Opportunities and Challenges in Energy-Efficient Lighting

North American and International Standardization Activities, and LED Marketing

CNC/CIE workshop
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Lighting System goal

To safely place the correct amount and type of light where we want it, when we want it, and for the lowest life cycle cost

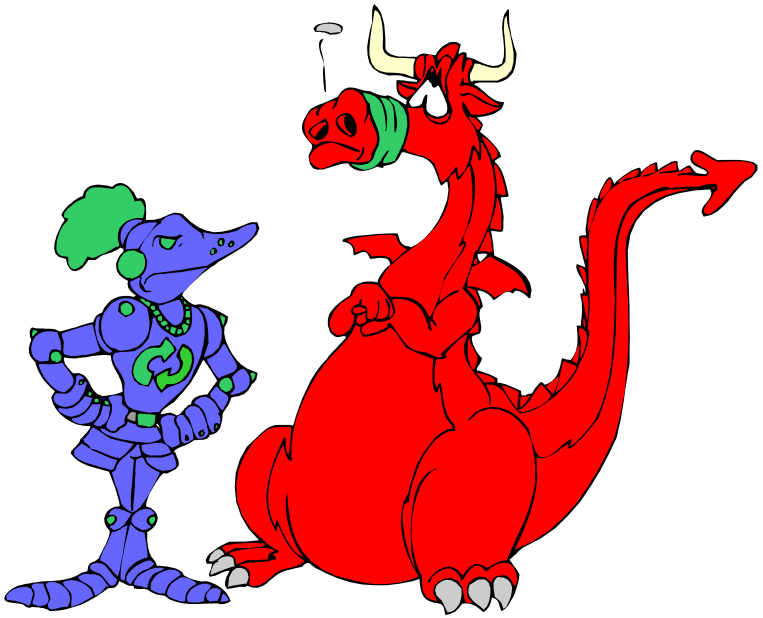
To achieve goal, need

- Consistency
- Standards

Then products will

- Be safe
- Allow interchangeability of system components
- Not interfere with mains distribution/environment

In the LED standards “dark” ages (before 2005)



Welcome to the Wild, Wild West

There were no LED Standards!!!!!

THEN

Then came the age of Enlightenment!

US DOE Hosted Standards Workshop March 1, 2006

- Gathering of all standards and test methods organizations
- Review of LED standards and methods needs
- Review of development process and impacting timelines
- DOE providing on-going technical support for standards development.

N. A. Standards – started in 1996

Performance

- ANSI/IES RP-16-10 (nomenclature and definitions)
- IES LM-79-08 (SSL photometry)
- IES LM-80-08 (measuring lumen maintenance of LED light sources)
- IES TM-21-11 (projecting lumen maintenance of LED light sources)
- ANSI_NEMA_ANSLG C78.377-2011 (SSL chromaticity specifications)
- IES LM-82-12 (photometric testing of LED lamps and light engines as a function of temperature)
- NEMA SSL-1 (LED drivers)
- NEMA SSL-4 (Performance of LED Lamps)
- NEMA SSL-6 (dimming LED lamps)
- UL 1598C (LED retrofit kit safety)

Safety

- UL 8750 leading to CSA 250.13
- FCC CFR part 15 and ICES 003
- *IEEE P1789*

What additional standards/Specifications are needed?

EG, upgrade of ANSLG C82.77

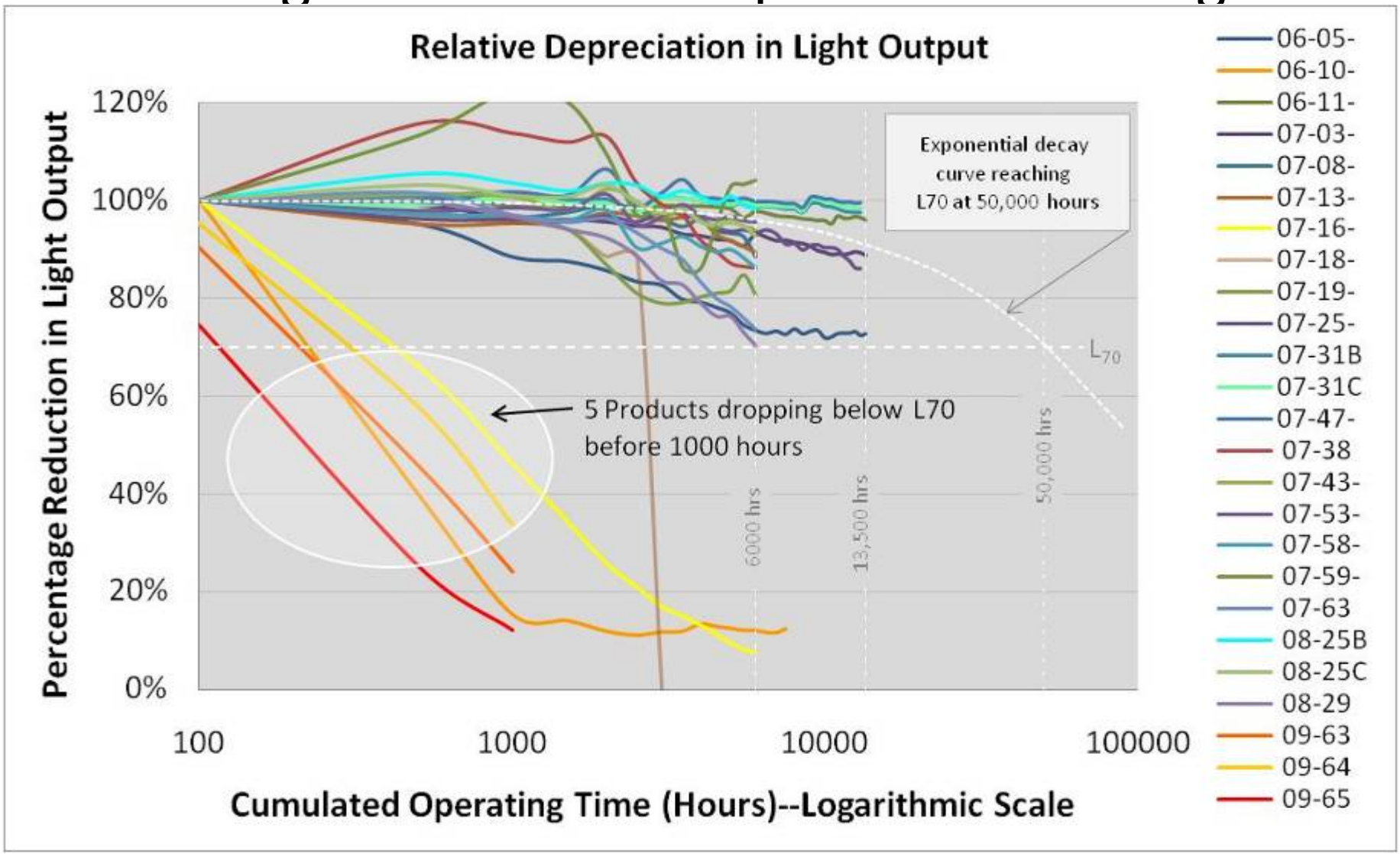
IES LM 79 (Luminaire photometric testing)

- **Reproducible measurements** of total luminous flux, electrical power, luminous intensity distribution, and chromaticity, of solid-state lighting (SSL) products for illumination purposes, under **standard conditions**
- Uses **Absolute photometry** wherein the absolute luminous intensity distribution of a luminaire is measured without separate measurement of the lamps (LEDs).
- Covers LED-based SSL products incorporating control electronics and **heat sinks** requiring only line voltage or DC power supply, SSL **luminaires** (fixtures incorporating light sources) as well as integrated LED lamps
- Does ***not*** cover SSL products requiring **external operating circuits** or **external heat sinks** (I.e. LED chips, packages, and modules or fixtures designed for SSL products **sold without a light source**

IES LM-80 Lumen Depreciation Testing (packages, modules)

- Addresses the **measurement of lumen maintenance testing** for LED light sources designed and certified to meet lighting industry standards
- Describes the **procedures** by which LED light sources can be operated under controlled conditions to obtain optimally comparable data on changes in light output during the life of the lamp
- Covers the measurement of lumen maintenance of inorganic **LED-based packages, arrays and modules**
- Does not attempt to induce any failure modes other than the maintenance of lumens

Long-Term Lumen Depreciation Testing



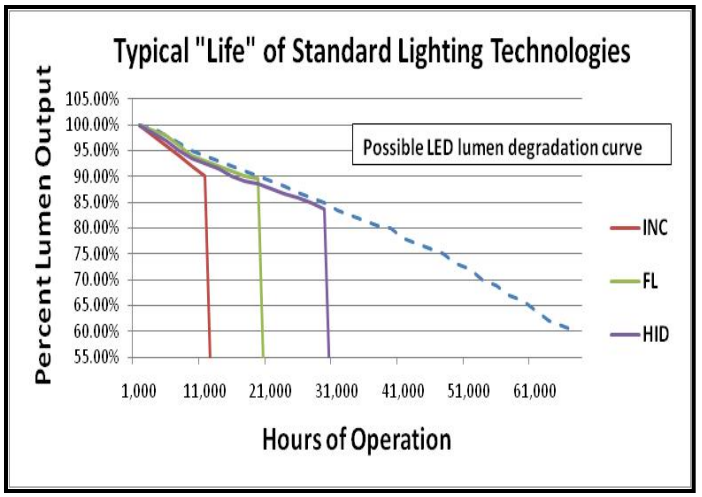
IES TM-21 or How does a LED manufacturer predict LED life

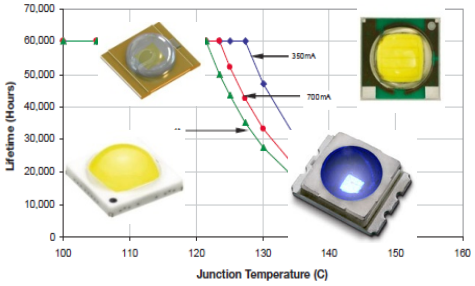
- Good question!
- Remember, LM80 only provides a procedure for measuring LED light output, not for predicting life

IES TM-21 and Lumen Maintenance

- TM-21 **does not** determine traditional life or "time to failure" of an LED Lighting system
  - The useful life of an **LED system** has many components that need to be considered (lamp, driver, lens, etc.)
  - LEDs degrade (like all light sources) but for potentially very long periods of time. Instead of outright failure, LEDs will eventually dim to a point that is too low to serve their purpose
- TM-21 **does** project the lumen maintenance of an **LED source** (package/array/module) using an algorithm

  ….. Which can then be used to project the expected lumen output of the source as part of a system (fixture)





IES TM-21 and Lumen Maintenance

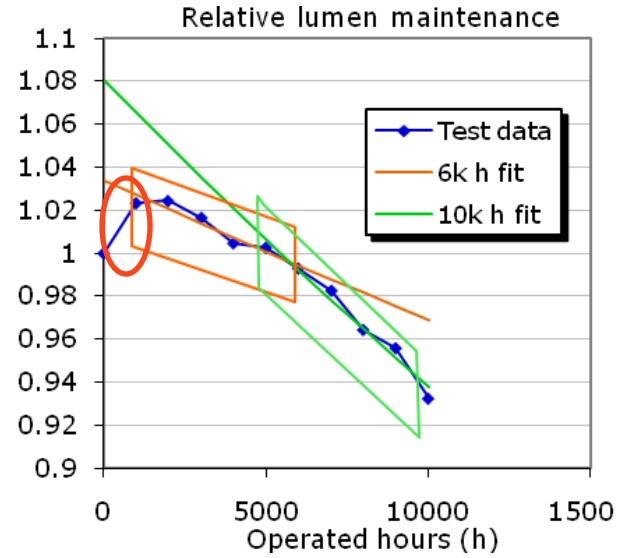
- Initial data variability (i.e., "hump") is difficult for models to evaluate (0-1000 hr)
- Later data exhibits more characteristic decay curve of interest
  - Verification with long duration data sets (>10,000 hr) shows better model to reality fit with last 5,000 hours of 10,000 hour data
- For 6,000 hours of data (LM-80 minimum) and up to 10,000 hours: Use last 5,000 hours
- For > 10,000 hours: Use the last ½ of the collected data

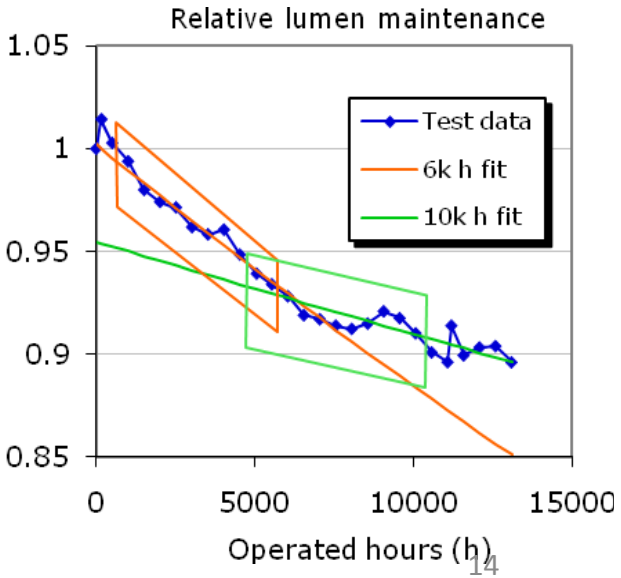
L_{70}(6k) = 34000 hours for 6000 hours test data

L_{70}(10k) = 51000 hours for 10000 hours test data

L_{70}(6k) > 36000 hours for values with the 6 times rule applied

L_{70}(4k) = 4400 hours for value reached experimentally





ANSI C82.377

- This standard **specifies the range of chromaticities** recommended for general lighting with Solid State Lighting (SSL) products, as well as to ensure that the white light chromaticities of the products can be communicated to consumers.
- This **standard applies to LED-based SSL products** with control electronics and heat sinks incorporated--that is, those devices that require only AC mains power or a DC voltage power supply to operate.
- This document **covers fixtures** incorporating light sources as well as integrated LED lamps
- This document **does not cover**
  - products that require external operating circuits or additional external heat sinks
  - fixtures sold without a light source.
  - SSL products for outdoor applications.
  - SSL products for some indoor applications that intentionally produce tinted or colored light

NEMA SSL – 1, ELECTRONIC DRIVERS FOR LED DEVICES, ARRAYS, OR SYSTEMS

- Provides specifications for and operating characteristics of non-integral electronic drivers (power supplies) for LED devices, arrays, or systems
- However, the driver generally is or contains the weakest link in the luminaire system – electronic components and the electrolytic capacitor.
- Electronic components and heat
- +10º C = life/2

Weakest part of a LED product

IEEE P1789 - Recommended Practice of Modulating Current in High Brightness LED's for Mitigating Health Risks to Viewers

- ***Under development*** – estimate mid-late 2013 publish date
- There are no standards or recommendations on safe modulating frequencies for LEDs. Suggested driving frequencies range from very low to high frequencies. Past work has shown that modulation at low frequencies can cause health related problems, such as headaches, eye strain and epileptic seizure.
- The detrimental effects depend on factors such as brightness, angle of viewing, wavelength, depth of modulation, among others. The purpose of this standard is to 1) describe some possible health risks, such as **headaches, eye strain and epileptic seizure**, associated with low frequency modulation of LEDs in different applications and 2) provide recommended practices to aid design of LED driving systems to modulate at safe frequencies for their particular applications in order to protect against the described health risks.
- **CONCERNS**
  - **General Lighting – extended exposure**
  - **Street & Area Lighting include impact on drivers/passengers and on people in residences**

EPA Energy Star – Luminaires
CSA C866 (similar to Energy Star)

Version 1.1 - ENERGY STAR Product Specification for **Luminaires**

Voluntary – 36 pages. Published last year

- Photometric Performance Requirements.
- Electrical Performance Requirements
- Thermal Performance Requirements
- Safety Requirements
- Product Labeling & Packaging Requirements
- Lighting Toxics Reduction Requirements: Directional and Non-Directional Luminaires
- Warranty Requirements: Directional and Non-Directional Luminaires

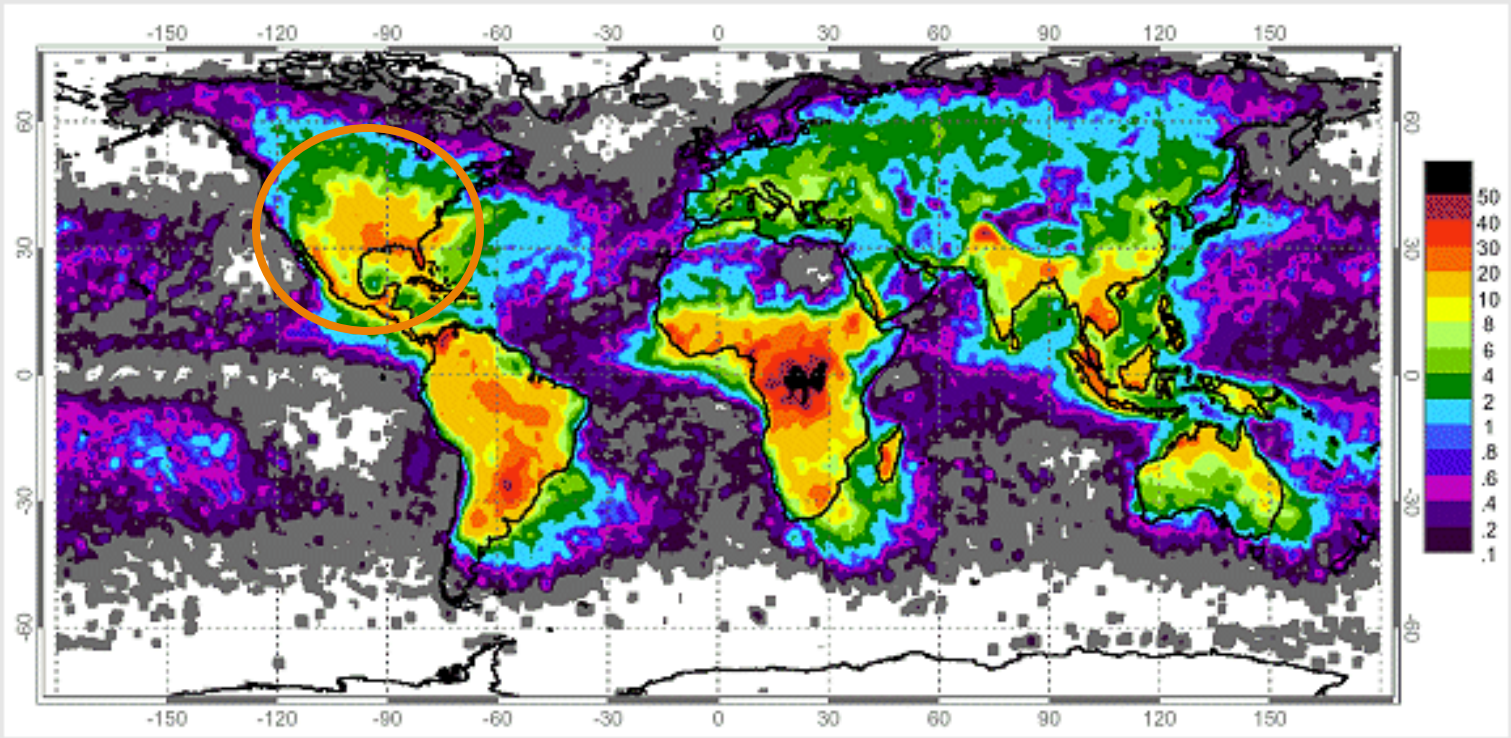
EPA Energy Star – Lamps
CSA C871

CSA 871 will use NEMA SSL4 as baseline and ES as high performance

Energy Star DRAFT 2 - Version 1.0 ENERGY STAR Product Specification for **Lamps** - Voluntary - 53 pages. Target for publishing – Q213 (maybe)

- Contains lamp requirements for
  - Beam spread
  - Color
  - Life
  - Lumen depreciation
  - Efficacy
  - Stress testing
  - Electrical
  - Dimming
  - Labeling
  - Warranty

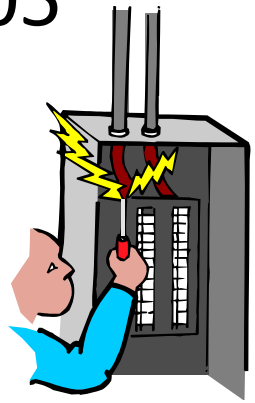
Whoops – another potential issue with LED Street and Area Lighting



Above: Data from space-based optical sensors reveal the uneven distribution of worldwide lightning strikes. Units: flashes/km^2/yr. Image credit: NSSTC Lightning Team.

US Safety standards

- UL 8750/CSA 250.13
- UL 1598/CSA250
- FCC part 15/ICES 005



UL 8750 Light Emitting Diode (LED) Equipment for Use in Lighting Products (Canada C250.13)

- **"Voluntary"** Safety requirements for LED equipment that is an integral part of a luminaire or other lighting equipment and which operates in the visible light spectrum between 400 – 700 nm
- Requirements **also cover the component parts** of light emitting diode (LED) equipment, including LED drivers, controllers, arrays, modules, and packages as defined within this standard
- These lighting products are intended for installation on branch circuits of 600 V nominal or less in accordance with the National Electrical Code (NEC), CEC, ANSI/NFPA 70, and for connection to isolated (non-utility connected) power sources such as generators, batteries, fuel cells, solar cells, and the like
- Requirements in this standard are intended to supplement those in 12 other UL end-product standards including UL1598

UL 1598/CSA 250/NMX-J-307/1-ANCE

- **"Voluntary"** Standard for Safety for Luminaires – 304 pages
- This Standard applies to luminaires for use in non-hazardous locations and that are intended for installation on branch circuits of 600 V nominal or less between conductors
- Covers Incandescent, HID, Fluorescent, and SSL luminaires
- Similar to IEC 598
- Also covers safety for LED retrofit kits in UL 1598C

UL 1598(C) different than CSA TIL B79

1.1 These requirements **apply to light-emitting diode (LED) retrofit luminaire conversion kits** that are intended to replace existing light sources and systems in previously installed luminaires that already comply with the requirements in the Standard for Luminaires, UL 1598. The kits are intended for use on:

- a) Luminaires where specific luminaire model or part numbers are identified in the kit installation instructions; or
- b) One or more generic type luminaires that meet specific criteria identified in the installation kit instructions.

1.2 This standard contains requirements that supplement the luminaire requirements contained in the Standard for Luminaires, UL 1598 that apply to the retrofit kit and the luminaire.

1.3 LED retrofit kits covered by these requirements include but are not limited to LED lamps and arrays, LED control modules, LED drivers, LED power supplies, wiring, lampholders, brackets, wire connectors, reflectors, diffusers, and other associated mechanical, electrical, or optical devices.

1.5 This standard **does not cover luminaire conversion lamps that are intended to replace existing lamps without any modification, rewiring, or component replacement in the luminaire other than direct replacement of the lamp using the existing lampholder**.

CSA Temporary Information Letter TIL B79

LED T8 replacement lamps

- This T.I.L. extends the scope of requirements published in TIL No. 64 to include products employing
- light-emitting-diode (LED) lamp technologies, with or without a driver or power supply, intended for
- direct connection to the mains or to a lamp holder. These LED kits may consist of parts and/or
- subassemblies intended for field installation in Field Installed Luminaires.
- The LED devices or kits are evaluated such that they will not adversely affect the operation of the complete unit when used in accordance with the manufacturer's instructions.

FCC Part 15/ICES 003

- **Mandatory** per US and Canadian governments
- Covers conducted and radiated EMI and EMC
- Somewhat similar to CISPR 15 (IEC and Europe)
- FCC/ICES practice faster and less costly than IEC

Zhaga standard

- Lighting industry used to standardized light sources, but LED engines are not
- Zhaga promotes interchangeability of LED light engines by specifying interfaces
- Zhaga specs to be limited to mechanical, thermal, photometric, electrical interfaces
- Initially voluntary, but will submit spec to IEC for standardization
- Both US and Europe expected to adopt as standards

Twelve Questions you or your customer should ask in Specifying LED Products

1) Is your LED supplier a reliable company? How do you know?
2) Has your supplier provided an IESNA LM-80 test report from an accredited laboratory?
3) What is the operating temperature range specification and what is the maximum junction temperature
4) What is the expected L_{70} lifetime of the fixture? How was it calculated – TM 21 or?
5) Can the manufacturer supply an IESNA LM-79 test report from an accredited laboratory as well as an .ies data file?
6) What are the delivered lumens and lumens per watt (LPW) of the fixture?

Twelve Questions you or your Customer should ask in Specifying LED Products

7) What is the chromaticity of the fixture in the ANSI C78.377A color space and is it stable over time? How do you know?

8) Does the color of the light output vary from fixture to fixture or in different spatial locations for a single fixture?

9) What is the power factor of the fixture? How much power does it consume in the "off" state (s/b one watt or less)?

10) Have you applied for the EPA Energy Star or Design Lights Consortium listing?

11) Is the fixture lead-free, mercury-free and RoHS compliant?

12) What is the warranty and do you have the means to stand behind it?

Where to get lighting standards

- ANSLG and NEMA standards are available for purchase at http://www.nema.org/stds/
- IESNA standards are available for purchase at http://www.ies.org/store/
- UL standards are available for purchase at http://www.ul.com/global/eng/pages/corporate/standards/
- CALiPER Reports and test results *www.ssl.energy.gov/caliper.html*
- *CSA standards are available for purchase at http://shop.csa.ca/en/canada/products/icat/publications/*
- IEC standards are available for purchase at http://webstore.iec.ch/
- CIE standards are available for purchase at http://www.cie.co.at/index.php/Publications

Thank You
are there any questions??????

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