

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

Section 1: Purpose of this Document

The purpose of this document is to provide guidance regarding lumen maintenance test reports (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 performance requirements detailed in Program specifications for lighting products (“products”).

The most commonly employed approach to fulfilling ENERGY STAR lumen maintenance performance requirements is through projections based upon LM-80 test reports. This guidance addresses topics related to subcomponent-level lumen maintenance data that aren’t 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.

The 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 existing test reports while testing of successors is underway (section 5)

***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.*

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.

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

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, except as otherwise detailed in this document or in ENERGY STAR specifications.
3. LM-80 test reports must include the subcomponent model or series number tested, and an indication of which month and year the report was first issued, and revised (if applicable).
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 ($T_{MP,LED}$).
5. All case temperature (T_s) subsets of the sample used to generate each LM-80 test report must be of the same correlated color temperature(s). For 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.
6. 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 establish a product rated lumen maintenance life value using temperature data interpolation (see IES TM-21-11 section 6).
7. For LED arrays constructed as an assembly of LED dies on a printed circuit board or substrate (a.k.a. chip-on-board) with one common phosphor layer overlaying all dies: One LM-80 test report may represent a range of LED array sizes (i.e. number of LED dies) if all of the following are satisfied:
 - a. The report details the smallest LED array size (i.e. model number with the fewest number of dies) and the largest LED array size (i.e. model number with the greatest number of dies) for which the report is applicable, which may be accomplished by detailing all model numbers covered by the report; and,
 - b. LM-80 testing has been conducted on the smallest and largest LED array sizes, demonstrating both sizes meet ENERGY STAR requirements. For this testing each of the following must be held constant across all sample sets:
 - i. Product series / base model numbers for small and large LED array samples
 - ii. Selected elevated case temperature(s) (T_s)
 - iii. Correlated color temperature bins (warm white bins recommended to provide greatest flexibility; see section 4, item 4)

- iv. Wiring configuration: half of each case temperature (T_s) sample set wired with all dies in series, half with dies wired in a series/parallel configuration
 - v. Forward drive current: samples operated at rated drive current per subcomponent product literature
 - vi. Luminous flux binning: middle flux bin within each LED array size; and,
 - c. The reported lumen maintenance data is that of the tested LED array size, smallest or largest, with the lower lumen maintenance; and,
 - d. The current-per-die is reported; and,
 - e. The smallest and largest LED array reports are made available upon request.
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 presented either:
- a. for the individual LED packages incorporated into the array, or,
 - b. for the entire LED array, with current-per-LED package reported.

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

1. 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).
2. Partners may not claim on the product, product packaging or product literature, either printed or electronic, longer rated lumen maintenance life values than those established by the IES TM-21-11 projection method.
3. The subcomponent make(s) and model number(s) used in the product to be qualified must be reported, detailing the complete nomenclature(s) required by the subcomponent manufacturer(s) to sell the subcomponents.
4. 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 (2700K, 3000K and 3500K) samples may be referenced to support qualification of a product of any nominal CCT allowed in ENERGY STAR specifications.
 - b. LM-80 test reports for cool white (4000K, 4500K, 5000K, 5700K and 6500K) samples may be referenced to support qualification of a product of any nominal CCT 4000K or higher allowed in ENERGY STAR specifications.
5. 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.

6. Qualification of a product employing both phosphor-converted white and single-color LED packages must demonstrate compliance with lumen maintenance requirements by referencing an LM-80 test report for a sample of LED arrays incorporating both types of LED packages.
7. For LED arrays constructed as an assembly of LED dies on a printed circuit board or substrate (a.k.a. chip-on-board) with one common phosphor layer overlaying all dies: One LM-80 test report representing the performance of a range of LED array sizes may be presented to support product qualification, if all of the following are satisfied:
 - a. The report complies with guidance detailed in section 3, item 7 (above); and,
 - b. The LED array size used in the product is within the tested array size range (see section 3, item 7); and,
 - c. The report is for the same LED array product series / base model number; and,
 - d. The current-per-die in the product is less than or equal to the current-per-die employed in LM-80 testing.
8. 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 shall be used for lumen maintenance projection purposes.

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 dimensions of the LED die(s); and,
 - d. the same materials in the optical path after exiting epitaxial structures; and,
 - e. the same deposition processes employed; and,
 - f. the same tested case temperature (T_s) values; and,
 - g. the same nominal CCT; and,
 - h. equal or smaller overall dimensions which would affect fit; and,
 - i. equal or lower thermal resistance of the subcomponent; and,
 - j. equal or lower rated maximum recommended drive current; and,
 - k. 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 color maintenance performance requirements would be satisfied using the referenced original; and,
 - d. A minimum of 3,000 hours of LM-80 testing data (compliant with LM-80 and guidance in this document) is submitted for the successor subcomponent; 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. 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. 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.