ENERGY STAR® Requirements for the Use of LM-80 Data

Replaces "ENERGY STAR® Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products" dated September 9, 2011.

1 Introduction

The purpose of this document is to ensure uniform treatment of luminous flux maintenance and color maintenance ("maintenance") data by ENERGY STAR manufacturing partners ("partners"), subcomponent manufacturers, and EPA-Recognized Laboratories and Certification Bodies.

This document is intended to support the use of LM-80 data and associated projection methodologies (i.e. IES LM-80-08 and its Addendum A, ANSI/IES LM-80-15, and IES TM-21-11 and its Addendum B[1]) for ENERGY STAR certification of lighting products. It addresses maintenance testing and reporting for LED packages and modules ("subcomponent(s)") used to demonstrate compliance with ENERGY STAR Lumen Maintenance, Color Maintenance, and/or Rated Life requirements detailed in ENERGY STAR lighting program specifications.

This document addresses topics related to subcomponent-level maintenance data that are not explicitly covered in ENERGY STAR lighting specifications. The U.S. Environmental Protection Agency (EPA) will periodically review this document to ensure its content acknowledges the latest technological improvements to solid state lighting subcomponents.

***Please note**: this document includes requirements which may be in addition to, or in place of, the testing and reporting requirements that are detailed in LM-80. Laboratories must clearly notate in their test reports any and all variances from the LM-80 method of measurement.*

Timeline for Implementation

With the exception of Section 3—Content of LM-80 Test Reports—this document immediately supersedes the ***ENERGY STAR Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products*** (the 2011 requirements).

LM-80 test reports issued after December 27, 2017 must meet the requirements of Section 3. This may be accomplished through supplemental documentation (e.g. cover page). Test reports issued prior to December 27, 2017 must meet the 2011 requirements and will be accepted without supplemental documentation until March 27, 2019.

Beginning March 27, 2019, all reports and supplemental documentation used to support new ENERGY STAR certifications must meet the requirements of Section 3.

Contents

1 Introduction 1
Timeline for Implementation 1
2 Definitions 2
3 Content of LM-80 Test Reports for ENERGY STAR Certification 3
4 Application of LM-80 Test Reports for ENERGY STAR Certification 5
5 Requirements for Successor Subcomponents 6

[1] This document is applicable to the relevant standards (IES LM-80-08 and its Addendum A, ANSI/IES LM-80-15, and IES TM-21-11 and its Addendum B) as they are referenced in the ENERGY STAR lighting specifications.

2 Definitions

Case Temperature (T_S): The temperature of the DUT at the LED temperature measurement point (TMP_{LED}) defined by the DUT manufacturer. In some cases the temperature measurement point is defined as the solder point on the printed circuit board. In other instances this is defined as a specific location on the DUT case. Thus T_S is sometimes designated as Tsp or T_C in manufacturer's literature. (Adapted from ANSI/IES LM-80-15)

Chip-on-board (COB) LED packages: See multi-die LED Packages.

Correlated Color Temperature (CCT): The absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source. (ANSI/IES RP-16-17). CCT values in this document refer to the nominal CCT values and their associated targets and tolerances defined in ANSI C78.377-2015.

Current Density: ratio of the drive current reported in the LM-80 test report to the area of epitaxial structure, in mA/mm^2.

Device Under Test (DUT): an LED package, array or module which is undergoing the maintenance test. (ANSI/IES LM-80-15)

LED Array or Module: An assembly of LED packages (components), or dies on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces that are intended to connect to the load side of a LED driver. Power source and ANSI standard base are not incorporated into the device. The device cannot be connected directly to the branch circuit. (ANSI/IES RP-16-17)

LED Package: An assembly of one or more LED dies that includes wire bond or other type of electrical connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. Power source and ANSI standardized base are not incorporated into the device. The device cannot be connected directly to the branch circuit. (ANSI/IES RP-16-17)

LED Temperature Measurement Point (TMP_{LED}): The temperature measurement point for the device under test (DUT), designated by its manufacturer, which provides a surrogate temperature measurement location for the actual LED junction. In some cases the temperature measurement point is defined as the solder point on the printed circuit board. In other instances this is defined as a specific location on the DUT case.

Luminous Flux Maintenance: Luminous flux maintenance (often referred to as "lumen maintenance") is the remaining luminous flux output (typically expressed as a percentage of the initial luminous flux output) at any selected elapsed operating time. Luminous flux maintenance (or "lumen maintenance") is the converse of luminous flux depreciation (or "lumen depreciation"). (ANSI/IES LM-80-15)

Multi-die LED Packages: LED packages constructed as an assembly of LED dies on a printed circuit board (PCB) or other substrate (e.g. ceramic panel or molded surface-mounted device) with one phosphor layer overlaying all dies. Power source and ANSI standard base are not incorporated into the device. The device cannot be connected directly to the branch circuit. (Often referred to as "chip-on-board" or COB LED packages.)

Power Density: ratio of the total input power reported in an LM-80 test report condition to the total PCB or substrate area of the DUT, in W/mm^2.

Series: subcomponents marketed with naming that implies common construction processes and materials, and common performance attributes. Where this is not the case, series-related provisions detailed in this document must not be employed.

Examples illustrating "series":

- *Bridgelux "RS Array Series"*
- *Citizen Electronics "CL-L253E Series"*
- *Cree XP-G 'series'*
- *Lumileds LUXEON M 'series'*
- *Nichia "757G Series"*
- *OSRAM Opto Semiconductors Golden DRAGON Plus 'series'*

Subcomponent(s): LED package(s) or LED module(s).

Successor: an LED package or module may be considered a "successor" to another subcomponent if, relative to the referenced original subcomponent, it features all of the following:

1. Photometric performance (i.e. maintenance and initial luminous flux) greater than or equal to the performance detailed in the referenced original LM-80 test report; and,
2. A unique model number; and,
3. Equal or fewer LED dies; and,
4. The same materials in the optical path after exiting epitaxial structures; and,
5. The same type(s) of deposition processes employed; and,
6. Relevant tested case temperature (T_S) value(s) equal to those of the referenced original subcomponent;

   Example: if the referenced original subcomponent was tested at 55°/85°/105° C and the proposed successor was tested at 85°/105°/120° C, comparisons between 85° C and 105° C (the overlapping temperatures) would be allowed.
7. Nominal CCT within the same range as the referenced original subcomponent as follows:
   a. 2200 to 2700 K,
   b. 3000 and 3500 K, or
   c. 4000 to 6500 K; and,
8. Equal or lower thermal resistance:
   a. For LED packages, from junction to case or solder point,
   b. For LED modules, from junction to LED Temperature Measurement Point (TMP_{LED}); and,
9. Equal or lower tested subcomponent electrical input power; and,
10. Equal or lower average current density (i.e. mA/mm^2) or power density (i.e. W/mm^2) per LED die as determined per the applicable tested drive current and average measured initial forward voltage in the LM-80 report.

3 Content of LM-80 Test Reports for ENERGY STAR Certification

1. LM-80 test reports must reference third-party accreditation to illustrate that subcomponent testing was conducted in accordance with the testing method outlined in IES LM-80-08 and its Addendum A, or in ANSI/IES LM-80-15, except as otherwise detailed in this document or in ENERGY STAR specifications.
2. LM-80 test reports must comply with the reporting requirements outlined in IES LM-80-08 and its Addendum A, or in ANSI/IES LM-80-15, and include each of the items below, except as otherwise detailed in this document or in ENERGY STAR specifications.
   a. The date (i.e. month/day/year) testing was initiated;
   b. The date the report was first issued, and revised (if applicable);
   c. Sampling method as suggested in LM-80;
   d. Sample size as required in LM-80;
   e. Test results for each case temperature (T_S) and drive current combination;
   f. Description of the DUT including model number and whether it is an LED package or LED module;
   g. ANSI target and calculated CCT value(s) for each DUT in the sample set, at t=0;
   h. Calculated change in chromaticity ($\Delta u'v'$) on the CIE 1976 diagram from the 0-hour measurement to the chromaticity coordinates at the end of each measurement interval, for each DUT;
   i. Total input power (W), the product of LM-80 test current and the average measured initial forward voltage;
   j. Average current density per LED die (i.e. mA/mm^2) as determined per the applicable tested drive current in the LM-80 report;
   k. Average power density per LED die (i.e. W/mm^2); and,
   l. Representative Color Rendering Index (R_a) for the tested sample set. This may be reported as the mean or median value of the sample set, or per unit.
   m. Minimum spacing from die edge to die edge.

   Items listed above that are not required in a standard LM-80 report can be included in a cover sheet provided by the LED manufacturer. For example:

ENERGY STAR® LM-80 Cover Sheet

Administrative Information

Tested subcomponent series: _____
Tested subcomponent model number: _____
Report issue date: _____
Report revision date (if applicable): _____
Testing start date: _____
Testing completion date: _____
DUT sampling method: _____

DUT Identification

DUT manufacturer's name: _____
DUT identification, e.g., model number: _____
Description of DUT, including if the DUT is an LED package or module: _____

DUT Characteristics

Total input power (W): _____
Average current density per LED die (mA/mm^2): _____
Average power density per LED die (W/mm^2): _____
Representative CRI (R_a) of the tested sample set: (Indicate whether the reported value is the mean or median value of the sample set, or per unit) _____
Minimum die edge to die edge spacing: _____

3. LM-80 test reports must indicate the DUT's model or series number. Other subcomponent models or series numbers for which the reports are applicable may also be listed if the others are wholly identical and indistinguishable except for model or series number (i.e. model or series number was changed for marketing purposes only).

   Example: Baker Semiconductors tests the 2700K version of their JE-B series LED package. The LM-80 report must indicate that the "JE-B series" was tested. The SR-B series subcomponents are wholly identical and indistinguishable from the JE-B series except for the change in series number, for marketing purposes. The report may indicate that the report is also applicable to the SR-B series.

4. LM-80 test reports must include a minimum of one close up perspective view photograph or isometric view diagram of the DUT, and if necessary the DUT's immediate surroundings for context, illustrating the DUT's maximum overall dimensions (i.e. length, width, height) and the manufacturer-designated LED temperature measurement point (TMP_{LED}).

5. LM-80 test reports must include a minimum of one reported case temperature (T_S). Test reports need not include three T_S values, except as required to estimate a product's rated luminous flux maintenance life value using temperature data interpolation (as applicable; see IES TM-21-11 section 6 and its Addendum B).

6. If more than one case temperature (T_S) is reported, all T_S subsets of the sample used to generate each LM-80 test report must be of the same CCT(s).

   Example: the 55° C case temperature sample subset should be composed of subcomponents of the same CCT(s) as the other two case temperature subsets.

4 Application of LM-80 Test Reports for ENERGY STAR Certification

1. The subcomponent make(s) and model number(s) used in the product to be certified must be reported by the partner, detailing the complete ordering code(s)/nomenclature required by the subcomponent manufacturer(s) to sell the subcomponents to the partner.
2. The CCT(s) of the LM-80 sample set may differ from the certified product as follows:

CCT of LM-80 Sample Set	CCT of Certified Product within scope of the specification
2200K to 2700K	any nominal CCT ≥ 2200K
3000K and 3500K	any nominal CCT ≥ 2700K
4000K to 6500K	any nominal CCT ≥ 4000K

3. The LED package's or module's tested drive current value, or the average current density per LED die (i.e. mA/mm^2) reported in an LM-80 test report referenced to support certification of a product must be greater than or equal to that of the subcomponent as employed in the product.
4. Certification of a product employing both phosphor-converted and single-color LED packages must demonstrate compliance with all maintenance requirements by referencing an LM-80 test report for a sample of LED modules, with each module composed of both types of packages, or by referencing an LM-80 report and conducting a TM-21 projection for each type of package present in the product. In the latter case, projections for each type of LED package must each demonstrate compliance with the relevant luminous flux maintenance requirements independently.
5. For multi-die (aka "chip-on-board" or COB) LED packages:

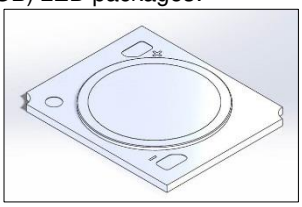

Figure 1: Example of Multi-die LED Package

   a. The LM-80 test report (or associated cover sheet) referenced to support certification of a product must:
      i. Include the LED package model or series number employed in the product; and,
      ii. Demonstrate that the average current density per LED die (i.e. mA/mm2) of the tested LED package model or series is greater than or equal to the current density per LED die employed in the product.
   b. One LM-80 test report may represent a range of multi-die LED package sizes (i.e. packages with a varying number of LED dies) and other subcomponent series if each of the following is satisfied:
      i. LM-80 testing has been conducted on the largest LED package (i.e. the package with the greatest number of LED dies) that the manufacturer believes will be used in a certified product; and,
      ii. The complete model number of the tested multi-die LED package is reported, and is noted as the tested model. The reported model number must include the complete ordering code/nomenclature required by the subcomponent manufacturer to sell the exact subcomponent tested; and,
      iii. The average calculated current density per die of the tested model or series is reported; and,
      iv. The model numbers for the other multi-die LED package sizes and series for which the test data are deemed applicable are detailed in the report (or associated cover sheet), and those models exhibit:
         1. Equal or fewer LED dies; and,
         2. Minimum die edge to die edge spacing greater than or equal to that of the tested LED package; and,
         3. Electrical power density (i.e. W/mm^2) less than or equal to the tested LED package; and,
         4. Average current density per LED die (i.e. mA/mm^2) less than or equal to the tested LED package; and,
         5. Identical materials used (note: this does not constrain phosphor quantity and/or dimensional adjustments); and,
         6. Identical construction processes used; and,
      v. The model numbers for the other multi-die LED package sizes for which the test data are deemed applicable may not be represented as having been tested to generate the data detailed in the report.

6. For LED modules constructed as an assembly of LED packages on a printed circuit board (PCB), each with their own phosphor layer:

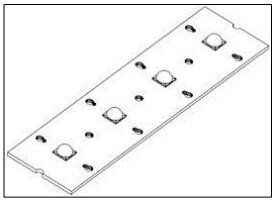

Figure 2: LED Module Employing 4 LED Packages

   a. The *in situ* temperature at the LED temperature measurement point (TMP_{LED}) of the hottest package in the module must be used for luminous or radiant flux maintenance projection purposes.
   b. LM-80 test reports must be available either:
      i. For the individual LED packages:
         1. For LED packages in the LED module that are within a defined ANSI C78.377 quadrangle, these LEDs can be covered by LM-80 reports consistent with Section 4.3.
         2. For LED packages in the LED module that are outside the ANSI C78.377 quadrangles, each different type of LED (e.g., phosphor-converted green, phosphor-converted amber, 1800K CCT phosphor-converted white, single-color red) must be supported by its own LM-80 report; or,
      ii. For the entire LED module, with current density per LED package reported.

5 Requirements for Successor Subcomponents

A partner may present a product for certification using a subcomponent considered a successor by the subcomponent manufacturer if the subcomponent meets the successor definition (see section 2); and each of the following is satisfied:

1. A complete LM-80 test report is provided for the referenced original subcomponent; and,
2. ENERGY STAR luminous flux maintenance and, as applicable, color maintenance performance requirements would be satisfied using the referenced original; and,
3. A minimum of 3,000 hours of LM-80 testing data are presented (and updated after 6,000 hours as noted below) for the successor subcomponent, compliant with reporting requirements detailed in LM-80 and this document; and,
4. The presented successor test data demonstrates that:
   a. Average initial luminous flux is greater than or equal to 99% of original subcomponent performance; and,
   b. Average luminous flux maintenance is greater than or equal to 99% of original subcomponent performance; and,
   c. Maximum change in chromaticity (i.e. color maintenance) observed on any unit at any measurement point is less than or equal to 101% of the maximum chromaticity shift observed on any original subcomponent unit; and,
   d. No individual unit has initial luminous flux or lumen maintenance less than 99% of the unit values reported for the original subcomponent; and
5. Partner provides a date, not to exceed 170 days from the 3,000 hour date, when the successor subcomponent's 6,000-hour LM-80 test report will be available from the subcomponent manufacturer, and partner agrees to provide the 6,000-hour LM-80 test report by that date.

Certification of products employing successor subcomponents may be withdrawn if the final 6,000 hour successor LM-80 test report is not provided in a timely manner, or if the test report does not demonstrate equal or improved performance relative to the referenced original LM-80 test report.