# PARKING GARAGE LIGHTING PERFORMANCE SPECIFICATION

## PART 1 – GENERAL

### 1.1 SUMMARY

The parking garage lighting performance specification is intended to provide adequate illumination in parking garages (structures) and save energy by reducing the installed power density of equipment below code as well as using controls to further reduce energy consumption. This is a document is being both adopted by the General Services Administration and the Department of Energy's Commercial Real Estate Energy Alliance (CREEA). Revisions to this specification may occur in the future.

### 1.2 REFERENCES

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

B. American National Standards Institute (ANSI)

1. ANSI C62.41.1-2002 – IEEE Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuits
2. ANSI C62.41.2-2002 – IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000W and less) AC Power Circuits
3. ANSI C82.SSL1 – SSL Drivers (in ANSI development)
4. ANSI C82.11 – For Lamp Ballasts, High Frequency Fluorescent Lamp Ballasts – Supplements

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

1. Std. 90.1-2007 – ANSI/ASHRAE/IENSA Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings

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

1. ASTM A 36 – Structural Steel
2. ASTM A 123 – Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A 153 – Zinc Coating (Hot-Dip) on Iron and Steel Hardware
4. ASTM A 595 – Steel Tubes, Low-Carbon, Tapered for Structural Use
5. ASTM F 1554 – Anchor Bolts, Steel, 36, 55, And 105-Ksi Yield Strength
6. ASTM B117-97 – Standard Practice for Operating Salt Spray (Fog) Apparatus
7. ASTM G53 – Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV – Condensation Type) for Exposure of Nonmetallic Materials

E. 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. LM-10-10, Photometric Testing of Outdoor Fluorescent Luminaires
4. LM-31-95, Photometric Testing of Roadway Luminaires Using Incandescent Filament and HID Lamps
5. LM-64-01, Photometric Measurements of Parking Areas
6. LM-69-95 (R2002), Interpretation of Roadway Luminaire Photometric Reports
7. LM-79-08, IESNA Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products
8. LM-80-08, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
9. RP-20-98, Recommended Practice for Lighting Parking Facilities

F. Institute of Electrical and Electronics Engineers (IEEE)

1. ANSI/IEEE C2 – National Electrical Safety Code

G. International Electrotechnical Commission (IEC)

1. IEC 60529 – Degrees of Protection provided by enclosures (IPCode)

H. National Electrical Manufacturers Association (NEMA)

1. LSD23-2002 – Recommend Practice – Lamp Seasoning for Fluorescent Dimming Systems
2. ANSI/NEMA/ANSLG C78.377-2008 – American National Standard for the Chromaticity of Solid State Lighting Products
3. WD 7-2000 – Occupancy Motion Sensors

I. National Fire Protection Association (NFPA)

1. NFPA 70 – National Electrical Code

J. Underwriter's Laboratory (UL)

1. UL 1598 – Luminaires
2. UL 935 – Standard for Fluorescent-Lamp Ballasts

## 1.3 RELATED DOCUMENTS

Contract Drawings, 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.

## 1.4 SECTION INCLUDES

Luminaires, including light sources, ballasts/drivers, wiring, and lighting controls for lighting in parking garages.

## 1.5 QUALITY ASSURANCE

A. Site owner may request standard production model luminaire samples identical (including LED package) 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. Testing shall be conducted per the applicable IESNA and ANSI approved methods for products using Solid-State Lighting (SSL) sources. Refer to the DOE SSL web site for a list of approved test laboratories at http://www1.eere.energy.gov/buildings/ssl/test_labs.html). Owner shall be sole judge regarding acceptability of optical system performance.

## 1.6 SITE LIGHTING SYSTEM PERFORMANCE

A. Energy Conservation

1. Lighting within the parking structure (excluding dedicated emergency lighting) shall not exceed a maximum of 0.225 W/ sf lighting power density (LPD).
2. A target LPD of 0.18 W / sf is desired.
3. Through the use of select controls, either occupancy or daylighting based, the lighting system shall be designed to save at least 20% energy compared to the total installed power times the full operating schedule of the garage.

B. Light Loss Factors (LLF)

1. Assume Luminaire Dirt Depreciation (LDD): 0.95 for all luminaires.
2. Assume the following Lamp Lumen Depreciation (LLD):
   a. 0.92 for fluorescent luminaires
   b. 0.70 for LED-dedicated luminaires, an alternate value may be used based on the use of the Site defined performance method. See Section XX for calculation.
   c. Assume the appropriate effects from temperature on the lumen output of the luminaire

C. Lighting Requirements

1. Maintained minimum horizontal illuminance of 1.25 fc
2. Maintained vertical illuminance of 0.5 fc at 5’ AFF
3. Variation in horizontal illuminance points shall have a Coefficient of Variation (CV) equal or less than 0.38. This corresponds to an average-to-minimum illuminance ratio of 4:1 or a maximum-to-minimum illuminance ratio of 7:1.

1.7 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 measurements (in footcandles) at grade. Spacing between measurement points shall be 10’ on center.

   b. Computer calculation should use the following applicable LLF values: 1.0 LLD and 1.0 LDD.

2. Computer generated photometric analysis of proposed **FUTURE DATE (**defined as assuming numerous thousands of hours of operation) of the lighting installation, submittal should include the following requirements:

   a. Provide horizontal illuminance measurements (in footcandles) at grade. Spacing between measurement points shall be 10’ on center.

   b. Computer calculation should use the LLF values as specified above.

3. Fluorescent Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

   a. Physical description of lighting fixture including dimensions.

   b. Ballast including: ballast type (e.g., instant-start or programmed rapid-start); Ballast Factor; catalog code; input watts for ballast when operating the applicable number of light sources.

   c. Luminaire Coefficient of Utilization data for reflectance values of 30/0/20 for both RCRs: 2 & 3.

   d. Luminaire efficiency (also known as fixture efficiency).

   e. Table of zonal lumen output in 10° vertical increments showing both the lumen value and the percentage of total output per 10° increment.

   f. Initial lumen output of light source and temperature at which the lumens are rated.

   g. Mean (also known as design) lumen output of light source and percentage of rated life in which mean/design value derived.

   h. Correlated Color Temperature (CCT) of light source.

   i. Color-Rendering Index (CRI) of light source.

   j. Mean Lumens Per Watt of Lamp + Ballast (mean lumens / ballast input watts).

   k. Luminaire Efficacy of luminaire (Initial lumens x ballast factor x luminaire efficiency / ballast input watts).

l. Target Efficacy Rating (TER) of luminaire (Initial lumens x ballast factor x (average of CU values for 30/0/20 at RCR 2&3) / ballast input watts).

4. LED Product Data: For each type of lighting fixture, arranged in order of fixture designation. Inclue data on features, accessories, finishes, and the following:
   a. Physical description of lighting fixture including dimensions.
   b. Driver including: Driver Efficiency; catalog code; and input watts
   c. Luminaire photometric reports per IESNA LM-79-08 including: laboratory name, report number, date, luminaire catalog number, luminaire, and light source specifications
   d. Luminaire Coefficient of Utilization data for reflectance values of 30/0/20 for both RCRs: 2 & 3 – if possible.
   e. Luminaire (also known as fixture) efficacy.
   f. Table of zonal lumen output in 10° vertical increments showing both the lumen value and the percentage of total output per 10° increment.
   g. Initial lumen output of light source and temperature at which the lumens are rated.
   h. Mean (also known as design) lumen output of light source and percentage of rated life in which mean/design value derived.
   i. Correlated Color Temperature (CCT) of light source with Du'v' values.
   j. Color-Rendering Index (CRI) of light source.
   k. A minimum of 6,000 hours of continuous operation of the LEDs at three different temperatures per LM-80-08.
5. Provide documentation of the expected useful life as defined in Section 2.4 D 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.
6. Provide safety certification and file number as required for the luminaire family which shall be listed, labeled, or identified per the National Electric Code (NEC). Applicable testing bodies are determined by the US 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).

1.8 WARRANTY

A. Fluorescent Luminaire Warranty:

1. Provide a written **five year** on-site replacement material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty shall include warranty against

failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

2. Provide a comprehensive **five year** warranty for the luminaire.

3. Provide a written **five year** replacement material warranty on all power supply units (PSUs).

B. LED Luminaire Warranty.

1. Provide a written **five year** on-site replacement material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

2. Provide a written **five year** replacement material warranty for defective or non-starting LED source assemblies.

3. Provide a written **five year** replacement material warranty on all power supply units (PSUs).

4. Provide a written **five year** replacement warranty for non-maintained illuminance levels (See section 1.6 C-G) on all light sources (LED package, LED array, or LED module) including, but not limited to the LED die, encapsulate, and phosphor. If the expected useful life of the luminaire system as defined in Section 2.4 D is not maintained, then the manufacturer shall replace the light source(s) or luminaire as needed.

## PART 2 – PRODUCTS

### 2.1 GENERAL

A. Luminaire shall be the type indicated on Drawings and as specified. Fixtures of same type shall be of one manufacturer.

B. Fixtures shall be of the types and manufacturers described in the LUMINAIRE REQUIREMENTS section below, 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 suppled provided the product meets or exceeds the specifications. The alternate fixtures must achieve the same photometric levels and uniformity ratios.

C. All fixtures shall be baked-on enamel or powder-coated, unless otherwise specified in subsections below.

### 2.2 LIGHT SOURCE REQUIREMENTS

A. Since parking garages are typically unconditioned spaces, not enclosed spaces, the lighting is extremely subject to the ambient temperature. In locations where the average daily ambient temperature is greater than 0° C, luminaires using fluorescent sources are

recommended; in locations where the average daily ambient temperature is less than 0 ° C, LED-dedicated luminaires recommended.

B. Fluorescent Lamps shall meet the following requirements:

1. Light sources in this application can be 32 W (nominal) 4’ T8 lamps (F32T8) [ Do not use “energy saving” T8 lamps]; 28 W 4’ T5 lamps (F28T5); or 54 W 4’ T5HO (F54T5HO) lamps:
2. All lamps shall have the following characteristics:
    a. Low-mercury meeting Toxicity Characteristic Leaching Procedure (TCLP) standards
    b. Produce at least 2,900 lumens (initial) when measured on a reference ballast
    c. A correlated color temperature (CCT) between: 3,000 – 4,100 K
    d. A Color Rendering Index (CRI): ≥ 80
    e. Lamp Lumen Depreciation (LLD) shall be 92% or greater at 20,000 hours

C. LED sources shall meet the following requirements:

1. Operating temperature rating shall be between -40°C and +50°C
2. Correlated Color Temperature (CCT): 2700 – 6500 K
    a. Nominal CCT: 2700 K (2725 ± 145)
    b. Nominal CCT: 3000 K (3045 ± 175)
    c. Nominal CCT: 3500 K (3465 ± 245)
    d. Nominal CCT: 4000 K (3985 ± 275)
    e. Nominal CCT: 4500 K (4503 ± 243)
    f. Nominal CCT: 5000 K (5028 ± 283)
    g. Nominal CCT: 5700 K (5665 ± 355)
    h. Nominal CCT: 6500 K (6530 ± 510)
    i. Duv tolerance of 0.001 ± 0.006
3. Color Rendering Index (CRI): ≥ 65
4. Luminaire manufacturer shall submit reliability reports indicating that the manufacturer of the LED (chip, diode, or package) has performed JEDEC (Joint Electron Devices Engineering Council) reliability tests on the LEDs as follows:
    a. High Temperature Operating Life (HTOL)
    b. Room Temperature Operating Life (RTOL)
    c. Low Temperature Operating Life (LTOL)
    d. Powered Temperature Cycle (PTMCL)

e. Non-Operating Thermal Shock (TMSK)

f. Mechanical Shock

g. Variable Vibration Frequency

h. Solder Heat Resistance (SHR)

## 2.3 BALLAST OR DRIVER REQUIREMENTS

A. Fluorescent ballasts shall meet the following requirements:

1. Ballasts shall be class P, electronic high-frequency (20 to 33 kHz or ≥ 40 kHz) programmed-rapid start type ballasts with a normal Ballast Factor (BF) of 0.88 (nominal).
2. Ballasts shall have the following Ballast Efficacy Factors (BEF), defined: as BF x 100 / input watts
   a. One-lamp configuration: ≥ 2.84
   b. Two-lamp configuration: ≥ 1.48
3. Ballasts shall have a minimum Relative System Efficiency (RSE) of 95%, defined as BEF x Total Rated Lamp Power / 100
4. Ballasts shall have a Power Factor (PF) of: ≥ 0.90
5. Ballasts shall have a Total Harmonic Distortion (THD) of: ≤ 20%
6. Ballasts shall be color coded per ANSI C82.11
7. Ballasts shall be Class A noise rated
8. Ballasts shall comply with FCC 47 cfr part 18 non-consumer RFI/EMI standards
9. Ballasts shall be Reduction of Hazardous Substances (RoHS) compliant. (see http://www.rohs.eu/english/index.html)

B. LED drivers shall meet the following requirements:

1. Drivers shall have a minimum efficiency of 85%
2. Starting Temperature: -40° C
3. Input Voltage: capable of 120 to 480 (±10%) volt, single phase or as required by the site
4. Power supplies can be UL Class I or II output
5. Surge Protection: The system must survive 250 repetitive strikes of "C Low" (C Low – 6kV/1.2 x 50 µs, 10kA/8 x 20 µs) waveforms at 1 minute intervals with less than 10% degradation in clamping voltage. "C Low" waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C
6. Drivers shall have a Power Factor (PF) of: ≥ 0.90
7. Drivers shall have a Total Harmonic Distortion (THD) of: ≤ 20%
8. Drivers shall comply with FCC 47 cfr part 18 non-consumer RFI/EMI standards

9. Drivers shall be Reduction of Hazardous Substances (RoHS) compliant. (see http://www.rohs.eu/english/index.html)

## 2.4 LUMINAIRE REQUIREMENTS

A. General Requirements

1. The luminaire shall produce a minimum of 20% of the zonal lumens in the 60° to 70° vertical zones
2. Luminaires will have a TER greater than 30 (an EEF value must be at least 0.45)
3. The luminaire shall have a ***luminaire efficacy*** greater than 63 LPW
4. Electrical system cavity shall be wet-location rated and be field accessible for service or repair needs.
5. Optical cavity shall be a minimum IEC 60529/IP65.
6. Luminaires shall be fully assembled and electrically tested before shipment from factory.
7. Luminaires shall have country appropriate governing mark and certification.
8. Color of the luminaire shall be as specified by the site owner.
9. If a lens not integral to the LED is used, the luminaire optical enclosure (lens/window) shall be constructed of a one piece, UV resistant, clear, polycarbonate, acrylic or glass.
10. 80% of the luminaire material by weight should be recyclable at end of life. Luminaire shall be designed for end-of-life disassembly.

B. Mechanical Vibration

1. The luminaire must be subjected to 100,000 cycles of 2 Gs applied at the center of gravity of the luminaire on 3 primary axis
   a. No damage to the luminaire is allowed
   b. The luminaire must be fully functional upon completing the test

C. LED-dedicated Luminaire 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 with no catastrophic failures. The $L_{70}$ lumen output must be capable of providing the illuminance levels and uniformity specified in Section 1.6.
   b. Site performance method: A lifetime of the number of hours specified by the Site based on expected Site lighting use and planned replacement where the lumen output at the specified useful life must be capable of providing the illuminance levels and uniformity specified in Section 1.6.
2. Useful Life Testing and Verification Procedure:

a. Simplified $L_{70}$ threshold: Perform LM-79-08 testing on the luminaire at both time intervals of 0 hours and ≥ 6,000 hours. The luminaire shall be operated continuously in the appropriate UL 1598/153 environment except when it is removed to perform the LM-79 light output tests. If the light output determined at ≥ 6,000 hours is ≥ 96%, the light output determined at 0 hours, the luminaire meets the simplified $L_{70}$ threshold for useful life.

b. Site defined performance method:
   1. Perform lumen depreciation testing per LM-80-08 on the light source(s) (module/array) for a minimum of 6000 hours (longer testing period is encouraged). Per LM-80-08, identify the case temperature measurement point ($T_s$) that is accessible to allow temporary attachment of a thermocouple for measurement of the LED temperature when installed in the luminaire. Access via a temporary hole in the housing, tightly resealed during testing with putty or other flexible sealant is allowable.
   2. Use the LM-80-08 test data to extrapolate the lumen depreciation of the LED module/array (lumen degradation at three temperatures) using a standard exponential decay curve fit as described in Appendix C.
   3. Identify the installed (in luminaire) operating temperature of the LED using the $T_s$ point under operating conditions as described in LM-79-08. Use this in-luminaire LED module/array temperature to interpolate a decay curve between the three extrapolated degradation curves derived from LM-80 and exponential decay curve fitting.
   4. From this interpolated curve, determine the lamp lumen depreciation (LLD) value and useful life that meets the needs of the Site defined hours of operation to end of useful life as well as the illuminance levels and uniformity specified in Section 1.6. for the useful life of the luminaire. 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.

## 2.5 CONTROL REQUIREMENTS

A. Daylighting Controls

1. All luminaires located along the perimeter shall be connected to photosensors and a daylight harvesting strategy sought

2. Switches shall be furnished in NEMA I General purpose enclosure unless noted otherwise. Switches located on the exterior or in "wet" locations shall have NEMA 3R, 4 or 4X enclosures as noted or required.

3. The Photocell control system shall 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

**Comment [CJ1]:** Need these numbers.

energized until the north sky light increases to approximately XX footcandles (XX values to be supplied by Site Owner. Actual value will depend on the lighting zone/required illuminance. A TURN-ON/TURN-OFF ratio ≤ 5:1 (the lights either turn on or off when the photocell measures 5x the required illuminace) should be used.).

c. Mounted in an un-obscured location for measuring the available north sky daylight with a separate control/calibration module mounted separately and in an accessible location.

d. Use relays that are UL 773 or UL 773A listed and designed to fail in the on position.

B. Occupancy Sensor Controls

1. 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, column locations, and dropped beams. Do not simply use gross rated coverage in manufacturer's product literature.

2. Occupancy/vacancy sensors shall comply with NEMA Standard WD 7-2000 which provides for testing requirements on the issues of performance sensitivity.

3. Ultrasonic Type: Integral to the luminaire. Detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

4. Sensors shall be located or shielded or controlled by software to adjust sensitivity based on ambient temperature or air temperature variations.

5. Sensor must incorporate a failsafe feature such that lamps fail "on" in the event of sensor failure.

C. End-of-Life

1. Provide End-of-Life mechanism into the luminaire. When the LED die output has reached end of useful life, the luminaire should enter a "failure mode".

## 2.6 PRODUCT MANUFACTURERS

A. Manufacturers List: The following manufacturers offer products complying with the required performance and operation criteria.

1. TBD – See GSA schedule that indicates equipment that is compliant with this specification

B. Substitution Limitations: Any manufacturer who offers products that comply with the required product performance and operation criteria is acceptable.

C. 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 & COMMISSIONING

A. Ultrasonic sensors should have their sensitivity adjusted when interference from air movement is at its maximum.

### 3.3 MANUFACTURER SERVICES

Manufacturers must provide installation and troubleshooting support via telephone.

END OF SECTION

# Appendix A – Definitions and Related Terms

Coefficient of Variation (CV):

This method is a measure of the weighted average of all relevant illuminance values and is commonly used in statistics, where the variance of a set of values is calculated as the ratio of standard deviation s of all values to the mean *x*.

$x_i$ = illuminance at point i,
N = number of points measured
$\bar{x}$ = mean illuminance

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}$$

$CV = \sigma / \bar{x}$