ANSI / IES LM-80-15

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Light is OSRAM

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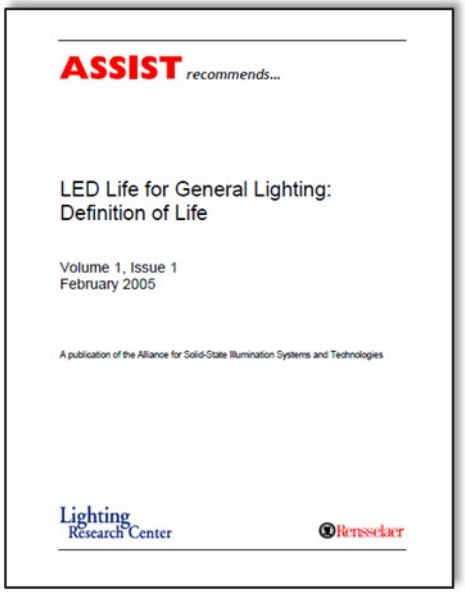
Outline

History: Why LM-80?

Timeline

- 2005
  - The U.S. DOE started to push SSL commercialization
  - Lessons learned from CFL: SSL products must have extended life with customer pleasing performance
  - RPI LRC published *ASSIST Recommends…* for LED life testing

- 2006
  - IES Testing Procedures Committee (TPC) initiated a project for developing LM-80
  - Intended to extend to test wide range of LEDs
  - Established LM-80 outline including:
    - Scope
    - References and Definitions
    - Ambient and Physical Conditions; Electrical Conditions
    - Test Procedures
    - Lumen Maintenance Projection



History: Why LM-80?

Critical change in LM-80 development

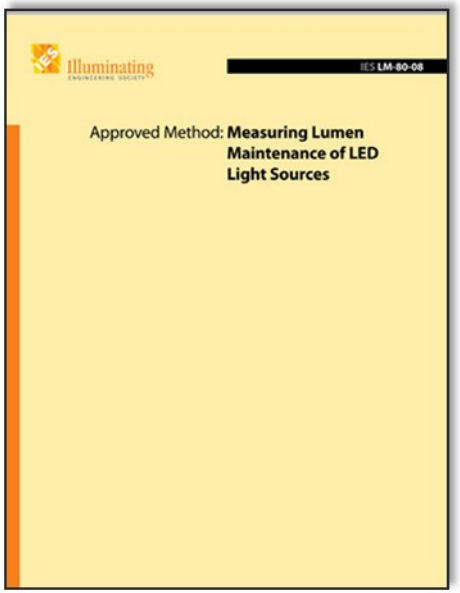
- 2007
  - Multiple versions of drafts developed

- 2008
  - Lumen maintenance projection debate
    - In IES TPC meetings in Punta Gordo FL, a question was raised about including lumen maintenance projection in LM-80
    - Projection does not fit in LM category
    - Committee could not reach an agreement for the proposed projection modules (seminar to *ASSIST Recommends…)*

  - Decision
    - LM-80 should only be a testing document
    - Projection methods should not be included in LM-80

History: Why LM-80?

IES LM-80-08



- Title
  - *IESNA Approved Method: Measuring Lumen Maintenance of LED Light Sources*

- Scope
  - To provide the methods of the measurement of lumen maintenance of sources including LED packages, arrays and modules only
    - Lumen maintenance is a characteristic measured under controlled condition
    - Performance in a particular application may be different
  - This approved method does not provide guidance or make any recommendations regarding predictive estimations or extrapolation for lumen maintenance beyond the limits of the lumen maintenance determined from actual measurements

History: Why LM-80?

Purposes of IES LM-80

- Industry needed a consistent testing procedure for long-term behavior of LED sources

- Decisions on test duration
  - Test duration must be long enough to show luminous flux decay trend, but
  - Such testing period has to be practical for product introduction into the market

- Decisions on case temperature
  - What has been practiced by LED manufacturers?
  - How many case temperatures should be tested?

- Clarification
  - LM-80 does not provide performance requirements
  - It does not give the criteria if a product is passing or failing

Outline

LM-80: Seven years of practice

What is good…

- Effectively generates needed data
  - Long duration test collected data for successful TM-21 extrapolations
- Allows some flexibility in methodology
  - Laboratories could use different approaches to get the same result
- Standardized testing temperatures
  - Required testing temperatures (55°C, 85°C) allowed results to be compared
- Practical method for labs
  - Allowed for normal testing situations such as damaged LEDs, timekeeping errors

LM-80: Seven years of practice

What are the issues…

- Vague or confusing requirements, subject to interpretation by lab auditors
  - Current can be de-rated
  - Voltage waveshape THD < 3%
  - Ripple voltage shall not exceed 2%
  - Airflow shall be minimized
  - Samples shall be representative
  - Ambient temperature shall be 25°C

- Testing temperature requirements too restrictive, e.g.
  - If only 1 temperature is needed
  - If more than 3 are desired
  - If 55°C and 85°C are not appropriate
  - Unnecessary test cases increase testing burden for no benefit

LM-80: Seven years of practice

What are the issues…

- Difficult case temperature monitoring
  - Optical radiation affects temperature readings
  - Thermocouples must be removed for optical measurements
  - Can require hundreds of thermocouples
  - Labs/auditors often ignored thermocouple requirements
  - Unclear if minimum or average T_s is used for sample set

- No requirement to report all samples
  - Some labs select best LEDs for LM-80 report

- Terminology sometimes inconsistent and confusing
  - LEDs, LED Sources, Unit, LED Unit, Devices and Modules all terms to refer to device under test (DUT)

Outline

New version of LM-80

Changes and updates- Accreditation and scope

LM-80-08	LM-80-15
• IES	• IES & ANSI

• Lumen maintenance	• Flux maintenance
	  • Luminous flux
	  • Radiant flux
	  • Photon flux

• Changes in chromaticity	• Color maintenance
	  • Chromaticity coordinates
	  • Peak wavelength
	  • Centroid wavelength

Scope enlarged to include:
blue or UV LEDs used in remote phosphor as pump sources
monochromatic LEDs for horticultural applications

New version of LM-80

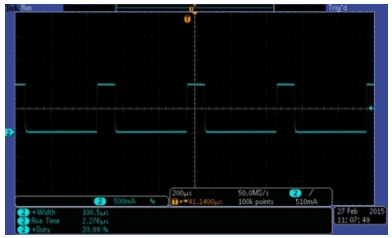
Changes and updates- Drive conditions

LM-80-08

- Auxiliary equipment including drivers
- Drive current
  - “Regulated to within +/-3% of the rated rms value”
  - “The current can be de-rated as a function of temperature”

LM-80-15

- DUT drivers
- Drive level, no de-rating with detailed specifications
  - DC Constant Current
  - Pulse Width Modulated Current
  - DC Constant Voltage
  - AC Regulated Voltage



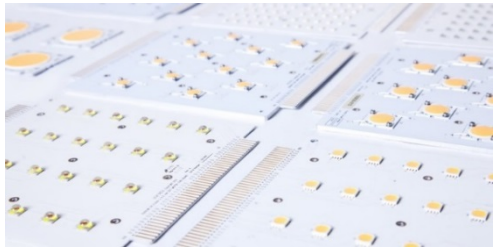
Pulse width modulated current waveform

Photo courtesy of Vektrex

New version of LM-80

Changes and updates- Physical and environmental conditions

LM-80-08	LM-80-15
• Vibration requirement • Operating orientation and LED unit spacing requirement	• No requirement for vibration • Removed the requirement for operating orientation and LED unit spacing



LEDs mounted on test load boards

Photo courtesy of Vektrex

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New version of LM-80

Changes and updates- Physical and environmental conditions (cont'd)

LM-80-08

- Case temperatures
  - 3 temperatures
    - 55° C, 85° C and the third temperature is user-chosen
- Air temperatures
  - "should" requirement
  - -5° C to +infinity

LM-80-15

- Case temperatures
  - 2 temperatures
    - One of them is suggested as 55° C or 85° C
- Air temperatures
  - "shall" requirement
  - -5° C to +infinity

Air temperature control is now required

Typical LM-80 System Configured For 3 Temperatures

Photo courtesy of Vektrex

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New version of LM-80

Changes and updates- Physical and environmental conditions (cont'd)

LM-80-08

- Air flow
  - Minimized
- Humidity
  - Maintain < 65% RH
- Case Temperature Monitoring
  - Thermocouples only

LM-80-15

- Air movement
  - No significant volume of external air below T_A
  - Passive or active control allowed
- Humidity
  - Maintain <65% RH, or
  - Maintain at specified humidity level +/- 5%, report level
- Case Temperature Monitoring
  - Other sensors may be used

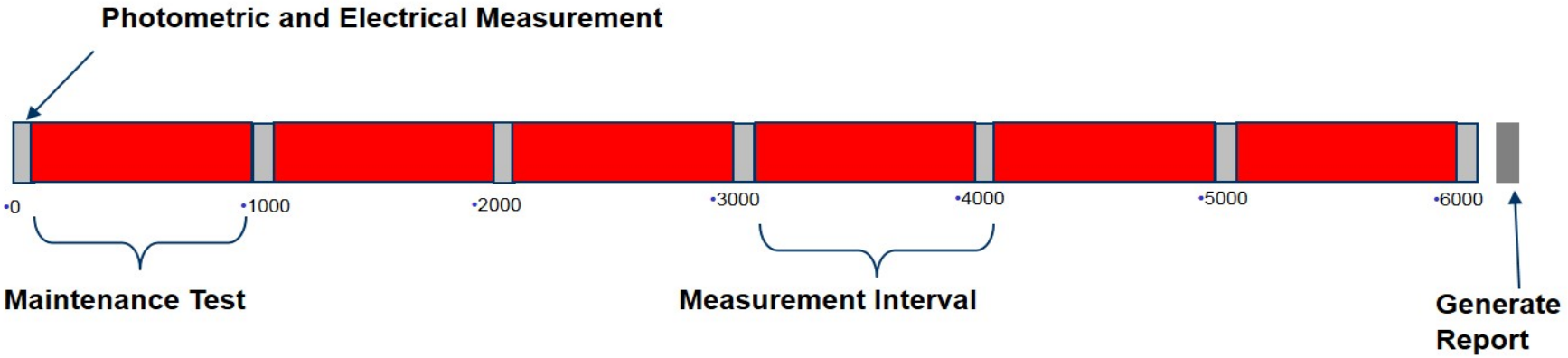
LM-80 now allows testing at a specified humidity level

New version of LM-80

Changes and updates- New definition for test activities

LM-80-08	LM-80-15

• Photometric measurements
• “burning” - Indirect reference
  • Operation of the LED light sources between photometric measurements
	• Photometric and electrical measurement
	• Maintenance test
	  • Measurement interval



New version of LM-80

Changes and updates- Maintenance test procedures

LM-80-08	LM-80-15

• Operating cycle
• Chromaticity
  • Measure and report chromaticity shift
	• Removed operating cycle
	• Chromaticity or wavelength
	  • Measure and report chromaticity values, or
	  • Measure and report peak or centroid wavelength
	  • u'v'

LM-80 now specifies CIE 1976 u'v'

New version of LM-80

Changes and updates- Maintenance test procedures (cont'd)

LM-80-08

- Lumen maintenance test
  - Test duration at least 6000 hours
  - Data collection at a minimum of every 1000 hours

LM-80-15

- Lumen maintenance test
  - Does not specify test duration
  - Does not specify photometric and electrical measurements interval
  - Consistent with other IES test methods (LM) document

LM-80 no longer specifies test duration

Timer (Hours:Minutes)			
Duration	Elapsed	Remaining	Estimated Completion
6000:00	4000:...	1999:59	10/26/2015 5:21 PM

Typical Software Duration Timer

New version of LM-80

Changes and updates- Maintenance test procedures (cont'd)

LM-80-08

- Unit marking
  - Track individual LED light sources
  - Identify with labels or other markings
- Instrumentation
  - Total time uncertainty < +/- 0.5%

LM-80-15

- DUT tracking
  - Each DUT must be tracked and reported
- DUT failure
  - Flux decrease 90%
- Time keeping
  - Accumulates only when DUTs are energized
  - Uncertainty is < +/- 0.5% of measurement interval

New requirement for reporting all DUTs – labs can no longer pick best LEDs for report

New version of LM-80

Changes and updates- Test report

- Reporting contents
  - Administrative information
  - DUT identification
  - Test condition
  - Test equipment
  - Test duration
  - Measurement interval
  - Failed DUTs
  - Test results

- Optional items
- Statement of uncertainties
- Sampling method
- Change in chromaticity

Summary of Testing Conditions

	I	II	III
Case temperature (solder point)	T_S = 55 °C	T_S = 85 °C	T_S = 105 °C
Device drive current	I_F = 120 mA	I_F = 120 mA	I_F = 120 mA
Number of samples	25	25	25
Test start	22.10.2012	22.10.2012	22.10.2012
Test duration	9,000 hours	9,000 hours	9,000 hours
Nr. of failures	0	0	0

Outline

What's next: LM-80 data usage and TM-21

LM-80 data

- Flux and chromaticity (or wavelength)
  - Raw data shall not be used for comparison
  - If the DUT is tested to a given duration (e.g., 3000 hours), the flux maintenance shall only be reported or identified for the same duration by using the last measurement value (e.g., 90%)

- Avoid misconception
  - Long-term DUT decay or change in behavior cannot be identified by LM-80
  - Data does not represent "good" or "bad"
  - Data cannot be used for "pass" or "fail" criteria

What's next: LM-80 data usage and TM-21

Use LM-80 data for projection

- Data collection
  - Additional measurements after the initial 1000 hours at intervals smaller than 1000 hours (including every 1000 hour points) are encouraged
  - Additional measurements beyond 6000 hours are encouraged and will provide the basis for more accurate lumen maintenance predictions

- Data selection
  - Data collected within a ± 48 hour window of each "1000 hour measurement point" (e.g., from 952 hours to 1048 hours, from 1952 hours to 2048 hours, etc.) are acceptable for use in DUT flux projections
  - The ± 48 hour window is also applicable to other intervals smaller than 1000 hours
  - The exact time designation shall be used in the projection calculation

What's next: LM-80 data usage and TM-21

Use LM-80 data for projection (cont'd)

- Data preparation for projection
  - Normalize all collected data to a value of 1 (100%) at 0 hours for each DUT tested
  - Average the normalized measured data of all samples (exclude failed DUTs) within the same data set for each test condition (same forward current, case temperature, etc.) at each measurement point
  - First 1000 hours data shall not be used for projection calculation

- Test duration for projection
  - Minimum of 6000 hours

- Sample size for projection
  - 20 or more samples, projection multiplier is 6
  - 10-19 samples, projection multiplier is 5.5

Summary

Usage of LM-80

- It is a consistent testing method
  - Understand the test conditions
  - Follow the procedures
  - Report what has been done: DUT, equipment, conditions, processes, and results
- It is not a specification
- It is not a calculation or comparison tool
  - Use TM-21 to make projection
  - Use TM-21 projection results to make comparison
- It will be continually improved based on industry's best practice

Thank you.

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