



**U.S. Department of Energy**

**ENERGY STAR<sup>®</sup>  
Manufacturer's Guide for  
Qualifying Solid-State  
Lighting Luminaires**

September 2008



# ENERGY STAR Manufacturer's Guide for Qualifying Solid State Lighting Luminaires

September, 2008

## Table of Contents

Manufacturer Submission Checklist.....	3
Scope.....	4
Pre-qualification Activities.....	4
Submittal Process.....	6
On-line Product Submission Tool.....	6
Timeline.....	7
Testing.....	8
Temperature Measurement Point (TMP).....	8
TMP for the LED (TMP <sub>LED</sub> ).....	8
TMP for the Power Supply (TMP <sub>PS</sub> ).....	8
Required Test Reporting and Tolerance.....	8
Lumen Depreciation (Maintenance) Testing.....	12
OPTION 1: Component Performance.....	12
IESNA LM-80-2008.....	12
In Situ Temperature Measurement Test (ISTMT).....	12
Conditions for Use.....	14
Test Procedure.....	14
Guidance for Thermocouple Attachment.....	14
TMP Evaluation.....	14
Component Performance “Passing” Threshold.....	16
Submittal requirement.....	16
OPTION 2: Luminaire Performance.....	17
Luminaire Performance “Passing” Threshold.....	17
Submittal requirement.....	17
Power Supply Qualification.....	17
Power Supply “Passing” Threshold.....	17
Submittal requirement.....	17
Attachment A.....	18
Product Groups.....	18
LED Platform.....	18
Component Substitution.....	19
Additional Requirements.....	19

## Manufacturer Submission Checklist

### Prequalification Activities

1. Sign up as a Partner
  - Read and understand the Program Requirements.
  - Read and understand the ENERGY STAR criteria for SSL Luminaires
  - Fill out Partnership Agreement and send to [partnership@energystar.gov](mailto:partnership@energystar.gov)
  - Read and understand the SSL Manufacturer's Guide
2. Find approved laboratories to test your products
  - Photometric Testing, LM-79 Testing – *Laboratory approved and verified through DOE's CALiPER program*
  - In Situ Temperature Measurement Test – *Laboratory approved by OSHA as Nationally Recognized Testing Lab (NRTL)*
    - For hardwired products, use ANSI/UL 1598
    - For corded products, use ANSI/UL 153
  - LM-80 Testing – *Provided by LED package, array or module manufacturer*
3. Create a "Product Group" (if qualifying multiple products)
  - Choose one model for testing that represents a group of products. It must be representative of all other group members within allowable variations identified in Table 1 in the Manufacturer's Guide, and consistent with additional guidance on product groups provided in Attachment A.
4. Submit One (1) sample of the representative model for testing to each of the following:
  - DOE CALiPER approved labs – test for luminaire efficacy, light output, zonal lumen density, Color Rendering Index, Correlated Color Temperature, Color Spatial Uniformity, Color Maintenance, and optionally, lumen depreciation. (See lumen depreciation test options on page 12.)
  - OSHA approved NRTLs – conduct In Situ Temperature Measurement Testing
  - Independent or manufacturer-based testing laboratory - test for output operating frequency and noise

### Submission Process

1. Sign in to your My ENERGY STAR Account (MESA)
  - To obtain a username and password, you must sign up as a partner
2. Launch the on-line product submission tool at <http://www.energystar.gov/partners>
3. Enter product information
  - Required Documentation to upload into on-line tool
    - A. IESNA LM-79-08 Photometric Test Report (Formatted to LM-63-03)
    - B. IESNA LM-79-08 Integrating Sphere Output Report
    - C. For Lumen Depreciation, use either:
      - Option 1 – Component Performance**
        - LED Package Manufacturer LM-80 Test Report with results showing relative light output over time
        - In situ temperature measurement test showing measured  $TMP_{LED}$
        - Diagram or picture of the Temperature Measurement Points for the package, array or module
      - Option 2 – Luminaire Performance**
        - IESNA LM-79-08 Test Report at time = 0 and  $\geq 6,000$  hours, respectively.
    - D. For Power Supply
      - In situ temperature measurement test showing measured  $TMP_{PS}$
      - Diagram or picture of the Temperature Measurement Point for the power source
    - E. Warranty
  - Required Documentation for self-certification
    - A. Self-certification for Color Spatial Uniformity, Color Maintenance, Output Operating Frequency, Noise

## Scope

This document is an accompaniment to DOE's ENERGY STAR<sup>®</sup> Criteria v1.0 and provides manufacturers with the necessary information for product submission, testing laboratories, details of the testing requirements and how to utilize "product groups" to reduce testing costs.

## Pre-qualification Activities

Before submitting products for ENERGY STAR qualification there are a number of activities a manufacturer should undertake.

### A. Become an ENERGY STAR Partner

All manufacturers who wish to earn the ENERGY STAR label for their products must first become an ENERGY STAR SSL Partner. ENERGY STAR Partnership Agreements can be obtained by downloading a copy from [www.energystar.gov](http://www.energystar.gov) or by submitting an e-mail request to [partnership@energystar.gov](mailto:partnership@energystar.gov). Regardless of whether or not your company is already an ENERGY STAR partner under a different product category, manufacturers will need to fill out a new form.

### B. Find a DOE-Approved Laboratory

ENERGY STAR requires independent product testing to verify performance against the key requirements laid out in the criteria. DOE maintains a list of approved independent testing laboratories to perform the required testing, as outlined below:

#### Photometric Testing

Independent testing laboratories approved and verified through DOE's CALiPER program shall be used for photometric testing under the ENERGY STAR program. Labs must satisfactorily complete round-robin testing verification adhering to IESNA LM-79-08 test procedures for integrating sphere and/or goniophotometric testing of SSL luminaires and lamps. A list of currently qualified test labs, as of September 30, 2008, is listed below. Manufacturers are encouraged to check for updates to this list available at:

[http://www.netl.doe.gov/ssl/comm\\_testing-labs.htm](http://www.netl.doe.gov/ssl/comm_testing-labs.htm)

Integrating Sphere (LM-79 Section 9.1 and 9.2)

- [Independent Testing Laboratories, Inc.](#) – Boulder, CO
- [Lighting Sciences, Inc.](#) – Scottsdale, AZ
- [Lighting Research Center; Rensselaer Polytechnic Institute](#) – Troy, NY
- [Luminaire Testing Laboratory, Inc.](#) – Allentown, PA

Goniophotometry (LM-79 Section 9.3)

- [Independent Testing Laboratories, Inc.](#) – Boulder, CO
- [Luminaire Testing Laboratory, Inc.](#) – Allentown, PA
- [Lighting Sciences, Inc.](#) – Scottsdale, AZ

#### In situ Temperature Measurement Test (ANSI/UL 1598-04 or ANSI/UL 153-05)

Product safety testing of electrical equipment is required under OSHA Safety Standards (29 CFR

Part 1910). In particular, SSL luminaires submitted for ENERGY STAR qualification must be tested and certified to ANSI/UL 1598-04 or ANSI/UL 153-05 standards. OSHA has approved a number of organizations as Nationally Recognized Testing Laboratories (NRTLs), and can accept products that have been properly certified by these laboratories.

Consequently, DOE will accept UL 1598 or UL 153 testing and certification from the following NRTLs, recognized as qualified by OSHA:

- Canadian Standards Association (CSA);
- Intertek Testing Services NA, Inc. (ITSNA);
- MET Laboratories, Inc. (MET);
- NSF International (NSF);
- SGS U.S. Testing Company, Inc. (SGSUS);
- TUV America, Inc. (TUVAM);
- TUV Product Services GmbH (TUVPSG);
- TUV Rheinland of North America, Inc. (TUV);
- Underwriters Laboratories Inc.(UL); and
- Wyle Laboratories, Inc. (WL).

A complete and current listing of NRTLs, as well as detailed qualifications and contact information, is provided on OSHA’s NRTL Program webpage (<http://www.osha.gov/dts/otpca/nrtl/>).

**C. Submit Products to Labs for Testing**

Manufacturers are responsible for the cost of having products tested. Each product needs to demonstrate adherence the following standards and test procedures. DOE will allow manufacturers to qualify one product as a representative sample of similar models.

**D. Creating Product Groups**

DOE will allow manufacturers to qualify multiple products of a similar nature using one model. For example, the same basic fixture may be available with various shade, reflector, finish, or trim options. Manufacturers will be allowed to self define the product groupings and select the specific model to be tested. When choosing the single product to represent the group, applicants should choose the product variation of the group for which it will be the most difficult to meet the ENERGY STAR criteria, thus ensuring that other variations would perform at least as well as the tested product. Table 1 below summarizes allowable variations.

**Table 1 - Variations within Product Groupings**

<b>Housing/Chassis</b>	not allowed <sup>†</sup>
<b>Heat Sink/Heat Management</b>	not allowed
<b>Finish</b>	allowed
<b>Reflector/Trim</b>	allowed
<b>Shade/Diffuser</b>	allowed
<b>Mounting</b>	allowed
<b>Light Source</b>	allowed, w/ conditions
<b>Power Supply</b>	allowed, w/ conditions
<sup>†</sup> Unless the light source, heat sink, and power supply are integrated into housing/chassis variations in such a way that the thermal	

performance of the luminaire is not significantly degraded by the housing/chassis.

As seen in the table, housing/chassis variations and heat sink/heat management component variations within a group are not allowed because they may materially impact LED performance (although a possible exception for chassis/housing variations is allowed as noted). Finish, reflector/trim, and shade/diffuser variations are allowed.

Light source and power supply variations are allowed, subject to certain conditions. Products qualified under the “Product Groups” may include LED module(s)/array(s) and power supplies from more than one manufacturer, but the LED module(s)/array(s) and power supplies must be substitutable components used to manufacture essentially identical luminaires and must be intended to produce the same quantity and quality of light. LED module(s)/array(s) and power supply substitutions intended to produce different CCT, CRI, total flux, and other quantitative and qualitative differences in light may not be included in a single product grouping. Further, all LED module(s)/array(s) substitution components must separately comply with the Option 1 (Component Performance) requirements in the Lumen Depreciation section. More information on Product Groups can be found in Attachment A.

## **Submittal Process**

### **On-line Product Submission Tool**

To submit your test results for ENERGY STAR approval, DOE has created an on-line product submission tool for partners. Partners are to submit their information via this on-line tool that is posted in the Partner Resources section of [www.energystar.gov](http://www.energystar.gov). The process will be as follows:

#### **Step 1. Set up your “My ENERGY STAR® Account” (MESA)**

Once you register as an ENERGY STAR SSL Partner, you will receive an e-mail that contains your MESA set-up information. This information will include a user name and password required for accessing the on-line product submittal tool.

#### **Step 2. Launch the On-line Product Data Submittal Tool**

A link to the On-line Product Data Submittal Tool will be added to your ENERGY STAR SSL Partner landing page. Launching the tool will begin the data submittal process, and take you to the tool’s main screen which displays the manufacturer’s information (i.e., name, address, contacts, etc.).

#### **Step 3. Enter Product Information**

The On-line Product Data Submittal Tool will provide entry fields for all information needed for ENERGY STAR qualification. Next to each data entry field will be guidance on its required minimum level of detail. You will be able to upload LM-79 test reports directly to the tool and receive instant feedback on how the photometric results compare with specific ENERGY STAR product category requirements. The tool will also allow you to upload other test reports and packaging proofs for review by ENERGY STAR.

At any time during the submittal process, you will be able to save your work for

completion at a later date. A progress meter will indicate your stage of completion in the data submittal / qualification process.

#### **Step 4. Submit Application**

Once you have completed the appropriate data entry fields, click “Submit” and the On-line Product Data Submittal Tool will provide instant feedback indicating if the submittal (individual product or product grouping) meets ENERGY STAR criteria. For submittals not meeting all requirements, the tool will identify deficiencies and allow you to delete the submittal, or resubmit with updated information.

#### **Timeline**

The timeline for the application will be determined by the manufacturer. Once a product has been submitted by a manufacturer, ENERGY STAR will review the results and notify the applicant within 3 business days of acceptance, rejection, or the need for additional information.

## Testing

### Temperature Measurement Point (TMP)

LED package, array or module manufacturers and power supply/driver manufacturers designate specific locations on their products which act as surrogate points for measuring junction temperature ( $t_j$ ) or, in the case of power supplies, the point to which the warranted temperature is measured. DOE generically designates these locations as the temperature measurement points (TMPs) for the purposes of measurement in testing.

#### **TMP for the LED (TMP<sub>LED</sub>)**

Knowledge of the thermal pathway between the LED die junction and a designated external measurement point on the package, array or module allows manufacturers to accurately estimate junction temperature. The surrogate temperatures and their measurement locations vary from manufacturer to manufacturer. Some manufacturers use temperatures measured at the solder joint ( $t_s$ ) at the board attachment site; some use the package case temperature ( $t_c$ ); and others use the board temperature ( $t_b$ ) on the module. Collectively, these locations serve the same function, i.e., to correlate an external temperature to the junction temperature, which is critical for determining LED lumen depreciation. For purposes of this document, the measurement locations for  $t_s$ ,  $t_c$ , and  $t_b$  are Temperature Measurement Points for LEDs (TMP<sub>LED</sub>).

#### **TMP for the Power Supply (TMP<sub>PS</sub>)**

The longevity of power supplies is highly dependent upon operating temperature and thermal environment. It is standard practice in the lighting industry to tie the product warranty to maintained operating temperature—referred to as the case temperature ( $t_c$ )—for which most manufacturers designate a measurement location on the power supply case. For purposes of this document, the measurement locations for  $t_c$  (or other manufacturer designated location) are Temperature Measurement Points for power supplies (TMP<sub>PS</sub>).

### Required Test Reporting and Tolerance

Manufacturers are required to test their products at approved testing laboratories, and provide the results to DOE as part of the submittal process. Table 2 defines the required testing and reporting, sample size and applicable tolerance for the ENERGY STAR criteria. Table 3 presents the zonal lumen tolerances for the individual Category A applications.

**Table 2 - Required Test Reporting and Tolerance**

<b>Performance Characteristic</b>	<b>Methods of Measurement/ Reference</b>	<b>Approved Test Facility</b>	<b>Required Documentation</b>	<b>Sample Size</b>	<b>Tolerance</b>
<b>Luminaire Efficacy</b>	IESNA LM-79-08 Section 9.1, 9.2 or 9.3  ANSI C82.2	DOE CALiPER Approved	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) <b>and/or</b> Goniophotometer Test Report <b>and/or</b> Integrating Sphere Output Report	One	-3%
<b>Minimum Light Output</b>	IESNA LM-79-08 Section 9.1, 9.2 or 9.3	DOE CALiPER Approved	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) <b>and/or</b> Goniophotometer Test Report <b>and/or</b> Integrating Sphere Output Report	One	- 10%
<b>Zonal Lumen Density</b>	IESNA LM-79-08 Section 9.3	DOE CALiPER Approved	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) <b>and/or</b> Goniophotometer Test Report	One	See Table 3
<b>Lumen Depreciation (L<sub>70</sub>)</b>	<b>OPTION 1: Component Performance</b>				
	IESNA LM-80-08	LED Package Manufacturer	LED package manufacturer test report (data table and chart) showing relative light output over time.  For L <sub>70</sub> of 25,000 hours, average of sample at least 6,000 hours shall have lumen maintenance of ≥ 91.8% of initial light output.  For L <sub>70</sub> of 35,000 hours, average of sample at least 6,000 hours shall have lumen maintenance of ≥ 94.1% of initial light output.	Average of at least 25 samples for each temperature measured	0%

	In situ Temperature Measurement Test (ISTMT)  ANSI/UL 1598-04, ANSI/UL 153-05	OSHA approved Nationally Recognized Testing Laboratories (NRTLs)	<ol style="list-style-type: none"> <li>1. Test report indicating the Temperature Measurement Point for the hottest LED (TMP<sub>LED</sub>) in the luminaire.</li> <li>2. Diagram/picture of the TMP<sub>LED</sub> location with an arrow indicating the thermocouple attachment point.</li> </ol>	One	N/A
<b>OPTION 2: Luminaire Performance</b>					
	IESNA LM-79-08 Section 9.1, 9.2 or 9.3	DOE CALiPER Approved	<p>IESNA LM-63-03 Formatted Photometric Report <b>and/or</b> Goniophotometer Test Report <b>and/or</b> Integrating Sphere Output Report</p> <ol style="list-style-type: none"> <li>1. Report @ t = 0 hours</li> <li>2. Report @ t ≥ 6,000 hours</li> </ol>	One	N/A
<b>Color Rendering Index</b>	IESNA LM-79-08 Section 9.1 CIE 13.3-1995 IESNA LM-58	DOE CALiPER Approved	Integrating Sphere Output Report	One	- 2 points of CRI
<b>Correlated Color Temperature</b>	IESNA LM-79-08 Section 9.1 ANSI C78.377-08	DOE CALiPER Approved	Integrating Sphere Output Report	One	ANSI C78.377 Defined
<b>Color Spatial Uniformity</b>	IESNA LM-79-08 CIE 15: 2004 IESNA LM-58 IESNA LM-16	DOE CALiPER Approved	<p>Self Certification</p> <p><b>Note:</b> A laboratory test report must be submitted upon DOE request.</p>	One	N/A
<b>Color Maintenance</b>	IESNA LM-79-08 CIE 15: 2004 IESNA LM-58 IESNA LM-16	DOE CALiPER Approved	<p>Self Certification</p> <p><b>Note:</b> A laboratory test report must be submitted upon DOE request.</p>	One	N/A
<b>Power Factor</b>	ANSI C82.77	DOE CALiPER Approved	Laboratory test report	One	- 3%
<b>Power Supply TMP<sub>PS</sub></b>	ISTMT ANSI/UL 1598-04, ANSI/UL 153-05	NRTLs	<ol style="list-style-type: none"> <li>1. Test report indicating the Temperature Measurement Point for the power supply (TMP<sub>PS</sub>) in the luminaire.</li> <li>2. Diagram/picture of in the TMP<sub>PS</sub> location with an arrow indicating the thermocouple attachment point.</li> </ol>	One	N/A

<b>Output Operating Frequency</b>	Oscilloscope Manual	Any	Self Certification  <b>Note:</b> A laboratory test report must be submitted upon DOE request.	One	N/A
<b>Noise</b>	Not to exceed 24 dB when measured 12" in any direction	Any	Self Certification  <b>Note:</b> A laboratory test report must be submitted upon DOE request.	One	N/A

**Table 3 - Zonal Lumen Tolerances**

Category A Application	Zonal Lumen Density Requirement		Tolerance (Values below are subtracted from minimum % values on the left)	Method of Measurement
	Zone (bilaterally symmetrical)	Minimum Percentage of Total Lumens		
<b>Under-cabinet kitchen lighting</b>	0-60°	60%	- 5%	IESNA LM-79-08 Section 9.1
	60-90°	25%	- 10%	
<b>Under-cabinet shelf-mounted task lighting</b>	0-60°	60%	- 5%	
	60-90°	25%	- 10%	
<b>Portable desk task lights</b>	0-60°	85%	- 15%	
<b>Recessed downlights</b>	0-60°	75%	- 10%	
<b>Outdoor wall-mounted porch lights</b>	0-90°	85%	- 5%	
<b>Outdoor step lights</b>	0-90°	85%	- 10%	
<b>Outdoor pathway lights</b>	0-90°	85%	- 10%	

## Lumen Depreciation (Maintenance) Testing

The ENERGY STAR program offers two compliance methods for lumen depreciation testing: 1) Component Performance and 2) Luminaire Performance. Given the potential delays in market introduction required for full luminaire testing, DOE anticipates the majority of products submitted will be qualified via component performance testing.

### **OPTION 1: Component Performance**

The Component Performance option allows the applicant to demonstrate compliance with the lumen depreciation requirement by demonstrating the hottest LED package, array or module operates at or below temperatures yielding an  $L_{70}$  of 25,000 or 35,000 hours, respectively.

#### *IESNA LM-80-2008*

The *IESNA LM-80-2008 Approved Method For Measuring Lumen Maintenance of LED Light Sources* prescribes the measurement of lumen maintenance for LED-based packages, arrays and modules only and does not entail testing of the entire luminaire. LED packages, arrays or modules are tested over time at a minimum of three discrete case temperatures: 25°C, 55°C and 85°C ± 2°C. Light output is measured and recorded for a minimum of 6,000 hours at minimum intervals of 1,000 hours. From this data LED manufacturers are able to make projections of useful life.

#### *In Situ Temperature Measurement Test (ISTMT)*

IESNA LM-80 defines lumen maintenance testing for LED packages, arrays and modules. Because LEDs are incorporated into luminaires with heat sinks, optical elements, power supplies, etc. and then operated in a variety of ambient environments, LM-80 by itself is not an a predictor of luminaire lumen maintenance. In order to relate the results of the LM-80 test to the luminaire, DOE requires the luminaire to be tested in environments that simulate real-world applications (in situ) with direct measurement of the hottest LED in the luminaire and the power supply at steady-state thermal equilibrium. The test procedure to accomplish this is called the *In-situ Temperature Measurement Test (ISTMT)* which follows *ANSI/UL 1598-2004 Luminaires* or *ANSI/UL 153-2005 Portable Luminaires* with the addition of two (or more) thermocouples, one for the LED package, array or module and one for the power supply.

According to UL, hard-wired luminaires are separated into two broad categories: 1) Surface - products that are surface-mounted, suspended or freestanding where the fixture housing is exposed to free air and 2) Recessed - products recessed into ceilings or walls and often placed in direct contact with insulation. ANSI/UL1598 prescribes enclosures for luminaires for the purposes of simulating in situ operation and conducting temperature measurements for electrical safety (see Figure 1). In efforts to facilitate testing and minimize costs, DOE has reduced the number of environments to the fewest possible without significantly affecting the resulting steady-state temperatures. Table 4 lists the appropriate section references in ANSI/UL 1598.

Portable luminaires shall follow the procedures contained within ANSI/UL 153.

Figure 1 - ANSI/UL 1598 Test Environments

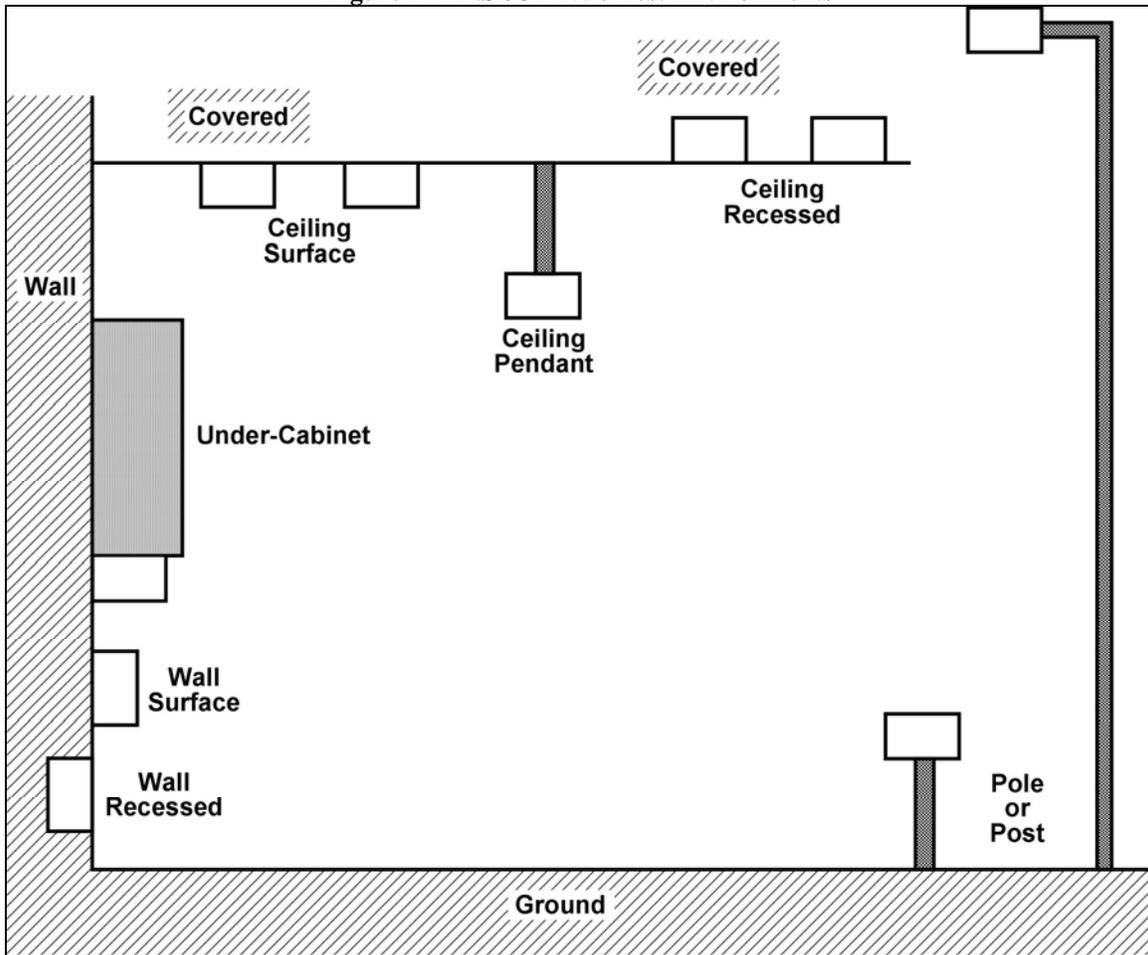


Table 4 – In Situ Test Environments

Luminaire Types	Mounting Orientation	
	Horizontal	Vertical
<b>Surface</b>		
Surface	Section 19.10	Section 19.11
Surface-mounted under-cabinet	Section 19.12	
Suspended	No apparatus required except if in situ mounting is $\leq 4"$ from the surface in which case mount to Section 19.10 defined apparatus	
Freestanding	No apparatus required	
<b>Recessed</b>		
Non-IC	Section 19.13	Section 19.13 except without insulation
IC	Section 19.15	Section 19.15

### *Conditions for Use*

To be eligible for the component performance option, **ALL** three of the conditions below must be met. If **ANY** of the conditions are not met, the component performance option may not be used and the applicant must use the luminaire performance option for compliance.

1. The LED package, array or module used in the fixture has been tested according to LM-80.
2. The LED package, array or module manufacturer prescribes/indicates a TMP on the package, array or module.
3. The LED package, array or module TMP is accessible to allow temporary attachment of a thermocouple for measurement of in situ operating temperature. Access via a temporary hole in the housing (no larger than 0.375" diameter), tightly resealed during testing with putty or other flexible sealant is allowable. The size and location of the access port shall be documented in the submittal for the purposes of repeatability.

### *Test Procedure*

The ISTMT follows all requirements of ANSI/UL 1598/153 with the following additions:

1. One (or more) additional thermocouples are attached to the hottest LED package or module in the luminaire (i.e.,  $TMP_{LED}$ ).
2. One (or more) additional thermocouples are attached to the power supply/driver at the  $TMP_{PS}$ . For off-the-shelf remote power supplies manufacturers typically provide a measurement location (case temperature designated by a “dot” adjacent to a ( $t_c$ ) symbol) for warranty purposes. In situations where the  $TMP_{PS}$  is not designated by the manufacturer, or where power supplies are integrated with the LED package(s), array or module(s), fixture manufacturers should identify the  $TMP_{PS}$  to be used for warranty purposes.

### *Guidance for Thermocouple Attachment*

- Manufacturers shall select and designate the hottest LED package, array or module in the luminaire. In most cases the individual LED in the middle of symmetric arrays should be hottest. A well designed thermal management solution will minimize the temperature gradient across packages.
  - For square/rectangular/circular arrays the individual LED closest to the center
  - For other configurations it is recommended manufacturers sample several LEDs to find the hottest within the luminaire.
- Temperature probes shall be in contact with the TMP and permanently adhered. Permanent adhesion consists of high temperature solder, conductive adhesives (e.g. accelerator/UV activated or epoxy), melting the tip into plastic or other approved product recommended by the temperature probe manufacturer. Tape alone is not acceptable for providing good thermal contact at the thermocouple/TMP interface.
- The thermocouple tolerance shall conform to ASTM E230 Table 1 “Special Limits” ( $\leq 1.1^\circ\text{C}$  or 0.4%, whichever is greater).

### *TMP Evaluation*

DOE has established a pass/fail threshold for lumen maintenance compliance, based on the available 6,000 hour data provided by the LM-80 test report. The requirements differ for

applications requiring 25,000 hours of useful life and those requiring 35,000 hours, as follows:

Table 5

Application required minimum useful life ( $L_{70}$ )	Required lumen maintenance at 6,000 hours or greater
25,000 hours	91.8%
35,000 hours	94.1%

These percentages result from solving an exponential decay function for 25,000 and 35,000 hours, respectively, to determine the minimum lumen maintenance necessary to achieve those thresholds.

**Note:** The final version of LM-80 differs from prior drafts in several respects, including how the case temperature is maintained (via ambient temperature versus current modulation) and in the three LED case temperatures at which the packages are maintained (25°C, 55°C and 85°C versus 45°C, 65°C and 85°C). LM-80 requires data collection at these three temperatures at a minimum and encourages LED manufacturers to collect test data at other temperatures as appropriate.

DOE recognizes that all LED manufacturers may not have 6,000 hours worth of data for all three case temperatures prescribed in LM-80. DOE therefore will allow prior data collected to be used for compliance purposes until September 30, 2009, after which date new product submissions will be required to include a minimum of all three temperatures.

This next section describes how DOE will evaluate LM-80 data. There are three possible scenarios for determining the lumen maintenance for the product submitted to ENERGY STAR:

#### SCENARIO 1

The in situ measured  $TMP_{LED}$  is greater than the highest case temperature collected according to LM-80 procedures. In this case the product cannot be qualified as there is no test data to substantiate manufacturer claims.

#### SCENARIO 2

The in situ measured  $TMP_{LED}$  is less than the lowest case temperature measured collected according to LM-80 procedures. In this case the product must use the data from the lowest case temperature measured according to LM-80 procedures.

#### SCENARIO 3

The in situ measured  $TMP_{LED}$  is bounded above and below by case temperature data collected according to LM-80 procedures. In this case linear interpolation shall be used to determine the lumen depreciation (maintenance) for the proposed product, as follows:

$$L_{TMP} = L_{below} + \left( \frac{L_{above} - L_{below}}{T_{s, above} - T_{s, below}} \right) (TMP_{LED} - T_{s, below})$$

Where:

$L_{below}$  = Lumen maintenance (%) below the  $TMP_{LED}$  @  $\geq 6,000$  hours

- $L_{above}$  = Lumen maintenance (%) above the  $TMP_{LED}$  @  $\geq 6,000$  hours
- $T_{s, below}$  = LM-80 case temperature ( $^{\circ}C$ ) below the  $TMP_{LED}$
- $T_{s, above}$  = LM-80 case temperature ( $^{\circ}C$ ) above the  $TMP_{LED}$
- $TMP_{LED}$  = In situ measured TMP of the hottest LED within the luminaire
- $L_{TMP}$  = Calculated lumen maintenance of the hottest in situ LED within the luminaire

**EXAMPLE:**

In situ measured TMP ( $TMP_{LED}$ ) =  $67^{\circ}C$

LED Manufacturer LM-80 test data for XYZ Package

Time (hours)	Case Temperature		
	$25^{\circ}C$	$55^{\circ}C$	$85^{\circ}C$
0	100%	100%	100%
$\vdots$	$\vdots$	$\vdots$	$\vdots$
6,000	99%	95%	90%

Applying the equation above:

$$L_{TMP} = 95 + \left( \frac{90 - 95}{85 - 55} \right) (67 - 55)$$

$$\therefore L_{TMP} = 93.0\%$$

**Component Performance “Passing” Threshold**

The luminaire **PASSES** the Component Performance Lumen Depreciation requirements if:

1. The LM-80 test report for the package, array or module demonstrates lumen maintenance of  $\geq 91.8\%$  for a projected  $L_{70}$  of 25,000 hours (indoor residential) or  $\geq 94.1\%$  for a projected  $L_{70}$  of 35,000 hours (outdoor residential and all commercial) at the in situ temperature measured at the  $TMP_{LED}$ .
2. The drive current measured in the fixture is less than or equal to the drive current specified in the LM-80 test report.

**Submittal requirement**

Applicant submits the following information to ENERGY STAR:

1. LM-80 test report (data table and chart) showing relative light output over time at various case temperatures ( $t_c$ ) and at a drive current greater than or equal to the measured current of the LED package, array or module used in the luminaire.
2. In situ temperature measurement test report with the measured temperature of the hottest LED ( $TMP_{LED}$ ).
3. Diagram/picture of the  $TMP_{LED}$  location with an arrow indicating the thermocouple attachment point.

NOTE: If more than one type of LED is used in a luminaire, an LM-80 test report and the above described ISTMT and interpolation procedures must be applied to each type of LED used in the luminaire.

## **OPTION 2: Luminaire Performance**

The Luminaire Performance option allows the applicant to show compliance with the lumen depreciation requirement by demonstrating the light output from the luminaire at  $\geq 6,000$  hours yields  $\geq 91.8\%$  lumen maintenance for a projected  $L_{70}$  of 25,000 hours (indoor residential) or  $\geq 94.1\%$  lumen maintenance for a projected  $L_{70}$  of 35,000 hours (outdoor residential and all commercial).

### ***Luminaire Performance “Passing” Threshold***

The luminaire **PASSES** the Lumen Depreciation requirements if:

1. Based on the LM-79 test report, light output determined at  $\geq 6,000$  hours divided by the light output at 0 hours multiplied by 100 yields  $\geq 91.8\%$  lumen maintenance for a projected  $L_{70}$  of 25,000 hours (indoor residential) or  $\geq 94.1\%$  lumen maintenance for a projected  $L_{70}$  of 35,000 hours (outdoor residential and all commercial).
2. The luminaire must be operated continuously in the appropriate UL 1598/153 environment except when it is removed to perform the LM-79 light output tests.

### ***Submittal requirement***

Applicant submits the following information to ENERGY STAR:

1. LM-79 test report at 0 hours
2. LM-79 test report at  $\geq 6,000$  hours

## **Power Supply Qualification**

Power supplies integrated with the LED package(s), array(s) or module(s), or enclosed within the fixture shall be tested in situ under steady-state operating conditions, with power supply case temperature measured at the designated  $TMP_{PS}$ . The luminaire passes power supply requirements if the measured temperature at the  $TMP_{PS}$  is less than or equal to the warranted temperature specified by the power supply manufacturer.

### **Power Supply “Passing” Threshold**

The power supply **PASSES** if:

1. The power supply measured in situ at the  $TMP_{PS}$  is less than the power supply manufacturer’s three year minimum warranted temperature.

### **Submittal requirement**

Applicant submits the following information to ENERGY STAR:

1. ANSI/UL1598/153 Test Report with the measured temperature from the  $TMP_{PS}$ .
2. Diagram/picture of the  $TMP_{PS}$  location (if not permanently marked on the circuit board or power supply case) with an arrow indicating the thermocouple attachment point.
3. Warranty from the driver manufacturer indicating the maximum power supply case temperature for which a minimum three year warranty is offered.

## Attachment A

### Product Groups

Luminaires are often available in multiple variations and options. For example, the same basic fixture may be available with different shades, diffusers, trim, reflectors, mountings, and/or sizes. To avoid the need to test all product variations in the ENERGY STAR SSL program, DOE allows for qualification of product groups. Allowable variations within a qualified group may be a function of:

- Component substitution: where components of a single version of a luminaire may be substituted in the manufacturing process based on component availability, cost, etc., while not substantively affecting product performance.
- Product variations: where multiple versions of a luminaire are based on the same LED platform (i.e., LED module(s)/array(s) and driver), deliver similar function and performance, but vary in physical structure and appearance; and/or

ENERGY STAR partners may self-define product groups consisting of a collection of products sharing similar features, and submit a single luminaire from the group for testing. DOE will verify the applicant's grouping rationale and—if the submitted product passes testing—will extend the ENERGY STAR qualification to the entire product group. Continued group qualification will be contingent on successful follow-up testing under DOE's quality assurance (QA) program, as described in the ENERGY STAR Program Requirements for SSL Luminaires (ver. 1.0).

### LED Platform

All luminaires in a product group must share the same type of LED platform. The LED platform consists of an LED package, array or module with integrated thermal management (e.g., heat sinking), and a power supply (driver), assembled and operated to produce a specified quantity and quality of light. Substitution of platform components is allowed, provided that it does not significantly alter light output or color properties.

Substitute power supplies must provide the same input power as that used in the tested product, and may not exceed the drive current specified in LM-80 testing for the associated LED module(s)/array(s). Substitution of LED package, array or modules is allowed, subject to the light quantity and quality restrictions described above. Further, the package, array or module must be tested according to LM-80 and demonstrate the required lumen depreciation ( $L_{70}$ ) characteristics.

Consistent LED platform performance is critical to group qualification, as any luminaire in the group is subject to follow-up QA testing and must demonstrate the following:

- Total luminous flux  $\geq$  original qualifying luminaire;
- Zonal lumen density: still complies with requirements for the lighting application;
- Luminaire efficacy  $\geq$  original qualifying luminaire;

- CCT: still complies with requirements for the lighting application;
- CRI: still complies with requirements for the lighting application;
- Steady state package, array or module temperature measurement point ( $TMP_{LED}$ )  $\leq$  temperature at which the associated LM-80 test report indicates the product meets the  $L_{70}$  life requirements; and
- Power supply temperature measurement point ( $TMP_{PS}$ ) temperature  $\leq$  manufacturer warranted maximum.

## Component Substitution

Multiple luminaires qualified under a single application may incorporate LED packages, arrays or modules and power supplies from more than one manufacturer, but the substituted components and resulting LED platform must produce the same quantity and quality of light as the LED platform used in the qualifying luminaire. Further, all LED package, array or module substitution components must comply separately with ENERGY STAR lumen depreciation qualification requirements.

## Additional Requirements

For manufacturers seeking to qualify product groups on the basis of tests on a single product, DOE requires partners to submit for qualification the luminaire likely to be the lowest-performing (relative to ENERGY STAR requirements) luminaire within a group. Selecting the lowest performing luminaire within a group is the responsibility of the manufacturer. Successful qualification of the lowest-performing version will help ensure that other luminaires in the group will meet or exceed ENERGY STAR requirements, pass any subsequent QA testing, and maintain qualification status for the product grouping. Product groups may not span more than one of the lighting applications contained in Category A, e.g., individual porch lights and walkway lights may not be combined into a single product group.

Applicants are reminded that thermal management is a key element of LED luminaire performance, and that heat must be removed from the package, array or module —by conduction or convection—to maintain required light output, efficacy and color quality. For this reason, DOE will not allow significant variations in luminaire housings and chassis within product groupings that are likely to affect thermal performance because material and design changes can alter the LED thermal pathway and diminish lighting performance.

However, product variations, including housing and chassis variations that do not significantly degrade the thermal performance of products are allowed. For example, outdoor wall-mounted porch lights within a product group could include a coach lantern with metal mullions, or an opaque glass cylinder with a top shade—while sharing the same LED platform and internal mounting hardware. Similarly, outdoor pathway lights with the same LED platform and similar basic structure may be offered in a range of ornamental shapes and embellishments.

Limited variations of luminaire housings within product groups are allowed for ENERGY STAR qualification. Applicants self-define their product groups, and should explain their rationale for each product group proposed, including selection of the version submitted for testing. DOE will

evaluate grouping rationales on a case-by-case basis and, where appropriate, advise the applicant of any recommended modifications to the product group. Note that applicants ultimately bear the risk of inappropriate product grouping, which could result in failed follow-up QA testing, non-compliance, and revocation of product grouping eligibility.

As detailed in the ENERGY STAR eligibility criteria document, applicants may also include variations in luminaire finish, reflectors/trims, shades/diffusers, and mountings within product groups. In all cases, however, DOE encourages applicants to be conservative in their selection of grouped luminaires, and adhere to the following basic requirements and guidelines:

- 1) Use the same type of LED platform for all luminaires in a product grouping (MANDATORY);
- 2) To help ensure product group qualification, submit the lowest-performing compliant luminaire in the group for testing;
- 3) Limit product variations to allow grouped luminaires to still meet the performance of the qualifying luminaire and, by extension, all applicable ENERGY STAR requirements.