Practical Lumen Maintenance Testing Using LM-80

May 2011

A Discussion of Best Practices and Recent Standards Activity

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Abstract

LED lumen maintenance testing is widely performed using the techniques outlined in the IES LM-80 standard. While the standard provides a good overview of the testing to be performed, key best practices that are useful for effective lumen testing are omitted, particularly in the area of thermal management, data collection, and reporting. This paper discusses these practices and presents the current efforts of the IES subcommittee to capture this knowledge in a new revision of the LM-80 standard.

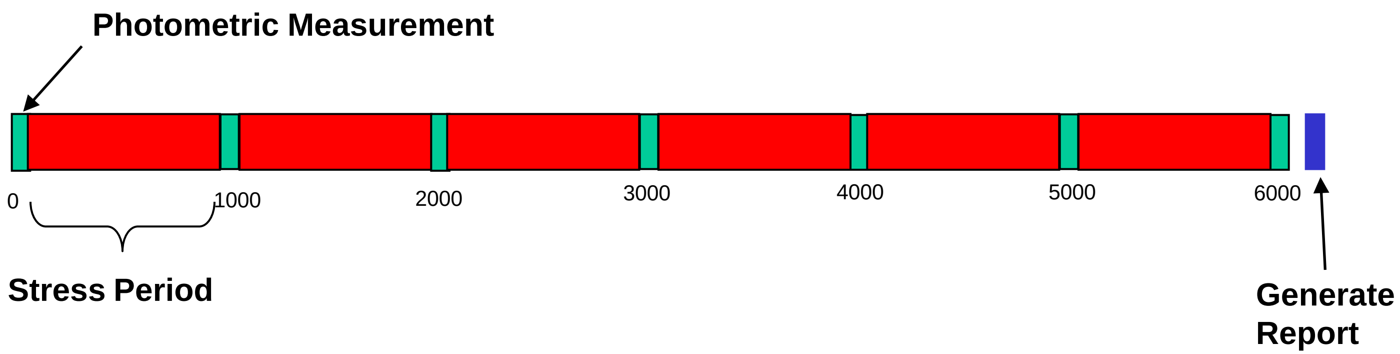
Outline

- Vektrex Overview
- LM-80 Overview
- Key Best Practices For Successful LM-80
- Current Work To Revise LM-80
- Conclusions

LM-80 Overview

LM-80

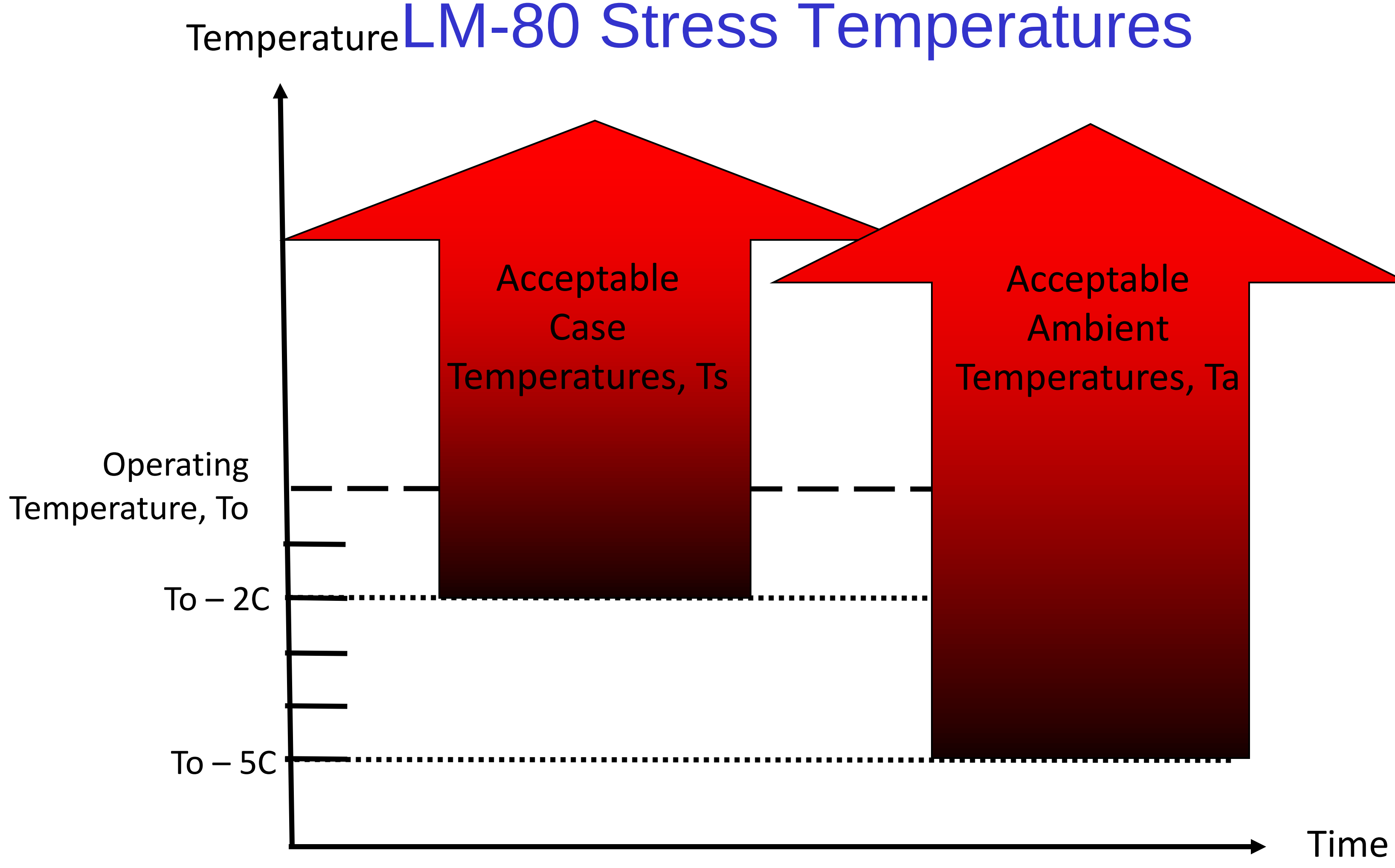
- Focused on Lumen Maintenance – that is the consistency of light output from LED lighting devices
- Activities 1) Photometric Measurements, 2) Device Stress, 3) Report Generation



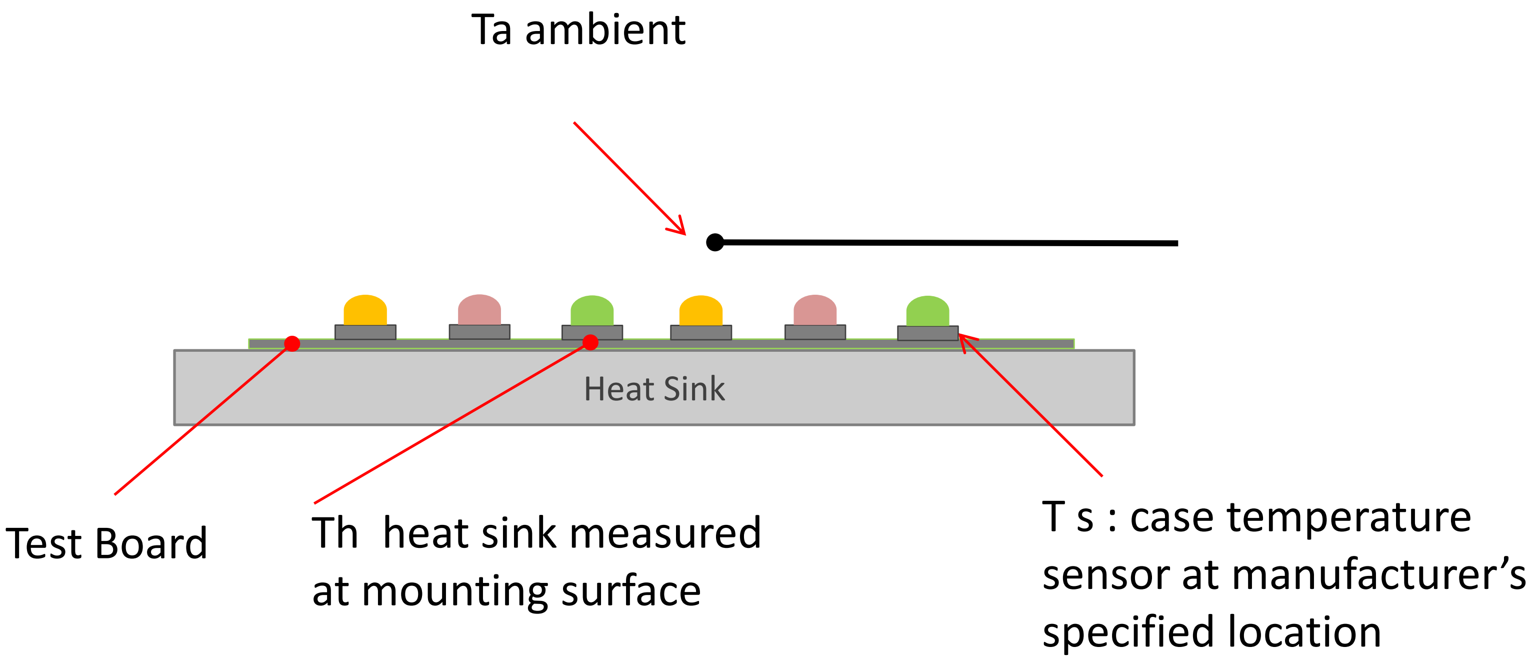
LM-80 Testing

- Three stress (operating) temperatures
  - 55C
  - 85C
  - Another temperature chosen by manufacturer
- Relative (mostly) photometric measurements
- Case temperature monitoring required
- Air temperature control/monitoring suggested but not required
- Methodology not completely specified - vague

LM-80 Stress Temperatures



Typical LM-80 Stress Setup



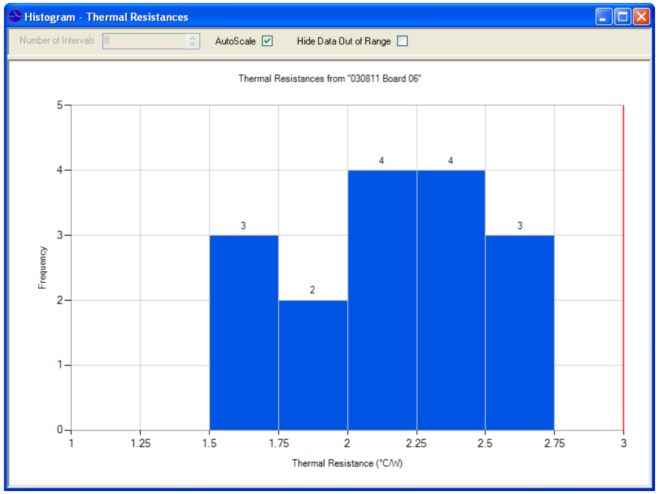
Key Best Practices

Keys To LM-80 Success

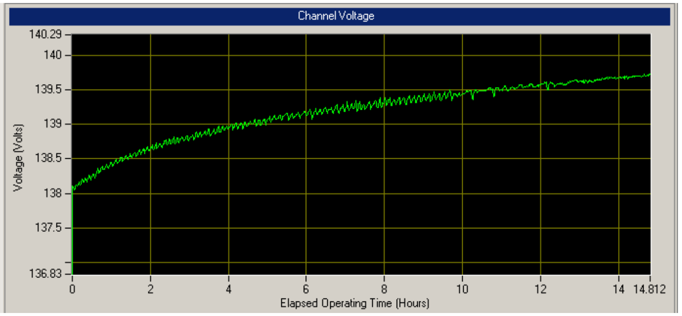
- Success Key #1 Efficient System/Process Design
- Success Key #2 Quality Equipment
- Success Key #3 Good Thermal Management
- Success Key #4 Precise Photometric Measurements

Success Key #1 Efficient System/Process Design

- Create standard “load board” for LEDS
- Pick devices carefully to meet business goals
- Check thermal resistance to ensure proper mount
- Make more frequent photometric measurements during the first 500 hours of stress
- Monitor LEDs during the stress period, look for anomalies
- Use computer-based timekeeping, record keeping



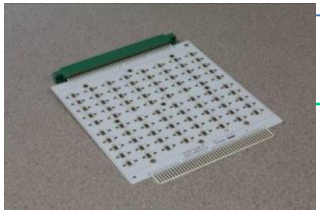
Rth Histogram



Vf Shift During Stress

Interchangeable Load Board Concept

Interchangeable
Load Board

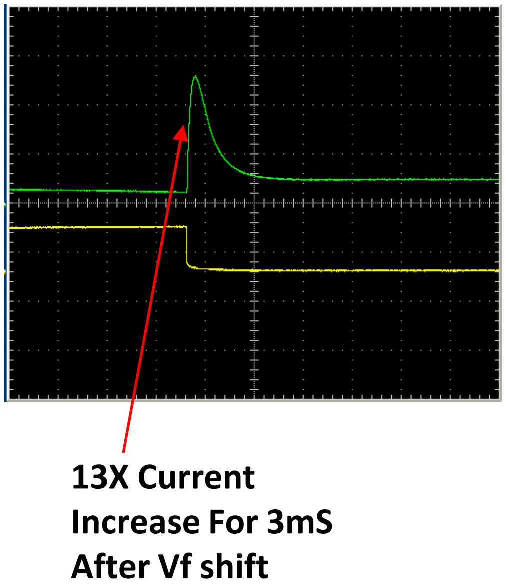


Stress

Photometric
Measurements

Success Key #2 Quality Equipment

- Use high quality current sources, ideally with spike protection
- Set up safety systems to prevent thermal overstress conditions that can damage LEDs
- Make sure all equipment has traceable calibration, ideally to ISO 17025
- Design fail-safes into system to protect data and load boards in the event of a power failure



Success Key #3 Good Thermal Management

- Specify a case temperature measurement location
- Determine case temperatures by analysis, not direct measurement
- Pick operating To based upon worst-case calculated temperatures
- Control air temperature in a chamber with forced air movement
- Ensure air temperature thermocouples are shielded from radiation

Shielded Air Temperature Probe

Example: Determine Case Temperatures By Analysis

- Measure sink temperature in chamber
- Measure representative LED case temperatures and Vf's in chamber
- Calculate average thermal resistance
- Calculate spread of potential case temperatures based upon thermal resistance and min/max Vf

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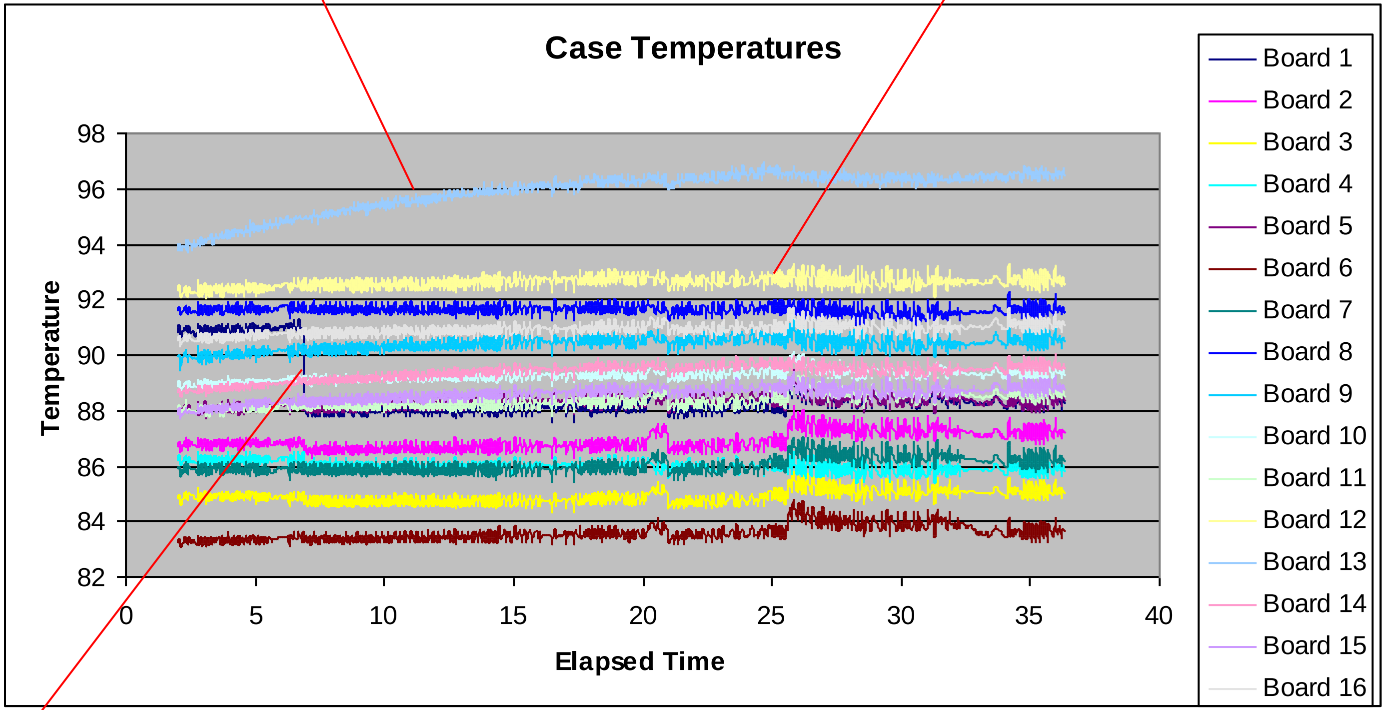
Example Case Temperature Analysis

Temperature Variation Prediction - Modified for 16 LEDs, Process Temp of 76C, Observed Case Temps				
Assumptions:				
Load Board Power	235.2			
Load Boards/Drawer	4			
Drawers/System	4			
Minimum Vf, V	19			
Typical Vf, V	21			
Maximum Vf, V	23			
Measured Device Thermal Resistance, C/W	0.68			
Stress Current, A	0.7			
Heat Sink Temperature Rise, Inlet to Outlet	2.8224			
Estimated Load Board Temperature Variation Due To Mounting Irregularities	3			
Temperature Predictions:				
	Nominal	**Min**	**Max**	**Contribution**
Process Temperature (Cooling Water Temp)	76			
Heat Sink Temperature	76	76	78.8224	2.8224
Best Case LED Case Temperature	85.996	85.044	89.7704	1.904
Actual Case Temperature Including Load Board Variation	85.996	85.044	92.7704	3
Total Temperature Spread	7.7264			
Note: Process temperature of 76 chosen to satisfy LM-80 requirement for 85C				

Typical Measured Case Temperatures – 85C Nominal

Board 13 Thermocouple Probably Disconnected From LED

Case Temperatures Show Good Temperature Control



Board 1 Temperature Dropped When Channel Went Off

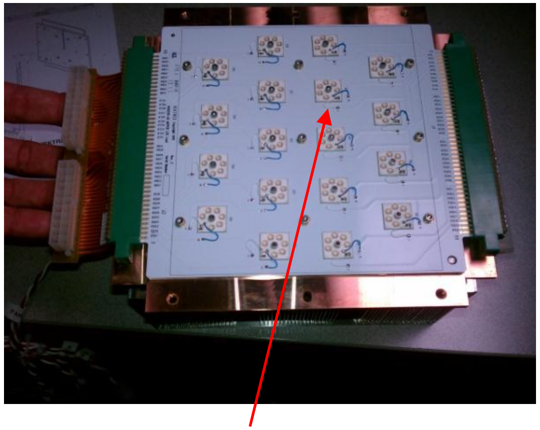
All Temperatures Within LM-80 Limits

Case Temperatures	
Maximum	97.07
Minimum	83.05
Average	88.85
Standard Deviation	3.01

Case Temperatures - Without 13	
Maximum	93.42
Minimum	83.05
Average	88.38
Standard Deviation	2.46

Success Key #4 Precise Photometric Measurements

- Design photometric system for automated measurement of one load board
- Make absolute optical measurements with a high quality spectrometer-based system
- Use stable calibration artifacts to correct long-term changes in photometric system
- Follow LM-79 test or new high power LED test methodology
- Maintain constant Ts during photometric testing



Load Board Installed On Photometric Temperature Platform

Current Work To Revise LM-80

LM-80 Revision Initiated in 2010

- IESNA Project Initiation Form (PIF) approved Oct 2010:
  - **The objective is to provide clarification in some areas that have been noted to be unclear to many readers, to provide additional detail regarding preferred techniques for instrumenting the test and controlling the environment during the test, and to provide more detail regarding format and content of the test report. In addition, recommendations from the TM-21 working group will also be incorporated into the document. These changes will improve the usability and support the ongoing effort to utilize lm-80 for Energy Star compliance testing.**

LM-80 Working Group Formed And Working Well

- Working group formed, met at April TPC meeting in San Antonio
- 17 present members:
  - Emil Radkov" <eradkov@illumitex.com>, "Greg McKee" <gmckee@labsphere.com>, "Hamid Kashani" <hamid@leotek.com>, "Hoon-Sung Jung" <hoonsung.jung@samsung.com>, "Jianzhong Jiao, Ph.D. OSRAM" <jianzhong.jiao@osram-os.com>, "Kei Haraguchi" <kei.haraguchi@nichia.com>, "Ku'uipo J. Curry" <kcurry@icfi.com>, "Mark Hodapp" <mark.hodapp@philips.com>, "Mark Sapcoe" <mark.sapcoe@sylvania.com>, "Miller, C. Cameron" <c.miller@nist.gov>, "Phil Elizondo" <philelizondo@bridgelux.com>, "Ralph Tuttle" <Ralph_tuttle@cree.com>, "Rand Lee" <rlee@orboptronix.com>, "rolf.bergman@sbcglobal.net" <rolf.bergman@sbcglobal.net>, "Zong, Yuqin" <yuqin.zong@nist.gov>,
- First draft of changes created
- Bi-weekly phone calls setup

Proposed LM-80 Changes – Mostly Clarifications

- Likely LM-80 changes:
  - Rewritten for better clarity
  - Ambient temperature control changing to a required item
  - Better explanation of temperatures during testing
  - Additional detail in report
  - Requirement for u’,v’
  - Separate discussions of DC and AC LEDs
  - Ability to use other thermal sensors (RTDs, etc.)
- Under Discussion:
  - Reducing stress temperatures from 3 to 2
    - Proposed buy one member, not well supported

LM-80 Revision Timeline

- LM-80-11 to be drafted in teleconferences this year
- Likely to be presented for ballet in October 2011
- Goal is to publish in December 2011

Conclusion

- Present LM-80 standard, though vague in some areas is sufficient and being used successfully
- LM-80 practitioners should follow suggested best practices to assure success with minimum investment
- Provide input to LM-80 subcommittee now to influence next version of LM-80