3-PART TINSSL WEBINAR SERIES: UNDERSTANDING AND EVALUATING LM-79 AND LM-80 TEST REPORTS FOR SSL TECHNOLOGY

Day 1: *Understanding & Evaluating LM-79 Reports*
August 10, 2010: 12:00 - 1:30pm EST

Day 2: *Understanding & Evaluating In Situ TMP & LM-80 Reports*
August 11, 2010: 12:00 - 1:30pm EST

Day 3: *Walking Through Examples of Real LM-79 & LM-80 Reports*
August 12, 2010: 11:00am - 12:30pm EST

Hosted by the U.S. Department of Energy and Northeast Energy Efficiency Partnerships

U.S. DEPARTMENT OF ENERGY

neep

Northeast Energy Efficiency Partnerships

www.neep.org

REGIONAL **INITIATIVES** | PUBLIC **POLICY** | EM&V **FORUM** | NEEP **SUMMIT**

ABOUT NEEP



NEEP is a non-profit organization that facilitates regional partnerships to advance the efficient use of energy in homes, buildings and industry in the Northeast U.S. NEEP works to leverage knowledge, capability, learning and funding through regionally coordinated policies, programs and practices.

As a regional organization that collaborates with policy makers, energy efficient program administrators, and business, NEEP is a leader in the movement to build a cleaner environment and a more reliable and affordable energy system. [More]

DOE Technical Information Network

"One & Done" Connection to DOE's SSL Work

- DOE's Technical Information Network for Solid-State Lighting (TINSSL) increases awareness of SSL technology, performance, and appropriate applications.
- TINSSL members receive regular updates on technical progress of SSL technologies, upcoming meetings and events that address market issues related to SSL, and outreach materials developed for target audiences.
- Coverage includes:
  - CALiPER
  - Gateway Demonstrations
  - Lighting Facts
  - L Prize

DESIGNLIGHTS CONSORTIUM

www.designlights.org

HOME | SOLID STATE LIGHTING | HPT8 | TRAINING | LINKS/RESOURCES | SPONSORS | SKYLIGHTING



The DesignLights™ Consortium (DLC) is the Northeast's premier resource for high-quality, energy-efficient, commercial lighting design and information!

The DLC — a collaboration of utility companies and regional energy efficiency organizations — is committed to raising awareness of the benefits of efficient lighting in commercial buildings.

OUR SPONSORS support and enable the efforts of the DLC, and through their participation they demonstrate their commitment to quality and performance in energy efficiency.

OUR MISSION is to help – builders, architects, designers, and commercial property owners to implement improved design practices in all areas of the commercial lighting market.

OUR GOAL is to ensure that high-quality, energy-efficient lighting design becomes commonplace in all lighting installations.

NEWS

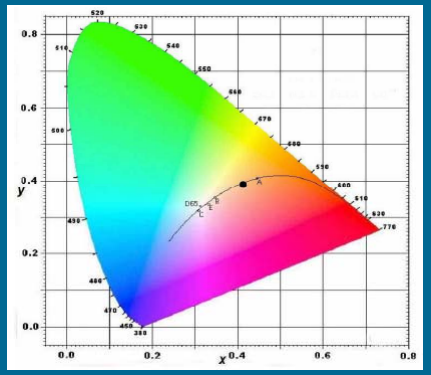
Highlights

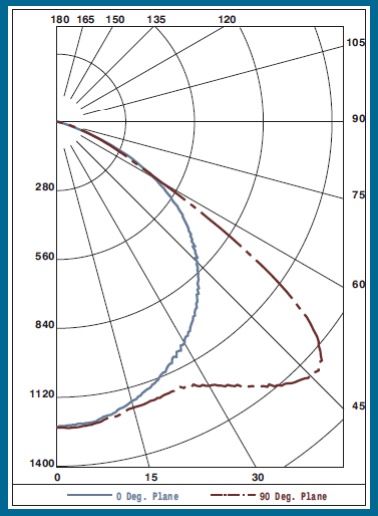
The DesignLights Consortium Qualified Products List project was presented at the DOE SSL Market Introduction Workshop, July 20-22, Philadelphia, PA

EFFICIENT LIGHTING PRODUCTS + EFFICIENT LIGHTING DESIGN = SMART LIGHTING

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Day 1:
Understanding and Evaluating LM-79 Reports





Three-Part TINSSL Webinar Series:

Understanding and Evaluating

LM-79 and LM-80 Reports

Jason Tuenge

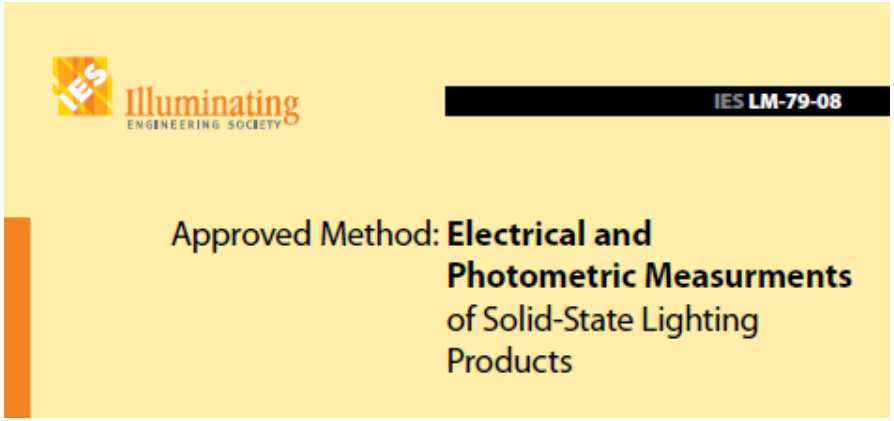
Kelly Gordon

Pacific Northwest National Laboratory

August 10, 2010

LM-79 Scope

- …“LED-based SSL products with control electronics and heat sinks incorporated, […] devices that require only AC mains power or a DC voltage power supply to operate.”



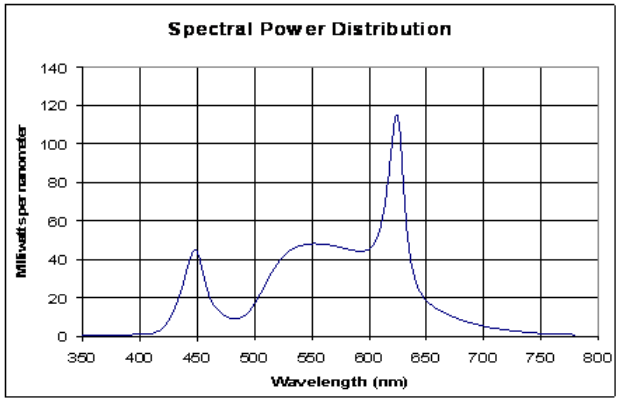


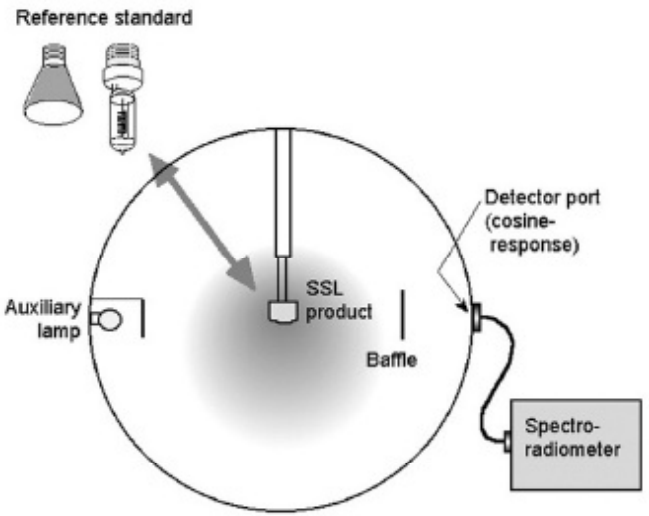




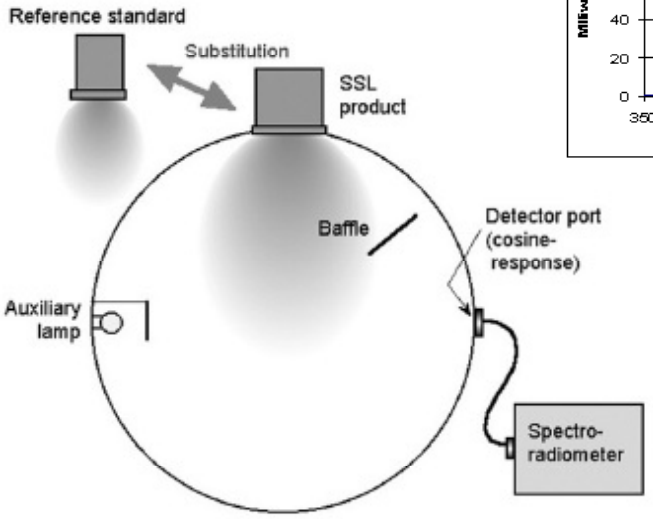
LM-79 Scope

- Addresses test conditions and measurement methods
  - Spectral power distribution (mW/nm)
    - Typically via integrating sphere
    - Derived: CCT, D_{uv}, CRI
      - ➢ New: CQS





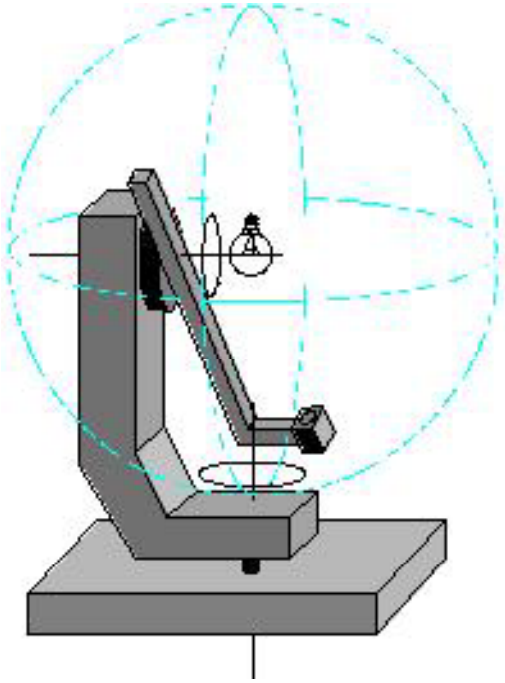
(a) 4π geometry

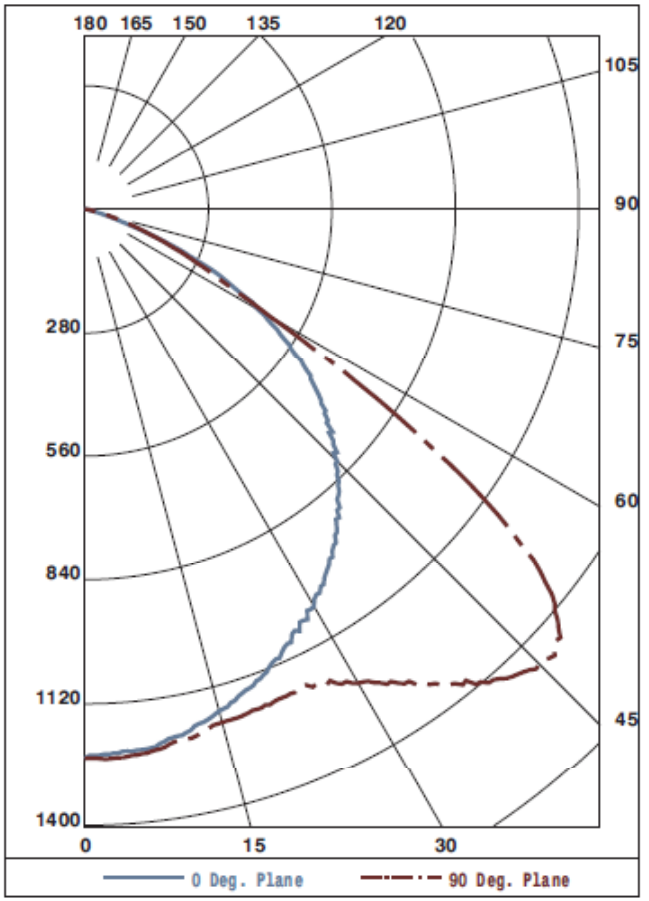


(b) 2π geometry

LM-79 Scope

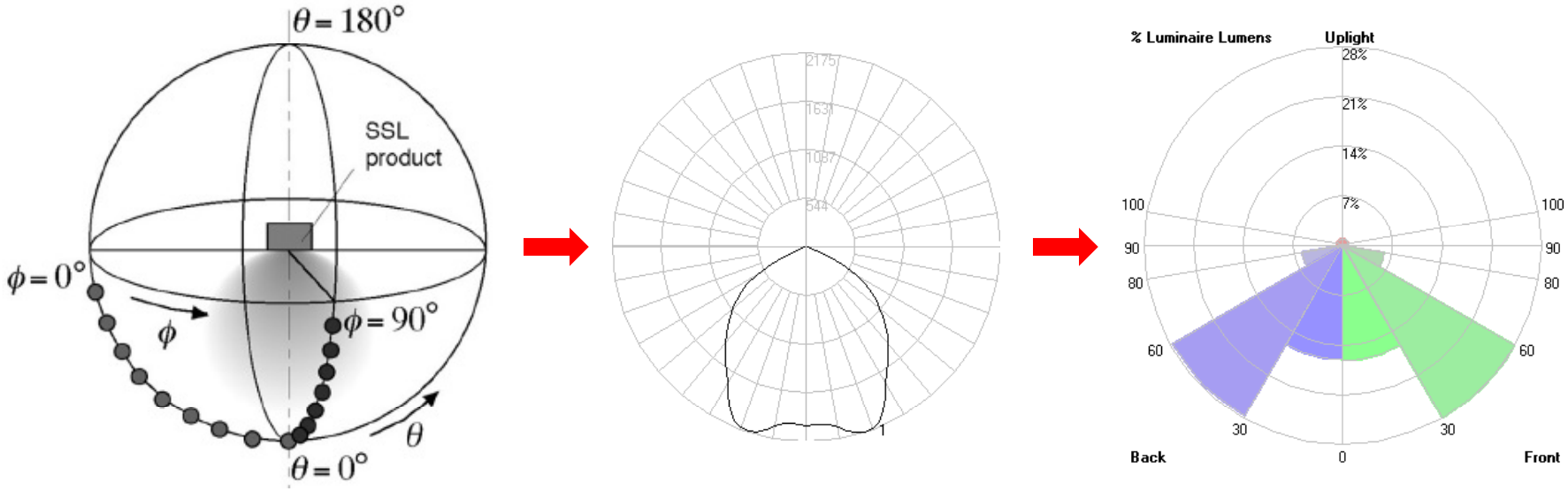
- Addresses test conditions and measurement methods
  - Luminous intensity distribution (candelas)
    - Only via goniophotometer
    - Derived: zonal lumens, BUG





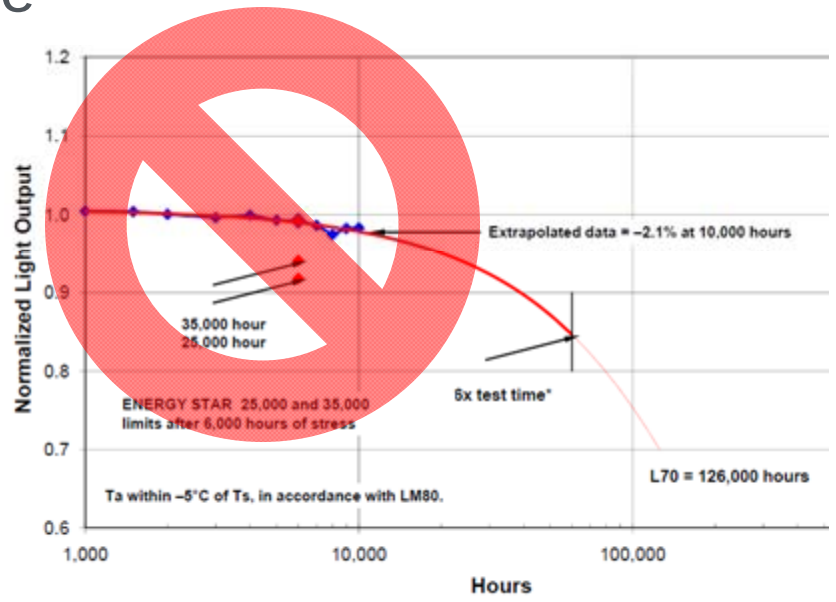
LM-79 Scope

- Addresses test conditions and measurement methods
  - Electrical input (volts, amperes, watts)
    - Derived: efficacy (lm/W)
  - Total luminous output (lumens)
    - Interpolation required for gonio data



LM-79 Scope

- **Does not** address measurement or determination of
  - LED *drive* current
    - As opposed to driver *input* current
  - In situ operating temperature
    - See ISTMT
  - Lumen or color maintenance
    - See LM-80
  - Useful/rated lifetime
    - Awaiting TM-21…



LM-79 Scope

- **Does not** standardize report format or content
  - Spatial and spectral data may not be in same report
    - Can be just spatial (BUG) or just spectral (CCT)
    - Manufacturers often unaware data is incomplete
  - Reports generally don't indicate make/model info for LEDs integrated into lamp or luminaire
    - Would be useful in evaluating submitted LM-80, but test lab probably not able to determine
      - Even close-up photos of LEDs in off state wouldn't necessarily give positive identification
  - Reports may include off-state power draw if requested

LM-79 Content (Suggested?)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- "Typical items reported"
  - Date and testing agency
  - Make/model info
  - Rated electrical values and nominal CCT
  - Hours of operation prior to measurement
  - Total operating time during testing
  - Ambient temperature
  - Operating position/orientation during test
  - Stabilization time
  - Photometric method/instrument
  - Designation/type of reference standard/source
  - Correction factors applied

LM-79 Content (Suggested?)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- "Typical items reported" (continued)
  - Measurement geometries and/or reflectances
  - Measured total luminous flux
  - Measured input watts, amperes, and voltage
  - Luminous intensity distribution
  - Color quantities
  - Spectral power distribution
  - Bandwidth of spectroradiometer
  - Equipment used
  - Statement of uncertainties
  - Explanation of any deviation from standards

LM-79 Content

designlights.org/solidstate.manufacturer.requirements.php

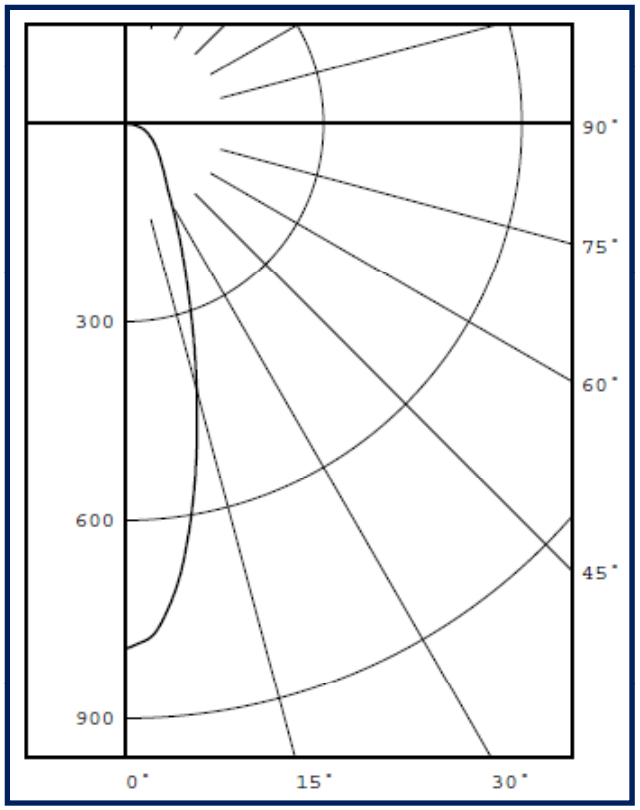
- DLC QPL Technical Requirements Table v1.4
  - Items covered by LM-79

	✓	✓	✓	✓	✓		
Application	Minimum Light Output	Zonal Lumen Requirements	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	Minimum LED Lumen Maintenance at 6000hrs[1]	Minimum Luminaire Warranty

LM-79 Content

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Spatial distribution data
  - Sometimes requires hand-calculations



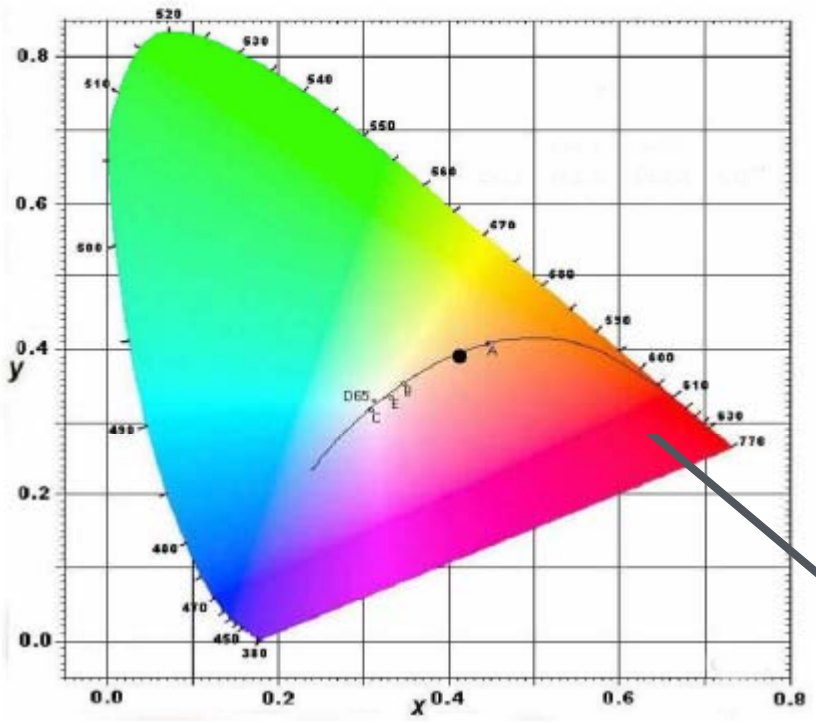
ZONAL LUMEN SUMMARY		
ZONE	LUMENS	%FIXT
0- 30	274	52.0
0- 40	343	65.1
0- 60	450	85.4
0- 90	527	100.0
90-180	0	0.0
0-180	527	100.0

EFFICACY = 65.9 Lm/W
CIE TYPE - DIRECT
LUMINAIRE SPACING CRITERION = 0.5
BEAM ANGLE (50%) : 31.4 DEGREES
FIELD ANGLE (10%): 86.3 DEGREES

ZONAL LUMEN SUMMARY	
0- 5	19.
5- 10	48.
10- 15	59.
15- 20	57.
20- 25	49.
25- 30	42.
30- 35	36.
35- 40	33.
40- 45	30.
45- 50	28.
50- 55	26.
55- 60	24.
60- 65	21.
65- 70	19.
70- 75	16.
75- 80	12.
80- 85	7.
85- 90	3.

LM-79 Content

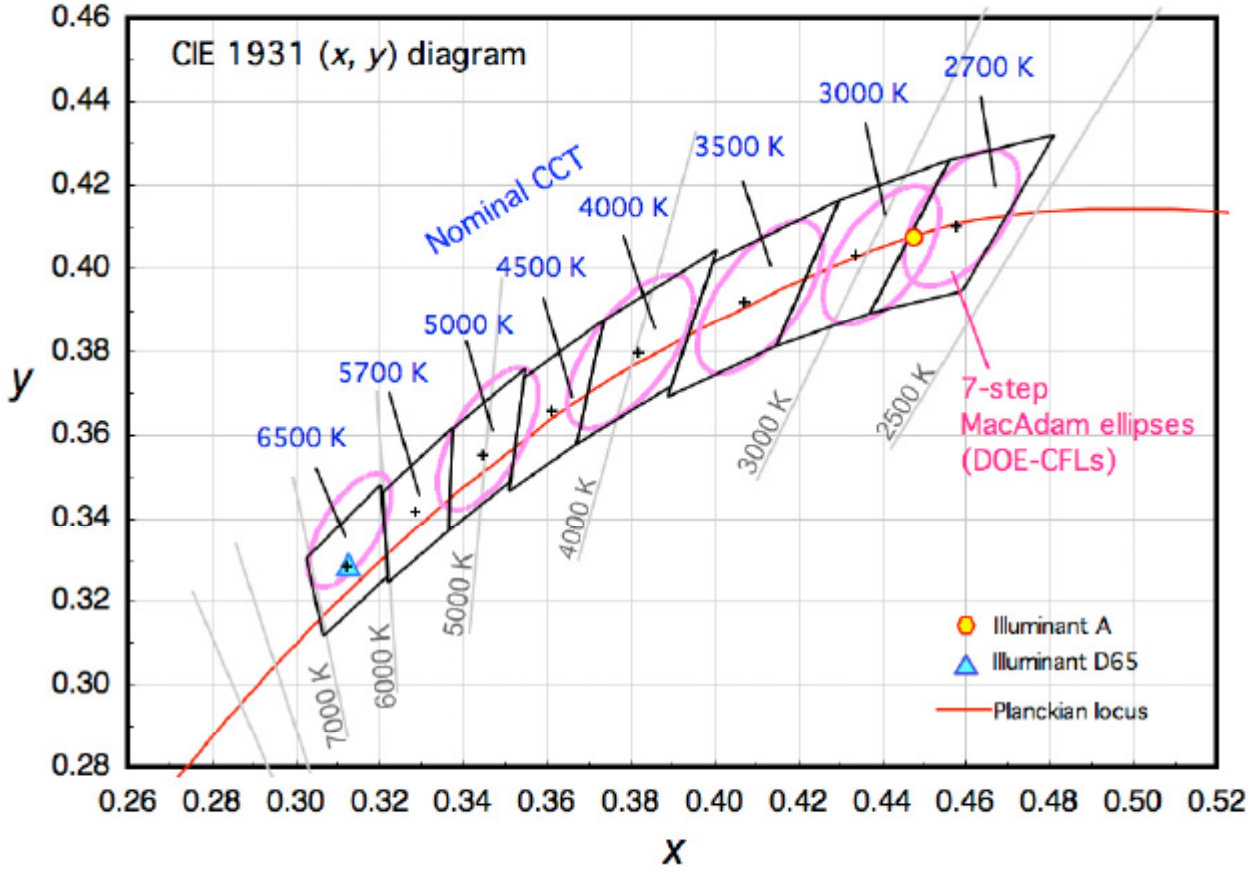
- Colorimetry
  - (x,y) or (u',v') coordinates
  - CCT and **D_{uv}**



Planckian (blackbody) locus

LM-79 Content

- Colorimetry
  - ANSI_NEMA_ANSLG C78.377-2008



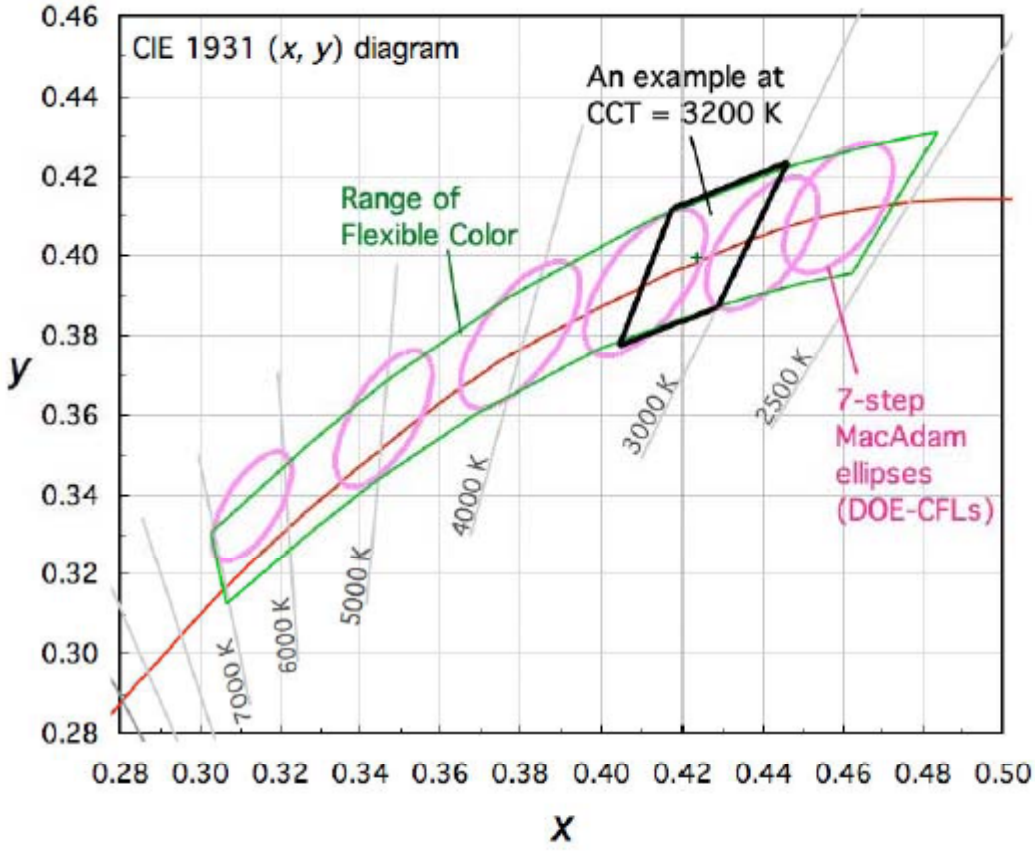
LM-79 Content

- Colorimetry
  - ANSI_NEMA_ANSLG C78.377-2008

Nominal CCT[1)]	Target CCT and tolerance (K)			Target Duv and tolerance		
2700 K	2725	±	145	0.000	±	0.006
3000 K	3045	±	175	0.000	±	0.006
3500 K	3465	±	245	0.000	±	0.006
4000 K	3985	±	275	0.001	±	0.006
4500 K	4503	±	243	0.001	±	0.006
5000 K	5028	±	283	0.002	±	0.006
5700 K	5665	±	355	0.002	±	0.006
6500 K	6530	±	510	0.003	±	0.006
Flexible CCT (2700 - 6500 K)	T [2)]	±	ΔT [3)]	D_{uv} [4)]	±	0.006

LM-79 Content

- Colorimetry
  - o ANSI_NEMA_ANSLG C78.377-2008



(Flexible CCT)

Nominal CCT
3200 K

Min CCT	2998
Max CCT	3402
Center Duv	0.0002

4 corners (x, y)

x	y
0.4464	0.4234
0.4180	0.4116
0.4046	0.3774
0.4289	0.3871

LM-79 Content

- Absolute and relative photometry
  - Relative photometry traditionally considered adequate for other (non-SSL) technologies
    - Lamp, ballast and luminaire treated separately
    - Luminaire output and efficacy a function of
      - Luminaire efficiency
      - Rated lamp lumens
      - Ballast factor
    - Reduces # of lamp-luminaire combinations that must be tested
    - Over 100% efficiency for some T5HO luminaires?!

LM-79 Content



- Absolute and relative photometry
  - o "Traditional [relative] luminaire photometry methods do not work for SSL products […] LED lamp sources are not designed to be removed from the luminaire."
  - o Absolute photometry required due to significant dependence on thermal management
    - Hence the heat sinks often visible on LED products
    - No standard means of determining/using rated "lamp" lumens for LED sources
    - Efficiency isn't calculated – only efficacy

Product Groups/Families

- So test every possible variation?...
  - "If a manufacturer offers the same luminaire with different correlated color temperatures (CCTs), ENERGY STAR will allow those products to be grouped together, so long as the LED package(s)/module(s)/array(s), drive current, electronics, and thermal management are otherwise identical. At a minimum, manufacturer must submit one set of LM-80, In-situ Temperature Measurement Test (ISTMT), and LM-79 test results applicable to the product version with the lowest CCT."
    - Variations in optics/distributions are allowed

Product Groups/Families

- Creating Product Groups
  - *Manufacturers* will define the product group and identify the specific model used for testing to represent the entire group. When choosing this test sample, DOE advises applicants to choose the variation which will have *the most difficulty* meeting the ENERGY STAR criteria.

Table 1 - Variations within Product Groupings

Housing/Chassis	allowed, with conditions†
Heat Sink/Heat Management	not allowed
Finish	allowed
Reflector/Trim	allowed
Shade/Diffuser	allowed
Mounting	allowed
Light Source	allowed, w/ conditions
Power Supply	allowed, w/ conditions

† The light source, heat sink, and power supply are integrated into housing/chassis variations in such a way that the thermal performance of the luminaire is not significantly degraded by the housing/chassis.

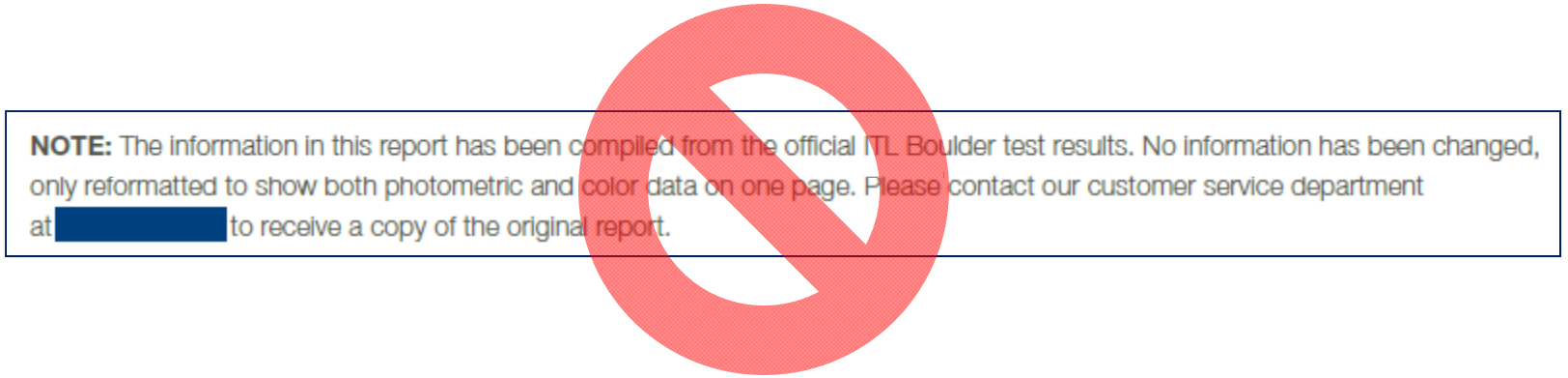
Product Groups/Families

- Further clarification of allowable test-sharing per DLC QPL "Product Family" criteria
  - Same LED chip as tested/accepted model except with different phosphor that produces a higher CCT than the tested/accepted model
  - Exterior housing has a different color
  - Refrigerated case end-mounted model that is symmetric with the opposite end-mounted model
    - "Left" *distribution* passes if "right" passes

LM-79 Checklist

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- ☑ Report produced by a qualified test lab
  - www1.eere.energy.gov/buildings/ssl/test_labs.html
  - (Eventually NVLAP)
- ☑ Data manipulation by supplier appears unlikely
  - ☑ PDF is preferred
  - ☑ Test lab letterhead (original)

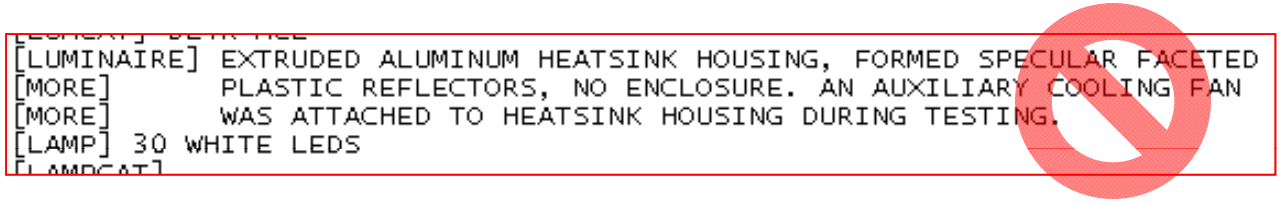


NOTE: The information in this report has been compiled from the official ITL Boulder test results. No information has been changed, only reformatted to show both photometric and color data on one page. Please contact our customer service department at [redacted] to receive a copy of the original report.

LM-79 Checklist

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- ☑ Consistent with submitted product and cutsheet*
  - ☑ Catalog number is complete and unique
    - ☑ No text not clarified by cutsheet
  - ☑ Product description
    - ☑ Input current, voltage, and wattage
    - ☑ Number of LEDs and/or drive current
    - ☑ CCT
    - ☑ Optical distribution *appears to be* worst-case
    - ☑ No thermal management not indicated on cutsheet



* Or meets Product Group/Family criteria

LM-79 Checklist

☑ No apparent errors attributable to manual entry

- **Efficacy** & **power factor** are relatively new to reports and may not have been generated automatically

CLEAR PLASTIC OPTICS BELOW EACH LED.
LED POWER SUPPLY: INTEGRAL
ELECTRICAL VALUES: 120.0VAC, 0.1403A, 16.43W, PF=0.976
NOTE: THIS TEST WAS PERFORMED USING THE CALIBRATED
PHOTODETECTOR METHOD OF ABSOLUTE PHOTOMETRY.*

Zonal Lumen Summary

Zone	Lumens	% of Lamp	% of Luminaire
0-30	442.4	N/A	58.7%
0-40	499.6	N/A	66.3%
0-60	659.2	N/A	87.5%
0-90	753.7	N/A	100.0%
90-180	0.0	N/A	0.0%
0-180	753.7	N/A	100.0%

Total lumen Output	753.7 Lumens
Luminaire efficacy:	59.8 Lumens per Watt
CIE Type:	Direct
Spacing Criterion:	0.13

753.7 lm / 16.43 W = **45.9** lm/W

To Be Continued…

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- ☑ Locate the following
  - ☑ ISTMT & LM-80 Reports
    - Needed for ENERGY STAR Option 1 compliance path for lumen and color maintenance
    - Not needed for Option 2, which substitutes two LM-79 tests
      - One at 0 hours (per usual)
      - Another after 6,000 hours of operation per ENERGY STAR requirements
  - ☑ Rated drive current as indicated on product cutsheets by manufacturer of luminaire or integral lamp
- ☑ Final punch

Thank you!

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Questions?