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REVISION OF SECTIONS 613 & 715
LIGHTING

Sections 613 and 715 of the Standard Specifications are hereby revised for this project as follows:

Delete Section 613 and replace with the following:

**SECTION 613
LIGHTING**

DESCRIPTION

613.01 This work consists of furnishing and installing foundations, light standards, luminaires, lamps, conduit, cable, wiring, and incidental materials for highway lighting in accordance with these specifications and in conformance with the details, lines, grades, and locations shown on the plans or established.

MATERIALS

613.02 Highway lighting materials shall conform to Section 715, and shall be compatible with the requirements of the local electrical utility company.

- (a) *Foundation.* Concrete Foundation Pads and Light Standard Foundations shall be precast concrete or cast-in-place concrete. A complete foundation includes the concrete, reinforcing steel, ground rods, connector bolts, and anchor bolts.

Connector bolts and anchor bolts shall accommodate the anchorage of the light pole from its base flange to the transformer base, and from the transformer base to the light standard foundation.

- (b) *Light Standard.* A complete light standard includes the metal light pole, mast arm or arms, base or transformer base, approved breakaway device (optional), in-use receptacles (optional), grounding system, and all hardware. When a transformer base is not used, the pole shall have a handhole.

Pole and mast arm or arms shall be the type and size shown on the plans.

- (c) *Conduit.* Conduit includes all elbows and fittings required to install complete runs.

- (d) *Electrical Warning Tape.* Electrical warning tape shall consist of pre-manufactured non-adhesive polyethylene material that is unaffected by acids, alkalines and other soil components. The color of the tape shall be red, and it shall be, at a minimum, 3.5 mils thick and 6 inches wide. Its tensile strength shall be 1,750 psi lengthwise.

The electrical tape shall include the following identification printed in black letters continuously along the length of the tape: "CAUTION BURIED ELECTRIC LINE BELOW".

The identification note and color of tape shall conform to the requirements of the "America Public Works Association (APWA) Uniform Color Codes (Red) – Electrical Power Lines, Cables, Conduit and Lighting Cables".

- (e) *Luminaire.* A complete luminaire includes the housing, lens, reflector, lamp, lamp holder, ballast or power generator, mounting slip-fitter or approved manufacturer mounting, all necessary internal wiring, and photoelectric control (optional). Luminaires shall operate at either 120 VAC, 60 Hz or 240 VAC, 60 Hz. Luminaires shall meet electrical utility company requirements.

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- (f) *Lighting Control Center.* A complete lighting control center includes the load center, grounding system, contactors, relays, meter housing, maintenance receptacle, photoelectric control, NEMA 4 enclosure and all related components, and connections to the power supply.
- (g) *Secondary Service Pedestal.* A complete pedestal includes the NEMA 4 enclosure and all related components and connections to the power supply.
- (h) *Wiring.* Complete wiring includes control wiring, luminaire wiring, main circuit wiring, ground wiring, service entrance wiring, and all other wiring necessary for a complete installation,
- (i) *Materials List.* At the preconstruction conference the Contractor shall submit to the Engineer three copies of a list of all materials and equipment to be incorporated into the work. The Contractor shall include the following items on the list:
- (1) Light standard foundations
 - (2) Foundation pads
 - (3) Light standard type (steel or aluminum)
 - (4) Luminaire manufacturer's product information including data in Illuminating Engineering Society of North America (IESNA) format, IESNA photometric distribution type for vertical and lateral distribution (example: full cutoff, Type III), and a photograph or line drawing
 - (5) Luminaire mounting hardware
 - (6) Lamp wattage and type
 - (7) Ballasts or power generators
 - (8) Lighting control centers
 - (9) Secondary service pedestals
 - (10) All other items required for a complete installation

The Engineer will return lists that are incomplete or that include unacceptable materials to the Contractor for correction and re-submission.

The Contractor shall not order materials or equipment until the Engineer and the party or agency responsible for maintenance have reviewed and approved the materials and equipment list. The Engineer's approval of the list shall not relieve the Contractor of responsibility for the proper functioning of the completed installation.

CONSTRUCTION REQUIREMENTS

613.03 General. All work shall conform to these specifications and the National Electrical Code, and shall comply with applicable regulations as specified in subsection 107.01.

Each system shall be installed as shown on the plans or as designated. The Contractor shall furnish and install all incidentals necessary to provide a complete working unit or system.

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613.04 Concrete Foundation Pads and Light Standard Foundations. Foundations shall be installed as shown on the plans, complete with grounding.

The Contractor shall test and report soil conditions to the Engineer as necessary to ensure proper installation of foundations. Foundations shall be installed at the final grade as shown on the plans.

All anchor bolts shall be positioned by means of steel templates. The center of the template shall coincide with the center of the base.

Conduits shall be properly positioned and anchored before the concrete is placed.

All foundations shall have ground rods conforming to the National Electrical Code. All foundations on structures shall be grounded to the structure steel by a method that is in accordance with the National Electric Code and which is approved by the Engineer.

613.05 Light Standards. Poles shall be set plumb on the light standard foundation using non-corrosive metal shims.

Defects and scratches on galvanized poles shall be given two coats of acceptable zinc-rich paint as directed. Defects and scratches on painted poles shall be primed and painted.

613.06 Luminaires and Lamps. Roadway Luminaires shall be mounted on the mast arm by a slipfitter clamp or other approved device. Luminaires shall be adjusted vertically and horizontally to provide the required mounting height and maximum light distribution on the roadway and to meet Illuminating Engineering Society of North America (IESNA) full cutoff requirements.

Each luminaire shall be controlled a photoelectric control in a centralized control cabinet. For modified systems, individual photoelectric control may be used. The photoelectric control shall be positioned northward to minimize sun interference.

After their installation and prior to their acceptance, refractors and lenses shall be cleaned to provide maximum lumen output.

Lamps of the specified type and size shall be installed in the luminaires. The type and size of lamp shall be marked on each luminaire or pole. Tags will be furnished by the local utility company or the Department, if required.

Wall type luminaires for use under overpass structures shall be mounted as shown on the plans. All wall type luminaires shall include side shielding to prevent glare in the motorist's view. The beam angle setting shall be adjusted to meet the illumination requirements.

613.07 Conduit The electrical conduit system shall be installed in accordance with CDOT's, *A Policy on the Accommodation of Utilities on Colorado Highways Rights-of-Way* and the following:

Plastic conduit shall be in accordance with subsection 715.06

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In the conduit system the locations of conduit, pull boxes, splice boxes and expansion joints shown on the plans are approximate. Actual locations shall be established during construction. The conduit system shall be located to avoid interference with known present or known future construction installations. All underground conduit runs and conduit risers on poles shall be installed as needed even though they may not be shown on the plans.

All conduit installed under the roadway shall be at least 2 inch inside diameter unless otherwise designated on the plans. The Contractor may use larger conduit than specified. If larger conduit is used, it shall be for the entire run from outlet to outlet. Reducer couplings shall not be used.

Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Where new conductors are to be added to existing conductors in a conduit, all conductors shall be removed and the conduit cleaned as described above. All conductors shall be pulled into the conduit as a unit.

Conduit terminating in standards or pedestals shall extend approximately 2 inches vertically above the foundations and shall slope toward the handhole opening. Conduit entering pull boxes shall terminate 2 inches inside the box wall and 2 to 5 inches above the bottom, and shall slope toward the top of the box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduits shall enter from the direction of the run.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt or come together for their full circumference.

Slip joints or running threads shall not be used for coupling conduit. When a standard coupling cannot be used for coupling metal type conduit, an approved threaded union coupling shall be used. All threads on ferrous metal conduit, not previously treated with a corrosion preventative, shall be painted with rust preventive paint before couplings are connected. All couplings for metal type conduit shall be tightened providing a continuous electrical connection throughout the entire length of the conduit run. Areas where the coating on ferrous metal conduit has been damaged shall be painted with rust preventive paint.

Non-metallic conduit shall be cut with a hacksaw or other approved tool. Non-metallic conduit connections shall be the solvent-weld type.

All metal conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings. Non-metallic conduit ends shall be capped until wiring is started.

Conduit connections at junction or splice boxes shall be tightly secured and waterproofed. All conduit ends shall be sealed with duct seal after installation of wiring. The duct seal shall be rated for outdoor use.

When specified, conduit shall be installed under existing pavement by jacking or drilling operations. Where plans show that existing pavement is to be removed, jacking the conduit is not required. Jacking or drilling pits shall be kept a minimum of 2 feet clear of the edge of pavement. Water shall not be used as an aid in the jacking or drilling operations.

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When trenching is specified to place conduit under existing pavement that is not to be removed, the trench width shall be 6 inches or less. Trenches shall be filled to 2 inches below the existing grade with structure backfill (flowfill), or another material if directed. The remaining 2 inches shall be filled to existing grade with hot mix asphalt within one calendar day after the roadway is trenched.

Trenching shall be backfilled and compacted as follows: Backfill shall be deposited in uniform layers. Each layer shall be 6 inches or less thick prior to compaction. The space under the conduit shall be completely filled. The remainder of the trench and excavation shall be backfilled to the finished grade. The backfill material shall be compacted to the density specified in subsection 203.07. Each layer shall be mechanically compacted by tamping with power tools approved by the Engineer. Compaction methods or equipment that damage the conduit shall not be used.

Red electrical warning tape shall be installed between 6 inches and 12 inches below finished grade for all underground conduit runs.

Underground conduit shall be buried a minimum of 2 feet below finished grade. There shall be no sag between boxes. Conduit under roadways shall be buried at least 30 inches below finished grade.

Rigid metallic conduits on bridges shall have an expansion fitting at every expansion joint of the bridge. Expansion joint fittings shall be precisely aligned with the conduit run to ensure proper expansion and deflection and to 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; only the connecting expansion nipple shall cross 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.

Pull or splice boxes shall be installed every 200 feet or less. Boxes shall be placed at conduit ends, at all wiring splices, at all conduit angle points, and at all other locations shown on the plans. The Contractor may install additional pull or splice boxes to facilitate the work.

Where practical, pull and splice boxes near curbs shall be placed adjacent to the back of the curb. Pull boxes adjacent to light standards shall be placed along the side of foundations as shown on the plans.

Unless otherwise shown on the plans, pull and splice boxes shall be installed so that the covers are level with curb or sidewalk grade. Covers shall be level with the surrounding ground when no grade is established.

Where a conduit stub out is called for on the plans, a sweeping elbow shall be installed in the direction indicated. The stub out shall be terminated in a box. All conduit stub outs shall be capped.

613.08 Wiring. Unless otherwise authorized, the multiple system of electrical distribution shall be used. Conductors of the size and material required, whether single or in cable, shall be installed for control wiring, luminaire wiring, main circuit wiring, ground wiring, service entrance wiring, and all other wiring necessary for a complete installation.

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Conductors shall be sized to prevent a voltage drop of more than 3 percent per feeder run. All conductors shall be installed in conduit.

When 120 volt luminaires are installed, 120/240 VAC shall be brought to the base of each light standard, and individual luminaires shall be connected to one leg or the other in a manner that minimizes overall voltage drop.

A complete grounding system shall be installed for the entire lighting installation. Grounding shall consist of: ground cables, conduits, grounding rods, wire or strap, and ground fittings, as required by the National Electrical Code.

All electrical conductors shall be identified and tagged as follows: Electrical conductor cable tags shall be located at each splice termination. The tags shall be attached with cable ties. The information shall be written on the tag with a permanent marker. The information shall include the direction and approximate length of the cable, and the feeder or circuit destination (line and load sides). Each incoming (line side) conductor shall be individually color coded with one tape mark; each outgoing conductor (load side) shall be coded with two tape marks.

613.09 Lighting Control Center and Secondary Service Pedestals. Each Lighting Control Center and Secondary Service Pedestals shall include a load center, a panelboard, contactors, a maintenance receptacle, a meter housing, a photoelectric control, a grounding rod system, a Nema 4 enclosure with all related components, and connections to the power supply.

One copy of the cabinet drawings, one line diagram, a luminaire schedule, and a list of all system components and their manufacturers shall be placed in a heavy duty plastic envelop with side opening that is attached to the inside cabinet door.

613.10 Testing. Prior to final acceptance, the Contractor shall demonstrate to the Engineer's satisfaction that all electrical and lighting equipment installations are in proper working condition. Temporary power and all cable connections required for testing shall be provided by the Contractor.

The Contractor shall operate the lighting system from sunset to sunrise for ten consecutive days. Lamps, ballasts, power generators and photoelectric control that fail shall be replaced immediately. However, replacement of these items will not require a restart of the test.

The Contractor shall perform grounding tests at each grounding system location including light standards, lighting control centers, and other ground rod locations. Grounding tests shall show that the ground resistance is 10 ohms or less. If the measured resistance to ground exceeds 10 ohms, additional ground rods shall be added to the grounding electrode system.

The Contractor shall perform voltage drop tests at furthest point on each circuit such that voltage drop is within 3 percent of supply voltage.

The Contractor shall certify the records of all testing including grounding, voltage drop (within 3 percent) and other required tests as meeting specification requirements and submit the records to the Engineer.

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METHOD OF MEASUREMENT

613.11 Concrete Foundation Pads and Light Standard Foundations will be measured by the actual number installed and accepted.

Light standards will be measured by the number of light standards installed.

Luminaires will be measured by the number of luminaires of the specified wattage installed.

Lighting control centers will be measured by the number of centers installed.

Secondary service pedestals will be measured by the number of pedestals installed.

Conduit will be measured by the linear foot in place.

All wiring necessary for the complete installation will be measured as a single lump sum.

BASIS OF PAYMENT

613.12 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Light Standard Foundation	Each
Concrete Foundation Pad	Each
Light Standard _____ (_____ Foot) (Furnish Only) (Install Only)	Each
Luminaire (_____) (_____ Watt)	Each
Luminaire (_____) (Wall Type) (_____ Watt)	Each
Luminaire (_____) (_____ Watt) (Furnish Only) (Install Only)	Each
Luminaire (Wall Type) (_____) (_____ Watt) (Furnish Only) (Install Only)	Each
_____ Inch Electrical Conduit (Furnish Only) (Install Only)	Linear Foot
_____ Inch Electrical Conduit (Plastic) (Furnish Only) (Install Only)	Linear Foot
_____ Inch Electrical Conduit (Jacked) (Furnish Only) (Install Only)	Linear Foot
Wiring	Lump Sum
Lighting Control Center	Each
Secondary Service Pedestal	Each

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When the Contractor, at his option, installs larger conduit than specified, it will be paid for at the original contract price for the size specified.

The following items will not be measured and paid for separately, but shall be included in the work:

- (1) Soil testing for foundations
- (2) Junction boxes, splice boxes, pull boxes, pull wire, weatherheads, adaptors, and expansion joints for conduit
- (3) Additional pull or splice boxes installed at the Contractor's option
- (4) Saw cutting; trenching; excavation; backfill; jacking; drilling pits; underground electrical warning tape; removal of pavement, sidewalks, gutters, and curbs and their replacement in kind to match existing grade; and all other work necessary to complete conduit installation
- (5) Electrical conductor tagging
- (6) Direct burial cable in conduit
- (7) Testing of the lighting installation, including temporary power and all required cable connections

The lump sum price bid for wiring will be full compensation for all electrical circuitry necessary to complete the lighting installation as shown on the plans. All conductors in conduit, regardless of type, are part of the wiring item and will not be measured and paid for separately.

Delete Section 715 and replace with the following:

SECTION 715
LIGHTING AND ELECTRICAL MATERIALS

715.01 General. Materials shall be of a standard line from a name brand manufacturer. Electrical material shall be listed by the Underwriters' Laboratories, Inc., and shall conform to the National Electrical Code.

Material shall be the same as, or compatible with, that used and accepted by the agency responsible for maintenance.

The Engineer may inspect all lighting materials and all electrical materials and accept or reject them at the project site. Samples may be taken or manufacturer's certifications may be accepted in lieu of samples.

715.02 Light Standard Foundations and Concrete Foundation Pads. Concrete shall be Class B conforming to Section 601.

Anchor bolts shall be designed by the Contractor's Engineer and shown on the working drawings. The threaded ends of the anchor bolts, the nuts, and the washers shall be galvanized in accordance with ASTM A 153. Galvanizing on anchor bolts shall extend 2 to 4 inches beyond the threads.

Reinforcing steel shall conform to Section 602.

715.03 Light Standards.

- (a) *General.* All structural components of light standards, bases, couplers, anchor bolts, luminaires, and other attachments to be used for lighting shall be designed for a minimum of 90 MPH wind velocity, in accordance with AASHTO's *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

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All breakaway bases and couplers shall meet the breakaway requirements specified in AASHTO's *Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, Section 7,1.7.2. Conformance shall be verified by crash tests reviewed and accepted by FHWA. A certificate of compliance shall be provided.

- (b) *Metal Light Standards.* Metal light standards shall be fabricated of either steel or aluminum, unless otherwise specified. Whenever Light Standard Metal is specified, the Contractor may furnish either steel or aluminum. Material type and shape of light standards shall be the same throughout the project, unless otherwise shown in the Contract.

All standards shall have cable-entrance holes located in conformity with the type of arm mounting used. Metal surfaces shall be free of imperfections marring the appearance and of burrs or sharp edges that might damage the cable.

All metal poles shall be tapered and shall be supplied with pole caps.

Aluminum alloys shall have a minimum yield strength of 25,000 psi. Aluminum poles, arms, and fittings shall be made of aluminum alloy conforming to the following for the material form required:

ASTM Standard	Alloy Number
B 209	6061-T6
B 211	6061-T6
B 221	6061-T6 6063-T6 6005-T5
B 241	6061-T6 6063-T6

Aluminum poles may also be made of aluminum alloy 5086-H34 conforming to ASTM B 313 (excluding pressure and burst tests).

Aluminum mast arms shall be tapered unless otherwise shown on the plans.

Steel mast arms shall be made of Schedule 40 standard steel pipe conforming to ASTM A 53.

All steel poles, mast arms and base flanges shall be hot-dip galvanized in accordance with ASTM A 123. Units on which the spelter coating has been damaged shall be repaired as provided in AASHTO M 36, or other approved method.

Base flanges for both aluminum and steel poles shall have continuous welds both inside and outside, unless otherwise permitted. Base flanges inserted into the pole and bonded shall meet the requirements for materials and strength stated herein.

Base flanges for aluminum poles and transformer bases shall be aluminum castings of alloy ANSI 356.0-T6 or UNS A03560 T6 conforming to ASTM B 26 or an acceptable equivalent.

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Each metal light standard shall be wired with a breakaway fused connector of proper capacity rating. The fused connector shall be located in the transformer base. If the light standard has no transformer base, the fused connector shall be located in the pole at the hand hole.

All transformer bases shall have vandal resistant, removable access doors.

The transformer base shall be a frangible breakaway type as shown on the plans and shall accommodate the anchorage and base flange of the light pole supplied. Each transformer base shall have a ½ inch bolt or lug fastened inside the base for grounding; the lug or bolt shall be visible from the door opening. The transformer base shall have a wire hole for outside grounding, if required.

- (c) Hardware used with steel standards shall be either cadmium plated steel, hot dip galvanized steel, or stainless steel. All hardware used with aluminum standards shall be anodized aluminum or stainless steel. Bolts to be inserted in aluminum threads shall be stainless steel.

715.04 Luminaires and Lamps. Luminaires shall be UL or ETL Listed for use in wet locations and IP66 rated. Luminaires shall be adaptable to the type of power distribution system to be used.

(a) *General.* Luminaires shall conform to the following requirements:

- (1) **Housing.** The luminaire enclosure shall be an injection-molded or die-cast opaque housing. The housing shall have a powder-coated, corrosion-resistant finish. The color shall be as specified on the plans. The mounting shall be as shown on the plans.

The housing shall have a door that provides access to all internal components. The door shall be equipped with a safety catch and a latch. The housing shall have an inner rolled flange to support the door frame. The door frame shall be an aluminum casting, hinged to the housing. The door frame shall be sealed to the housing with a molded silicone gasket and shall be secured with a minimum of four captive screws.

- (2) **Optical Chamber.** The luminaire distribution shall be an IESNA full-cutoff, type III reflector system for lamps over 3200 lumens. The optical chamber shall be completely sealed from the housing, or the housing shall be completely sealed. A seamless one piece memory-retentive gasket shall seal the optical chamber or housing against the luminaire lens door. All wires entering the optical chamber shall be gasketed at their point of entry. Socket mountings, rivets used in the construction or support of the reflector system, and all other penetrations into the optical chamber shall be completely sealed. The optical chamber shall be water tight when the luminaire door is closed.
- (3) **Lens and Lens Door.** The lens shall be constructed of clear, flat (for lamps over 3200 lumens), tempered glass. The glass shall be thermal-resistant and impact-resistant, The lens shall be sealed to the door frame with continuous silicone gasketing. The door shall have an easy-access, quick-release safety latch. The door shall have aluminum or stainless steel quick-release hinge pins for tool-less or one-hand easy and secure opening. When the door is closed, the electrical component compartment and the optical chamber shall be completely sealed.
- (4) **Electrical Components.** All components shall be UL listed for wet locations. Luminaires shall operate at either 120 or 240 VAC as specified on the plans or adaptable to the type of power distribution system to be used. Sockets shall be porcelain with nickel plated current-carrying parts. Sockets shall be rated for at least 600 VAC at 302 °F. All internal wiring and quick disconnects shall be rated for at least 600 VAC and insulated for 203 °F. The ballast or induction lamp power generator shall be easily removable from the luminaire housing without the use of tools. If induction lamps are used, the luminaire shall be designed for the operating conditions of an induction lamp.

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- (b) *Roadway Luminaires.* Roadway luminaires shall be high pressure sodium, induction, or metal halide. All luminaires for the project shall be the same type and design unless the plans specify otherwise. Cobra head style shall have a bubble level for leveling.
- (c) *Wall and Pendant Type Luminaires.* Wall and pendant type luminaires for use under overpass structures shall be complete, pre-wired lighting devices. Luminaire shall be furnished with a fixed hood for moderate glare control along roadway.
- (d) *Pedestrian Luminaires.* Pedestrian luminaires shall be the type and style shown on the plans.
- (e) *Lamps.* Lamps for luminaires shall be high pressure sodium, metal halide, compact fluorescent, or induction-type of the wattage shown on the plans. Mercury vapor shall not be used.

Lamps shall be installed and operated only in luminaires designed to accommodate the specific lamp. Lamps shall be compatible with ballasts and power generators supplied with the luminaires in which they are to be installed. Metal halide (150 watts or less), fluorescent, and induction lamps shall have a color temperature of 3000K. All lamps of a similar type shall be provided by the same manufacturer.

The induction lamp system shall consist of three main components: the vessel, the power coupler, and the high frequency power generator. All three components shall be supplied by one manufacturer as one system and shall be warranted by the manufacturer for parts and labor for a minimum of five years. The power factor shall be greater than 0.9, and the total harmonic distortion shall be less than 10 percent.

715.05 Ballasts and Induction Lamp Power Generators.

- (a) *Ballasts.* Ballasts shall be the magnetic regulator type specifically manufactured for use with the lamp shown on the plans, and shall operate at a minimum of 90 percent power factor. Operation shall be suitable with a line voltage variation of ± 10 percent. Satisfactory starting operation shall be obtained with an ambient temperature of -20 °F. Electronic ballasts for metal halide lamps of 150 watts or less shall have an ANSI Transient Insulation Level of at least 10,000 VAC for roadway lighting applications.
- (b) *Induction Lamp Power Generators.* Power Generators shall be supplied with the lamp. Power generators for induction lamps shall have an input voltage of 120 or 240 VAC/60Hz. Minimum operating temperature shall be -40 °F. The heat sink shall be designed to maintain 80 percent of peak luminous flux in ambient temperatures between -10 °F and $+110$ °F.

715.06 Conduit. Unless otherwise specified, conduit shall be rigid metallic or semirigid plastic electrical conduit. Metallic conduit shall be clean, free of burrs, and galvanized.

Plastic conduit shall be a semirigid type currently recommended and approved by Underwriters' Laboratories, Inc. for the proposed use. Underground plastic conduit for street lighting shall conform to ASTM-F 441 schedule 80. Fittings shall be the type used outside the conduit. Fittings shall connect the conduit in a manner that makes the joints watertight.

Junction boxes used in structures shall be galvanized steel, 6 inches square by 4 inches deep, with weatherproof covers.

Pull boxes and splice boxes shall be a minimum of 16 inches by 12 inches and 6 inches deep unless otherwise shown on the plans. Pull and splice boxes shall have heavy duty weatherproof covers rated for roadway

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applications. The housing shall be resistant to sunlight exposure, weathering, and chemicals; it shall be unaffected by freeze/thaw cycles. Covers shall fit flush to the sidewalk, turf area, or roadway surface. Hardware and inserts shall be stainless steel. The cover for street lighting circuits shall be marked "ELECTRICAL" or "STREET LIGHTING". The cover shall list the minimum HS load rating of 20,000 psi.

715.07 Lighting Circuitry and Wiring. Lighting systems shall be photoelectric controlled. Photoelectric controls shall be the hermetically sealed, cadmium sulfide twist-lock type with high impact polypropylene cover with clear UV stabilized window. Photoelectric controls shall have a turn-on setting of 1.4 foot-candles \pm 0.2 foot-candles. The maximum ratio of the turn-off to turn-on setting shall be 3:1.

All electrical apparatus used in the lighting system shall be rated to adequately handle the necessary loads and shall conform to power source requirements.

715.08 Secondary Service Pedestals and Lighting Control Centers

Secondary Service Pedestals and Lighting Control Centers shall be metal conforming to ANSI C47.12.28, *Pad Mounted Enclosure Integrity Standard* and shall be the nominal size and dimensions shown in the Contract.

The cabinets shall be constructed of 12 gauge corrosion-resistant steel with hoods and covers constructed of 14 gauge corrosion-resistant steel. Cabinets shall be NEMA 4 construction and shall be UL listed as "Enclosed Industrial Control Equipment" (UL508). Cabinets shall be vandal resistant dead-front enclosures.

The cabinet's external finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness. The cabinet's internal finish shall be polyurethane industrial grade powder paint of 1.7 mil minimum thickness or bare aluminum.

All external fasteners, rivets, screws and bolts shall be stainless steel. Fasteners, except sealing screws, shall not be removable by external access. Hinges shall be stainless steel continuous piano hinge type hinges.

External nameplates shall be permanently attached to the cabinet. A stainless steel handle shall be provided on the front exterior of each cabinet door or hood. Cabinet shall be equipped with a three point catch and lock. These locks shall be furnished with two keys for each cabinet, and all locks shall be master keyed Type I police lock. When final acceptance of the project is made, the Engineer will distribute the keys to the agencies responsible for maintenance of the system.

The cabinet shall have separate isolated sections for metering equipment (if required), utility termination, and CDOT equipment. All sections must be sealed and pad lockable.

The metering section shall have a hinged swing back hood with an integral hinged polycarbonate sealable window for visual access to meters.

The utility termination section shall be sealed and securable with a padlock. The section shall have a lift off cover with a stainless steel handle. Sufficient clearance shall be provided for a 4 inch diameter conduit for utility cables. Utility landing lugs shall be UL listed and shall accommodate 6 - #350 kcmil conductors.

The CDOT compartment door shall be sealed and securable with a padlock. The compartment door shall be anchorable in an open position. There shall be a print pocket on the inside of the door. The print pocket shall hold all wiring schematics and instructions in a clear weatherproof sleeve with a side opening. Required UL labeling shall be located on the inside of the CDOT door. Distribution and control equipment shall be behind an internal

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dead-front door with a quarter-turn securing latch and be hinged to open more than 90 degrees. The dead-front door shall be hinged on the same side as the CDOT section door.

Pedestal mounting bolts shall not be visible or accessible externally. Pedestal mounting shall include pedestal mounting base and hardware. Pad mounting shall include concrete pad mounting base, anchor bolt kit and hardware.

Secondary Service Pedestals and Lighting Control Centers shall be rated for 600 VAC, installed with protection against damage from greater currents. The pedestals and centers shall be grounded with grounding rods in conformance with the National Electric Code. The following equipment is for a typical installation and may or may not be required as shown on the plans:

- (1) Meter Sockets (100 amp minimum)
- (2) Main circuit breaker that is installed in a circuit load center as sized on the plans
- (3) Circuit load center with an all-copper bus for CDOT loads as shown on the plans
- (4) Circuit breakers
- (5) Ground Fault Interrupter Receptacle (20 amp, 120 VAC)
- (6) Multiple Pole Light Contactors
- (7) Test Switch
- (8) Photoelectric Control Relay
- (9) Mounting pans or false backs for circuit breakers, contactors, relays, switches, transformers, and other types of electrical equipment mounted inside the cabinet

The internal wiring of cabinets shall be assembled by a UL listed facility. Cabinets shall conform to one or more of the following standards where appropriate: UL 50, Cabinets and Boxes; UL 67, Panel Boards and UL 869A, Service Equipment.

Circuit breakers and equipment shall be labeled with an engraved permanent label on the dead-front panel to indicate the circuit controlled.

Multiple Pole Light Contactors shall be "lighting" type, specifically rated for the type of lighting load specified. The contactors shall have a 600 Volt rating. All multiple pole light contactors shall be unenclosed, single phase with the number of poles specified on plans; they shall be open type lighting contactors with the rating shown or specified. Contactors shall be constructed for surface mounting on a false back or bracket within a weatherproof cabinet. The contactor coil shall operate on 120 Volt for 240 Volt circuits and 240 Volt, 208 Volt, and 277 Volt for 480 Volt circuits. Contact material shall be designed for lighting ballast loads and require no maintenance such as filing, burnishing, or dressing at any time the contactor is in service.

A 277 VAC rated test switch shall be installed in the control cabinets if shown. The test switch shall be a heavy-duty single pole switch or circuit breaker rated at 20 amps and shall be installed in the control cabinet as a roadway lighting test switch. The switch shall be wired to shunt the photoelectric control relay power contactor and energize the lighting circuit contactors.

All components of the photoelectric control relays shall be housed in a weatherproof, locking, non-rusting container. The photoelectric control relay shall attach to a three pole locking receptacle by a twisting motion.

The photoelectric control shall have a built in surge protective device for protection from induced high voltage and overcurrents. The photoelectric control relay shall meet or exceed the requirements of ANSI C136.10. The photoelectric control shall be factory set to turn on lights when ambient light falls to 1.4 footcandle plus or minus

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0.2 footcandle when operated at 120 VAC. When operated at 250 VAC, turn on shall not change more than plus or minus 0.3 footcandle from the 120 VAC value. The maximum off to on ratio shall be 1.5:1. The photoelectric control shall be a cadmium sulfide photoelectric control encapsulated for humidity protection, or a silicon junction

type photo transistor. The photoelectric control shall be designed for normal operation at a dual voltage of 105 V and 285 V. Power consumption shall be less than 1 watt. At the designated voltage, the photoelectric control shall be capable of controlling a minimum load of 1000 watts. Minimum operating temperature range shall be from -40 °F to 150 °F. A time delay control circuit shall prevent false turn offs by transient lighting conditions. The unit shall include a fail safe circuit for the lighting load such that the lighting systems remain energized if any functional failure of the photoelectric control circuit occurs.