

# BBA High Efficiency Wall Pack Lighting Specification & Guidance

A Better Buildings Alliance (BBA) Project

Version 1.0

## WALL PACK LIGHTING SPECIFICATION AND APPLICATION GUIDANCE

The U.S. Department of Energy (DOE) Better Building Alliance (BBA) identified wall packs as an area in which the effective application of more efficient lighting and its application can dramatically improve lighting quality and energy performance. A BBA Project Team comprising members from the retail, commercial real estate, and hospital sectors, with support from the Pacific Northwest National Laboratory, developed this technical specification and application guidance document that prescribes equipment characteristics and application guidance including controls that support reduced energy use compared to common standard practice.

### PART 1 – GENERAL

#### 1.1 BACKGROUND

Wall pack lighting has a variety of applications, including illuminating walkways, parking, doorways, and other exterior areas or tasks. With new technology advances and more effective design and placement of lighting, these applications can experience a higher quality of light that uses less energy.

Companies can use the product specification portion of this document (Part 2) to stipulate performance expectations as well as warranty and testing information to manufacturers to get a product that outperforms traditional wall pack lighting sources.

The guidance portion (Part 3) provides design suggestions that can be used to most effectively apply wall pack light to eliminate ineffective and unneeded light. These may form part of a set of requirements for design and product application as determined by the Site Owner or builder.

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

#### 1.2 FORMAT

This document includes both product specification and application guidance that applies to wall pack lighting that is typically installed on buildings and are not covered with canopies. The lighting is typically applied for walkway, building edge parking, building perimeter, building access, and security but is not intended to provide façade lighting or floodlighting. The product specification section (Part 2) focuses on specifying a robust and energy-effective product. The user of this document is also encouraged to consider the inclusion of portions of the applicable guidance section (Part 3) to their final specification document when the guidance has application to their project and would improve energy reduction. The guidance on appropriate application of wall packs to non-entry areas and for security concerns and the guidance on the use of controls are of particular importance as they have the potential for major energy savings.

#### 1.3 DEFINITIONS

Lighting terminology used in this document is defined in this section, found in IES RP-16 or in other referenced documents.

1. The term “wall pack” is used herein to describe lighting equipment that is typically attached to a building wall or other vertical exterior surface and that provides illumination for building edge parking, walkways, building perimeter identification, entry and exit, and

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security.

2. The term “driver” is used herein to broadly cover both drivers and power supplies, where applicable.
3. The term “LED light source(s)” is used herein in accordance with IES LM-80 to broadly cover light-emitting diode (LED) package(s), module(s), and array(s).
4. The term “traditional” when referring to lighting sources is used herein to describe commonly used lighting technology for exterior applications other than LED. These will typically include high-pressure sodium, metal halide, and compact fluorescent lamps.
5. Lighting Zones

To provide as much information about the lighting zone, both the ANSI/ASHARE/IES Std. 90.1 and IES RP-33 exterior lighting zone definitions are combined below for zones where area light is expected to be applied. Lighting Zone (LZ0) is not expected to include area lighting as described in this specification and is therefore not included here.

- a. Lighting Zone (LZ1) – Developed areas of national parks, state parks, forest land, and rural areas. The vision of human residents and users is adapted to low light levels. Lighting may typically be used for safety and convenience but it is not necessarily uniform or continuous. After curfew, most lighting should be extinguished or reduced as activity levels decline.
- b. 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.
- c. Lighting Zone (LZ3) – Areas not classifiable under the other 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.
- d. 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.

## 1.4 REFERENCES

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

### A. American National Standards Institute

1. ANSI C78.376-2001 – Electric lamps - Specifications for the Chromaticity of Fluorescent

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2. ANSI C78.377-2011 –Specifications for the Chromaticity of Solid-State Lighting Products
- B. American society of Heating and Refrigerating Engineers (ASHRAE)
1. ANSI/ASHRAE/IES 90.1 – 2010, Energy Standard for Buildings Except Low-Rise Residential Buildings
- C. Council of the European Union (EC)
1. RoHS Directive 2011/65/EC
- D. Illuminating Engineering Society of North America (IES)
1. G-1-03 – Guidelines for Security Lighting
  2. HB-10-11 – IES Lighting Handbook, 10<sup>th</sup> Edition
  3. LM-79-08 – Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products
  4. LM-80-08 – Approved Method for Measuring Lumen Maintenance of LED Light Sources
  5. RP-16-10 – ANSI/IES Nomenclature and Definitions for Illuminating Engineering
  6. RP-33-99 – Lighting for Exterior Environments
  7. TM-15-11 – Luminaire Classification System for Outdoor Luminaires
  8. TM-21-11 – Projecting Long Term Lumen Maintenance of LED Light Sources
- E. International Electrotechnical Commission (IEC)
1. IEC 60529 – Degrees of Protection Provided by Enclosures (IP Code)
- F. National Electrical Manufacturers Association (NEMA)
1. WD 7-2011 – NEMA Guide Publication: *Occupancy Motion Sensors*
- G. Underwriters Laboratories (UL)
1. UL 1598 - Luminaires
- H. Other
1. ISTMT, Contained within the ENERGY STAR Manufactures Guide:  
[www.energystar.gov/index.cfm?c=ssl\\_res.pt\\_ssl](http://www.energystar.gov/index.cfm?c=ssl_res.pt_ssl)

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## PART 2 – WALL PACK PRODUCT SPECIFICATION

### 2.1 SCOPE

This product specification applies to wall pack lighting that is installed on exterior surfaces that are not covered with canopies. The lighting is typically applied for walkway, building edge parking, building perimeter, building access, and security purposes and is not intended to include lighting provided for façade lighting or floodlighting. The product specification section focuses on specifying a robust and energy-effective product. Appropriate standard product specification language should be added to these provisions as needed to form a complete specification document for bidding and construction purposes.

### 2.2 LUMINAIRE AND COMPONENT REQUIREMENTS

#### A. General Requirements

1. All housing finishes must be baked-on enamel, anodized, or powder-coated, unless otherwise specified in subsections below.
2. The complete luminaire must be listed for wet locations by an OSHA NRTL with a minimum rating of IEC 60529/IP65.
3. The wiring cavity must be field accessible for service or repair needs.
4. Luminaires must be fully assembled and electrically tested before shipment from the factory.
5. Luminaires must be rated for -20 °C to +40 °C operation.
6. Luminaires must have locality-appropriate governing mark and certification.
7. Luminaire optical enclosures (lens/window) must be constructed of clear and UV-resistant polycarbonate, acrylic, or glass.
8. 80% of the luminaire material by weight should be recyclable at end of life and the luminaire designed for ease of component replacement and end-of-life disassembly.

#### B. Efficacy

1. All LED luminaires must have a Luminaire Efficacy Rating (LER) of at least 70 lm/W. (<http://www.designlights.org> )
2. All traditional light source luminaires must have a LER of at least 60 lm/W. ([http://www1.eere.energy.gov/femp/technologies/eep\\_exterior\\_lighting.html](http://www1.eere.energy.gov/femp/technologies/eep_exterior_lighting.html) )
3. LER data may not be available for some manufacturer's products. If an LER is not available, buyers may estimate the LER using this formula:

$$\text{LER} = \frac{\text{(luminaire efficiency * total rated lamp lumens * ballast/driver factor)}}{\text{}}$$

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luminaire input watts (lamp+ballast/driver)

For example, a complete luminaire with the following characteristics

- luminaire efficiency = 77%
- total lamp nominal lumen output = 9600 lumens
- ballast factor (BF) = 0.80
- total luminaire input watts (lamp+ballast/driver) = 89

will have a calculated LER of:  $(0.77 * 9600 * 0.80)/89 = 66.4$

Luminaire efficiency (LE), total rated lamp lumens, ballast factor (BF), and luminaire input watts may typically be found in manufacturers' product specification sheets and photometric reports for the luminaire, lamp, and ballast.

## C. Light Distribution

Luminaires shall have a tested uplight rating of U0 where the luminaire emits no light above 90 degrees and a glare rating of G1 according to TM-15-11.

## D. Ballasts and Drivers must meet the following requirements:

1. Minimum efficiency of 85%.
2. Power factor of  $\geq 0.90$  at full power.
3. Reduction of Hazardous Substances (RoHS) compliant
4. Where dimming will be required as part of any control strategy, the ballast or driver shall be dimmable and compatible with a standard dimming control circuit of 0–10V or other dimming system that is compatible with any other exterior lighting controls and approved by the Site Owner.

## E. Electromagnetic Interference of Lighting System

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

## F. Light Source Color

1. Correlated color temperature (CCT) shall be as selected by Site Owner.
2. Color rendering index (CRI):  $\geq 65$

## G. Emergency Egress Application

Wall Pack lighting that is installed in locations that the local authority has determined to be part of an outdoor path of egress must meet applicable emergency requirements. This may include requirements to provide lighting equipment that has a separate normally off lamp and power

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supply or combination unit with remote capacity, battery backup, or similar capability.

## H. Expected Useful Life

1. For traditional light sources, the useful life of a lamp shall be the manufacturer's reported value based on applicable IES procedure testing.
2. For LED technology, the useful life of a luminaire in terms of lumen output must be as specified by one of the following sets of criteria as specified by the Site Owner. Demonstration that the chosen criteria have been met must be provided per Appendix A.
  - a. Simplified  $L_{70}$  threshold: A minimum of 50,000 operating hours before reaching the  $L_{70}$  lumen output degradation point.
  - 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 designed illuminance levels and uniformity.

## I. Integrated controls

1. Occupancy sensor controls integrated into the luminaire or installed as part of a system to control one or more luminaires must
  - a. be capable of detecting motion within at least 30 feet of the luminaire across a detection angle of at least 100 degrees for a flat wall application (50 degrees from each side of the center of the sensor) or as required by the Site Owner for other applications
  - b. within a maximum of 5 minutes of detecting no motion, be able to turn lighting off or reduce its power use to at most 50% of nominal wattage and then return to full power and light output when motion is detected
  - c. if sensor fails, cause the luminaire to operate at full power and light output
  - d. have a maximum ramp-down time of 5 minutes.
2. Photocell controls integrated into the product must
  - a. have a 10- to 30-second built-in time delay to prevent response to momentary lighting such as lightning flashes, or car headlights
  - b. be shielded from direct sunlight and located on the top of the luminaire to have maximum unobstructed view of the sky
  - c. use relays that are UL 773 or UL 773A listed and designed to fail in the on position.

## J. Other Tests

1. At time of order, the 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.

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## PART 3 – WALL PACK APPLICATION GUIDANCE

Typical entrance, exit and similar wall pack applications can be straightforward, but diligence in determining the most effective design for proper light levels and applicable controls can provide maximum energy savings. Other historically common applications of wall pack lighting have more to do with either demarcation of the building exterior or some real or perceived security function. These are areas where great energy savings can be achieved and should be carefully considered. The following sections provide guidance and/or suggested language for project requirements related to equipment application that can help achieve the maximum energy effectiveness through design and control.

### 3.1 EFFECTIVE APPLICATION

#### 1. Entrance, Exit, Walkway, Parking

Entrance, exit, building walkway, and building edge parking applications are well suited to wall pack fixture application. Their ability to minimize energy use will depend on a mix of efficient technology, appropriate design, and effective control. Sections 3.2–3.4 provide guidance and specifications that can be used to affect best design and control.

#### 2. Building Perimeter

The use of wall pack fixtures to provide light around the perimeter of a building is often done but is typically not needed and should not be installed unless a specific issue is identified. For example, the military recommends lighting only at entry and exit points for buildings with low levels of security. For perimeter lighting that is not associated with a door entry, walkway, or other invited pedestrian activity, there are typically no universally applied lighting requirements, and the need for such lighting and its function should be carefully evaluated. Several options are recommended that can drastically reduce energy use:

- a. Eliminate wall pack lighting that only identifies perimeter walls. Unless there is a specific building access issue, the lighting of solid wall surfaces other than for signage or architectural feature façade lighting does not serve any primary human or business need.
- b. If lighting is required to identify building boundaries, consider strategically placed wall packs only at corners.
- c. Apply occupancy sensor control. The preferred options are to eliminate the lighting that is not needed. However, if this type of perimeter lighting cannot be eliminated from a design, then specific control requirements should be applied as specified in Section 3.4.

#### 3. When security is an issue

In cases where security is considered an issue, additional wall pack lighting may be desired to provide visual access to building surroundings or to deter criminal activity. However, it is well established that having light on all surfaces of a facility and/or increased light levels are not the only or necessarily the best way to maintain facility security. Considerations include points of access, improved security camera equipment and placement, use of motion detectors to trigger increased light levels, and increased lighting uniformity.

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For site areas initially identified as a specific security concern or for high-risk facilities, first consult IES G-1-03, section 4 to determine an actual level of security lighting need. Then consider alternative options to continuous lighting of blank wall areas:

- a. For other than high-risk operations, eliminate wall pack lighting that only identifies perimeter walls. Unless there is a specific building access issue (see section 3.1.2), the lighting of solid walls other than signage, does not serve any primary human or business need.
- b. If perimeter wall lighting cannot be eliminated from a design, then specific control requirements should be applied as specified in section 3.4, such as occupancy sensors. The motion-activated lighting will provide a direct deterrent to criminal activity or trespass and will allow lighting to be off for a majority of the time.

## 3.2 LIGHTING POWER USE LIMITS

The following lighting power density (LPD) limits are based on the latest requirements of the ANSI/ASHRAE/IES 90.1 – 2010 Energy Standard that provides energy limits that are strict but achievable with commonly available efficient products. Additional savings may be realized with the use of advanced-efficiency products and innovative design. For applications not defined here, minimal application to desired or required light levels with maximum-efficiency equipment should form the basis of design. (See section 1.3 for Lighting Zone definitions)

- A. Walkway - Defined as a sidewalk or other walkway that runs along a wall edge and typically is not covered by a canopy.

**Table 1. Walkway LPD Limits**

	Maximum LPD for Walkway less than 10 feet wide (W/linear ft)	Maximum LPD for Walkway wider than 10 feet (W/linear ft)
Lighting Zone 1	0.7	0.14
Lighting Zone 2	0.7	0.14
Lighting Zone 3	0.8	0.16
Lighting Zone 4	1.0	0.20

- B. Building Edge Parking Areas - Defined as the group(s) of parking spots located adjacent to the building wall.

**Table 2. Building Edge Parking Area LPD Limits**

	Maximum LPD (W/ft <sup>2</sup> )
Lighting Zone 1	0.04
Lighting Zone 2	0.06
Lighting Zone 3	0.10
Lighting Zone 4	0.13



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C. Doorways - Defined as the area in front of a doorway.

**Table 3. Doorway LPD Limits**

	<b>Main Entry Doors (W/linear ft)</b>	<b>Other doors (W/linear ft)</b>
<b>Lighting Zone 1</b>	20	20
<b>Lighting Zone 2</b>	20	20
<b>Lighting Zone 3</b>	30	20
<b>Lighting Zone 4</b>	30	20

### 3.3 LIGHTING DESIGN REQUIREMENTS

Wall pack lighting may serve multiple purposes, including walkway lighting, parking lighting, doorway identification and illumination, building perimeter identification, and security. Each application may have different illumination needs as described in this section. The site lighting must follow the illuminance requirements specified in Table 4 through Table 6 (based on IES Handbook 2010) for each application or as specified by the Site Owner. Guidance for field measurements can be found at

[http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/lighting\\_measurement\\_evaluation\\_protocol.pdf](http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/lighting_measurement_evaluation_protocol.pdf). (See section 1.3 for Lighting Zone definitions)

A. Walkway - Illuminance requirements of area taken at grade.

**Table 4. Walkway Illuminance**

	<b>Minimum Horizontal Illuminance (footcandle)</b>
<b>Lighting Zone 1</b>	0.5
<b>Lighting Zone 2</b>	0.5
<b>Lighting Zone 3</b>	0.5
<b>Lighting Zone 4</b>	1.0

B. Building Edge Parking Areas - Illuminance requirements of area taken at grade.

**Table 5. Building Edge Parking Area Illuminance**

	<b>Minimum Horizontal Illuminance (footcandle)</b>	<b>Uniformity Average: Minimum</b>
<b>Lighting Zone 1</b>	0.1	4:1
<b>Lighting Zone 2</b>	0.2	10:1

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<b>Lighting Zone 3</b>	0.4	10:1
<b>Lighting Zone 4</b>	0.5	10:1

C. Doorways - Illuminance requirements of area taken at grade.

**Table 6. Doorway Illuminance**

	<b>Minimum Horizontal Illuminance (footcandle)</b>	<b>Uniformity Average: Minimum</b>
<b>All Zones</b>	0.2	4:1

## 3.4 CONTROLS

Controls are the most effective way to save lighting energy and are particularly effective in applications such as exterior when occupancy can be limited or sporadic. When evaluating the use of controls, consider the application of wireless or wired systems that take advantage of single photosensors that can control multiple luminaires when their control needs are similar. This section provides a set of recommended controls that should be considered as a minimum level of control for practical energy savings. These control requirements may be included in construction documents as design and installation requirements.

### A. Recommended Controls

1. All applications in areas not significantly enclosed (i.e., in parking garages or tunnels) must be controlled with a minimum of a photocell, an astronomical time switch, or an intelligent control system that provides automatic on and off based on daylighting.
2. Wall packs that are used for door entry, walkway, and other pedestrian activity lighting must have a scheduled or other intelligent control that turns off or reduces light levels after expected activity ends (known as a “curfew” control) by either:
  - a. specific areas turned off after expected activity ends or
  - b. minimum 50 percent reduction of lighting power after expected activity ends.
3. Wall packs that are not associated with a door entry, walkway, or other pedestrian activity must have an occupancy-sensor-based control that is set to turn off lighting within 5 minutes of all occupants leaving the area.

### B. Control Characteristics for On-fixture, Wireless or Wired Systems

1. Switches, relays, or other control components located on the exterior or in “wet” locations must have NEMA 3R, 4, or 4X enclosures as noted or required.
2. Photocell systems must have the following characteristics:

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- a. a 10- to 30-second built-in time delay to prevent response to momentary lighting such as lightning flashes or car headlights.
  - b. sensors mounted in location with a view to the sky (not obscured) for measuring the available north sky daylight but shielded from direct sunlight and with a separate control/calibration module mounted separately in an accessible location.
  - c. relays that are UL 773 or UL 773A listed and designed to fail in the “on” position.
3. Occupancy sensor controls must have the following characteristics:
- a. Controls must be installed and aimed to achieve coverage of areas indicated. Coverage patterns shall be as recommended by manufacturer for mounting and obstruction characteristics. Do not simply use gross rated coverage in manufacturer’s product literature.
  - b. Occupancy sensor coverage shall be verified using the tests defined in NEMA Standard WD 7-2011.
  - c. Infrared: Integral to the luminaire. Detect occupancy by changes 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. Sensor must incorporate a failsafe feature such that lamps fail “on” in the event of sensor failure.
  - e. If sensors are to be installed integral to the luminaire, installation must be performed by the luminaire manufacturer.
4. Time switch(s) must control specific circuit “off” functions during dark hours and be
- a. digital-microprocessor-based with battery backup and capable of retaining programmed settings for at least 10 hours.
  - b. 7-day, 24-hour astronomic time switching capability.
5. Intelligent control systems must have the following capabilities:
- a. two-way communication with the luminaire
  - b. scheduling for both time of day and astronomical events
  - c. remote accessibility.

## 3.5 FINDING WALL PACK PRODUCTS

Finding products that will meet specific requirements or desired performance capabilities can involve an extensive search because product manufacturers’ information does not always provide what is needed. Listings exist of products that meet specific criteria such as efficacy, LER, light output, color, etc. Rating systems can also provide comparable information. Note that appropriate products meeting all specification criteria may or may not be found in listings or have established ratings or labels. Therefore, other sources of products should be considered, but the minimum requirements should be verified.

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- For all product types, manufacturer catalogs and specification sheets can provide the information needed to choose appropriate products. Utilities may also provide listings of appropriate products meeting specified criteria that are rebated or subsidized.
- For LED products, the DesignLights™ Consortium provides a variety of resources for energy-efficient commercial lighting design and information, including specifications and qualified products. See <http://www.designlights.org/>.
- Lighting Facts provides voluntary labeling of critical performance information for LEDs for comparison of similar products. See <http://www.lightingfacts.com/content/label>.

## 3.6 TESTING BEFORE PURCHASE

Installing a product that may be unfamiliar to the Site Owner should be carefully considered. The Site Owner may want to request standard production model samples of proposed product for inspection and evaluation. If sufficient performance data on the product is not available, the evaluation may include independent testing of samples to verify luminaire performance and compliance with the specifications. If this is to be done, the testing should be conducted in accordance with the applicable IES- and ANSI-approved methods for products. Test laboratories should be accredited by the National Voluntary Laboratory Accreditation Program for the appropriate testing as part of the Energy-Efficient Lighting Products Laboratory Accreditation Program or for SSL testing, one of the qualified labs listed on the LED Lighting Facts® Approved Testing Laboratories List. (<http://www.lightingfacts.com/approvedlabs>).

## 3.7 WARRANTY

If a warranty is to be included for the equipment and installation, the following terms may be useful as a template for creating a warranty for traditional as well as LED projects.

- A. Provide a written **5-year** on-site replacement material warranty for defects in 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.
- B. Provide a written **5-year** replacement material warranty for defective or non-starting assemblies.
- C. Provide a written **5-year** replacement material warranty on all drivers, ballasts, and power supplies.
- D. Provide a written **5-year** replacement warranty for luminaires producing inadequately maintained illuminance levels at the end of warranty period, as prorated from levels expected at the end of useful life.
- E. Provide a written **5-year** replacement warranty for luminaires with correlated color temperature shift greater than 200 K over a **5-year** period.
- F. Site Owner may request an optional **10-year** replacement warranty for inadequately maintained illuminance levels, finish of luminaire, ballasts and power supplies, or defective lamp or LED source assemblies. The terms of the extended warranty will be negotiated by the Site Owner and the luminaire manufacturer for an additional cost.

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- G. 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 before final payment.

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## Appendix A – Estimating LED Lumen Maintenance

IES TM-21-11 allows for extrapolation of expected lumen maintenance from available test data at various temperatures on LED packages and modules and may further be used to relate to complete luminaire lumen maintenance. The extent of such extrapolation is limited by the duration of testing completed and the number of samples used in the testing. The TM-21-11 methodology must be used by the manufacturer to determine lamp lumen depreciation at the end of lumen maintenance life.

The user 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 following conditions must be met. If ANY of the conditions is not met, the component performance option may not be used and the user must use Option 2 for compliance.

- The LED light source(s) have been tested according to LM-80-08.
- The LED drive current specified by the luminaire manufacturer is less than or equal to the drive current specified in the LM-80-08 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 of 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-80-08 test report for the corresponding drive current or higher, within the manufacturer's specified operating current range.
- The ISTMT laboratory must be either:
  - Approved by the U.S. Occupational Safety and Health Administration as a Nationally Recognized Testing Lab
  - Listed on the LED Lighting Facts Approved Testing Laboratories List (<http://www.lightingfacts.com/approvedlabs>)
  - Recognized through Underwriters Laboratories' (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.

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## **Option 2: Luminaire Performance**

Under this compliance path, the applicant must submit TM-21-11 calculations based on LM-79-08 photometric test data for no less than three samples of the entire luminaire that together encompass a total of no less than 10 LED light sources (LED package, array, or module). Duration of operation and interval between photometric tests must conform to the TM-21-11 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-79-08 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-79-08 test procedure or must be listed on the LED Lighting Facts® Approved Testing Laboratories List (<http://www.lightingfacts.com/approvedlabs>). The extent of allowable extrapolation (either 5.5 or 6 times the test duration) depends on the total number of LED light sources installed in the luminaire samples, as per TM-21-11.

Under either compliance path, values used for extrapolation must be summarized per TM-21-11 Tables 1 and 2. Submitted values for lumen maintenance lifetime and the associated percentage lumen maintenance must be “reported” rather than “projected” as defined by TM-21-11.