LED SITE LIGHTING (PARKING LOT) SPECIFICATION

Parking lots can gain higher-quality light that uses less energy and can be more easily controlled by replacing traditional high-intensity discharge (HID) lighting sources with light-emitting diode (LED) lighting sources. LEDs work better than HID lamps with controls (e.g., occupancy sensors and dimmers) and have the same or longer-rated lifespans.

The U.S. Department of Energy (DOE) Commercial Building Energy Alliances (CBEA) identified parking lots as an area in which LED lighting sources can dramatically improve lighting quality and energy performance. A CBEA Project Team comprising members from the retail, commercial real estate, and hospital sectors, with support from the Pacific Northwest National Laboratory, developed a technical specification that indicates an installed power density that is below ASHRAE Standard 90.1-2007 energy code. Additional energy savings are possible from the use of lighting controls. Companies can use the specification to stipulate performance expectations as well as warranty and testing information to manufacturers in order to get a product that outperforms traditional HID lighting sources.

For more information on this and other technical specifications being developed by CBEA members, visit http://www1.eere.energy.gov/buildings/alliances/technologies.html.

PART 1 – GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by their basic designation only.

B. American National Standards Institute (ANSI)

1. C82.SSL1 – SSL Drivers (in ANSI development)
2. C136.2-2004 - American National Standard for Roadway and Area Lighting Equipment – Luminaire Voltage Classification
3. C136.3-2005 – American National Standard for Roadway and Area Lighting Equipment – Luminaire Attachments
4. C136.10-2010 – American National Standard for Roadway Lighting Equipment – Locking-Type Photocontrol Devices and Mating Receptacle Physical and Electrical Interchangeability and Testing
5. C136.15-2011 – American National Standard for Roadway and Area Lighting Equipment – Luminaire Field Identification
6. C136.22-2004 (R2009) – American National Standard for Roadway and Area Lighting Equipment – Internal Labeling of Luminaires
7. C136.25-2009 – American National Standard for Roadway and Area Lighting Equipment – Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures
8. C136.31-2010 – American National Standard for Roadway Lighting Equipment – Luminaire Vibration

9. C136.37-2011 – American National Standard for Roadway and Area Lighting Equipment – Solid-State Light Sources Used in Roadway and Area Lighting

C. American Society for Testing and Materials International (ASTM)

1. B117-09 – Standard Practice for Operating Salt Spray (Fog) Apparatus
2. D1654-08 – Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
3. D523-08 (or latest) – Standard Test Method for Specular Gloss
4. G53 – 06 – Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV – Condensation Type) for Exposure of Nonmetallic Materials
5. G154 – 06 (or latest) – Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

D. Council of the European Union (EC)

1. RoHS Directive 2002/95/EC, on the restriction of the use of certain hazardous substances in electrical and electronic equipment

E. Federal Trade Commission (FTC)

1. Green Guides, 16 CFR Part 260, Guides for the Use of Environmental Marketing Claims

F. Illuminating Engineering Society of North America (IESNA)

1. DG-13-98 – Guide for the Selection of Photocontrols for Outdoor Lighting Applications
2. G-1-03 – Guidelines for Security Lighting
3. HB-10-11 – IES Lighting Handbook, 10th Edition
4. LM-64-01 – Photometric Measurements of Parking Areas
5. LM-69-95 (R2002) – Interpretation of Roadway Luminaire Photometric Reports
6. LM-79-08 – IESNA Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products
7. LM-80-08 – IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
8. RP-16-10 – ANSI/IES Nomenclature and Definitions for Illuminating Engineering
9. RP-20-98 – Recommended Practice for Lighting Parking Facilities
10. RP-33-99 – Recommended Practice for Lighting for Exterior Environments
11. TM-15-11 – Luminaire Classification System for Outdoor Luminaires
12. TM-21-11 – Projecting Long Term Lumen Maintenance of LED Light Sources

G. International Electrotechnical Commission (IEC)

1. IEC 60529 – Degrees of Protection Provided by Enclosures (IP Code)

H. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE C62.41.1-2002 – IEEE Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuits
2. IEEE C62.41.2-2002 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000W and less) AC Power Circuits

I. National Electrical Manufacturers Association (NEMA)

1. ANSI/NEMA/ANSLG C78.377-2008 – American National Standard for the Chromaticity of Solid-State Lighting Products
2. WD 7-2000 – NEMA Guide Publication: *Occupancy Motion Sensors*

J. National Fire Protection Association (NFPA)

1. 70 – National Electrical Code (NEC)

K. Next Generation Lighting Industry Alliance/Department of Energy

1. LED Luminaire Lifetime: Recommendations for Testing and Reporting – 1st Edition

L. Underwriters Laboratories (UL)

1. 1449 – Surge Protective Devices
2. 1449 – Luminaires
3. 1449 – Light-Emitting Diode (LED) Equipment for Use in Lighting Products

M. U.S. Department of Defense

1. MIL-HDBK 217F (Change 2) – Reliability Prediction of Electronic Equipment

1.2 RELATED DOCUMENTS

Contract Drawings and conditions of Contract (including General Conditions, Addendum to the General Conditions, Special Conditions, Division 01 Specifications Sections and all other Contract Documents) apply to the work of this section.

1.3 DEFINITIONS

A. Lighting terminology used herein is defined in IES RP-16. See referenced documents for additional definitions.

1. Exception: The term “driver” is used herein to broadly cover both drivers and power supplies, where applicable.
2. Clarification: The term “LED light source(s)” is used herein in accordance with IES LM-80 to broadly cover LED package(s), module(s), and array(s).

1.4 QUALITY ASSURANCE

A. Site Owner may request standard production model luminaire samples, including LED package, identical to product proposed to be installed for inspection. Owner may request

independent testing of sample luminaires to verify luminaire performance and compliance with the specifications. Conduct testing in accordance with the applicable IES and ANSI-approved methods for products using solid-state lighting (SSL) sources. Test laboratories must be either National Voluntary Laboratory Accreditation Program accredited for SSL testing as part of the Energy-Efficient Lighting Products Laboratory Accreditation Program or one of the qualified labs listed on the DOE SSL website (http://www1.eere.energy.gov/buildings/ssl/test_labs.html).

B. If luminaires are believed to be underperforming in early life, the site owner may choose to take field measurements between 2,000 and 3,000 operating hours of the completion of installation to confirm that lighting levels are in accordance with the site-specific photometric requirements in this specification. If uniformity is more than 15% worse or average light levels are more than 15% below the **DAY 1** submittal (see 1.7.A.1) and the luminaire locations in the field are as designed, the luminaire manufacturer must provide additional luminaires to achieve the specified light levels and uniformity. Variance from specified tolerances may be allowed provided prior approval by owner.

C. Guidance for pre- and post-installation field measurements (measurement and verification plan) can be found at http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/lighting_measurement_evaluation_protocol.pdf.

1.5 SITE LIGHTING SYSTEM PERFORMANCE

A. Energy Conservation

1. Site lighting must meet the following lighting power density (LPD) requirements (paved area of site defines the applicable area) based on the exterior zone location for the project (see Appendix A for zone definitions):
   a. Lighting zone (LZ)-2 – LPD maximum of 0.05 W/SF
   b. LZ-3 – LPD maximum of 0.06 W/SF
   c. LZ-4 – LPD maximum of 0.08 W/SF

B. Site Lighting Requirements

1. Main Parking Area
   a. Defined as the group(s) of parking spots comprising the majority of the site. The zone starts from the edge of the front aisle and extends to the center of the outermost driving lane. See Appendix B for diagram of exterior areas.
   b. Illuminance requirements of area:

Table 1. Main Parking Area

	Minimum Horizontal Illuminance	Uniformity Maximum:Minimum	Minimum Vertical Illuminance
Lighting Zone 2	0.50 fc	10:1	0.25 fc

Lighting Zone 3	0.75 fc	10:1	0.40 fc
Lighting Zone 4	1.00 fc	10:1	0.50 fc

c. Horizontal illuminance measurements must be taken at finished grade. Vertical illuminance in the center of the main parking area must be taken at 5 ft above parking surface at the point of lowest horizontal illuminance, excluding facing outward along boundaries.

2. Perimeter Parking Areas

   a. Defined as the group(s) of parking spots on the perimeter of the site. The zone starts on the center of the outermost driving lane and goes to the boundary of the paved area. See Appendix B for diagram of exterior areas.

   b. Illuminance requirements of area:

Table 2. Perimeter Parking Area

	Minimum Horizontal Illuminance	Uniformity Maximum:Minimum
Lighting Zone 2	0.20 fc	10:1
Lighting Zone 3	0.40 fc	10:1
Lighting Zone 4	0.50 fc	10:1

3. Front Aisle

   a. Defined as the driving/walking area from the façade of the building through the nearest set of drive lanes. See Appendix B for diagram of exterior areas.

   b. Illuminance requirements of area:

Table 3. Front Aisle

	Minimum Horizontal Illuminance	Uniformity Maximum:Minimum
Lighting Zone 2	1.00 fc	10:1
Lighting Zone 3	1.50 fc	10:1
Lighting Zone 4	2.00 fc	10:1

4. Entry Drives, Bale and Loading Areas, Rear Drives

   a. Entry drive is defined as the roadway for entering and leaving the parking lot. The zone starts at the end of the public road and ends where the perimeter parking zone starts. See Appendix B for diagram of exterior areas.

   b. Loading area is defined as the roadway along the façade where loading and unloading for the building occur. See Appendix B for diagram of exterior areas.

   c. Rear drive is defined as the roadway behind the building, where customer parking does not occur, and extends from the façade of the building to the boundary of the paved area. See Appendix B for diagram of exterior areas.

d. Illuminance requirements of area:

Table 4. Entry Drives, Loading Areas, Rear Drives

	Minimum Horizontal Illuminance	Uniformity Maximum:Minimum
Lighting Zone 2	0.20 fc	10:1
Lighting Zone 3	0.40 fc	10:1
Lighting Zone 4	0.50 fc	10:1

5. Retail Spill Light Control (Light Trespass)

   a. The lighting system must produce less than the vertical illuminance listed in the table below at any point 5-ft above finished grade (AFG) along the site boundary (normal to the boundary and facing the site):

Table 5. Site Lighting Trespass Maximum Vertical Illuminance Values

Lighting Zone	Maximum Illuminance
LZ-2	0.30 fc
LZ-3	0.80 fc
LZ-4	1.50 fc

6. When security is an issue – Note that increased light levels are not the only or necessarily the best way to improve security in parking lots. Considerations include improved security camera equipment and placement, use of motion detectors to trigger increased light levels, increased lighting uniformity, etc. However, when specific security issues requiring light levels exceeding recommendations in A through F above are identified by the Site Owner, reference IES G-1-03, section 4. If all the requirements are met in G-1-03, use an LPD multiplier of 1.50 for each of the LZs.

1.6 SUBMITTALS

A. Performance reports – Submit the following for approval when required by the Site Owner:

1. Computer-generated photometric analysis of proposed **DAY 1** (defined as the initial illuminance values) of the lighting installation. Submittal should include the following requirements:

   a. Provide horizontal illuminance calculations with spacing between computer calculation points must be 10 ft.

   b. Provide vertical illuminance calculations.

   c. Computer calculation must use the following applicable light-loss factor (LLF) values: 1.0 lamp lumen depreciation (LLD), 1.0 luminaire dirt depreciation (LDD), and 1.0 luminaire ambient temperature factor (LATF).

   d. Mesopic multipliers as listed in section 1.6.A.4.

2. Computer-generated photometric analysis of end-of-useful-life date (see 2.1 G) of the lighting installation, submittal should include the following requirements:
    a. Provide horizontal illuminance measurements with spacing between computer calculation points must be 10 ft.
    b. Provide vertical illuminance calculations.
    c. Computer calculation must use the LLF values specified in section 1.6.A.3.
    d. Mesopic multipliers as listed in section 1.6 A. 4.
3. Light Loss Factors
    a. LLD: 0.70. An alternate value may be used based on the use of the site defined performance method if allowed by Site Owner. See section 2.1 G for calculation.
    b. LDD: Use http://www.epa.gov/airtrends/pm.html#pmloc to determine the particulate matter (PM) for the site and determine the applicable LLD for the site based on the PM according to RP-20.
    c. LATF: 1.00 for all luminaires.
4. Use of HB-10 mesopic multipliers
    a. Use a scotopic/photopic (S/P) ratio of 1.00 for all luminaire. If owner allows, use nominal S/P ratio and bilinear interpolation. Mesopic multiplier(s) used shall be clearly indicated in the calculations.

B. Luminaire photometric reports per IES LM-79-08, including laboratory name, report number, date, luminaire catalog number, and luminaire/light source specifications. Report must contain lumen values in Backlight-Uplight-Glare (BUG) zones according to IES TM-15-11 and roadway-type classifications, luminous intensity, zonal lumen summary, and an iso-footcandle diagram according to LM-31 as well as documentation that specified standards and test methods were followed.

C. Provide documentation of the expected useful life as defined in section 2.1 G, including the testing and calculation of useful life and verification of site lighting performance at that life. If the site-defined performance method is used, document the use of LM-80 test data, the specific extrapolation procedure used, the interpolation between the three sets of LM-80 data, and all calculations applied in deriving the proposed LLD and useful life.

D. Summary of Joint Electron Devices Engineering Council (JEDEC) or Japan Electronics and Information Technology Industries (JEITA) reliability testing performed for LED packages.

E. Summary of reliability testing performed for LED drivers.

F. Written product warranty in accordance with section 1.7.

G. Provide safety certification and file number as required for the luminaire family that must be listed, labeled, or identified per the National Electric Code (NEC). Applicable testing bodies are determined by the U.S. Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

1.7 WARRANTY

A. Standard Warranty

1. Provide a written **5-year** on-site replacement material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty must include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
2. Provide a written **5-year** replacement material warranty for defective or non-starting LED source assemblies.
3. Provide a written **5-year** replacement material warranty on all power supply units (PSU).
4. Provide a written **5-year** replacement warranty for luminaires producing inadequately maintained illuminance levels at end of warranty period, as prorated from levels expected at end of useful life.
5. Owner may request an optional **10-year** replacement warranty for inadequately maintained illuminance levels, finish of luminaire, PSU, or defective LED source assemblies. The terms of the extended warranty will be negotiated by the Site Owner and the luminaire manufacturer for an additional cost.
6. Warranty period must begin on date of possession. The supplier will provide the Site Owner with appropriate signed warranty certificates. The Site Owner must receive certificates prior to final payment.

PART 2 – PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

A. General Requirements

1. Luminaires must be the type indicated on Drawings and as specified. Fixtures of the same type must be provided by one manufacturer.
2. Luminaires must be of the types and manufacturers described in the LUMINAIRE REQUIREMENTS section, with light source, wattage and voltage as indicated on Drawings. Specific manufacturer and model number references are indicated as a standard of performance and quality. Other manufacturers' models may be supplied provided the product meets or exceeds the specifications. The alternate fixtures must achieve the same photometric levels and uniformity ratios.
3. All housing finishes must be baked-on enamel, anodized, or powder-coated, unless otherwise specified in subsections below.
4. Luminaire shall have an external label per ANSI C136.15.
5. Luminaire shall have an internal label per ANSI C136.22.
6. The luminaire must be subjected to 100,000 cycles of 2 Gs at the resonant frequency of the luminaire (between 5 and 30 Hz) applied at the center of gravity of the luminaire on three primary axes per ANSI C136.31 without damage to the luminaire. The luminaire must be fully functional upon completing the test.

7. Luminaire must be UL-listed for wet locations and wiring cavity must be field accessible for service or repair needs.
8. Optical cavity must be a minimum IEC 60529/IP65.
9. Fully assemble and electrically test luminaires before shipment from factory.
10. The coating must be capable of surviving ASTM B117 Salt Fog environment for 500 hr minimum without blistering or peeling. The coating must demonstrate gloss retention of greater than or equal to 90% for 500 hr exposure QUV test per ASTM G53 UVB313, 4 hr UV-B 60˚C/4 hr condensation 50˚C.
11. Luminaires must be rated for -20°C to +40°C operation
12. Luminaire arm bolts must be 304 stainless steel or zinc-plated steel and Grade 8.
13. Luminaires must have locality-appropriate governing mark and certification.
14. Color of the luminaire must be as specified by the Site Owner.
15. If a lens not integral to the LED is used, construct the luminaire optical enclosure (lens/window) of clear and UV-resistant polycarbonate, acrylic, or glass.
16. 80% of the luminaire material by weight should be recyclable at end of life. Design luminaire for ease of component replacement and end-of-life disassembly.

B. Luminaire Distribution

1. Luminaires must not have BUG ratings greater than any of the values in the applicable tables below from the MLO:

Table 6. Maximum Allowable Backlight Rating

	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Greater than 2 mounting heights from the property line	B4	B5	B5
1 to less than 2 mounting heights from the property line and ideally oriented*	B3	B4	B4
0.5 to 1 mounting heights from property line and ideally oriented**	B2	B3	B3
Less than 0.5 mounting height to property line and properly oriented*	B0	B1	B2

2. To be considered “ideally oriented,” the luminaire must be mounted with the backlight portion of the light output oriented perpendicular and toward the property line of concern.

Table 7. Maximum Allowable Uplight Rating

	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Allowed uplight rating	U2	U3	U4
Allowed % light emission above 90° for street or area lighting	0%	0%	0%

Table 8. Maximum Allowable Glare Rating

	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Allowed Glare Rating	G2	G3	G4
Any luminaire not ideally oriented** with 1 to less than 2 mounting heights to any property line of concern	G0	G1	G2
Any luminaire not ideally oriented ** with 0.5 to 1 mounting heights to any property line of concern	G0	G1	G1
	G0	G0	G1

C. Drivers must meet the following requirements:

1. Must have a minimum efficiency of 85%.
2. Rated case temperature shall be suitable for operation in the luminaire operating in the ambient temperatures.
3. Input Voltage: capable of 120 to 480 (±10%) volt, single phase as required by the site.
4. Power supplies can be UL Class I or II output.
5. Operating frequency must be 50/60 Hz.
6. Drivers must have a power factor of ≥ 0.90.
7. Drivers must be Reduction of Hazardous Substances (RoHS) compliant (see http://www.rohs.eu/english/index.html).
8. Minimum time between failures (MBTF = total hours of testing / number of failures) shall be greater than 300,000 hours at full load and 25°C ambient, in accordance with MIL-HDBK-217.
9. Lifetime = 100,000 hours at full load and 25°C ambient.

D. Electromagnetic Interference

1. Shall have a maximum total harmonic distortion (THD) of: ≤ 20% at full input power and across specified voltage range.
2. Shall comply with FCC 47 CFR part 15 non-consumer radio frequency interference/electromagnetic interference standards.

E. Electrical Safety Testing

1. Luminaire shall be listed for wet locations by an OSHA NRTL.
2. Luminaires shall have locality-appropriate governing mark and certification.

F. LED sources must meet the following requirements:

1. Correlated color temperature (CCT) shall be one of the following, as selected by Site Owner:

Table 9. Allowable Nominal CCT (adapted from ANSI C136.37-2011)

Outdoor White Color Range	Manufacturer-Rated Nominal CCT (K)	Allowable LM-79 Chromaticity Values	
		Measured CCT (K)	Measured Duv
Warm	2700	2580 to 2870	-0.006 to 0.006
	3000	2870 to 3220	-0.006 to 0.006
	3500	3220 to 3710	-0.006 to 0.006
Neutral	4000	3710 to 4260	-0.005 to 0.007
	4500	4260 to 4746	-0.005 to 0.007
Cool	5000	4745 to 5311	-0.004 to 0.008
	5700	5310 to 6020	-0.004 to 0.008
	6500	6020 to 7040	-0.003 to 0.009

2. Color rendering index (CRI): ≥ 65

G. Expected Useful Life (Light Output) and Depreciation

1. Useful life requirement: The useful life of the luminaire in terms of lumen output must be as specified by one of the following two methods:

   a. Simplified L_{70} threshold: A minimum of 50,000 operating hours before reaching the L_{70} lumen output degradation point, accounting for individual LED lumen depreciation and catastrophic failures. Fifty percent of the sample population must reach the 50,000-hr point – this is known as B_{50}. The L_{70} lumen output must be capable of providing the illuminance levels and uniformity specified in section 1.5. Only 10 percent of the luminaires can have failed in a conventional sense – this is known as F_{10}.

   b. Site performance method: A lifetime (in hours) specified by the Site Owner based on expected site lighting use and planned replacement where the output at the specified useful life must be capable of providing the illuminance levels and uniformity specified in section 1.5.

2. Useful Life Testing and Verification Procedure:

   a. Demonstrate light source life per Appendix C.

H. Electrical System Requirements

1. Primary fuse protection: Provide double fusing with fuse holder appropriately sized to the current.
2. Under voltage protection via shutoff and short circuit protection via current limitation.
3. Internal luminaire design must incorporate modular electrical connections.
4. All luminaires shall meet the “Basic” requirements in Appendix D. Site can choose “elevated” requirements.

I. Other Tests

1. At time of order, Site Owner can request additional tests for extreme environmental condition (e.g., sea salt near water, extreme cold weather operation) if site is located in adverse locations.

2.2 CONTROL REQUIREMENTS

A. Daylighting Controls

1. All exterior parking lot, drive, and front aisle areas must be controlled with a photocell, time switch, or intelligent control system that allows automatic on and off based on daylighting plus timed off after expected parking lot activity ends. Photosensor is used to energize all luminaires at dusk, and to switch off any security lighting left on overnight by time switch.
2. Furnish switches or relays in NEMA I general-purpose enclosure unless noted otherwise. Switches located on the exterior or in "wet" locations must have NEMA 3R, 4, or 4X enclosures as noted or required.
3. The photocell system must have the following characteristics:
   a. 15 to 30 second built-in time delay to prevent response to momentary lightning flashes, car headlights or cloud movements.
   b. Settings to energize the lighting system when the north sky light decreases to approximately XX footcandles, and maintains the system energized until the north sky light increases to approximately XX footcandles. *Note: XX values to be supplied by Site Owner. Actual value will depend on the lighting zone/required illuminance as specified in section 1.6. A TURN-ON/TURN-OFF ratio ≤ 5:1 (the lights either turn on or off when the photocell measures 5x the required illuminance) should be used.*
   c. Mounted in an unobscured location for measuring the available north sky daylight with a separate control/calibration module mounted separately and in an accessible location and shield the sensor from direct sunlight
   d. Use relays that are UL 773 or UL 773A listed and designed to fail in the on position.
4. The time switch(s) must control specific circuit "off" functions during dark hours and be:
   a. Digital microprocessor-based with battery backup capable of retaining programmed settings for at least 10 hours.
   b. 7-day, 24-hour astronomic capable.
5. Intelligent control systems must have the following characteristics:
   a. Power-line carrier (PLC) systems or wireless.
   b. Allow for two-way communication with the luminaire.
   c. Allow for scheduling for both time of day and astronomical events.
   d. Be remotely accessible.

B. Optional Controls

Optional controls installed in addition to the primary control system may include but are not limited to:

1. After hours dimming control – dims light levels to X% *[Site Owner must specify between 10% – 50% of full lumen output]* after expected parking lot activity ends (a.k.a. "curfew" control)
2. After hours switching control – turns off or reduces light levels after expected parking lot activity ends (a.k.a. "curfew" control)
    a. Specific areas turned off after expected parking lot activity ends.
    b. Overall reduction of light level after expected parking lot activity ends.
3. Lumen maintenance – Luminaires are initially dimmed to 70% of full output, with input power then gradually (and automatically) increased over time to compensate for LLD.
4. Occupancy Sensor Controls
    a. Install and aim sensors in locations to achieve coverage of areas indicated. Coverage patterns shall be derated as recommended by manufacturer based on mounting height of sensor and tree locations. Do not simply use gross rated coverage in manufacturer's product literature.
    b. Occupancy/vacancy sensors shall comply with NEMA Standard WD 7-2000, which provides for testing requirements on the issues of performance sensitivity.
    c. Infrared: Integral to the luminaire. Detect occupancy by changed in infrared energy within a coverage area and must be capable of operating between -20°C to +40°C and be wet-location rated.
    d. Sensors shall be located or shielded or controlled by software to adjust sensitivity based on ambient temperature or air temperature variations.
    e. Sensor must incorporate a failsafe feature such that lamps fail "on" in the event of sensor failure.
    f. If sensors are to be installed integral to the luminaire, installation must be performed by luminaire manufacturer.
5. End-of-Life
    a. Provide end-of-life mechanism into the luminaire. When the LED die output has reached end of useful life, the luminaire should enter a visible "failure mode" (e.g., intermittent flashing or flickering).

2.3 PRODUCT MANUFACTURERS

A. Substitution Limitations: Any manufacturer who offers products that comply with the required product performance and operation criteria may be considered.

B. Product Options

1. The above product description, performance and operation requirements must be followed.

2. Other mutually exclusive product options offered by qualified manufacturers such as housing color or lamp type are to be determined by the customer/project manager prior to selection and installation of the product.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Disconnect all power sources prior to installation.

B. Follow manufacturers' recommended installation procedures.

3.2 TESTING AND COMMISSIONING

A. Set appropriate time delay. Adjust sensitivity setting as necessary.

3.3 MANUFACTURER SERVICES

A. Manufacturers must provide installation and troubleshooting support via telephone.

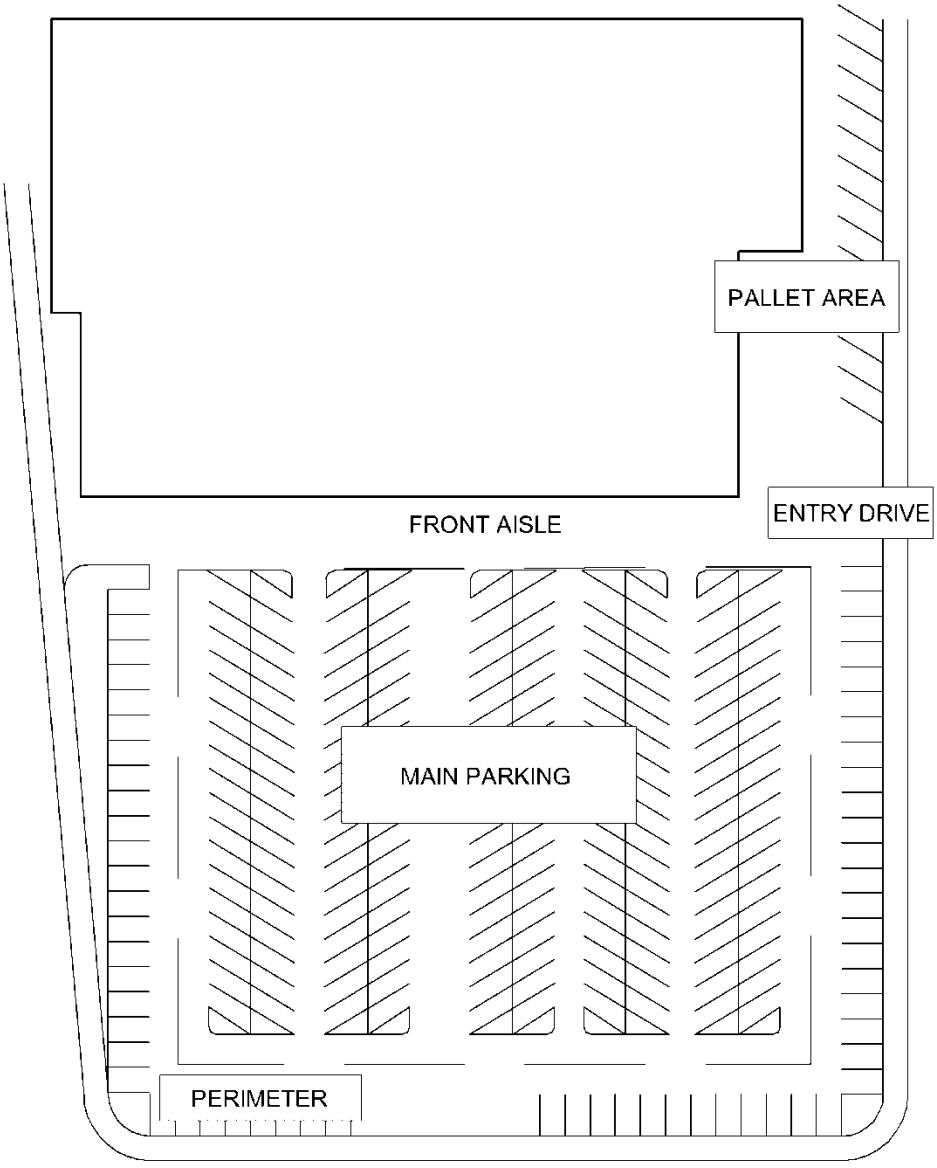
END OF SECTION

Appendix A – Definitions and Related Terms

Lighting Zones:

1. To provide as much information about the lighting zone, both the ASHRAE/IESNA Std. 90.1 and IES RP-33 exterior lighting zone definitions are combined below for zones where area lighting is expected to be applied. Lighting Zone (LZ0) is not expected to include area lighting as described in this specification but is described here for reference.
2. Lighting Zone (LZ2) – Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed use areas. Lighting may typically be used for safety and convenience but it is not necessarily uniform or continuous. After curfew, lighting may be extinguished or reduced as activity levels decline.
3. Lighting Zone (LZ3) – Areas not classifiable under the other four Lighting Zones. Areas of human activity where the vision of human residents and users is adapted to moderately high light levels. Lighting is generally desired for safety, security and/or convenience and it is often uniform and/or continuous. After curfew, lighting may be extinguished or reduced in most areas as activity levels decline.
4. Lighting Zone (LZ4) – High activity commercial districts in major metropolitan areas as designated by the local jurisdiction. Areas of human activity where the vision of human residents and users is adapted to high light levels. Lighting is generally considered necessary for safety, security, and/or convenience and it is mostly uniform and/or continuous. After curfew, lighting may be extinguished or reduced in some areas as activity levels decline.

Appendix B – Diagram of Parking Areas Identified in This Specification



Appendix C – Estimating LED Lumen Maintenance

IES TM-21 allows for extrapolation of expected lumen maintenance from available test data. The extent of such extrapolation is limited by the duration of testing completed and the number of samples used in the testing. The TM-21 methodology shall be used by the manufacturer to determine lamp lumen depreciation at end of lumen maintenance life per section 1.6-C.

The applicant may estimate lumen maintenance in one of two ways.

Option 1: Component Performance

Under this compliance path, the applicant must submit calculations per TM-21 predicting lumen maintenance at the luminaire level using In Situ Temperature Measurement Testing (ISTMT) and LM-80 data. To be eligible for the component performance option, ALL of the conditions below must be met. If ANY of the conditions is not met, the component performance option may not be used and the applicant must use Option 2 for compliance.

- The LED light source(s) have been tested according to LM-80.
- The LED drive current specified by the luminaire manufacturer is less than or equal to the drive current specified in the LM-80 test report.
- The LED light source(s) manufacturer prescribes/indicates a temperature measurement point (T_S) on the light source(s).
- The T_S is accessible to allow temporary attachment of a thermocouple for measurement of in situ temperature. Access via a temporary hole in the housing, tightly resealed during testing with putty or other flexible sealant is allowable.
- For the hottest LED light source in the luminaire, the temperature measured at the T_S during ISTMT is less than or equal to the temperature specified in the LM-80 test report for the corresponding drive current or higher, within the manufacturer's specified operating current range.
    - The ISTMT laboratory must be approved by the U.S. Occupational Safety and Health Administration as a Nationally Recognized Testing Lab, must be qualified, verified, and recognized through DOE's CALiPER program, or must be recognized through UL's Data Acceptance Program.
    - The ISTMT must be conducted with the luminaire installed in the appropriate application as defined by ANSI/UL 1598 (hardwired luminaires), with bird-fouling appropriately simulated (and documented by photograph) as determined by the manufacturer.

Option 2: Luminaire Performance

Under this compliance path, the applicant must submit TM-21 calculations based on LM-79 photometric test data for no less than three samples of the entire luminaire. Duration of operation and interval between photometric tests shall conform to the TM-21 criteria for LED light sources. For example, testing solely at 0 and 6,000 hours of operation would not be adequate for the purposes of extrapolation.

Between LM-79 tests, the luminaire test samples must be operated long-term in the appropriate application as defined by ANSI/UL 1598 (hardwired luminaires). The test laboratory must hold National Voluntary Laboratory Accreditation Program accreditation for the LM-79 test procedure or must be qualified, verified, and recognized through the CALiPER program. The extent of allowable extrapolation (either 5.5 or 6 times the test duration) depends on the total number of LED light sources (no less than 10 and preferably more than 19) installed in the luminaire samples, as per TM-21.

This compliance path poses a greater testing burden to luminaire manufacturers but incorporates long-term testing of other components in the system, such as drivers.

Under either compliance path, values used for extrapolation shall be summarized per TM-21 Tables 1 and 2. Submitted values for lumen maintenance lifetime and the associated percentage lumen maintenance shall be “reported” rather than “projected” as defined by TM-21. Supporting diagrams are requested to facilitate interpretation by Site Owner.

Appendix D – Electrical Immunity

Test Procedure

- Electrical Immunity Tests 1, 2, and 3, as defined by their test specifications, shall be performed on an entire powered and connected luminaire, including any control modules housed within the luminaire, but excluding any control modules mounted externally, such as a National Electrical Manufacturers Association socket-connected photo control. A shorting cap should be placed across any such exterior connector.
- The luminaire shall be connected to an AC power source with a configuration appropriate for nominal operation. The AC power source shall have a minimum available short-circuit current of 200A. The luminaire shall be tested at the nominal input voltage specified in Appendix A, or at the highest input voltage in the input voltage range specified in Appendix A.
- Electrical immunity test waveforms shall be superimposed on the input AC power line at a point within 6 in. (15 cm) of entry into the luminaire using appropriate high-voltage probes and a series coupler/decoupler network appropriate for each coupling mode, as defined by ANSI/IEEE C62.45-2002. The test area for all tests shall be set up according to ANSI/IEEE C62.45-2002, as appropriate.
- Prior to electrical immunity testing a set of diagnostic measurements shall be performed, and the results recorded to note the pre-test function of the luminaire after it has reached thermal equilibrium. These measurements should include at a minimum:
    - For all luminaires, real power, input root-mean-square (RMS) current, power factor, and total harmonic distortion at full power/light output.
    - For luminaires specified as dimmable, real power, input RMS current, power factor, and THD at a minimum of four additional dimmed levels, including the rated minimum dimmed level.
- Tests shall be applied in sequential order (Test 1, followed by Test 2, followed by Test 3). If a failure occurs during Test 3, then Test 3 shall be re-applied to a secondary luminaire of identical construction.
    - Following the completion of Tests 1, 2, and 3, the same set of diagnostic measurements performed pre-test should be repeated for all tested luminaires, and the results recorded to note the post-test function of the luminaire(s).
    - A luminaire must function normally and show no evidence of failure following the completion of Test 1 + Test 2 + Test 3 (for a single tested luminaire), or the completion of Test 1 + Test 2 on a primary luminaire and Test 3 on a secondary luminaire. Abnormal behavior during testing is acceptable.
    - A luminaire failure will be deemed to have occurred if any of the following conditions exists following the completion of testing:
        a) A hard power reset is required to return to normal operation.
        b) A noticeable reduction in full light output (e.g., one or more LEDs fail to produce light, or become unstable) is observed.
        c) Any of the post-test diagnostic measurements exceeds by ±5% the corresponding pre-test diagnostic measurement.
        d) The luminaire, or any component in the luminaire (including but not limited to an electrical connector, a driver, a protection component or module) has ignited or shows evidence of melting or other heat-induced damage. Evidence of cracking, splitting, rupturing, or smoke damage on any component is acceptable.

Test Specifications

Note: L1 is typically "HOT," L2 is typically "NEUTRAL," and PE = Protective Earth.

- **Ring Wave**: The luminaire shall be subjected to repetitive strikes of a "C Low Ring Wave" as defined in ANSI / IEEE C62.41.2-2002, Scenario 1, Location Category C. The test strikes shall be applied as specified by Table 1.

  Prior to testing, the ring wave generator shall be calibrated to simultaneously meet BOTH the specified short circuit current peak and open circuit voltage peak MINIMUM requirements. Note that this may require that the generator charging voltage be raised above the specified level to obtain the specified current peak. Calibrated current probes/transformers designed for measuring high-frequency currents shall be used to measure test waveform currents.

  Test waveform current shapes and peaks for all strikes shall be compared to ensure uniformity throughout each set (coupling mode + polarity/phase angle) of test strikes, and the average peak current shall be calculated and recorded. If any individual peak current in a set exceeds by ±10% the average, the test setup shall be checked, and the test strikes repeated.

Table 1. 0.5 µS – 100Hz Ring Wave Specification

Parameter	Test Level/Configuration
Short circuit current peak	0.5 kA
Open circuit voltage peak	6 kV
Coupling modes	L1 to PE, L2 to PE, L1 to L2
Polarity and phase angle	Positive at 90° and negative at 270°
Test strikes	5 for each coupling mode and polarity/phase angle combination
Time between strikes	1 minute
Total number of strikes	= 5 strikes × 3 coupling modes × 2 polarity/phase angles = 30 total strikes

- **Combination Wave**: The luminaire shall be subjected to repetitive strikes of a "C High Combination Wave" or "C Low Combination Wave," as defined in ANSI/IEEE C62.41.2-2002, Scenario 1, Location Category C. The test strikes shall be applied as specified by Table 2. The "Low" test level shall be used for luminaires with **basic** electrical immunity requirements, while the "High" test level shall be used for luminaires with **elevated** electrical immunity requirements.

  Prior to testing, the combination wave generator shall be calibrated to simultaneously meet BOTH the specified short circuit current peak and open circuit voltage peak MINIMUM requirements. Note that this may require that the generator charging voltage be raised above the specified level to obtain the specified current peak. Calibrated current probes/transformers designed for measuring high-frequency currents shall be used to measure test waveform currents.

  Test waveform current shapes and peaks for all strikes shall be compared to ensure uniformity throughout each set (coupling mode + polarity/phase angle) of test strikes, and the average peak current shall be calculated and recorded. If any individual peak current in a set exceeds by ±10% the average, the test setup shall be checked, and the test strikes repeated.

- **(EFT)**: The luminaire shall be subjected to "Electrical Fast Transient Bursts," as defined in ANSI/IEEE C62.41.2 -2002. The test area shall be set up according to IEEE C62.45-2002. The

Table 2: 1.2/50µS – 8/20 µS Combination Wave Specification

Parameter	Test Level/ Configuration	
1.2/50 µS open circuit voltage peak	Low: 6 kV	High: 10kV †
8/20 µS short circuit current peak	Low: 3 kA	High: 10kA
Coupling modes	L1 to PE, L2 to PE, L1 to L2	
Polarity and phase angle	Positive at 90° and negative at 270°	
Test strikes	5 for each coupling mode and polarity/phase angle combination	
Time between strikes	1 minute	
Total number of strikes	= 5 strikes × 3 coupling modes × 2 polarity/phase angles = 30 total strikes	

† This is a MINIMUM requirement. Note that for most combination wave generators, which have a source impedance of 2Ω, the generator charging voltage will need to be raised above the specified level (to somewhere in the vicinity of 20kV) to obtain the specified current peak.

- **Electrical Fast Transient** bursts shall be applied as specified by Table 3. Direct coupling is required; the use of a coupling clamp is not allowed.

Table 3: Electrical Fast Transient (EFT) Specification

Parameter	Test Level/ Configuration
Open circuit voltage peak	3 kV
Burst repetition rate	2.5 kHz
Burst duration	15 milliseconds
Burst period	300 milliseconds
Coupling modes	L1 to PE, L2 to PE, L1 to L2
Polarity	Positive and negative
Test duration	1 minute for each coupling mode and polarity combination
Total test duration	= 1 minute × 3 coupling modes × 2 polarities = 6 minutes