SECTION 16501 – PARKING STRUCTURE LIGHTING

PART 1 - GENERAL

1.1 SYSTEMS DESCRIPTION

A. Illumination Levels

1. The parking structure illumination level is intended to balance concerns for personal safety and security for the users as well as energy conservation. The parking structure lighting should meet the recommendations of the Illuminating Engineering Society of North America (IESNA) in their publication RP-20-98, “Lighting for Parking Facilities”, in addition to meeting IESNA publication G-1-03, “Guideline for Security Lighting for People, Property, and Public Spaces”. Parking Structure illumination levels shall correspond to those listed in the tables below.

<table>
<thead>
<tr>
<th>Area</th>
<th>Minimum Footcandles on pavement</th>
<th>Uniformity Ratio, Max/Min</th>
<th>Minimum Vertical Footcandles at 5 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Level</td>
<td>0.5</td>
<td>15:1</td>
<td>0.25</td>
</tr>
<tr>
<td>Covered Parking Levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Parking Area</td>
<td>1.0</td>
<td>10:1</td>
<td>0.5</td>
</tr>
<tr>
<td>Ramps</td>
<td>Day</td>
<td>Night</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>10:1</td>
<td>0.5</td>
</tr>
<tr>
<td>Entrance Areas</td>
<td>Day</td>
<td>Night</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1.0</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>10:1</td>
<td>10:1</td>
<td>0.5</td>
</tr>
<tr>
<td>Stairways</td>
<td>2.0</td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: Above values are maintained illuminance immediately prior to lamp replacement and fixture cleaning.

2. Parking Structure illumination levels for security shall correspond to those listed in the table below.

a. Roofs of Parking Structures

| Average Footcandles on pavement | 3 |
| Uniformity Ratio, Avg/Min       | 4:1 |

b. Covered Parking Levels

| Average Footcandles on pavement | 6 |
| Uniformity Ratio, Avg/Min       | 4:1 |

c. Elevators and Stairs
Average Footcandles on pavement (in a 30 ft radius from center of gathering point) 10
Uniformity Ratio, Avg/Min 4:1

Note: Above values are maintained illuminance immediately prior to lamp replacement and fixture cleaning.

3. Maximum light power density shall correspond to the ASHRAE 90.1-2010 energy limitation of 0.25 watts per sf and California Title 24 Energy Conservation Code.

B. Lighting Controls
1. Provide motion sensors in accordance with NEMA Guide publication WD 7-2000 to detect moving vehicles and pedestrians on a level by level basis in parking structures.
2. Motion sensors shall activate light fixtures to full light output on each level upon detection of movement of vehicles or persons. Locate motion sensors to provide detection of movement over the entire floor area and at vehicle and pedestrian access points to each level. When no activity exists for a period of 15 minutes, light fixtures shall dim to 50% of full light output. When activity is detected, light fixtures shall turn on to full light output for a minimum period of 15 minutes.
3. Provide circuiting of light fixtures or wireless daylight sensors at each light fixture or group of light fixtures on each side of an above-ground parking structure floor to turn off light fixtures during the daytime when adequate natural light is detected. Light fixtures within 30 feet of a perimeter wall opening shall be turned off from one hour after sunrise to one hour before sunset. Light fixtures within 30 to 60 feet of a perimeter wall opening shall use daylight sensors to detect natural daylight infiltration and shall turn off lights in that zone when the vertical illuminance at 5 feet above the floor exceeds 20 footcandles (100 Lux). Lights shall turn on when the vertical illuminance at 5 feet above the floor falls below 5 footcandles (50 Lux). Light fixtures located more than 60 feet from a perimeter wall opening shall remain on during all operating hours.

1.2 DEFINITIONS

A. Luminarie: A complete lighting unit consisting of a lamp or lamps and ballast (when applicable) together with parts required to distribute the light, position and protect lamps, and connect lamps to the power supply.

B. Lighting Unit: Fixture, or an assembly of luminaires with a common support, including a pole or bracket plus mounting and support accessories.

C. A light fixture: A luminaire.

1.3 SUBMITTALS

A. Design Development submittals shall include
1. Lighting system life-cycle analysis considering installed costs, energy use, lighting efficiency, maintenance costs, lamp life and watts-per-square foot connected load.

2. Manufacturers' literature and specifications for lighting control systems.

B. Final Design submittals shall include specifications and drawings prepared by a registered electrical engineer in the state where the project is located.

C. Product data describing luminaires, lamps, ballasts, poles, and accessories. Arrange product data for luminaires in order of fixture designation. Include data on features, poles, accessories, and the following:

1. Outline drawings of luminaires and poles indicating dimensions and principal features.
2. Electrical ratings and ingress protection rating with certified results of laboratory tests.
3. Provide test reports for LED luminaires in accordance with IESNA publication LM-79, "Electrical and photometric measurements of Solid State Lighting Sources" and LM-80, "Measuring Lumen Maintenance of LED Light Sources".
4. Provide photometric calculations for an entire floor area on a typical level and roof level using the point method and radiosity software such as AGI32 by Lighting Analysts.

D. Product certifications signed by manufacturers of lighting units certifying that their products comply with specified requirements.

E. Maintenance data for products for inclusion in Operating and Maintenance Manual

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 "National Electrical Code" for components and installation.

B. Comply with ANSI C2, "National Electrical Safety Code".

C. Listing and Labeling: Provide luminaires and accessories that are UL Listed and labeled for their indicated use and location on the Project.

D. Manufacturers’ Qualifications: Firms experienced in manufacturing lighting units that are similar to those indicated for this Project and that have a record of successful in-service performance.

1.5 EXTRA MATERIALS

A. Furnish extra materials matching products installed as described below, packaged with protective covering for storage, and identified with labels describing contents. Deliver extra materials to Owner.

1. Lamps: 1 lamp for each 10 of each type and rating installed. Furnish at least 2 of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 1 for each 50 of each type and rating installed. Furnish at least 2 of each type.
3. Ballasts: 1 for each 50 of each type and rating installed. Furnish at least 2 of each type.
4. Globes and Guards: 1 for each 20 of each type and rating installed. Furnish at least 2 of each type.

1.6 GLARE CONTROL

A. Vertical Illuminance at 5 feet above the ground at the property line shall not exceed 15 lux (1.5 fc) from dusk to 11:00pm, and shall not exceed 6 lux (0.6 fc) after 11:00pm. Provide shielding and/or optical control of the light fixture as required.

B. Covered Parking Levels

1. Lamp wattage shall not exceed 175W per lamp.
2. The luminous intensity at 80 degrees from a vertical line through the fixture shall not exceed 2500 candela.

C. Roof Level

1. Locate luminaires at interior column lines. Perimeter luminaires are prohibited.
2. Lamp wattage shall not exceed 400W per lamp.
3. The luminous intensity at 80 degrees from a vertical line through the fixture shall not exceed 2500 candela.

1.7 LIGHTING DESIGN CALCULATIONS

A. Provide point-by-point illuminance calculations per IES procedures in each of the areas identified in paragraph 1.8.

1. Point Spacing

a. Covered Parking Areas: 5-foot maximum.
b. Roof Parking Areas: 10-foot maximum.
c. All other areas: 2.5-foot maximum.

2. Perimeter analysis points shall be within 1 foot of area perimeter
3. Grid spacing shall result in one point directly under each light fixture (within 2.5 feet).

B. Light Loss Factors – The product of the following items shall determine the total light loss factor.

1. Ballast/Driver Factor

a. HID lamps: 0.95.
b. T8 Fluor. – Normal Power Electronic Ballast: 0.88.
c. T8 Fluor. – Low Power Electronic Ballast: 0.77.
d. T8 Fluor. – High Power Electronic Ballast: 1.15.
e. All other light sources: 1.0

2. Dirt Depreciation Factor
   a. 60,000+ hour lamp life: 0.80.
   b. 30,000 hour lamp life: 0.84
   c. 20,000-hour lamp life: 0.87.
   d. 10,000-hour lamp life: 0.90.

3. Temperature Factor (based on mean low daily temperature for January at project location).
   a. Induction Lamps: 1.0
   b. LED: 1.0
   c. T8 & T5HO Fluorescent Lamps (unenclosed).
      1) 60 degrees F: 0.91.
      2) 50 degrees F: 0.79.
      3) 40 degrees F: 0.65.
      4) 30 degrees F: 0.45.
      5) 20 degrees F: 0.31.

   d. T8 & T5HO Fluorescent Lamps (enclosed, IP65 rated)
      1) 60 degrees F: 0.99.
      2) 50 degrees F: 0.98.
      3) 40 degrees F: 0.93.
      4) 30 degrees F: 0.83.
      5) 20 degrees F: 0.61.

4. Lamp Lumen Depreciation (at 100% of rated lamp life)
   a. T8 Fluorescent: 0.90.
   b. T5HO Fluorescent: 0.95
   c. Induction Lamps: 0.65
   d. LED: 0.70

C. Surface Reflectance may be used in the illuminance calculation with the following limitations:

1. Unpainted concrete ceilings & walls: 35%.
2. White-painted ceilings & walls: 70%.
3. Concrete Floor: 20%.
4. Asphalt Floor: 7%.

D. Lighting Power Density (LPD).
1. Covered Parking Areas: LPD shall not exceed 0.15 watts per square foot of floor area.
2. Uncovered Parking Areas: LPD shall not exceed 0.07 watts per square foot of floor area.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Covered Parking Areas

1. Fluorescent
   b. Limelight
   c. Lithonia DMW.
   d. Day-Brite Vaporlume
   e. H.E. Williams 97 Series
   f. Beghelli Illumina Series
   g. Holophane

2. Induction
   a. ECO Parking Lights
   b. Gardco
   c. Neptun
   d. Widelight

3. Light-Emitting Diode (LED)
   a. Kenall TekDek
   b. Beta Lighting
   c. LSI Lighting
   d. McGraw Edison
   e. Holophane

B. Roof Parking Areas – Cutoff Luminaires

1. LED
   a. Beta Lighting
   b. Kenall
   c. LSI
   d. Gardco

2.2 FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs and sharp edges and corners.

B. Sheet Metal Components: Corrosion-resistant aluminum or stainless steel, except as indicated. Form and support to prevent warping and sagging.

C. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use with filter/breather.
D. Doors, Frames, and Other Internal Access Provisions: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in the operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.

E. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:
   1. White Surfaces: 85%.
   2. Specular Surfaces: 95%.

F. Plastic Parts: Resistant to yellowing and other changes due to aging and exposure to heat and UV radiation.

G. Lenses and Refractors: High-impact acrylic. Use heat-, aging- and ultraviolet resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.

H. Photoelectric Relay: UL 773, "Plug-in, Locking Type Photocontrols for Use With Area Lighting".
   1. Relays: Single-throw, arranged to fail in the "on" position and factory set to turn light unit on at 5 footcandles and off at 15 footcandles with 15 seconds minimum time delay unless noted otherwise on drawings.
   2. Mounting: In fixture housing.

I. All fixtures/ballast shall be protected by fuse of size and type recommended by manufacturer. Ballasts shall not contain polychlorinated biphenyls (PCB’s).

2.3 FLUORESCENT FIXTURES

A. Fixtures: Conform to UL 1570, "Fluorescent Lighting Fixtures".
   1. Fluorescent fixtures shall be prewired and factory polyester power coat painted. Lenses shall be 100% Virgin Acrylic, 0.125 in. thick minimum with UV stabilizer.
   3. Minimum Starting Temperature: 0°F.
   4. Minimum Power Factor: 98%.
   5. Minimum Operating Frequency: 20,000 Hz.
   6. Third Harmonic Content of Ballast Current: Less than 15%.

B. Ballasts: Conform to UL 935, "Fluorescent-Lamp Ballasts", certified by Electrical Testing Laboratory (ETL). Labeled by Certified Ballast Manufacturers Association (CBM).
1. Each ballast shall be protected by fuse of size and type recommended by ballast manufacturers.

2. Type: High-power-factor type rated for 0° F. starting and listed for use in outdoor fixtures.

3. Sound Rating: A.

4. Voltage: Match connected circuits.

5. Acceptable Ballast Manufacturers:
   
   a. Advance Transformer Company.
   b. Magnetek.
   c. Valmont Electric Co.
   d. Robertson Transformer Co.

2.4 **(NOT ALLOWED)EMERGENCY LIGHTING SYSTEMS**

A. Exit Signs: All exit signs shall be vandal resistant, tamper resistant, self-contained units, and UL approved for wet locations.
   
   1. The signs shall have a 25 year warranty on electronic components, 80 year warranty on the LEDs, and 10 years warranty on the nickel-cadmium batteries. Radioactive or self-illuminating exit lights are not allowed.

B. Battery Pack Fixtures (see following Section for Emergency Battery Packs): Battery pack fixtures shall be provided as shown on Drawings and listed in light fixture schedule. All battery pack fixtures shall be vandal resistant, tamper resistant, and UL approved for wet or damp locations unless otherwise specified.

   1. Battery Pack Fluorescent Fixtures: Battery pack emergency fluorescent fixtures shall contain battery, automatic charger, inverter, ready light and test switch. Upon loss of normal AC power, fixtures will automatically transfer to battery power and provide at least 1000 lumens for minimum of 90 minutes. Inverter shall automatically disconnect when battery is 87.5% discharged to prevent battery damage. Battery shall be maintenance free and not damaged when in 87.5% discharged condition at minus 30° C. Charger shall be capable of fully recharging battery in 12 hrs. or less after full discharge.

   2. Acceptable Manufacturers:
      
      a. Eclipse.
      b. Fail Safe.
      c. Northern.

C. Emergency Battery Packs: Emergency battery packs shall be provided as shown on Drawings and listed in light fixture schedule.

   1. Emergency battery packs shall contain battery, automatic charger, ready light and test switch. Upon loss of normal AC power, halogen lamp head fixtures will provide lighting for minimum of 90 minutes. Unit shall automatically disconnect when battery is 87.5% discharged to prevent battery damage. Battery shall be maintenance free and not damaged when in 87.5% discharged condition at minus 30° C. Charger shall be capable of fully recharging battery in 12 hrs. or less after full discharge. Case shall be NEMA 4X, UL listed for wet or damp locations.
2. Acceptable Manufacturers:
   a. Lithonia.
   b. Dual-Lite.

2.5 INCANDESCENT LIGHTING FIXTURES (NOT ALLOWED)

2.6 LIGHT-EMITTING DIODE LIGHT FIXTURES
   A. Conform to UL 8750, Safety Standard for LED Lighting

2.7 FIXTURES SUPPORT COMPONENTS
   A. Lighting Standards (Poles):
      1. Design of metal poles shall be based on local maximum wind velocity and effective projected area of luminaires. In no case shall design be below:
         a. 100 mph wind plus 30% gust effect for height of fixture above ground level. Supply calculations to Engineer/Architect for approval.
         b. 8 sq ft effective projected area.
         c. Arm, Bracket, and Tenon Mount Materials: Match the poles
         d. Mountings, Fastenings, and Appurtenances: Corrosion-resistant components compatible with the poles and fixtures that will not cause galvanic action at contact points. Provide mountings that will correctly position the luminaire to provide the indicated light distribution.
      2. Material:
         a. Steel Poles:
            1) Shaft of steel poles shall conform to ASTM A500 Grade B or ASTM A595 Grade A.
            2) Base of steel poles shall be ASTM A36 telescoped on pole base, welded top and bottom.
            3) Poles shall be internally coated with thermalplastic hydrocarbon resin.
         b. Anchor bolts shall be ASTM A675 Grade 90 with minimum yield strength of 50,000 psi. Bolts are "L" shape with 6 in. of threads and galvanized to
ASTM A153 for minimum of 8 in. on threaded end. Position bolts using manufacturer's template.

3. Accessories:
   a. Hand hole on all poles, 1 ft - 6 in. above base.
   b. Metal anchor bolt/pole base covers secured to pole with tamper resistant fasteners.
   c. Grounding lug.
   d. Level with anchor bolt bottom nuts and shims, then grout with no-shrink, non-metallic grout leaving path for water to drain from inside pole.
   e. Finish and color to match fixtures.
   f. Miscellaneous screws to be passivated or stainless steel.
   g. Provide lowering winch for all hinged poles.

4. Acceptable Manufacturers:
   a. Valmont Industries Inc.
   b. KW Industries.

2.8 LAMPS

A. As shown on Drawings and listed in light fixture schedule.

B. Conform to ANSI Standards, C78 series, applicable to each type of lamp. Provide fixtures with indicated lamps. Where lamps are not indicated, provide lamps recommended by manufacturer.

C. Incandescent lamps shall be 3500 hr industrial service, inside frost, 130 volts.

D. Fluorescent lamps shall be specified on fixture schedule.

E. High Pressure Sodium:
   1. Shall be first line, high quality high output lamps having heat resistant clear glass envelopes with sodium arc tube interior. Color temperature shall be 2100° K. Lumens and hours of life shall not be less than those values shown in following table:

<table>
<thead>
<tr>
<th>WATTS</th>
<th>INITIAL LUMENS</th>
<th>MEAN LUMENS</th>
<th>LIFE HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9,500</td>
<td>8,850</td>
<td>24,000+</td>
</tr>
<tr>
<td>150</td>
<td>16,000</td>
<td>14,400</td>
<td>24,000+</td>
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<tr>
<td>250</td>
<td>28,500</td>
<td>25,600</td>
<td>24,000+</td>
</tr>
<tr>
<td>400</td>
<td>50,000</td>
<td>45,000</td>
<td>24,000+</td>
</tr>
</tbody>
</table>

   2. The mean lumen output of the HPS lamp after 12,000 hrs. use shall produce minimum of 90% of its initial lumen rating.
   4. See drawings for different or special requirements.
F. Metal Halide Lamps:

1. Shall be first line, high quality high output lamps having heat resistant clear glass envelopes with quartz arc tube interior. All lamps shall be of pulse start design. Lumens and hours of life shall not be less than those values shown in following table:

<table>
<thead>
<tr>
<th>WATTS</th>
<th>INITIAL LUMENS</th>
<th>MEAN LUMENS</th>
<th>LIFE HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9,000</td>
<td>6,800</td>
<td>15,000</td>
</tr>
<tr>
<td>150</td>
<td>15,000</td>
<td>11,300</td>
<td>15,000</td>
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<tr>
<td>175</td>
<td>17,500</td>
<td>14,000</td>
<td>15,000</td>
</tr>
<tr>
<td>200</td>
<td>21,000</td>
<td>16,800</td>
<td>15,000</td>
</tr>
<tr>
<td>250</td>
<td>26,300</td>
<td>21,040</td>
<td>15,000</td>
</tr>
<tr>
<td>400</td>
<td>44,000</td>
<td>35,200</td>
<td>20,000</td>
</tr>
</tbody>
</table>

2. The mean lumen output of the MH lamp taken at 40% of Rated Life.
3. Burning Position: All MH lamps must be designed to operate in position as required by fixture.
4. See drawings for different or special requirements.

G. Acceptable Lamp Manufacturers:

1. Philips.
2. OSRAM/Sylvania.
3. GE

H. Life of H.I.D. and fluorescent lamps shall be guaranteed for 1 yr. Any burn out in this time will be replaced by Contractor.

I. Induction Light sources

1. Philips QL
2. Osram Sylvania Icetron

J. LED Light Sources

1. Cree
2. Nichia
3. Lumiled

2.9 LIGHTING CONTROL EQUIPMENT

A. Surge Protection: Comply with UL 1449, "Transient Voltage Surge Suppressors".

B. Load Compatibility: Lighting control equipment is compatible with the controlled loads.

C. Contactors: Comply with NEMA ICS 2, "Industrial Control Devices, Controllers and Assemblies". Lighting contactors shall be electrically operated, mechanically held. Furnish contactors with number of normally open and normally closed contacts as
shown on plans. Contactors shall have 120 VAC coils and contacts rated 20 amps minimum, 277 volt AC minimum for switching lighting loads. Contactors shall be UL listed at full load rating. (Contact ratings shall always be equal to or greater than rating of breaker connected to that contact.)

1. Pilot lights must indicate closed position of each independent contactor.

D. Relays - Comply with NEMA ICS 2, "Industrial Control Devices, Controller and Assemblies". Relays shall be magnetic type, electrically-held, rated for control circuits and with number of poles indicated on Drawings.

E. Acceptable Contactor and Relay Manufacturers

1. Automatic Switch Co.
2. Siemens Lighting Systems.
3. Square D Co.
4. Zenith Controls, Inc.
5. Westinghouse.

F. Time Switches - Time Switches: Solid-state programmable units with alphanumeric display conforming to UL 917, "Clock Operated Switches". Time switches shall be digital 2 channel combination time of day/astronomic with skip-a-day feature with number of poles as indicated on Drawings and battery reserve power. (Time Switches are to be set to time of day mode unless otherwise specified on Drawings.)

1. Acceptable Time Switch Manufacturers
   a. Paragon Electric (EC72ST).
   b. Tork, Inc (DZS200A).

G. Photoelectric Relays - Conform to UL 773A, "Nonindustrial Photoelectric Switches for Lighting Control". Relays are solid state, with dry contacts for relay or contactor control, and have time delay to prevent false operation. Units shall have a weather tight housing, resistant to high temperatures and equipped with a sun glare shield and ice prevention. Photoelectric controls shall operate when natural light falls below design level. Units are adjustable for turn-on/turn-off levels. Set to turn on at 5 footcandles and off at 15 footcandles unless noted otherwise. Provide surge protection for top tier photoelectric control feed to LCP panel.

1. Acceptable Photoelectric Relay Manufacturers
   a. Area Lighting Research, Inc.
   b. Fisher Pierce.
   c. Intermatic, Inc.
   d. Paragon Electric.
   e. Tork, Inc.

H. Lighting Control Panel Enclosures - Size NEMA 12 panel with hinged cover to allow for future addition of 1 time switch, 3 contactors and 3 control switches. Provide lighting contactors, time switches, control relays, control switches, 120 volt L.E.D. pilot lights, terminal blocks, etc. as shown on Drawings.

I. Wireless Lighting Controls

1. Acceptable Manufacturers
   a. Adura Technologies (http://www.aduratech.com/)
b. Daintree Networks (http://www.daintree.net/)
c. TwistHDM (http://www.twisthdm.com/)

d.  

2.10 FINISH

A. Metal Parts: Baked on polyester-powder coat finish except as otherwise indicated. Finish shall be free of streaks, runs, holidays, stains, blisters, and similar defects. Remove poles, fixtures, and accessories showing evidence of corrosion or finish failure during Project warranty period and replace with new items.

B. Other Parts: Manufacturer's standard finish except as otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lighting fixtures as shown on Drawings and listed in fixture schedule. Coordinate fixture locations with structure and signage location. Set units plumb, square, level and secure according to manufacturer written instructions and shop drawings.

B. Lighting fixtures shall be fully lamped. This Contractor shall furnish lamps for all fixtures scheduled on plans. These lamps shall be new at time of acceptance by Owner.

C. Pole Installation: Use fabric web slings (not chain or cable) to raise and set poles.

D. Fixture Attachment: Fasten to indicated structural supports.

E. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.

F. Lamp fixtures with indicated lamps according to manufacturer's instructions. Replace malfunctioning lamps.

G. Install and wire outlets where shown on Drawings for illuminated signs.

H. Emergency Lighting System:

1. Illuminated Exit Signs: Connect circuits supplying illuminated exit signs to locked-on breakers in distribution panel indicated on Drawings.

2. Emergency Battery Packs:

   a. Connect emergency battery packs to circuit powering NL fixtures in that area.
   b. Mount fixtures with tamperproof bolts.
   c. Size conductors to remote lamps as shown on drawings and also to limit voltage drop to 3% or less.
   d. Aim heads as directed by Engineer/Architect.
3. Stairway and Security Fixtures (NL): Connect circuits supplying stairway and NL fixtures to locked-on breakers in distribution panel indicated.

I. Aim photoelectric controls away from nearby light sources and shield if required.

J. Furnish, install and connect lighting control equipment in lighting control panel as specified on Drawings.

1. Install switches in hinged cover of lighting control panel for control of all lighting fixtures as shown on plans. Switches shall be "Hand-Off-Auto" or "On-Off" switches as specified on Drawings, with pilot light to indicate operation of lights. All switches must provide a unique N.O. contact for each position. All levels shall be switched independently.

2. The size of all power conductors in the panel shall match home run conductor size specified on the panel schedules as a minimum.

3. Terminate conductor on screw type terminal blocks using ring type compression terminals. Terminal blocks shall be sized to accept from #6 to #10 conductors (or larger if specified on panel schedules).

4. Each conductor shall have heat shrink identification labels on each end of termination. All points of terminal strips are to be labeled to match conductor labeling.

5. Bundle train and support wiring in enclosures using wiring troughs. Wiring shall be routed neatly against the back of the enclosures and not located in front of any equipment, component, or terminal block.

6. Provide wiring between lighting power distribution panel, switching panel and control panel as necessary.

7. Engrave front plate with name tags as indicated on Drawings.

K. Install photoelectric controls and auxiliary relays as required to operate specified lights at dusk and at light levels indicated on Drawings. Photoelectric controls are to be aimed as indicated on the Drawings and away from nearby light sources and shielded if required.

L. Install "lock-on" devices on circuit breakers connected to circuits providing 120 volt control power.

3.2 GROUNDING

A. Ground fixtures and metal poles according to Division 26 Section "Common Work Results for Electrical", and as shown on the Drawings.

3.3 FIELD QUALITY CONTROL

A. Inspect installed units for damage.

B. Provide advance notice of dates and times for field tests.

C. Provide instruments to make and record test results.
D. Tests: Verify normal operation of lighting units after installing fixtures and energizing circuits with normal power source. Include the following:

1. Photometric Tests: Measure light intensities at locations where specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
2. Check for excessively noisy ballasts.
3. Check for uniformity of illuminations.
4. Written report of tests indicating actual illumination results.

E. Replace or repair damaged and malfunctioning units and retest.

3.4 ADJUSTING AND CLEANING

A. Clean components on completion of installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities.

C. Adjust time switches for lighting functions scheduled on Drawings and/or scheduled by Owner for management of parking facility.

D. Adjust photoelectric controls to switch at the levels indicated on Drawings.

3.5 DEMONSTRATION

A. Train Owner's personnel to operate, service, and maintain equipment and system components. Schedule training with at least 7-days' notice.

3.6 COMMISSIONING

A. Operational Tests: Energize systems, program control, and check each controlled area for light levels and lamp and component noise. Use light meters appropriate for the test and calibrated to NIST standards. Adjust components and revise installation as required to correct deficiencies. Operate the system to prove compliance with requirements.

B. Correct malfunctions and retest until proper operation is achieved.

END OF SECTION 16501

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