IESNA standards on LED and SSL: LM-79, LM-80, and future standards

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IESNA (Illuminating Engineering Society of North America)

Testing Procedures Committee
(Chair, Mike Grather)

Subcommittee A Indoor Luminaires
Subcommittee B Light Sources
Subcommittee C Outdoor Luminaires
**Subcommittee D Solid State Lighting**
(Kevin Dowling, Chair)

TPC meets twice a year.
IES LMs for traditional lamps

LM-9-09 Electrical and Photometric Measurements of Fluorescent Lamps
LM-66-00 Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps
LM-45-00 Electrical and Photometric Measurements of General Service Incandescent Filament Lamps
LM-51-00 Electrical and Photometric Measurements of HID Lamps
LM-54-99 Lamp Seasoning
LM-59-00 Electrical and Photometric Measurement of Low Pressure Sodium Lamps
LM-40-01 Lift Testing of Fluorescent Lamps
LM-47-02 Life Testing of High Intensity Discharge (HID) Lamps
LM-49-01 Life Testing of General Lighting Incandescent Filament Lamps
LM-60-01 Life Testing of Low Pressure Sodium Lamps
LM-65-01 Life Testing of Single-Ended Compact Fluorescent Lamps
LM-78-06 Total Luminous Flux Measurement of Lamps Using an Integrating Sphere Photometer
IES LMs for traditional luminaires

LM-41-98 Approved Method for Photometric Testing of Indoor Fluorescent Luminaires
LM-46-04 Photometric Testing of Indoor Luminaires Using HID or Incandescent Filament Lamps
LM-10-96 Photometric Testing of Outdoor Fluorescent Luminaires,
LM-31-95 Photometric Testing of Roadway Luminaires Using Incandescent Filament and HID lamps
LM-35-02 Photometric Testing of Floodlights Using High Intensity Discharge or Incandescent Filament Lamps
LM-11-97 Photometric Testing of Searchlights

LM-75-01 Goniophotometer Types and Photometric Coordinates
LM-63-02 Standard File Format for the Electronic Transfer of Photometric Data and Related Information.
SSL Energy Star Specifications

ENERGY STAR® Program Requirements for Solid State Lighting Luminaires
Eligibility Criteria – Version 1.0

Program started from Sep. 30, 2008.

Required standards for

• Test method and measurement .................. IESNA LM-79
• Chromaticity specification ........................ ANSI C78.377
• Test method for lifetime of LEDs ................. IESNA LM-80
• Laboratory accreditation for measurement .. NVLAP EELP-SSL
• Terminology ................................. ANSI/IESNA RP-16 addendum a
LED light sources and SSL products

LED packages
- (low power)
- (high power)

LED arrays / modules

LED light engines

Complete SSL products
- Integrated LED lamps
- LED luminaires
Current Status of Standardization Activities

LED chips/ packages
(high power)
IES LM-80
Lumen maintenance
IES TM-21
IESNA new project
CIE TC2-63, 64

(low power)
CIE 127:2007
CIE TC2-46

SSL products
(Integrated LED lamps & LED luminaires)
IES LM-79 Photometric meas.
IESNA new project
ANSI C78.377 Chromaticity
CIE TC1-69 Color rendering

LED arrays / modules
CIE TC2-50 LED clusters and arrays

LED light engines
(ASSIST Recommends ..)
IESNA new project

Definitions (terminology)
IES RP-16 addendum a
IEC TS 62504

Safety
UL 8750
CIE TC2-58 radiance/luminance
Several projects in IEC TC34A
Addendum to ANSI/IESNA RP-16-05

Nomenclature and Definitions for Illuminating Engineering

Addendum a to ANSI/IESNA RP-16-05 (under continuous maintenance)

6.8 Light Emitting Diode
6.8.1 LED die
6.8.2 LED Bin
6.8.3 Power source
6.8.3.1 Power supply
6.8.4 LED control circuitry
6.8.4.1 LED driver
6.8.4.2 LED driver, Class II
6.8.5 LED luminaire
6.8.5.1 LED package
6.8.5.2 LED array
6.8.5.3 LED module
6.8.5.4 LED lamp, non-integrated
6.8.5.5 LED lamp, integrated
6.8.5.1 LED package - An assembly of one or more LED dies that contains wire bond connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. The device does not include a power source, does not include an ANSI standardized base, and is not connected directly to the branch circuit.

6.8.5.2 LED array - An assembly of LED packages on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces. The device does not contain a power source, does not include an ANSI standardized base, and is not connected directly to the branch circuit.

6.8.5.3 LED module - A component part of an LED light source that includes one or more LEDs connected to the load side of LED power source or LED driver. Electrical, electronic, optical, and mechanical components may also be part of an LED module. The LED module does not contain a power source and is not connected directly to the branch circuit.
6.8.5.4 LED lamp, non-integrated - A lamp with LEDs, without an integrated LED driver or power source and with an ANSI standardized base designed for connection to a LED luminaire.

6.8.5.5 LED lamp, integrated - A lamp with LEDs, an integrated LED driver, and an ANSI standardized base that is designed to connect to the branch circuit via an ANSI standardized lampholder/socket.

6.8.5 LED luminaire - A complete LED lighting unit consisting of a light source and driver together with parts to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED array, an LED module, or an LED lamp. The LED luminaire is intended to connect directly to a branch circuit.

Revision of this Addendum is being discussed at IESNA TPC.
Approved Method: **Electrical and Photometric Measurements of Solid-State Lighting Products**

Prepared by the Subcommittee on Solid-State Lighting of the IES Testing Procedures Committee

Solid-State Lighting Subcommittee
Kevin Dowling, Chair
Yoshi Ohno, Technical Coordinator
IESNA LM-79 Approved Method for Electrical and Photometric Measurement of SSL Products

- Test method used for DOE SSL Energy Star
- Covers LED luminaires and integrated LED lamps.

Covers measurements of
- Total luminous flux (lumen)
- Luminous efficacy (lm/W)
- Chromaticity, CCT, CRI (4π integrated)
- Luminous intensity distributions

Methods using
- Sphere-spectroradiometer
- Sphere-photometer
- Goniophotometer
Points to Note

- LED sources generally cannot be separated from LED luminaires by users.

- The luminous efficacy (lm/W) of the whole luminaire (called “Luminaire efficacy”) needs to be measured and evaluated.

- Traditional lamp luminaires are commonly measured relative to measured luminous flux of the bare lamp(s) used in the luminaire (Relative photometry), which does not work for LED luminaires.

- Luminous efficacy (thus, total luminous flux) of small LED luminaires can be measured in a similar way as LED lamps.
IESNA LM-79

(1) Method using a sphere-spectroradiometer

Total spectral radiant flux standard lamp

4 $\pi$ geometry

2 $\pi$ geometry
(2) Method using a sphere-photometer

Total luminous flux standard lamp

4 $\pi$ geometry

2 $\pi$ geometry
(3) Method using a goniophotometer

9.3.7 Calibration

◆ calibrated against the illuminance or luminous intensity standards traceable to national standards
◆ shall be validated by measurement of total luminous flux standard lamps traceable to national standards.
Prepared by the Subcommittee on Solid-State Lighting of the IES Testing Procedures Committee
Covers LED packages, arrays and modules only (not LED luminaires).

Lifetime of LEDs is strongly dependent on the junction temperature.

Lifetime of LEDs can be very long (e.g., 50,000 h) so it is predicted by extrapolation.

Final purpose is to determine lifetime of SSL products (required by Energy Star).
How it is supposed to work

Case Temperature

$T_s = T_x$

Interpolation for 90°C (e.g.)

Fitting and extrapolation

$L_{70}$ of the luminaire

Relative luminous flux

Operating time (h)

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LM-80 Final Version

- Defines Lumen Maintenance Life:
  - $L_{70}$ (hours): 70% lumen maintenance
  - $L_{50}$ (hours): 50% lumen maintenance
- Does not consider failure rate.
- Does not cover predictive estimations or extrapolation.

- Test Method
  - Testing (aging) at the LED case temperatures 55°C, 85°C, and a 3rd temperature selected by manufacturer, for 0 to 6000 h or longer, at every 1000 h. Ambient temperature within - 5°C from the case temperature.
  - Measured color and any failures shall also be reported.
  - The ambient temperature during lumen and chromaticity measurements shall be 25°C ± 1°C.

IES TM-21-xx
Large Gap between LED manufacturers and Lighting Industry

<LED manufacturer>
• LEDs measured in production.
• LEDs are measured with short pulses.
• LEDs are binned and rated at $T_j=25^\circ C$.

<Lighting industry>
• LEDs in luminaires are hot ($T_j=60^\circ C$ to over $100^\circ C$)
• Photometric measurements in steady DC mode.

LED performance varies with temperature
Pulse vs. DC?

Performance of LEDs $\neq$ Performance of SSL products
IESNA LM-xx Approved Method for Electrical and Photometric Measurement of High Power LEDs

Task Group chair: Y. Ohno

**High power LED:** an LED device that requires a heat sink or other type of thermal management as an integral part of the operation.

- Covers LED packages and LED arrays, white LEDs as well as single color LEDs.
- Covers measurements in pulse mode as well as DC mode (NIST method).
- Thermal conditions set at a junction temperature.
- Covers measurements of
  - Total luminous flux (lumen)
  - Luminous efficacy (lm/W)
  - Total radiant flux (W)
  - Chromaticity, CCT, CRI
DC mode operation of LED (NIST method)

(a) Set the heat sink temp. to desired $T_j$ and stabilize it. Then measure $V_F$.

(b) Set the heat sink temp. to desired $T_j$ and stabilize it. Apply pulse current, and measure $V_F$.

(c) Feedback control of heat sink temperature. Photometric measurement at $T_j$ (in DC mode).

Rated current $V_F(0)$

$V_F(t)$

$t = 0$

Optical Technology Division
Method using a sphere-spectroradiometer

2\pi geometry (for small spheres)

4\pi geometry (for large spheres)
Method using a sphere-spectroradiometer

Alternate Calibration Method

- Cosine-response window
- Spectroradiometer
- Baffle
- Auxiliary lamp
- Test LED
- Reference standard LED (For absolute scale)
- Spectral irradiance standard lamp (For relative spectral scale)
Method using a sphere-photometer

2 $\pi$ geometry
(for small spheres)

4 $\pi$ geometry
(for large spheres)
IESNA Standards published on LED/SSL
- LM-79-08 Approved Method for Electrical and Photometric Measurement of SSL Products
- LM-80-08 Approved Method for Measuring Lumen Maintenance of LED Light Sources
- RP-16-05 addendum a (2008) - section on light emitting diodes

IESNA Standards being developed
- LM-xx Electrical and Photometric Measurements of High Power LEDs (Y. Ohno)
- TC-21 Lumen Depreciation Lifetime Estimation Method for LED Light Sources (E. Richman / E. Radkov)

Standards being discussed
- Characterization of LED Light Engines and Integrated LED Lamps for Electrical and Photometric Properties as a Function of Temperature (J. Jiao)
- RP-16-05 addendum a (2008) revision (J. Jiao)

Standards needed
- Photometric testing of roadway and street lighting luminaires
Thank you for your attention.

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