

ENERGY STAR® Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products

September 9, 2011

Section 1: Purpose of this Document & Timeline for Implementation

The purpose of this document is to provide guidance regarding lumen maintenance testing and reporting (i.e. IES LM-80-08, or “LM-80”) for LED packages, LED arrays, and LED modules (“subcomponent(s)”) referenced to demonstrate compliance with ENERGY STAR lumen maintenance and/or color maintenance performance requirements detailed in Program specifications for lighting products (“product(s)”).

The most commonly employed approach to fulfilling ENERGY STAR lumen maintenance performance requirements is through projections based in part upon LM-80 test reports. This guidance addresses topics related to subcomponent-level lumen maintenance data that are not explicitly covered in ENERGY STAR lighting specifications because of the quickly evolving nature of solid state lighting technology. The U.S. Environmental Protection Agency (EPA) will periodically review this guidance to ensure its content acknowledges the latest technological improvements to solid state lighting subcomponents.

This document supports all ENERGY STAR lighting specifications that include solid state lighting within their scope, and is intended to ensure uniform treatment of lumen maintenance data by ENERGY STAR manufacturing partners (“partners”), subcomponent manufacturers, and EPA-Recognized Laboratories and Certification Bodies.

This document addresses:

- the content of LM-80 test reports (section 3)
- the application of LM-80 test reports in support of product qualification (section 4)
- the use of preexisting test reports while testing of successors is underway (section 5)

EPA’s intention is for testing and reporting to follow this guidance going forward.

This guidance as it relates to testing applies to LM-80 testing not already initiated as of November 9, 2011, and thus does not apply to testing already completed, currently underway or in the final planning stages.

This guidance as it relates to reporting of LM-80 test data applies to all reports issued or revised on or after September 9, 2011. Preexisting test reports issued prior to September 9, 2011 may be referenced as existing without any changes.

Please note: this document includes guidance which may be in addition to, or in place of, the testing and reporting requirements that are detailed in IES LM-80-08. Laboratories must clearly notate in their test reports any and all variances from the IES LM-80-08 method of measurement.

Section 2: Definitions

ENERGY STAR program requirements for lighting products generally reference definitions provided by the Illuminating Engineering Society's (IES) recommended practices document RP-16-10, as well as addenda as they become available. Subcomponents addressed by this guidance are LED packages, LED arrays, or LED modules. Questions about these definitions, or the application of the definitions to subcomponent testing, should be directed to the IES.

The use of the term “series” in this document denotes 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’
- Nichia “183A Series”
- OSRAM Opto Semiconductors Golden DRAGON Plus ‘series’

Correlated color temperature (CCT) values in this document refer to the nominal CCT values and their associated targets and tolerances defined in ANSI C78.377-2008. Other important definitions are outlined at the beginning of each ENERGY STAR lighting specification.

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Section 3: Guidance Regarding the Content of LM-80 Test Reports Submitted in Support of ENERGY STAR Qualification of Lighting Products

1. LM-80 test reports must illustrate that subcomponent lumen maintenance testing was conducted in accordance with the testing method outlined in IES LM-80-08, 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 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 first initiated, and the date the report was first issued, and revised (if applicable); and,
 - b. sampling method and sample size as required in LM-80 section 4.3; and,
 - c. test results for each T_s and drive current combination; and,
 - d. a description of the subcomponent including model number and whether device is an LED package, LED array or LED module; and,
 - e. ANSI target, and calculated CCT value(s) for each subcomponent in the sample set; and,
 - f. $\Delta u'v'$ chromaticity shift value on the CIE 1976 diagram for each subcomponent in the sample set.
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 is 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 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 detailed in 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).

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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 LED arrays constructed as an assembly of LED dies on a printed circuit board (PCB) (a.k.a. chip-on-board) or substrate (e.g. ceramic panel or molded surface-mounted device) with one common phosphor layer overlaying all dies; or, with phosphor layers overlaying individual dies with or without single-color dies also incorporated:

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

- a. LM-80 testing has been conducted on the largest LED array (i.e. the array with the greatest number of LED dies) that the manufacturer believes will be used in a qualified product; and,
 - b. the complete model number of the tested LED array 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,
 - c. the average calculated current-per-die of the tested model or series is reported; and,
 - d. the model numbers for the other LED array sizes and series for which the test data is deemed applicable are detailed in the report, and they exhibit each of the following:
 - i. equal or fewer LED dies; and,
 - ii. die spacing greater than or equal to the tested LED array; and,
 - iii. power density (i.e. W/mm^2 of PCB or substrate total area, or equivalent calculation) less than or equal to the tested LED array; and,
 - iv. identical materials used (note: this does not constrain quantity and/or dimensional adjustments); and,
 - v. identical construction processes used; and,
 - e. the model numbers for the other LED array sizes for which the test data is deemed applicable may not be represented as having been tested to generate the data detailed in the report.
8. For LED arrays constructed as an assembly of LED packages on a printed circuit board, each with their own phosphor layer:
LM-80 test reports must be available either:
 - a. for the individual LED packages; or,
 - b. for the entire LED array, with current-per-LED package reported.

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Section 4: Guidance Regarding the Application of LM-80 Test Reports in Support of ENERGY STAR Qualification of Lighting Products

1. LM-80 test reports issued or revised on or after September 9, 2011 and referenced to support product qualification must comply with guidance detailed in section 3 of this document. Preexisting test reports issued or revised prior to September 9, 2011 may be referenced as existing without changes.
2. 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).
3. Partners may not claim on the product, product packaging or product literature, either printed or electronic, longer rated lumen maintenance life values than those estimated by the IES TM-21-11 projection method (as applicable).
4. The subcomponent make(s) and model number(s) used in the product to be qualified must be reported, detailing the complete ordering code(s)/nomenclature(s) required by the subcomponent manufacturer(s) to sell the subcomponents to the product manufacturer.
5. The correlated color temperature(s) of the LM-80 sample set may differ from the product as follows:
 - a. LM-80 test reports for warm white samples (2700K, 3000K or 3500K) may be referenced to support qualification of a product of any nominal CCT 2700K or higher allowed in ENERGY STAR specifications.
 - b. LM-80 test reports for cool white samples (4000K, 4500K, 5000K, 5700K or 6500K) may be referenced to support qualification of a product of any nominal CCT 4000K or higher allowed in ENERGY STAR specifications.
6. The drive current value reported in an LM-80 test report referenced to support qualification of a product must be greater than or equal to the subcomponent drive current employed in the product.
7. Qualification of a product employing both phosphor-converted white and single-color LED packages must demonstrate compliance with lumen and color maintenance requirements by referencing an LM-80 test report for a sample of LED arrays, with each array composed of both types of packages.

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8. For LED arrays constructed as an assembly of LED dies on a printed circuit board (a.k.a. chip-on-board) or substrate (e.g. ceramic panel or molded surface-mounted device) with one common phosphor layer overlaying all dies; or, with phosphor layers overlaying individual dies with or without single-color dies also incorporated:
The LM-80 test report referenced to support qualification of a product must satisfy each of the following:
 - a. include the LED array model or series number employed in the product; and,
 - b. demonstrate that the average calculated current-per-die in the tested LED array model or series is greater than or equal to the average calculated current-per-die employed in the product.
9. For LED arrays constructed as an assembly of LED packages on a printed circuit board, each with their own phosphor layer, the *in situ* TMP_{LED} temperature of the hottest package in the array must be used for lumen maintenance projection purposes.

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Section 5: Guidance Regarding Subcomponents Presented to EPA-Recognized Certification Bodies as Successors to Previously Tested Subcomponents

1. **Definition:** an LED package, LED array or LED module may be considered a “successor” to another subcomponent if photometric performance (i.e. lumen maintenance and luminous flux) is greater than or equal to the performance detailed in the referenced original LM-80 test report, and is primarily attributable to improvements in internal quantum efficiency, phosphor or thermal management. In addition, relative to the referenced original subcomponent, a successor features:
 - a. a unique model number; and,
 - b. the same number of LED dies; and,
 - c. the same materials in the optical path after exiting epitaxial structures; and,
 - d. the same type(s) of deposition processes employed; and,
 - e. the same tested case temperature (T_s) value(s); and,
 - f. the same nominal CCT; and,
 - g. equal or lower thermal resistance of the subcomponent; and,
 - h. equal or lower tested subcomponent drive current; and,
 - i. equal or lower per-chip current density (e.g. mA/mm²).
2. **Application:** a partner may present a product for qualification using a subcomponent considered a successor by the subcomponent manufacturer if each of the following are satisfied:
 - a. the subcomponent meets the above successor definition; and,
 - b. a complete LM-80 test report is provided for the referenced original subcomponent; and,
 - c. ENERGY STAR lumen maintenance and, as applicable, color maintenance performance requirements would be satisfied using the referenced original; and,
 - d. a minimum of 3,000 hours of LM-80 testing data is presented for the successor subcomponent, compliant with LM-80 and guidance in this document; and,
 - e. that data demonstrate lumen maintenance, color maintenance and luminous flux greater than or equal to the original subcomponent at 3,000 hours; and,
 - f. the 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,
 - g. the partner agrees to provide the complete LM-80 test report for the successor subcomponent as soon as it is available.
3. 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.