DESIGN STANDARD
PHOTOMETRIC ANALYSIS*	AASHTO Roadway Lighting Design Guide, Latest Edition, ILLUMINANCE METHOD
POLES AND FOUNDATIONS	AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, MASH
ELECTRICAL	NFPA-70 National Electric Code, Latest Edition
LIGHTNING	NFPA 780, LPI 175

*See Additional Design Considerations

TABLE 2: OPERATING CONDITIONS

SYSTEM OPERATING CONDITION REQUIREMENTS (ENVIRONMENTAL, ELECTRICAL)
System shall start within 10 minutes and operate in continuous service for the following environmental conditions: <ul style="list-style-type: none"> • -4°F (-20°C) to +104°F (+40°C) ambient • Snow and Ice with accumulations per AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals
SYSTEM SHALL START AND OPERATE IN CONTINUOUS SERVICE FOR THE FOLLOWING ELECTRICAL SERVICE CONDITIONS:
<ul style="list-style-type: none"> • For non-interstate routes, interstate entrance and exit ramps (excluding High Mast Lighting), and roundabouts: Single Phase 120/240VAC at 60 Hz. • For interstate mainline or other High Mast Lighting: 240V Single Phase or 480V Three Phase for multiple pole locations or extended runs. • Input voltage fluctuations of $\pm 10\%$. • System shall be able to restart automatically upon a restoration of power during a "call for lighting".

1.2.1 Additional Design Considerations:

The following are additional design considerations that shall be considered:

- Locate high mast light poles (HMLP) to minimize traffic impacts such that no lane closures occur during system maintenance.
- Mount HMLPs a minimum of 4 feet behind guardrail. On highways with no guardrail, poles shall be setback 46 feet from edge of travel lane. HMLPs located less than 46 feet from the nearest edge of travel way, shall be protected by guardrail or barrier wall.
- HMLPs shall be designed using a baseplate with a minimum of eight anchor bolts.
- Standard Roadway Lighting Poles should only be located in areas such as ramp terminal ends or other perimeter locations where a photometric analysis indicates the high mast systems will require supplementation, or in areas where installation of high mast systems is determined to be impossible or impractical.
- Design system to minimize the number of required controller cabinets.
- Roadway lighting shall be powered and controlled independently of other systems (ex. sign lighting, ITS, etc).
- Voltage drop is limited to 3% on branch circuits and 2% on feeders for a combined total of 5% from the service entrance.

1.3 Existing Conditions:

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.

1.4 Coordination:

All work under this Section shall be coordinated with other trades to ensure 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.

1.5 Utilities:

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

1.6 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, required training, and inspection required by local and state governments for this construction.

1.7 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.

In addition to drawings, submit Photometric layouts including IES files as well as catalog cuts for the proposed Light Emitting Diode (LED) roadway luminaire. Photometric evaluation must show that proposed luminaire will meet or exceed the design shown in the plans. Conduct photometric analysis using a 6 feet by 6 feet grid. LED luminaires must be limited to 90% of their lumen output during analysis. Consideration must be taken for the potential of "light pollution" in surrounding area.

1.8 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

1.9 Maintenance and Operating Manual:

The Contractor shall furnish the Department two (2) 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.

1.10 Submittals and Approvals:

Before any materials or equipment are ordered or delivered to the site, submit three (3) sets of South Carolina Professional Engineer (PE) stamped shop drawings and equipment specifications to the Director of Traffic Engineering for approval on the following materials:

- Control Panels, including all devices and Equipment
- Luminaires, Poles, and Lowering Systems
- Wire, Cable, and electrical disconnects (fuses, etc.)
- Raceways and Fittings
- Pull Boxes and Junction Boxes
- Foundations, including breakaway hardware where required

2. DEFINITIONS:

2.1 Partial Interchange Lighting – lighting of ramp terminals and on/off ramps found along a freeway or interstate road design.

2.2 Complete Interchange Lighting – places lights in the merging traffic and gore areas in the same locations as partial interchange lighting. In addition, lighting is placed along the ramps and on the crossroad between the ramp terminals. This configuration may not include lighting the mainline running through the interchange.

2.3 Continuous Freeway Lighting – includes complete interchange lighting and also includes lighting between interchanges along the mainline. Continuous lighting can include a number of interchanges and is usually provided in urban areas

2.4 Luminaire – a complete lighting unit consisting of a driver, housing, lamp or lamps together with the parts designed to distribute the light (refractors, mirrors, lens, etc.), to position and protect the lamps, and connect the lamps to the power supply, also referred to as “Fixture”.

2.5 Illuminance Based Design - a design approach, which calculates the amount of light on the roadway surface. The illuminance method of roadway lighting design determines the amount of light incident on the roadway surface from the roadway lighting system, illuminance is the density of luminous flux (light) incident on a surface.

2.6 Standard Roadway Lighting Pole – less than 50 feet in height, with breakaway foundations with one to two fixtures attached.

2.7 High Mast Light Pole (HMLP) – greater than 75 feet in height and will have multiple luminaires attached at the top with an integrated lowering system.

3. **MATERIALS**

3.1 General:

Electrical materials shall conform to all requirements in the current edition of the NFPA 70, "National Electrical Code" (NEC). Electrical materials shall also conform to the standards of the American National Standards Institute (ANSI), the National Electrical Manufacturers Association (NEMA), and the Underwriters Laboratories, Inc. (UL), in every case where a standard has been established. All materials shall be listed by one or more of these organizations. The mark of the listing organization shall appear on electrical material and equipment. Units of any one item (such as poles, luminaires, lamps, control devices, enclosures, circuit breakers, etc.) shall be made by the same manufacturer.

3.2 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 Director of Traffic Engineering ten (10) days before bids are taken. Requests shall be accompanied by samples, descriptive literature, and engineering information (ex. 3rd party certified photometric data files in IES format for any alternate luminaire submitted for approval), 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.

3.3 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. The power conductor cable shall be copper.

Cable type, size, number of conductors, strand and service voltage shall be determined by the Contractor and designed in accordance with the latest version of the NEC and voltage drop requirements.

NOTE: Voltage drop is limited to 3% on branch circuits and 2% on feeders for a combined total of 5% from the service entrance.

3.4 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), or fused ILSCO "Streetwise Streetlight connectors". 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.

3.5 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.

3.6 Galvanized Rigid Conduit and Fittings:

Hot-dipped galvanized conduit shall be used for all exposed conduit runs. 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.

3.7 HDPE Rolled Conduit:

Underground 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.

3.8 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.

3.9 Marking Posts:

Marking Posts shall be round dome type, ProMark PM303 or approved equal, red in color with the word "ELECTRIC" as well as the following messages and phone numbers:

XXXXX County Roads and Bridges – XXX-XXX-XXXX
After Hours – XXX-XXX-XXXX

3.10 Concrete and Reinforcement:

Concrete for light pole foundations and concrete encasement of conduits shall conform to the requirements of ASTM C387 and shall be rated for 4000 psi minimum compressive strength at 28 days.

Reinforcing steel shall be deformed steel reinforcement bars conforming to the requirements of ASTM A706, Grade 60. Anchor bolts shall be provided as shown on the shop drawings for the foundation, meeting the requirements of ASTM F1554, Grade 55 (Bolts), ASTM A563 (Nuts). ASTM identification and grade shall be provided with pole documentation. Bolts and nuts shall be galvanized in accordance with ASTM A123.

3.11 All Roadway Light Emitting Diode (LED) Luminaire Assemblies:

The luminaire manufacturer shall provide (if requested) documentation of no less than five (5) years of experience in manufacturing LED-based lighting products. The manufacturing facility must be ISO 9001 certified. In addition the manufacturer shall provide a minimum five (5) year warranty covering maintained integrity and functionality of the luminaire housing, wiring, and connections, LED light source(s) and LED driver. Negligible light output from more than ten (10) percent of the LED packages constitutes luminaire failure.

3.11.1 Fixture Assembly

3.11.1.1 UL Labeling shall include:

- Labels indicating it is suitable for use in wet locations and listed to UL1598
- External label per ANSI C136.15
- Internal label per ANSI C136.22, internal label shall identify the manufacturer, year and month of manufacture and the manufacturer's part number.

3.11.1.2 Fixture Construction:

Luminaire exposed hardware shall be stainless steel, all mating surfaces shall be gasketed, fixtures must utilize borosilicate glass prismatic optics, and housing shall be coated cast aluminum. The housing must include a level indicator that is attached and the exterior surface shall be smooth and free of burrs.

Additionally:

- LED Driver and light source must be replaceable independent of luminaire housing.
- Provide a barrier-type terminal block secured to housing for power connection to luminaire
- Provide lugs with screws for wire sizes up to 6 AWG. Identify each terminal position
- Terminal blocks shall be easily accessible to installers or repair personnel. Wire nuts are prohibited inside the luminaire housing.
- Grommets shall be installed in cable entry holes. Cable entry holes shall be free from sharp edges which might cut conductors or an ungloved hand.
- All conductors inside the luminaire shall be neatly secured with tie-wraps as needed to prevent pinch points and assist in trouble shooting.
- All internal components shall be assembled and pre-wired using modular electrical connections.

3.11.1.3 Corrosion resistance requirements:

Luminaires shall exceed a rating of six per ASTM D1654 after 1000 hours of salt spray fog testing per ASTM B117. The housing coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6.

3.11.1.4 Mechanical requirements:

At a minimum have been tested to ANSI 136.31 3.0G vibration requirements or greater.

3.11.1.5 Thermal Management:

Mechanical design of protruding external surfaces (heat sink fins) on roadway luminaires shall facilitate hose-down cleaning and discourage debris accumulation. The luminaire shall have a minimum heat sink surface such that the LED manufacturer's maximum junction temperature is not exceeded at maximum rated ambient temperature per Table 2.

Additionally:

- Thermal management shall be via natural convection only; no active cooling methods such as fans shall be permitted.
- Mounting to heat sinks internally, must be via screws, thermal grease shall not be used.
- All LEDs shall provide the same optical pattern such that catastrophic failures of individual LEDs will not constitute a loss in the distribution pattern.

3.11.1.6 Surge Protection:

The luminaire shall be protected by an integral surge protection device tested in accordance with ANSI/IEEE standard C62.4 for standard and optional waveforms defined in ANSI/IEEE C62.41.2 location category C (High) for 10 KV Basic Impulse Level (BIL).

- Both common and differential mode protection shall be provided.
- The failure mode of the surge protector shall be to turn the luminaire off.
- The surge protector shall be field replaceable in the event of failure and shall automatically reset after operation with no manual intervention required.

3.11.1.7 Performance

Luminaire compliance and performance claims shall be independently certified by an approved U.S. Department of Energy National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory in accordance with Illuminating Engineering Society of North America (IESNA) LM-79 and LM-80. Reports shall be provided with each luminaire. The luminaire will have long term lumen maintenance documented according to the most current version of Illuminating Engineering Society of North America (IESNA) TM-21.

All assembled luminaires must be electrically tested before shipment from factory, so as to ensure lighting output matches those values required in the plans.

3.11.1.8 LED Driver

The replaceable (see construction requirements above) LED Driver shall operate at 120V, 240V, or 480V line voltages as shown in the plans. The driver operating frequency should be high enough to avoid visible flicker in the light output. The driver shall be UL certified for use in dry or damp locations and shall reduce output power to LEDs if maximum allowable case temperature is exceeded.

Additionally:

- Driver life expectancy shall be 50,000 hours at 80 °C and 100,000 hours at 70 °C.
- Power factor (PF) of at least 0.90 at full input power at the specified voltage
- Compliant with UL standard UL 1012 or UL 1310
- The driver will not be adversely affected by the cycling or failure of one or more LED modules during the life of the driver.
- The driver must reliably start and operate the lamp in ambient temperatures from -20 °C to 40 °C for the rated life of the lamp.

3.11.1.9 LED Lamp

Each LED should be rated for a minimum operational life of 50,000 hours at 40 °C and comply with IESNA L-85 standards at 20 °C ambient temperature. Photometry must be in compliance with IESNA LM-79 when operating at an ambient temperature of 25 °C. The LED module shall lose no more than 10% optical intensity when operating at 40 °C than its initial delivered lumens at 25 °C.

- All LED modules shall be constructed so that the failure of one LED will not result in the loss of the entire luminaire and so that modules can be replaced without replacing the entire luminaire.
- Each LED die or the LED module should be enclosed in a non-removable transparent lens of borosilicate glass.
- The LED module shall produce a nominal correlated color temperature of 4000K \pm 250K with a color rendering index (CRI) of at least 70 and a minimum output of 80 lumens per watt efficacy.

3.11.2 LED Underdeck Luminaires Additional Requirements

The only type of luminaire to be used for underdeck lighting shall be a wall mounted assembly mounted on the bridge pier or pier cap. The luminaires should be mounted level and perpendicular to the roadway surface being lighted.

The material component requirements for a LED underdeck luminaire shall be the same as those for a standard LED roadway luminaire. The same

manufacturer shall provide the luminaire and accompanying driver. The requirements for the light emitting diodes shall also be the same as for the roadway light emitting diodes.

In accordance with current AASHTO guidelines, the lighting levels under bridge decks shall at a minimum be at the same level as the adjacent roadway. In addition, the lights must be spaced and positioned to achieve the requirements for uniformity.

3.11.3 LED High Mast Luminaires Additional Requirements

The luminaires for high mast applications shall be suitable for mounting on poles 100 feet or taller. Six luminaires shall be arranged in a circular, symmetrical configuration and mounted on a top latching lowering device (ring) supplied by the luminaire manufacturer. The luminaire shall be mounted to the lowering device using a four bolt mounting system.

The luminaires shall be available in a variety of symmetrical and asymmetrical light distribution patterns. Asymmetrical fixtures shall be equipped with a rotatable optical assembly capable of throwing light towards the roadway for offset installations.

The material component requirements for a LED high mast luminaire shall be the same as those for a standard LED roadway luminaire. The same manufacturer shall provide the luminaire and accompanying driver. The requirements for the light emitting diodes shall also be the same as for the roadway light emitting diodes.

3.12 Lighting Control Assembly:

Control cabinets shall be installed at locations as suggested on the plans with final locations determined by the Contractor and approved by the Engineer of Record.

Foundation sizing for controller cabinets must provide for a minimum of 24" between the edge of the cabinet and the edge of concrete, on all sides. Foundation must extend above the ground elevation a minimum of 6"

3.12.1 Cabinet:

Components for control of lighting shall be mounted inside a weatherproof NEMA 3R stainless steel pedestal type enclosure, as manufactured by Milbank, Hoffman Engineering, GE, Square-D, or Austin Berryhill. Enclosure must include the meter base within the single enclosed pedestal. The utility metering must be isolated, lockable, and sealable. Meter socket shall conform to utility requirements and must be viewable from the exterior via lockable window panel (unless conflicts with utility requirement). Pedestal pad anchorage shall not be visible from outside.

Panel shall be equipped with 3-point latching door with provision for padlocking.

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.

3.12.2 Internal Cabinet Components:

The cabinet shall have an auxiliary device circuit at 120 V AC, single phase to supply a ground fault interrupting, duplex convenience receptacle, a fluorescent or LED cabinet light and photocell for the lighting system. The cabinet light shall be a 17 W (fluorescent rating) minimum surface mounted fixture with protected lamp cover and directly connected to a door actuated switch. The lamp shall not be mounted to the door. The receptacle shall be a 20 A, ground fault interrupting, duplex receptacle, in a weatherproof box with appropriate cover (NEMA 5-20R-GFCI).

Panelboards shall be as manufactured by Milbank, Siemens, 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. All feeders, branch circuits, and auxiliary and control circuits shall have overcurrent protection. The overcurrent protection shall be by means of circuit breakers. Circuit breakers shall be standard UL-listed, molded case type, thermal magnetic as specified on the drawings.

Lighting contactors shall be electrically operated, mechanically held type. Contactor control input voltage must match photocell. Ampere rating of contactors shall not be less than required for the duty shown on the plans. A Hand-Off-Auto selector switch shall be provided to override the photocell. Contactors shall be manufactured by General Electric, Square D, Siemens, Westinghouse, or I-T-E.

Photocell shall have an integral, locking type, brass 3 prong plug according to NEMA specification SH16-1962. The gasket shall be of a moisture proof seal to the luminaire socket. Photocell shall be rated 1000 watts at 120 volts. Photocell shall be mounted exterior to the control cabinet and facing North. Photocells shall not be mounted to individual luminaires. If the photocell fails, the luminaires shall remain on as a notification of needed maintenance. Photocell shall be of a long-design life of 20 years and match the manufacturer of the LED luminaires. Photocell receptacle shall be rotatable.

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

3.13 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".

3.14 Standard Roadway Lighting Poles:

Poles and accessories shall be spun brushed aluminum. 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 FHWA approved frangible breakaway couplings as well as a breakaway electrical coupling (see Cable Connections). Anchor bolts shall be provided as shown on the shop drawings for the foundation, meeting the requirements of ASTM F1554, Grade 55 (Bolts), ASTM A563 (Nuts). ASTM identification and grade shall be provided with pole documentation. Bolts and nuts shall be galvanized in accordance with ASTM A123.

3.15 High Mast Lighting Poles:

Poles shall be either round or multi-sided 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 A123. 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 ensure 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 F1554 Grade 55 steel and shall be provided with a bearing plate of ASTM A36

steel. Threaded ends of anchor bolts shall be galvanized per ASTM A153. Each anchor bolt shall be supplied with two anchor nuts and two flat washers.

3.16 High Mast Lowering System (Top Latching Type):

High mast poles and lowering device shall be of the same manufacturer as the luminaire or approved equal (ensuring compatibility).

The lowering system shall consist of head frame, luminaire ring, and 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 A164 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 A386 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 ¼" diameter. The drum shall be supported at both ends and keepers shall be provided to ensure that uncoiled cable will rewrap onto the drum.

3.17 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.

4. CONSTRUCTION METHODS

4.1 General Requirements:

All work shall be installed in a neat and orderly manner. At least one of every three persons in each work crew shall be a certified journeyman electrician, they shall be present and have involvement with all work required for installation and operation testing of electrical materials and equipment. They shall also possess at a minimum an IMSA Roadway Lighting Level 1 Certification. 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. SCDOT reserves the right to require repair or replacement of defective or inferior workmanship and material without additional compensation to the Contractor.

4.2 Supports:

Conduits, boxes, cabinets, enclosures, fixtures, etc., mounted above ground shall be securely attached to structural members or structural walls at intervals required by the NEC or as recommended by the manufacturer.

4.3 Cutting and Patching:

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

4.4 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.

4.5 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.

4.6 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.

4.7 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 top soiling, 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.

4.8 Marking Posts:

Marking Posts shall be placed at 500 foot 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.

4.9 Grounding:

Entire system shall be grounded and bonded in accordance with the requirements of the National Electrical Code. Design and installation must consider additional requirement of added lightning protection per NFPA 780 and LPI 175.

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.

4.10 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.

4.11 Pull Boxes:

Pull boxes shall be placed at intervals of 250 feet 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.

4.12 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 and employ silicone gel filled enclosures

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.

4.13 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. Ensure that conductors for a circuit (ie. supply and return) are routed together when passing through conductive material (ex. Metal conduit).

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.

4.14 Placing Pole 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 46 feet of the roadway when there is no shielding available.

4.15 Pole Foundations:

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. Ensure that all reinforcement and anchor bolts have 3 inch minimum clearance from the outside edge of the concrete. Ensure 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 ensure there are no voids in the foundation. Allow 28 days for curing prior to placing poles on foundation.

4.16 Controller Cabinet Foundations:

Cabinet foundation sizing must provide for a minimum of 24 inches between the edge of the cabinet and the edge of concrete, on all sides. Foundation must extend above the ground elevation a minimum of 6 inches.

4.17 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 instructions 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.

4.18 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.

4.19 Ground Rod 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.

4.20 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. Ensure that all equipment and luminaires are operational. Instruct SCDOT maintenance personnel in the operation and maintenance of the system.

SCDOT at their discretion may perform an as-built photometric analysis to ensure system conformance to desired lighting.

4.21 Acceptance Testing:

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 Department, remove all debris from the site. Clean and touch up paint on fixture lenses and trims, cabinets, enclosures, cover plates, etc.