**LED Lighting Facts®**
**LED Lumen Maintenance and Warranty Label Changes**
**Frequently Asked Questions**

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***Is the lumen maintenance percentage a lifetime metric?***

No. The optional percentage listed on the LED Lighting Facts label describes the lumen maintenance (the amount of light remaining after a specified time, compared to the initial output) of the LED light source while operating in the thermal environment of the lamp or luminaire. SSL lifetime and reliability, by contrast, take into account the performance of other system components over time, including electronics (e.g. the power supply or driver), optics (e.g. lenses and reflectors), thermal management system, housing, and related components.

There is no industry standard method for measuring or estimating the lifetime and/or reliability of SSL products, taking the entire system into account, though some manufacturers have their own methods for doing so. LED Lighting Facts uses industry standard test procedures whenever possible to ensure apples-to-apples comparisons of product performance.

***Why not list an actual lifetime?***

TM-21 focuses on a specific light source component (package, module, array) while operating in the thermal environment of the lamp or luminaire, but doesn't take into account the performance of the entire luminaire or lamp. A complete luminaire is a complex system, with many components that can affect lifetime, such as the driver, optics, thermal management, and housing. The failure of any one of these can mean the end of the luminaire's useful life, even if the light source is still functioning. There is not yet a standard test to determine SSL system lifetime, so in the meantime, estimating the light source lumen maintenance with the TM-21 standard is the most reliable approach.

***Why isn't the lumen maintenance being reported using $L_{70}$ terms?***

$L_{70}$ is a useful metric for estimating when an LED will no longer produce acceptable light levels. It was relatively common in the early years of the LED general illumination market to use $L_{70}$ values for the LED light source a proxy for the lifetime of the complete LED luminaire or replacement lamp. Such use of this performance data has the potential to mislead stakeholders, because there is not yet an industry standard method for estimating LED luminaire or replacement lamp lumen maintenance or lifetime. While some manufacturers may have robust engineering data to support their claims, others may not, and LED Lighting Facts cannot evaluate lumen maintenance or lifetime of a LED luminaire or replacement lamp without an industry standard method. LED light source lumen maintenance is only one factor affecting LED luminaire and replacement lamp lifetime. The driver, other electronics, optics, and thermal and mechanical components of an LED product can all fail or degrade over time, and a robust lifetime or reliability analysis must consider them all.

TM-21 introduces provisions to limit $L_{70}$ values based on the amount of LM-80 data collected (more data available means a higher value can be claimed), but even so, values of 36,000 hours and higher are possible. Given the risk of these high hourly values being misconstrued as lifetime claims, LED Lighting Facts, in cooperation with DOE's reliability and lifetime working group, decided to represent lumen maintenance at a fixed point in time–25,000, 15,000, or 10,000 hours, at the option of the manufacturer. Instead of projecting at what point in time the product will reach a given percentage of initial output, as $L_{70}$ does for a fixed 70% lumen maintenance level, this metric represents the percentage of initial output projected to be reached at a fixed point in time.

***Will all manufacturers be required to list lumen maintenance and warranty on the label?***

No. Both the proposed lumen maintenance and warranty information are completely optional. Manufacturers would have the option of downloading and presenting four versions of the LED Lighting Facts label. The label could include the following information:

1) Current and required label metrics
2) Current and required label metrics + Warranty
3) Current and required label metrics + LED Lumen Maintenance
4) Current and required label metrics + LED Lumen Maintenance + Warranty

***How do you use the TM-21 calculator tool to calculate LED lumen maintenance at 25,000 hours, 15,000 hours, or 10,000 hours?***

To streamline the review process as much as possible, LED Lighting Facts requires partners claiming the optional LED luminaire or replacement lamp lumen maintenance metric to use the ENERGY STAR program's TM-21 calculator tool, which was developed in cooperation with the National Institute of Standards and Technology. LED Lighting Facts will verify that information from the product's In-Situ Temperature Measurement Test (ISTMT) report and the LM-80 report for the LED light sources used in the product has been entered correctly, and that the submitted claim matches the calculator's results.

Instructions are included in the tool, but it is important to know how to use it to calculate LED lumen maintenance at 25,000 hours, 15,000 hours, or 10,000 hours. The necessary fields for each section of the tool's "TM-21 Calculator" tab are listed below. All section titles reference the blank tool.

1) "LM-80 Testing Details" section
    a. *Total number of samples tested*
    b. *Number of failures*
    c. *Number of samples measured*
    d. *Test duration (hrs)*
    e. *Tested drive current*
    f. *Tested case temperature 1*
    g. *Tested case temperature 2*[a]
    h. *Tested case temperature 3*[a]
2) "Tested Case Temperature 1" section
    a. *Time (hrs)* and *Lumen Maintenance (%)* for the average of each set of measurements at the given time in the LM-80 report.
        i. If more than 20 measurements were taken, enter the last measurement from the LM-80 report in row 20 for the *Meas.* column and work backwards.
        ii. Be sure to enter *Lumen Maintenance (%)* values as percentages. Entering 1 for 100% will result in a miscalculation.
    b. Repeat for each case temperature entered in the "LM-80 Testing Details" section.
3) "In-Situ Test Inputs" section

[a] LED Lighting Facts encourages partners to supply as much performance data as possible. *Tested case temperatures 2 & 3* are optional; however, submitting at least two case temperatures is highly recommended. If data from only one LM-80 tested case temperature is entered and the product's tested case temperature is higher, a partner may not claim LED lumen maintenance. If the product's tested case temperature is lower than the LM-80 tested case temperature, *Tested case temperature 1* data will be used.

a. *Enter drive current for each LED package/array/module (mA)*
b. *Enter in-situ case temperature*

4) "Results" section
    a. *Enter time (t) to estimate lumen maintenance (hrs).* This must be the same as the time selected in the submission form.

Once all of the above information is entered, the value in the cell for *Lumen maintenance at time (t) (%)* is the LED lumen maintenance percentage. Like other LED Lighting Facts optional metrics, there will be no tolerance on the LED lumen maintenance percentage claim; the claim must be entered to the hundredths decimal place as indicated in the TM-21 Calculator.

Save the file, using the model number being submitted to LED Lighting Facts in the filename, before uploading with other supporting documentation.

***What supporting documentation do I need to submit for verification?***

To claim an LED lumen maintenance value for a product submission, partners must upload the following supporting documentation for verification:

1) ISTMT report in PDF form with LED drive current (if measured)[b] and ambient temperature included in the report. Laboratory policies for ISTMT are detailed below.
2) LM-80 report in PDF form for each LED light source used in the lamp or luminaire. Laboratory policies for LM-80 measurements are detailed below.
3) Saved copy of completed ENERGY STAR TM-21 Calculator in a Microsoft Excel file format.
    a. Save the file, using the model number being submitted to LED Lighting Facts in the filename, before uploading with other supporting documentation.
4) Specification sheet for the lamp or luminaire in PDF form with the following information disclosed:
    a. The manufacturer (OEM or private labeler) organization name and brand. ***Organization name and brand in the specification sheet will not affect the verification process. Organization name and brand must match the LM-79 and ISTMT reports.***
    b. Product model number matching test report and LED Lighting Facts submission.
        1. Ordering code for a product family is acceptable if the model number in the test report and LED Lighting Facts submission is included.
    c. Image or technical drawing of the product.
    d. Nominal rated (or tested) initial wattage.
    e. Nominal rated (or tested) initial light output.
    f. Driver characteristics or compatible drivers.
    g. Contact information for the organization listed in the specification sheet.
    h. Indication of warranty (if applicable).
    i. Indication of variable drive current controls to maintain light output and/or color over time (if applicable).
        1. Maximum possible increase above nominal initial wattage over the service life of the product (expressed in watts) should then be included.

***What are the testing requirements for LED lumen maintenance?***

Partners may claim an LED lumen maintenance percentage at 25,000 hours, 15,000 hours, or 10,000 hours as an optional metric. An In-situ Temperature Measurement Test (ISTMT) and LED light source lumen maintenance test, conducted in accordance with the *IESNA LM-80-2008 Approved Method for Measuring Lumen Maintenance of LED Light Sources*, must be uploaded.

- ISTMT
    - The ISTMT follows all requirements of the appropriate ANSI/UL standard, with the following addition: one or more additional thermocouples are attached to the highest

[b] LED drive current in the luminaire or lamp may be up to 5% greater than the LM-80 drive current for the corresponding LM-80 case temperature.

temperature LED light source in the luminaire or lamp (i.e., $TMP_{LED}$). The most common standards and the product types they cover are:
    - ANSI/UL 1598: luminaires
    - ANSI/UL 1993: self-ballasted lamps and lamp adapters
    - ANSI/UL 153: portable electric luminaires
    - ANSI/UL 1574: track lighting systems
    - ANSI/UL 2108: low-voltage lighting systems
    - ANSI/UL 8750: LED equipment for use in lighting products
  - For more information about proper ISTMT test environment and thermocouple attachments, please see pages 18-20 of the *DOE ENERGY STAR® Manufacturer's Guide for Qualifying Solid State Lighting Luminaires – Version 2.1.*
  - In keeping with past DOE guidance for the ENERGY STAR solid-state lighting program, LED Lighting Facts will accept ISTMT test reports from laboratories that meet one of the following requirements:
    1) An Occupational Safety and Health Administration (OSHA) Nationally Recognized Testing Laboratory (NRTL). For a list of laboratories, visit www.osha.gov/dts/otpca/nrtl/.
    2) A laboratory recognized through UL's Data Acceptance Program (DAP). For more information, visit www.ul.com/global/eng/pages/offerings/services/programs/dap/.

- LM-80
  - *IESNA LM-80 Approved Method for Measuring Lumen Maintenance of LED Light Sources* defines the test procedure for obtaining lumen maintenance data for LED light sources.
  - An LM-80 report must come from a laboratory accredited for LM-80 testing through NIST's NVLAP program or a laboratory accredited for LM-80 testing through an accreditation body that is an International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) signatory. For more information about ILAC MRA signatories, visit www.ilac.org/ilacarrangement.html.
  - Regarding the content and application of LM-80 reports in support of submissions to LED Lighting Facts, the program defers to guidance published in September 2011 by ENERGY STAR, with some exceptions. See the LED Lighting Facts Partner Participation Manual for details: www.lightingfacts.com/Downloads/LF_PartnerParticipationManual_V3.pdf.

***What are the differences between LM-79, LM-80, and TM-21?***

It is important to understand the difference between these three standards because they are all used to determine the performance metrics on the label, including the optional lumen maintenance metric.

- LM-79 is an approved method for taking electrical and photometric measurements of SSL products. It covers total flux (light output), electrical power, efficacy, chromaticity, and intensity distribution. The five required metrics on the LED Lighting Facts label come from LM-79 test results.
- LM-80 is an approved method for measuring the lumen maintenance of LED packages, arrays, and modules (i.e., the LED light source) at various temperatures. It specifies a minimum testing period of 6,000 hours, although 10,000 hours is preferred, and it requires testing at a minimum of 1,000-hour increments. LM-80 provides no determination or estimate of expected life or lumen maintenance beyond the test data, which, even with 10,000 hours of testing, falls far short of the claimed lifetimes of most SSL products on the market today.
- TM-21 provides guidelines for using LM-80 data to estimate the light source lumen maintenance beyond the LM-80 test period. LM-80 and TM-21 are designed to work hand-in-hand, with TM-21 using the LM-80 data, along with in-situ temperature performance data, to project the lumen maintenance of an LED light source.

***How does this new metric relate to requirements for ENERGY STAR?***
While LED Lighting Facts would be the first program to specifically list the lumen maintenance at 25,000 hours, that metric is derived from TM-21, LM-80, and in-situ temperature measurements, which is the same combination of testing and projections used by ENERGY STAR. The new LED Lighting Facts metric can be translated into an $L_{70}$ value relatively quickly, which could then be used by other qualification programs.

***Why doesn't the label include information on color shift and replaceable parts?***
There are no standard test procedures for color shift and no standard definition on what are replaceable parts for SSL luminaires and lamps. The LED Lighting Facts program strives to provide data that can be substantiated by industry approved testing methods, whenever possible.

***Why isn't there an option to claim lumen maintenance values at times longer than 25,000 hours?***
In developing this new metric, LED Lighting Facts and the DOE SSL Reliability and Lifetime Working Group worked to avoid the implication that long lumen maintenance times translated directly to long lifetimes of the complete lamp or luminaire. Long lumen maintenance times, which are commonly quoted up to 50,000 hours, have still not been verified through rigorous lifetime and reliability testing.

***Why is the warranty claim limited to "yes" or "no" instead of the number of years?***
Rather than provide the warranty period in years, the LED Lighting Facts label will only state if a warranty is available to provide a more consistent comparison across products and manufacturers. For example, two products with 5-year warranties may in reality be quite different because of different components covered or other warranty terms that are inconsistent. For products with a "yes" designation for warranty, LED Lighting Facts has added the ability to link to the manufacturer's warranty information directly from the LED Lighting Facts products list.

***What about products with special features? Are they included?***
Following are several product features that can affect lumen maintenance, and LED Lighting Facts policies on those products:

- ***Products with variable LED drive current to maintain light output over time:***
  Some products incorporate electronic controls that adjust the LED drive current during long-term operation to maintain light output near initial performance levels. This product design will affect the LED lumen maintenance. Manufacturers submitting products with variable drive current controls may claim LED lumen maintenance, but without a standard methodology for accurately projecting LED lumen maintenance as the drive current is adjusted over time, it must be clear that LED lumen maintenance claims are based on initial performance. Partners must indicate that the product incorporates variable drive current controls on the submission form by marking the appropriate checkbox. When this box is checked, a note will appear on the label that the product includes electronic controls to maintain light output over time, that LED lumen maintenance claims are based on initial performance, and that wattage may increase over time.
- ***Products with variable LED drive current for other purposes:***
  In addition to varying the drive current over time to maintain light output, some products may incorporate controls that affect other performance attributes, such as color in products with multiple LED light sources. In such cases, the LED lumen maintenance may be affected by the electronic controls. Manufacturers submitting products with controls to vary the wattage for purposes other than maintaining light output may claim LED lumen maintenance, but without a standard methodology for accurately projecting LED lumen maintenance for such products over time, it must be clear that LED lumen maintenance claims are based on initial performance. Partners must indicate that the product incorporates variable wattage controls on the submission form by marking the appropriate checkbox. When this box is checked, a note will appear on the label that the label information is based on initial performance and the wattage may change over time.

- ***Products with multiple LED light source types:***
  Some products incorporate two or more unique LED light sources to achieve desired light levels or color that cannot be attained by a single type of light source alone. These multiple light sources will likely exhibit different lumen maintenance performance. Partners may still claim LED lumen maintenance, but must use a formula provided in the LED Lighting Facts Partner Participation Manual to obtain an accurate lumen maintenance claim for the combination of the LED light sources' lumen maintenance. Partners must indicate the product incorporates multiple LED light sources by marking the appropriate checkbox in the product submission form and upload LM-80 data for each light source, ISTMT data with temperature measurements for each light source, and saved copy of completed ENERGY STAR TM-21 Calculator in a Microsoft Excel file format for each light source.
- ***Products with remote phosphors:***
  Some products incorporate remote phosphors that tune the color of the light emitted from the lamp or luminaire, but that are physically separated from the LED light source. Since they are not integrated into the LED light source, their effect on performance is not included in the new TM-21-based metric. Partners are thus not permitted to claim LED lumen maintenance for products employing remote phosphors.

  Please note that some LED light source manufacturers may use similar features *within the light source* that may still be termed "remote phosphors." Since performance effects of such products are captured by LM-80 and TM-21, luminaire and lamp manufacturers using such LED light sources are still permitted to claim an LED lumen maintenance value. Partners should direct any questions about allowable product designs to the LED Lighting Facts Team for clarification.