



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

October 21, 2016

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.

Note box 1 Note boxes throughout explain all the changes that were made. EPA invites stakeholders to send comments to lighting@energystar.gov, with the subject “Comments – ENERGY STAR Requirements for the Use of LM-80 Data” by November 18, 2016.

1 Introduction

The purpose of this document is to ensure uniform treatment of luminous and radiant 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 (i.e. IES LM-80-08 and its Addendum A, ANSI/IES LM-80-15¹) for ENERGY STAR certification of lighting products. It addresses luminous and radiant flux maintenance and color maintenance (“maintenance”) testing and reporting for LED packages, LED arrays, and LED modules (“subcomponent(s)”) referenced to demonstrate compliance with ENERGY STAR lumen maintenance and/or color maintenance requirements detailed in the Program specification for luminaires and lamps (“product(s)”).

Note box 2: EPA intends to adopt Addendum A to IES LM-80-08 as well as ANSI/IES LM-80-15 in the next revision of the ENERGY STAR Lamps and Luminaires specifications (i.e., V2.1). This document will be applicable to Addendum A to IES LM-80-08 and LM-80-15 test reports once V2.1 specifications are released.

EPA encourages partners to familiarize themselves with [Addendum A](#) to LM-80-08, as well as [LM-80-15](#). For reference, IES has also published an [LM-80-08 Errata](#).

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

On the date of final publication of this document, these requirements may apply to LM-80 testing already completed, currently underway or in the final planning stages.

90 days after final publication of this document, these requirements for reporting of LM-80 test data apply to all issued or revised reports. Preexisting test reports issued prior to that date may be referenced as existing without any changes.

Note box 3: EPA seeks feedback on the proposed implementation timeline for reporting.

¹ This document will be applicable to Addendum A to IES LM-80-08 and LM-80-15 once V2.1 Lamps and Luminaires specifications are released.

Contents

- 1 Introduction..... 1
 - Timeline for Implementation 1
- 2 Definitions..... 3
- 3 Content of LM-80 Test Reports for ENERGY STAR Certification..... 4
- 4 Application of LM-80 Test Reports for ENERGY STAR Certification 6
- 5 Requirements for Successor Subcomponents 7

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2 Definitions

Case Temperature (T_s): The temperature of the thermocouple attachment point on the LED light source package as defined by the manufacturers of the package. (IES LM-80-08)

Chip-on-board (COB) 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 common phosphor layer overlaying all dies.

Correlated Color Temperature (CCT): The absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source. (IES RP-16-10). CCT values in this document refer to the nominal CCT values and their associated targets and tolerances defined in ANSI C78.377.

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. (IES RP-16-10)

LED Driver Case Temperature Measurement Point (TMP_c): A location on an LED driver case, designated by its manufacturer, which will have the highest temperature of any point on the driver case during normal operation.

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. (IES RP-16-10)

LED Temperature Measurement Point (TMP_{LED}): A location on an LED package/module/array, designated by its manufacturer, which provides a surrogate temperature measurement location for the actual LED junction. The TMP_{LED} may be a solder joint at the board attachment site, a point on the LED package case, or a location on the board of an LED module or array.

Lumen Maintenance: The luminous flux output remaining (typically expressed as a percentage of the initial output) at any selected elapsed operating time. Lumen maintenance is the converse of lumen depreciation (adapted from IES LM-80-08).

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 "183A Series"*
- *OSRAM Opto Semiconductors Golden DRAGON Plus 'series'*

Successor: an LED package, array, or module may be considered a "successor" to another subcomponent if it features:

- a. Photometric performance (i.e. maintenance and luminous flux) greater than or equal to the performance detailed in the referenced original LM-80 test report;
- b. A unique model number;
- c. The same materials in the optical path after exiting epitaxial structures;
- d. The same type(s) of deposition processes employed;
- e. Relevant tested case temperature (T_s) value(s) equal to those of the referenced original subcomponent;

For 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.

- f. The same or higher nominal CCT;
- g. Equal or lower thermal resistance of the subcomponent;
- h. Equal or lower tested subcomponent power dissipation; and,
- i. Equal or lower average current density per LED die (i.e. mA/mm²).

Note box 4: EPA relocated the “successor” definition to section 2 and removed the requirement that a successor must feature the same number of LED dies. Additionally:

1. The requirement that a successor have “same or higher tested case temperature” has been changed to require “Relevant tested case temperature (T_s) value(s) equal to those of the referenced original subcomponent; EPA’s intent is to not inhibit the comparison of test reports with overlapping case temperatures, as long as the in situ case temperature falls between those overlapping temperatures. For 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.
2. To align with Section 4 of this document, the requirement that a successor have the “same nominal CCT” has been changed to require “the same or higher nominal CCT” than the referenced original subcomponent.
3. The requirement that a successor have “equal or lower tested subcomponent drive current” has been changed to require “equal or lower tested subcomponent power dissipation”; and
4. The requirement that a successor have “equal or lower per chip current density” has been changed to require “equal or lower average current density per LED die.”

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

1. LM-80 test reports must illustrate that subcomponent testing was conducted in accordance with the testing method outlined in IES LM-80-08 and its Addendum A, or in IES LM-80-15², 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 IES LM-80-15³, 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 and sample size as required in LM-80;
 - d. Test results for each case temperature (T_s) and drive current combination;
 - e. Description of the subcomponent including model number;
 - f. ANSI target, and calculated CCT value(s) for each subcomponent in the sample set;
 - g. Chromaticity shift value ($\Delta u'v'$) on the CIE 1976 diagram at each measurement point for each subcomponent in the sample set;
 - h. Average current density per LED die (i.e., mA/mm²); and,
 - i. Color Rendering Index (R_a) and R_9 , or spectral power distribution (SPD) for wavelengths from 380 nm to 780 nm (at a minimum), with an interval not greater than 5 nm.

Note box 5: For item 2d, EPA removed the requirement that the description of the subcomponent include whether the device is an LED package, array, or module because it is irrelevant to evaluation. EPA added reporting of CRI (R_a and R_9) or SPD on test reports since it is not required by the current standard and may aid in future updates to this document.

3. LM-80 test reports must indicate the tested subcomponent’s model or series number. Other subcomponent models or series numbers for which the data 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

² This document will be applicable to Addendum A to IES LM-80-08 and LM-80-15 once V2.1 Lamps and Luminaires specifications are released.

³ This document will be applicable to Addendum A to IES LM-80-08 and LM-80-15 once V2.1 Lamps and Luminaires specifications are released.

diagram of the subcomponent, illustrating the subcomponent's maximum overall dimensions (i.e. length, width, height) and including notation of 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 as required by LM-80, except as required to estimate a product's rated lumen maintenance life value using temperature data interpolation (as applicable; see IES TM-21-11 section 6 and its Addendum B⁴).

Note box 6: EPA intends to adopt Addendum B to IES TM-21-11 in the next revision of the ENERGY STAR Lamps and Luminaires specification (i.e., V2.1). This would allow for projections in accordance with TM-21-11 and its Addendum B. This document will be applicable to Addendum B to IES TM-21-11 once V2.1 specifications are released.

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 correlated color temperature(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.

7. For chip-on-board (COB) LED packages:

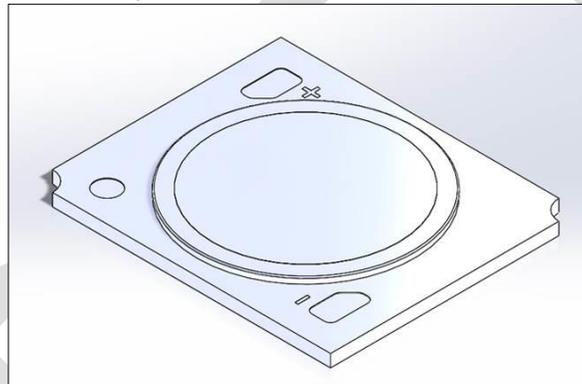


Figure 1: Example of COB LED Package

One LM-80 test report may represent a range of LED package sizes (i.e. packages with a varying number of LED dies) and other subcomponent series if each of the following is satisfied:

- a. The complete model number of the tested LED package is reported, and is noted as the tested model. The reported number must include the complete ordering code/nomenclature required by the subcomponent manufacturer to sell the exact subcomponent tested; and,
- b. the average calculated current-per-die of the tested model or series is reported; and,
- c. The model numbers for the other LED package sizes and series for which the test data are deemed applicable are detailed in the report, and those models exhibit:
 - i. electrical power density (i.e. W/mm² of PCB or substrate total area, or equivalent calculation) less than or equal to the tested LED package; and,
 - ii. average current density per LED die (i.e. mA/mm² of epitaxial structures) less than or equal to the tested LED package; and,
 - iii. identical materials used (note: this does not constrain phosphor quantity and/or dimensional adjustments); and,
 - iv. identical construction processes used; and,
- d. The model numbers for the other 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.

⁴ This document will be applicable to Addendum B to IES TM-21-11 once V2.1 Lamps and Luminaires specifications are released.

Note box 7: Item 7 focuses on applicability of test data for chip-on-board devices. Based on stakeholder input EPA has:

1. Removed the requirement that LM-80 testing be conducted on “the largest LED array that the manufacturer believes will be used in a product” and added a new requirement that the same LM-80 report can represent packages having average current density per LED die less than or equal to the tested LED package. Based on feedback EPA has received, this should be a more reliable indicator of performance than testing the largest LED array.
2. Clarified the requirement that models for which the test data are deemed applicable exhibit electrical power density less than or equal to the tested LED package;
3. Clarified that the requirement in item 7.b.iii is not constrained by the quantity of phosphor; and
4. Removed the requirement that models for which the test data are deemed applicable exhibit “equal or fewer LED dies” in order to not limit industry use of greater quantities of smaller dies, which typically results in lower overall electrical and thermal stress on the epitaxial structures which improves lumen maintenance.
5. Removed the requirement that models for which the test data are deemed applicable exhibit “die spacing greater than or equal to the tested LED array” because it was deemed overly burdensome and unrealistic to expect a laboratory to remove LED package encapsulant(s) and take accurate measurements of the die spacing dimensions.

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

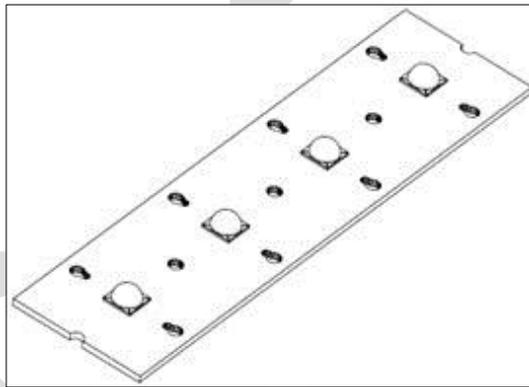


Figure 2: LED Module Employing 4 LED Packages

LM-80 test reports must be available either:

- a. for the individual LED packages; or,
- b. for the entire LED array, with current density-per-LED package reported.

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

1. LM-80 test reports issued or revised on or after (90 days after final publication of this document) and referenced to support product certification must comply with section 3 of this document. Preexisting test reports issued or revised prior to (90 days after final publication of this document) may be referenced as existing without changes.

Note box 8: Because IES TM-21-11 does not permit projections to temperatures above the highest case temperature tested with LM-80, EPA removed previous item #2 that stated “A minimum of one reported case temperature (T_s) greater than or equal to the in situ measured TMP_{LED} value must be included in the LM-80 test report for the employed subcomponent(s).”

EPA seeks feedback on the proposed implementation timeline for reporting.

2. 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(s) required by the subcomponent manufacturer(s) to sell the subcomponents to the partner.

3. The correlated color temperature(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
2200K, 2500K, 2700K	any nominal CCT \geq 2200K covered by the specification
3000K, 3500K	any nominal CCT \geq 2700K covered by the specification
4000K, 5000K	any nominal CCT \geq 4000K covered by the specification

Note box 9: EPA did not include any changes related to CRI, and seeks input on the applicability of test data for samples with one CRI to support the certification of products with higher CRI (e.g. 80 CRI test data supporting a product with 90 CRI). For EPA to act on this input, technical data supporting this input must be submitted.

EPA intends to adopt ANSI C78.377-2015 in the next revision of the ENERGY STAR Luminaires specification (i.e., V2.1). This would allow certification of luminaires with 2200K and 2500K nominal CCT.

4. The LED package, array or module's drive current value, or the average current density per LED die (i.e. mA/mm²) 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.

Note box 11: EPA has included average current density per LED die as an option for meeting this requirement.

5. Certification of a product employing both phosphor-converted white and single-color LED packages must demonstrate compliance with all maintenance requirements by referencing an LM-80 test report for a sample of LED arrays, with each array composed of both types of packages.
6. For chip-on-board LED packages the LM-80 test report referenced to support certification of a product must:
- Include the LED package model or series number employed in the product; and,
 - Demonstrate that the average current density per LED die (i.e. mA/mm² of epitaxial structures) in the tested LED package model or series is greater than or equal to the current density per LED die employed in the product.

Note box 12: 6b was revised to be based on "average current density per LED die" rather than "average calculated current per die".

7. For LED arrays constructed as an assembly of LED packages on a printed circuit board, each with their own phosphor layer, the *in situ* temperature at the LED temperature measurement point (TMP_{LED}) of the hottest package in the array must be used for luminous or radiant flux maintenance projection purposes.

5 Requirements for Successor Subcomponents

1. 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,
- a complete LM-80 test report is provided for the referenced original subcomponent;
 - ENERGY STAR lumen maintenance and, as applicable, color maintenance performance requirements would be satisfied using the referenced original;
 - a minimum of 3,000 hours of LM-80 testing data are presented for the successor subcomponent, compliant with LM-80 and this document;
 - presented data demonstrate:
 - initial luminous flux greater than or equal to the original subcomponent;
 - lumen maintenance and color maintenance greater than or equal to the original subcomponent at 3,000 hours and after 6,000 hours of LM-80 testing;
 - Partner provides a date, not to exceed 170 days from the 3,000 hour date, when the successor subcomponent's complete (i.e. final, 6,000 hour) LM-80 test report will be available from the subcomponent manufacturer and agrees to provide the complete LM-80 test report for the successor subcomponent as soon as it is available.

Note box 13: EPA received a stakeholder request that item 5.1.e be revised to only require that a successor have maintenance greater than or equal to the original subcomponent. To ensure positive consumer experience with ENERGY STAR certified products over time, EPA has elected to retain the requirement that lumen maintenance, color maintenance, and light output of a successor must be at least as good as the original subcomponent.

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.

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