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LED Optical Aging Test Instrument

Product No: LEDLM-80PL

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LEDLM-80PL LED Lumen Maintenance and Aging Life Test System is designed according to IES-LM-80 and TM-21, it used to test & record the optical and electrical Maintenance for single LED or LED module, the software is based on Arrhenius model and TM-21 to calculate the LED life. The LEDLM-80PL needs to work with a GDJW/GW Series High Temperature Chamber and and DC12010 DC Power Source.

LEDLM-84PL LED Lumen Maintenance and Aging Life Test System is designed according to IES LM-84 and TM-28, it used to test & the optical and electrical Maintenance for LED luminaires, the software is based on Arrhenius model and TM-28 to calculate the LED LEDLM-84PL needs to work with a GDJW/GW Series High Temperature Chamber and and LSP-1KVARC AC Power Source.

Related Applications



LM-79 and LM-80 Test Solutions



Understanding LM-80: Measuring Lumen Maintenance of LED Light Sources

ANSI/IES LM-80-15 standard update content

How to choose LISUN products for Saudi Arabia' s latest standard SASO2902?

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LED packaging principle

How to Use TM-21 and LM-80 to Estimate LED Luminaries Life?

How to predict and test the life of LED?

LISUN successfully participate in the Lighting Poland 2018

### Related Successful Case

Costa Rica – Installation and training Integrating Sphere Test System, dustproof and waterproof test equipment, EMI/EMC test machine, etc.

Spain – LISUN engineer Jacky visited new customers

Design according to IES LM-80,  
IES LM-82 and TM-21



### Specifications:

- Record the changing curves of lumen, colorimetric and electrical parameters VS time
- Test and record the light attenuation data within a short time, then software will predict the LED life
- Please click here to see one of the **test report sample of LEDLM-80PL** (The LEDLM-84PL report is similar but only difference is based on TM-28)
- LEDLM-80PL/LEDLM-84PL test system can test 16 DUTs one time. (More DUTs can be special designed according to customers' requirements)
- LEDLM-80PL/LEDLM-84PL test system already include two sets of testing devices in the temperature chamber.
- The system supply two solutions for LED Lumen Maintenance and Aging Test:
  1. Strictly according to LM-80 or LM-84 to test up to 6000hours to get L50 and L70 test report based on TM-21 or TM-28, LISUN LEDLM-80PL/LEDLM-84PL test system will be fully automatic and no need human to operate during 6000hours test.
  2. LISUN LEDLM-80PL/LEDLM-84PL test system supply a fast accelerate the DUT, the software was designed based on the Arrhenius Model to simulat 6000hours testing in a "short time" to get the L50 and L70 test report based on TM-21 or TM-28. This solution save a lot of time for the testing company.



### Lumen Maintenance Table [%]

Model : YL-T3528W-AA-60C Ratings : 20mA, 6.5lm, 75(Ra), 6000K  
 Actual Temperature : Ta = 55.0°C, Ts = 65.0°C Humidity : R.H. = 60%  
 Number Of Failures : 0 Uncertainty : 4%  
 Drive Voltage : U = 220.1V, Freq. = 50.02Hz

No.	0H	24H	48H	168H	500H	1000H	2000H	3000H	4000H	5000H	6000H
1	100.45	100.36	100.00	99.46	97.21	99.01	98.01	97.47	96.75	95.85	95.74
2	99.91	100.09	100.00	99.28	98.01	99.36	98.54	98.08	97.63	96.53	96.53
3	99.82	100.27	100.00	99.65	98.31	99.55	98.74	98.38	97.92	96.92	96.83
4	100.09	100.27	100.00	99.54	100.27	99.72	98.99	98.62	98.16	97.15	97.15
5	100.00	100.18	100.00	99.50	100.20	99.44	98.52	97.96	97.50	96.38	96.31
6	99.91	100.18	100.00	99.15	100.32	98.99	98.17	97.71	97.25	96.24	96.25
Median	99.95	100.23	100.00	99.48	99.25	99.40	98.53	98.02	97.56	96.46	96.42
Average	100.03	100.23	100.00	99.43	99.05	99.34	98.49	98.03	97.53	96.51	96.47
Std. deviation	0.2260	0.0948	0.0000	0.1829	1.3750	0.2941	0.3587	0.4215	0.4998	0.4715	0.4893
Min.	99.82	100.09	100.00	99.15	97.21	98.99	98.01	97.47	96.75	95.85	95.74
Max.	100.45	100.36	100.00	99.65	100.32	99.72	98.99	98.62	98.16	97.15	97.15

LEDLM-80PL LED Optical Aging Test Report (Sample)

Tags : [LED Optical Aging Test Instrument](#) , [LEDLM-80PL](#)



Approved Method: **Measuring  
Luminous Flux and  
Color Maintenance  
of LED Packages,  
Arrays and Modules**

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**IES Approved Method: Measuring  
Luminous Flux and Color Maintenance  
of LED Packages, Arrays and Modules**

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**Publication of this Committee report  
has been approved by IES.  
Suggestions for revisions  
should be directed to IES**

**Prepared by:  
The Solid-State Lighting Subcommittee  
of the IES Testing Procedures Committee**

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Published by the Illuminating Engineering Society of North America, 120 Wall Street, New York, New York 10005.

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ISBN # 978-0-87995-315-7

*Printed in the United States of America.*

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## INTRODUCTION

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LEDs typically exhibit very long operational life characteristics and, depending on drive current and use conditions, can be in use for 50000 hours or longer. The light output from LEDs slowly decreases over time. This characteristic of declining output without catastrophic failure creates a risk that an LED-based lighting product near end-of-life may be operating, but performing outside the product's specification, or outside required codes, standard practices or regulations. LEDs may also undergo gradual shifts in the emitted spectra over time that may result in unacceptable appearance, color rendering or degraded efficacy.

This document describes the procedures by which LEDs are tested for the luminous (or radiant, or photon) flux maintenance and chromaticity maintenance or wavelength changes over time when operated under controlled environmental and operational conditions. The resulting measurements may be used for comparison of LEDs, and they may be utilized in models that project long-term changes in light output during the life of the LEDs.

*Summary of changes from the previously published IES LM-80-08 Approved Method: Measuring Lumen Maintenance of LED Light Sources*

The scope within this *ANSI/IES LM-80-15* has been expanded to include tests for three types of flux maintenance along with tests for how chromaticity changes over time. LED drive characteristics have been updated to include pulse width modulated current, DC constant voltage and AC regulated voltage drive. The maintenance test duration and measurement interval are no longer specified but rather left for determination according to the intended usage of the data. The reporting section is more specific with regard to the required data. Requirements for thermal measurements have been clarified to reflect industry best practices.

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## 1.0 SCOPE

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*ANSI/IES LM-80-15* provides the methods for measurement of luminous flux and color maintenance for LED packages, arrays, and modules. The document covers luminous, radiant, or photon flux maintenance and color maintenance including changes in chromaticity coordinates, peak wavelength, or centroid wavelength versus time. The maintenance characteristics are measured under controlled conditions that allow direct comparison of results obtained at different laboratories.

*ANSI/IES LM-80-15* does not provide guidance or make any recommendation regarding predictive estimations or extrapolation for the maintenance characteristics beyond the time duration of the actual measurements.

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## 2.0 NORMATIVE REFERENCES

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### 2.1 The IES Nomenclature Committee

*ANSI/IES RP-16-10, Nomenclature and Definitions for Illuminating Engineering.* Illuminating Engineering Society of North America. New York, New York, 2010.

### 2.2 ASTM Standard E230/E23M-112

*Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples,* ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).

---

## 3.0 DEFINITIONS

---

### 3.1 Air Temperature ( $T_A$ )

The temperature of the air surrounding the DUT (Device Under Test) during the maintenance test.

### 3.2 Case Temperature ( $T_s$ )

The temperature measurement point for the DUT is defined by the DUT manufacturer. In some cases the temperature measurement point is defined as the solder point on the printed circuit board. In other instances this is defined as a specific location on the DUT case. Thus  $T_s$  is sometimes designated as  $T_{sp}$  or  $T_c$  in manufacturer's literature.

### 3.3 Centroid Wavelength ( $\lambda_c$ )

Wavelength at the "center of gravity" of the spectrum shape of a monochromatic DUT is the weighted average of each wavelength defined by

$$\lambda_c = \frac{\int_{\lambda_1}^{\lambda_2} \lambda \cdot S(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} S(\lambda) d\lambda}$$

where  $\lambda$  is the wavelength; and  $S(\lambda)$  is the spectral power distribution of the monochromatic DUT.

### 3.4 Device Under Test (DUT)

An LED package, array or module which is undergoing the maintenance test.

### 3.5 Dominant Wavelength ( $\lambda_d$ )

The dominant wavelength  $\lambda_d$  is the wavelength of a monochromatic stimulus that, when additively mixed in suitable proportions with the specified achromatic stimulus, matches the color stimulus considered.

### 3.6 Drive Level

The nominal external voltage or current applied to a DUT during the maintenance test or a photometric or electrical measurement. Drive level is specified in amperes for DC constant current drive, volts for DC constant voltage drive, or RMS volts for AC regulated voltage.

### 3.7 DUT Failure

A DUT shall be declared a failure if it suffers damage due to mishandling or if its luminous flux, photon flux or radiant flux decreases by 90 percent, i.e., (10 percent of the initial flux value) or more.

### 3.8 Luminous Flux Maintenance

Luminous flux maintenance (often referred to as "lumen maintenance") is the remaining luminous flux output (typically expressed as a percentage of the initial luminous flux output) at any selected elapsed operating time. Luminous flux maintenance (or "lumen maintenance") is the converse of luminous flux depreciation (or "lumen depreciation").

### 3.9 Maintenance Test

Maintenance test is the continuing steady operation test for the DUT when it is energized under specific electrical and environmental conditions.

### 3.10 Measurement Interval

The measurement interval is the elapsed time between two photometric and electrical measurements.

### 3.11 Peak Wavelength ( $\lambda_p$ )

The peak wavelength  $\lambda_p$  is the wavelength at the maximum of the spectral distribution.

### 3.12 Photon Flux ( $\phi_p$ )

The photon flux emitted by a DUT in the wavelength interval from  $\lambda_1$  to  $\lambda_2$  is:

$$\phi_p = \int_{\lambda_1}^{\lambda_2} \frac{\lambda}{Nhc} \phi_\lambda(\lambda) d\lambda,$$

where  $N$  is Avogadro's number;  $h$  is Planck's constant;  $c$  is the speed of light and  $\phi_\lambda(\lambda)$  the spectral radiant flux, measured in W/nm.  $\phi_p$  is usually expressed in  $\mu$  mol/s.

### 3.13 Photon Flux Maintenance

Photon flux maintenance is the remaining photon flux output (expressed as a percentage of the initial photon flux output) at any selected elapsed operating time.

### 3.14 Radiant Flux ( $\phi_e$ )

Radiant flux  $\phi_e$  is the time rate of flow of radiant energy over an infinite wavelength interval, or a limited wavelength range of the measurement equipment ( $\lambda_1, \lambda_2$ ). It should be calculated as the integral of spectral radiant flux over that wave  $\phi_\lambda(\lambda)$  length interval:

$$\phi_e = \int_{\lambda_1}^{\lambda_2} \phi_\lambda(\lambda) d\lambda.$$

### 3.15 Radiant Flux Maintenance

Radiant flux maintenance is the remaining radiant flux output (typically expressed as a percentage of the initial radiant flux output) at any selected elapsed operating time.

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## 4.0 PHYSICAL AND ENVIRONMENTAL CONDITIONS

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### 4.1 General

It is recommended laboratory practice that the storage and testing of DUTs should be undertaken in a relatively clean environment. Prior to operation, DUTs should be cleaned to eliminate handling marks and the manufacturer's handling instructions should be observed, e.g., electro-static discharge (ESD) instructions. DUT testing chambers or test environments should not release volatile organic compounds, halogen and sulfur compounds, or other contaminants that can interact with silicone, lead frames or other components in a DUT.

## 4.2 Humidity

During the maintenance test, humidity shall be maintained to less than 65 percent RH, or other pre-defined RH level within a tolerance of  $\pm 5$  percent, throughout the maintenance test. The chosen humidity test condition (less than 65 percent or pre-defined) shall be reported.

## 4.3 Air Temperature

During the maintenance test, air temperature,  $T_A$ , shall be maintained at a temperature that is higher than the nominal test case temperature minus  $5^\circ\text{C}$  (e.g., if nominal case temperature =  $55^\circ\text{C}$ , then  $T_A \geq 50^\circ\text{C}$ ).  $T_A$  should be monitored within the test chamber or environment during the maintenance test.  $T_A$  should be measured at a location chosen to best represent the surrounding air without introducing inaccuracies (e.g., due to light absorption).

Note: Maintenance tests conducted in a chamber may have passive (i.e., no external air exchange) or active (i.e., forced external air) methods to maintain the air temperature.

## 4.4 Air Movement

During the maintenance test, the air movement should be controlled so that no significant volume of external air that is at a temperature below the surrounding air temperature,  $T_A$ , limit specified in **Section 4.3** is injected into the test chamber or environment.

## 4.5 Temperature Measurement Equipment or System

The temperature measurement equipment or system used for temperature measurements shall have an expanded uncertainty ( $k=2$ ) of less than  $2.5^\circ\text{C}$ . Thermocouples, if used, shall comply with ASTM E230 Table 1 "Special Limits" ( $\pm 1.1^\circ\text{C}$  or 0.4 percent, whichever is greater). Temperature sensor elements shall be shielded from direct DUT optical radiation.

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## 5.0 ELECTRICAL CONDITIONS

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### 5.1 DUT Drivers

DUTs shall be operated using external drivers. Electric power provided shall be one of the following: DC constant current; pulse width modulated (PWM) current; DC constant voltage; AC regulated voltage. The input power type should be chosen to match the DUT's primary mode of operation specified by

the manufacturer (e.g., constant current, constant voltage, or AC voltage).

### 5.2 Drive Level Value

The drive level value used for the maintenance test (DC current, DC voltage, or AC RMS voltage and frequency) shall represent the manufacturer's expectation for users' applications, and it should be within the DUT's recommended operating range. Ideally, the value should match that used for the manufacturer's datasheet flux rating.

### 5.3 DC Constant Current Drive

**5.3.1 Circuit Arrangement** DUTs shall be driven individually with dedicated drivers, or in series circuits with a constant current. At photometric and electrical measurement intervals, DUT forward voltage shall be measured and reported.

**5.3.2 Current Regulation** The forward current shall be regulated to within  $\pm 3$  percent of the nominal value during the maintenance test. Forward current regulation during photometric and electrical measurements shall be within  $\pm 0.5$  percent of the nominal value. Peak-to-peak current ripple shall not exceed 3 percent of the nominal value at any time.

### 5.4 Pulse Width Modulated (PWM) Current Drive

**5.4.1 Circuit Arrangement** DUTs shall be driven individually with dedicated drivers, or in series circuits with a PWM current. At photometric and electrical measurement intervals, DUT forward voltage shall be measured and reported.

**5.4.2 Current Regulation** The forward current shall be regulated to within  $\pm 3$  percent of the nominal value during the maintenance test. Forward current regulation during photometric and electrical measurements shall be within  $\pm 1$  percent of the nominal value. PWM current transitions (rising and falling current edges) shall occur within 1 percent of nominal on/off transition times. The cabling between the drivers and DUTs should be designed to minimize current errors due to cabling losses. For example, an inappropriately designed cable would result in current bypassing the DUTs by flowing through parallel cabling capacitance.

### 5.5 DC Constant Voltage Drive

**5.5.1 Circuit Arrangement** DUTs shall be driven individually with dedicated drivers, or in parallel circuits. External current regulating components such as resistors may be used per the manufacturer's

recommendation. At photometric and electrical measurement intervals, DUT forward current shall be measured and reported.

**5.5.2 DC Voltage Regulation** Forward voltage shall be regulated to within ±1 percent of the nominal value during maintenance test and within ±0.5 percent of the nominal value during photometric and electrical measurements.

## 5.6 AC Regulated Voltage Drive

**5.6.1 Circuit Arrangement** DUTs shall be driven individually with dedicated drivers, or in parallel circuits. The AC drive shall operate at the same frequency throughout the maintenance test. External current regulating components such as resistors may be used per the manufacturer's recommendation. At photometric and electrical measurement intervals, DUT RMS current shall be measured and reported.

**5.6.2 AC Regulation** The AC RMS voltage shall be regulated to within ±1.5 percent of the nominal value during maintenance test and within ±0.5 percent of the nominal value during photometric and electrical measurements. Voltage total harmonic distortion of the AC voltage source shall not exceed ±3 percent and the AC frequency shall be maintained within ±0.5 percent during maintenance testing.

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## 6.0 PHOTOMETRIC AND ELECTRICAL MEASUREMENT PROCEDURES

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At each measurement interval, the photometric and electrical measurements for the DUTs shall be performed per the following procedures. The measurement equipment calibration shall be in accordance with manufacturer specifications.

### 6.1 DUT Photometric and Electrical Measurements

Photometric and electrical measurements should be performed using a measurement method that optimizes the repeatability of the measurements. *IES LM-85-14 Approved Method: Electrical and Photometric Measurements of High Power LEDs* can be referenced for developing an appropriate method.

Flux and chromaticity measurements shall be made using a measurement system employing an integrating sphere, hemisphere or other equivalent geometry. Initial measurement value of radiant, photon or luminous flux shall be reported in the units defined in **Section 3.0**. Subsequent flux measurements

shall be normalized to a value of 1 (100 percent) at 0 hours. For such normalized measurements, many systematic error components will be cancelled out, assuming the same measurement set up is used with no changes during lumen maintenance testing of a DUT. To minimize errors due to differences in calibration references, the same standard lamp (or any other calibration reference source) should be used throughout the maintenance test. It may also be useful if stable LED packages ("monitor LEDs"), not part of the maintenance test, are measured together with DUT to monitor the stability of the sphere responsivity. Corrections may be applied based on this data and shall be documented in the test report.

For chromaticity maintenance, the chromaticity shall be expressed in CIE 1976 ( $u', v'$ ) coordinates. The change in chromaticity shall be calculated from chromaticity at 0 hour and chromaticity ( $u'_0, v'_0$ ) at 0 hours of ( $u'_t, v'_t$ ) operation:

$$\Delta u' = u'_t - u'_0$$

$$\Delta v' = v'_t - v'_0$$

$$\Delta u' v' = \sqrt{\Delta u'^2 + \Delta v'^2}$$

### 6.2 DUT Measurement Temperature Condition

The same DUT temperature condition shall be used for all DUT measurements. A condition of 25°C is commonly used in industry. To facilitate comparison of measurement data, the temperature condition and the temperature measurement point location shall be reported. The measurement point location may be a laboratory central monitoring point, such as a room ambient air temperature monitor, a sphere ambient air temperature probe, the temperature of an actively controlled heat sink, or any other point that can be correlated to the DUT selected temperature condition. The temperature measurement point shall be within ±2°C of the measurement temperature condition prior to starting any measurement.

### 6.3 DUT Measurement Drive Level

Photometric and electrical measurements shall be made using the maintenance drive level.

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## 7.0 MAINTENANCE TEST PROCEDURES

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### 7.1 Seasoning or Aging

No seasoning or aging shall be performed beyond that done by the manufacturer for the product prior to its release to consumers.



## 7.2 DUT Tracking

Each DUT sample that undergoes a maintenance test shall be tracked throughout the test. For DUT sample selection, see **Annex A**. Extra DUT samples may be useful in the event that some samples are determined to be failures under the guidelines listed in **Section 3.7**. All samples tested shall be included in the report.

## 7.3 Timekeeping

For a maintenance test, accurate recording of elapsed operating time is critical. Measurement intervals shall be timed with computer-based timers, an elapsed time meter, video monitoring, current monitoring or other monitoring devices. A timer shall be associated with a particular test position and shall accumulate time only when the installed DUTs are energized. In the event of a power failure, monitoring devices shall not accumulate time. Timing uncertainty, including time in which the DUTs are energized but not yet within the DUT case temperature limits, shall not exceed 0.5 percent of the measurement interval.

## 7.4 DUT Case Temperatures

DUTs shall be operated during the maintenance test at a minimum of two case temperatures,  $T_s$ . The case temperatures and drive level should be selected by taking into account the LED light sources' intended applications, the manufacturer's recommended operating parameters, and the eventual use of the testing data. At least one of the case temperatures shall be either 55°C or 85°C. These case temperatures are commonly used for industry testing to support direct product comparisons of testing results. The drive level may be different for different case temperatures. However interpolation, using the method described in *IES TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources + Addendum A*), which can predict luminous flux maintenance at temperatures between two testing case temperatures, requires the same drive level for the two case temperatures. Testing at three or more temperatures offers more accurate interpolations and a measured value at an intermediate temperature to cross-check against interpolated results based on higher and lower case temperatures.

During the maintenance test, the DUTs' case temperature,  $T_s$ , shall be maintained at a temperature that is higher or equal to nominal test case temperature minus 2°C (e.g., if nominal case temperature = 55°C, then  $T_s \geq 53^\circ\text{C}$ ). Case temperatures shall be monitored during the maintenance test using one of the monitoring methods listed in **Annex B**.

## 7.5 Maintenance Test Duration and Measurement Interval

An initial photometric (luminous flux, or radiant flux, or photon flux) and colorimetric (chromaticity values or wavelength) measurement shall be performed prior to commencing the maintenance test, and recorded as the zero hours data.

Photometric and colorimetric measurements of the DUT shall be made at each measurement interval of the maintenance test duration.

The maintenance test duration and measurement intervals shall be based on, and consistent with, the design operating life, the intent of the test including evidence of compliance to the regulations requested, and planned analysis of the data (e.g., data for predictive luminous flux maintenance modeling, or data for actual luminous flux maintenance validation).

## 7.6 Recording DUT Failures

Checking for DUT failures as defined in **Section 3.7** either by visual observation or automatic monitoring shall be done at every photometric and electrical measurement interval. Failed DUTs shall be reported. Failed DUT photometric and electrical measurement data shall be excluded from report **Section 8.8**.

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## 8.0 TEST REPORT

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The report shall list all pertinent data concerning conditions of testing, type of equipment, and types of DUTs. The items listed in **Sections 8.1 to Section 8.8** shall be reported:

### Administrative Information

1. Testing agency identification
2. Report issue date
3. Testing start date
4. Testing completion date

### DUT Identification

1. DUT manufacturer's name
2. DUT identification, e.g., model number
3. Description of DUT including if the DUT is an LED package, array or module
4. Number of DUTs (sample size) tested.

### Maintenance Test Conditions

1. Nominal case temperatures
2. Air temperatures

3. Description of air movement
4. Relative humidity level
5. Drive level for DUTs

#### Test Equipment

1. Description of testing equipment
2. External drive regulating components, if used

#### Maintenance Test Duration (in Hours)

#### Measurement Intervals (in Hours)

#### Failed DUTs

1. Number of DUT failures.
2. Approximate time of each failure observed

#### Working DUTs Results

1. Initial and subsequent luminous flux, or radiant flux, or photon flux
2. Initial and subsequent chromaticity coordinates, or dominant wavelength, or peak wavelength, or centroid wavelength
3. Average value, median value, standard deviation, minimum and maximum value for all of the DUTs at each measurement interval
4. Electrical drive level for the photometric and electrical measurements
5. Measurement point temperature and temperature measurement point location for photometric and electrical measurements
6. A description of the photometric measurement method

#### Optional Items

1. Statement of uncertainties (if required)
2. Change in chromaticity
3. DUT sampling method

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### INFORMATIVE REFERENCES

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1. *The IES Sub-Committee on Solid State Lighting, of the IES Testing Procedures Committee IES LM-85-14, IES Approved Method for the Electrical and Photometric Measurements of High-Power LEDs*, Illuminating Engineering Society of North America, 2014, New York, NY.
2. *The IES Sub-Committee on Solid State Lighting, of the IES Testing Procedures Committee IES LM-79-08, Approved Method for the Electrical and Photometric Measurements of LED Light Sources*, Illuminating Engineering Society of North America, 2008, New York, NY.
3. *Measurement of LEDs* (2nd ed.), CIE 127:2007, Commission Internationale de L'Eclairage, Vienna, Austria.
4. *The IES Sub-Committee on Solid State Lighting, of the IES Testing Procedures Committee, IES TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources*, Illuminating Engineering Society of North America, 2011, New York, NY.
5. *The IES Sub-Committee on Solid State Lighting, of the IES Testing Procedures Committee, IES TM-28-14, Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires*, Illuminating Engineering Society of North America, 2014, New York, NY.

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## ANNEX A. DUT SAMPLE SELECTION

(This informative annex is not part of *ANSI/IES LM-80-15* and is included for information only.)

Sample sources should be selected based upon the anticipated use of the test data. In some cases DUTs are selected to be representative of the overall LED light source population. In other cases sampling is specifically skewed to test DUTs that are known to be more prone to flux depreciation. For example, DUTs at warmer color temperatures might be selected to represent both warm and cool white LED light sources. For more information about sampling see *IES TM-21-11*.

## ANNEX B. MONITORING OF CASE TEMPERATURES (NORMATIVE)

Case temperature monitoring verifies that all DUTs are being operated within the temperature requirements of **Section 7.4**. Ideally, each individual DUT should be monitored using a separate temperature sensor. For maintenance testing on a small scale, direct measurement of DUT case temperature is practical. If directly measured, the temperature probe shall be attached at the manufacturer-designated case temperature measurement point on the DUT. Beyond a few dozen DUTs, it becomes very challenging to properly attach, shield and monitor the thermocouples or other sensors needed for direct measurements. If direct measurement of each DUT in a sample set is not practical, one of the methods below may be used. Regardless of the method used, the minimum DUT temperature in a sample set shall be used for the test report.

### B1. Temperatures Calculated Using a Thermal Model

In the Thermal Model method, DUT temperatures shall be calculated using a thermal model that is referenced to a known, directly measured temperature point. This is a mathematical model of the heat transfer from the DUT to its surrounding environment. The heat originates in the DUT from the applied electrical heating power. It is then conveyed to the surrounding environment through conduction, radiation, and convection. In many cases one type of heat transfer dominates – for example convection often dominates for low power radial lead LEDs tested on non-metallic circuit boards, and conduction is dominant for high power LEDs that are attached to a directly cooled Metal Core Printed Circuit Board

(MCPCB). Where one type of transfer dominates, a simplified model may be used to estimate case temperatures. The example below presents a high power LED calculation.

### DUT Characteristics:

$V_f$	3.4V nominal, 3.2V minimum, 3.5V maximum
$I_f$	700mA
Radiant heat transfer (obtained from optical measurements)	33 percent
Convective heat transfer (estimated based upon test conditions and air flow)	10 percent
Conductive heat transfer	57 percent

### Testing Scenario:

DUTs are mounted on a MCPCB that is attached to a water-cooled heat sink maintained at a process temperature (water inlet to heat sink) of 44°C. Radiated light is not reflected back to DUT.

### Calculation Results:

	Minimum	Median	Maximum
Heat Sink Temperature, Measure (°C)	44	45	46
Drive Level (A)	0.7	0.7	0.7
LED Light Source Forward Voltage (V)	3.2	3.4	3.5
Calculated LED Power (W)	2.2	2.4	2.5
Radiated Power ( percent)	33	33	33
Convective Power ( percent)	10	10	10
Conductive Heating Power (W)	1.2	1.4	1.4
Thermal Resistance of MCPCB (°C/W)	8.0	9.0	11.0
Temperature Rise Above Heat Sink (°C)	9.9	12.2	15.8
Calculated Case Temperature (°C)	53.9	57.2	61.8

In this example the DUT case temperatures will fall within a range, depending upon their location (cooler DUTs nearer the water inlet), the DUT  $V_f$  and the thermal resistance the DUT is subjected to from its mounting point to the heat sink.

The model should be validated by direct  $T_s$  measurements of representative DUTs – for example those near the heat sink water inlets and exits. Care should be taken with thermocouple placement to make sure the thermocouples do not influence the heat flow. Once a test set up has been validated it may not be necessary to repeat the direct measurements for subsequent maintenance tests on the same LED light sources, provided that the test set up has not changed.

## B2. Temperatures Characterized Using a Thermal Imaging Camera

In the thermal Imaging method, DUT temperatures shall be measured using a thermal imaging camera to identify the coldest DUT. This measurement may be made with some adjustments to the testing environment or chamber – such as opening a door, provided that the adjustments do not significantly alter the relative temperatures of the DUTs. As it is difficult to perfectly specify the emissivity, the temperatures obtained shall be treated as relative, rather than absolute. The DUT with the lowest temperature shall then be identified and instrumented with a thermocouple or other temperature sensor. The case temperature of this DUT shall then be monitored during the operating interval. This temperature shall be used to represent the entire sample.

## B3. Temperatures Characterized Using Thermocouples

In the thermocouple characterization method, a subset of the DUTs shall be chosen and instrumented with thermocouples to determine the relative temperatures of the DUTs. Like the Thermal Imaging method, the coldest DUT shall be identified. Once the coldest DUT has been identified, the remaining thermocouples may be removed. The thermocouple measurements from the coldest DUT shall then be used to represent the entire sample.

## B4. Temperatures Monitored Using a Reference Thermal Sensor

In the reference thermal sensor method, a reference thermal sensor shall be mounted in close proximity to the DUTs, in a location a fixed thermal resistance from the DUTs. The reference thermal sensor may be, for example, a RTD (resistive temperature detector) soldered to the DUT circuit card. It shall be attached permanently and reliably to give repeatable, low uncertainty measurements throughout the maintenance test. To determine the thermal resistance from the sensor to the coldest DUT, the coldest DUT shall first be identified using one of the methods specified in **Section B2** or **Section B3**. Once the

coldest DUT is identified, the thermal resistance from this DUT to the reference sensor shall then be measured using a thermocouple or other sensor directly attached to the DUT. After the thermal resistance has been established, the reference thermal sensor shall be monitored during the life test and the sum of the reference thermal sensor temperature and the DUT temperature rise due to the thermal resistance shall be reported as the minimum DUT temperature for the entire sample.

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## REFERENCES FOR ANNEX B

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- B1 V.Székely, Tran Van Bien: "Fine structure of heat flow path in semiconductor devices: a measurement and identification method", Solid-State El, V.31, No.9, pp.1363-1368 (1988)
- B2 M. Rencz, A. Poppe, E. Kollár, S. Röss, and V. Székely "Increasing the Accuracy of Structure Function Based Thermal Material Parameter measurements", IEEE Transactions On Components And Packaging Technologies, Vol. 28, No. 1, March 2005.
- B3 JESD51-51, Implementation of the Electrical Test Method for the Measurement of Real Thermal Resistance and Impedance of Light-Emitting Diodes with Exposed Cooling, April 2012.