The “Standard” Update…

What’s new in the world of standards and test methods!

2017 Standards Updates

American National Standards Institute

Horticulture

Illumination Engineering Society

Flicker

Other

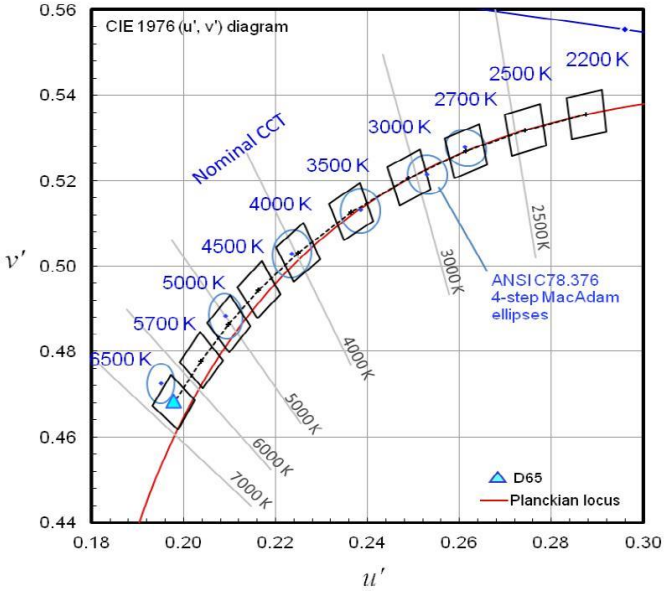
Metrics… Standards… and Test Methods

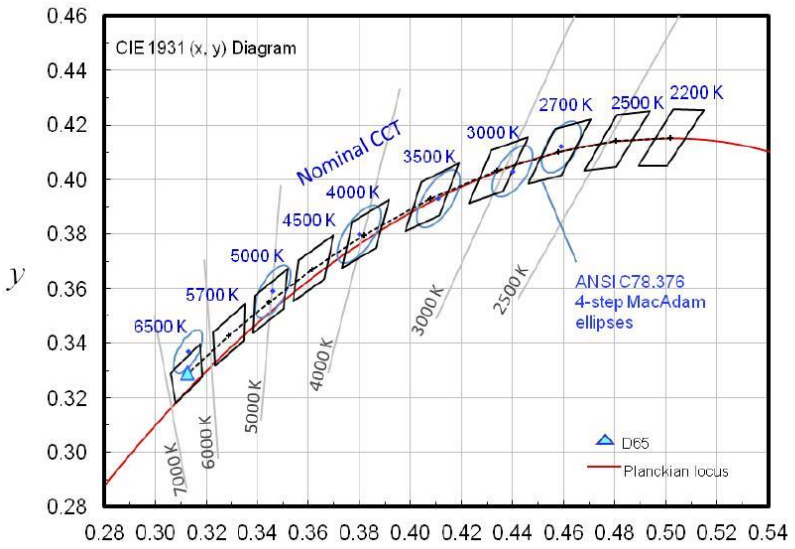
- Metrics are the language of measurement
- Common metrics are valuable to have comparable testing
- **It is hard to have a good conversation when we aren't speaking the same language!**

ANSI Standards: ANSI C78.377

ANSI C78.377: Electric Lamps - Specifications for the Chromaticity of Solid-state Lighting Products

- Contains ANSI Quadrangles for Chromaticity “bins”
- Primary Changes for the Updated Version
  - 2200K and 2500K CCT quadrangles added
- Also adds 4 step quadrangles and u’,v’ circles for consistency





ANSI Standards: ANSI C136.48

Remote Monitoring and Control for Roadway and Area Lighting Equipment

C136 Series addresses Roadway Lighting

- C136.48 addresses the minimum requirements that should be in place for Remote Monitoring Systems
- In development for several years
- Required for the V2.0 of the Networked Lighting Controls (for outdoor)
- Why?
  - A system needs a lot to work together
  - Remote lighting monitoring systems may need to work with other systems
  - Potential to improve:
    - Energy usage
    - Safety
    - Maintenance costs

ANSI Standards: ANSI C137.1

ANSI C137.1 is a standard in development for Analog Dimming:

- Based on 0-10V controls specified in C82.11 Annex A
- Covers LED Drivers, Fluorescent Ballasts, and Dimming Controls
- Adds a Standby / Electronic Off
  - No output, but still “listening” for electronic communications
  - Entered when signal is below 0.5V
- Adds specifications for Dynamic Response and Start Time
- Limits Voltage Drop to 0.3V for uniform operation
- Consistency for use of 0-10V systems

ANSI Standards: Other Potential Standards

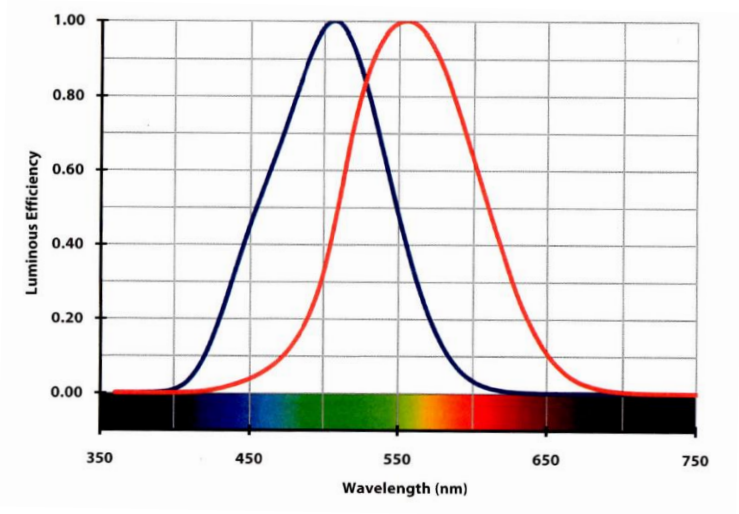
Proposed Standards:

- For Roadway and Area Lighting Equipment—Revenue Grade Energy Measurement within a Locking Type Control Device (C136.50)
- For Roadway and Area Lighting Equipment—LED Drivers with Integral Energy Measurement Means (C136.52)
- Occupancy Sensors For Roadway and Area luminaires (C136.54)
- Cybersecurity Requirements for Lighting Systems and Parking Facilities (C137.2)
- For Lighting Systems— Minimum Requirements for installation of Energy Efficient Power over Ethernet (PoE) Lighting Systems" (C137.3)

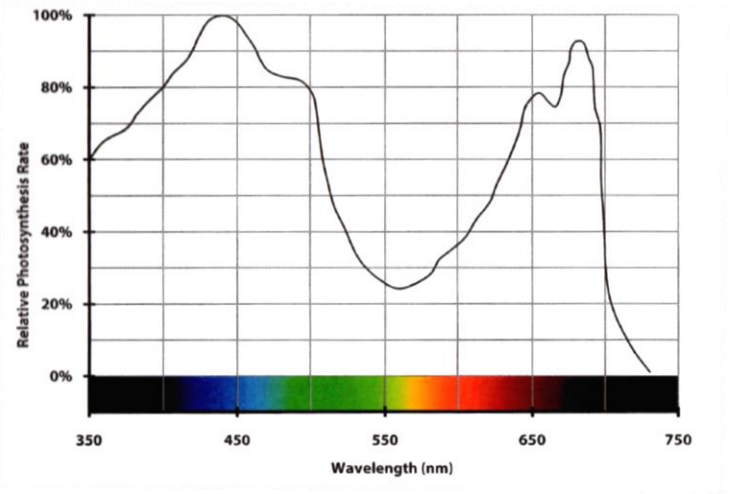
Horticultural Lighting Standards and Test Methods

Horticultural Lighting: Metrics

- Familiar metrics are all geared towards the human eye response
  - Lumens, Candela, Lux, CCT, CRI
- Human eye response is focused in the green and yellow areas, drops off for red and blue



IES Handbook 10th Edition



IES Handbook 10th Edition

- Plants absorb radiation through photosynthesis
  - And other mechanisms
- Photosynthetic radiation absorbs strongly in the deep blue and red spectrums
  - But not only in these spectrums

ASABE Documents – IN DEVELOPMENT

X640 – Definition of Metrics of Radiation for Plant Growth (CEA)

- Foundation document
  - Definitions are key to developing standards
  - Includes Quantities and Units
- Notable Metrics:
  - Photosynthetically Active Radiation (PAR) – Already a common metric, considers radiation that is used for photosynthesis, from 400 to 700 nm, in Watts
  - Photosynthetic Photon Flux Density (PPFD) – PAR photon rate per unit area on a surface
  - Daily Light Integral – PPFD integrated over a 24 hour period, influenced by operating time
  - Far-Red range – light in the 700 nm to 800 nm range
  - UV range – light in the 100 nm to 400 nm range
    - Realistically, UV-C is largely filtered out from sunlight by the atmosphere, so the general area of interest is 280 nm to 400 nm

ASABE Documents – IN DEVELOPMENT

X642 - Recommended Methods For Measurements and Testing of LED Products for Plant Growth and Development

- Covers a wide range of products, but only related to LED
  - LED packages / arrays / modules
  - LED lamps
  - Other LED Radiation Devices
- Test Methods are largely based on existing industry methods
  - References LM-58, LM-79, LM-80, LM-84, LM-85, TM-21, TM-27, TM-28, and others
- Consideration to use conditions for horticulture
  - Humidity
  - Temperature
- References appropriate metrics

ASABE Documents – IN DEVELOPMENT

X644 – Performance Measures of Lighting Systems for Plants

- Considers Device Level and Installed Performance
- Definitions
  - Photon Flux Distribution
  - Spectral Photon Distribution
  - Thermal Load
  - Phytochrome Photoequilibrium Value
  - Weighted Photon Flux
- Considers many aspects:
  - DLI
  - PAR
  - Mounting height / area
  - Uniformity
  - Power quality

UL Safety: Horticultural Lighting

- **UL 8800 - Outline of Investigation for Horticultural Lighting Equipment :**
  - Published on May 4, 2017
  - Next step to develop into a Standard – Estimated timeframe of 1 year
  - Covers Luminaires, Lampholders, LED Packages, ballasts/drivers, lamps, wire harnesses, plugs, connectors, and structures associated with lighting
  - **Plans to make the first edition of the Standard available in an IEC format**
- **Key Safety requirements for:**
  - Installation instructions
  - Environmental ratings – temperature, humidity, water and dust
  - Eye safety considerations (photobiological safety evaluation)
  - Polymeric materials (UV rated)
  - Electrical connections- Cords and plugs

Illumination Engineering Society Documents

Illumination Engineering Society: The IES

Many documents are being updated… what are they?

- **LM – Lighting Measurement Methods**
- **TM – Technical Memorandum**
- RP – Recommended Practice / Standard Practice
- DG – Design Guide
- G – Guidelines
- LEM – Lighting Energy Management
- H - Handbook

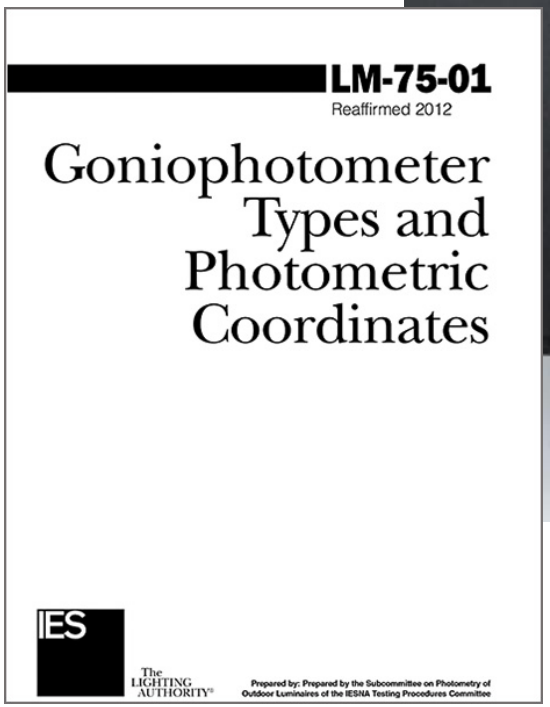
Updates not limited to LED:

- Roadway / Area Lighting Fluorescent and HID
- Fluorescent Lamp Measurement
- Uncertainty

IES Documents: REVISION IN DEVELOPMENT

IES LM-75 – Goniophotometer Types and Photometric Coordinates

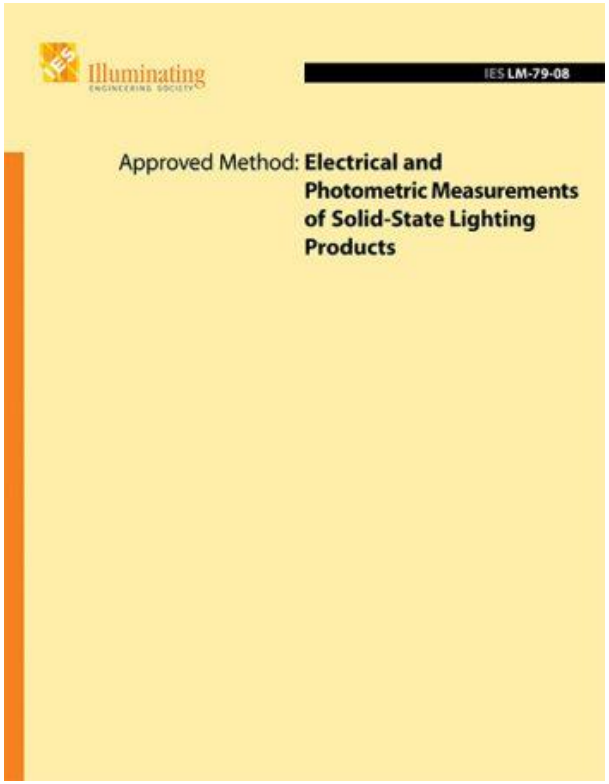
- In works for several years
- General guide to goniophotometry
- Intended to be referenced by other standards
- Updating format to current LM
- Expanding information about use
  - Goniophotometers
  - Goniocolorimeters
  - Goniospectrometers
- Stray Light Concerns?
  - Moving to applicable documents



IES Documents: REVISION IN DEVELOPMENT

IES LM-79 –Test Methods for SSL Products

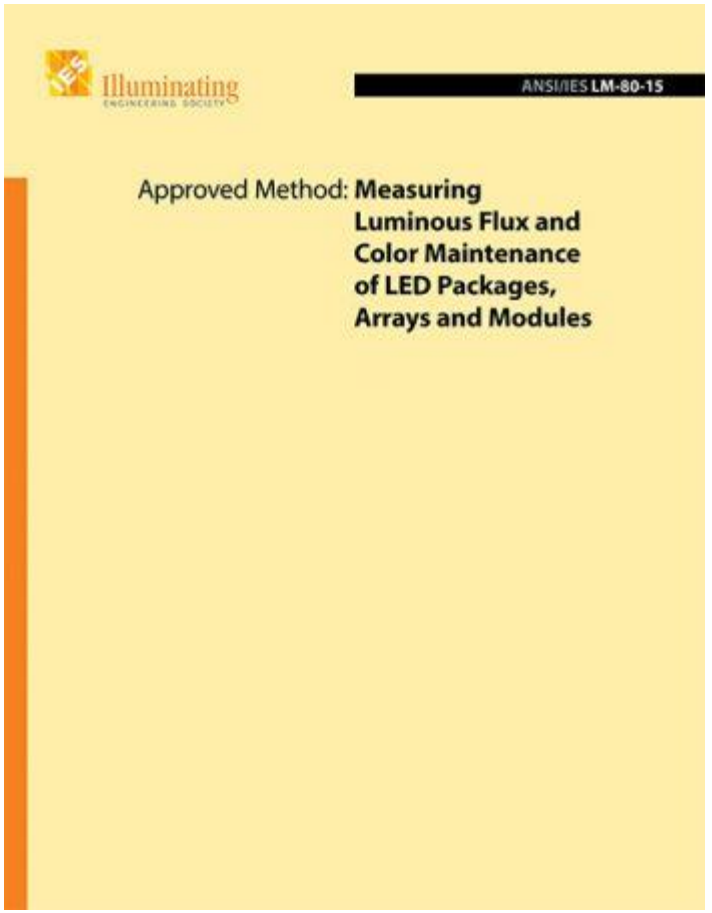
- Document update
- Addressing issues found in use
- May include informative annexes
- Potential areas of improvement
  - Chromaticity Uniformity
  - High Frequency
  - Power Supply Characteristics
  - Measurement Uncertainty



IES Documents: PUBLISHED

IES LM-80-15 – Lumen and Color Maintenance of LED Packages / Arrays / Modules

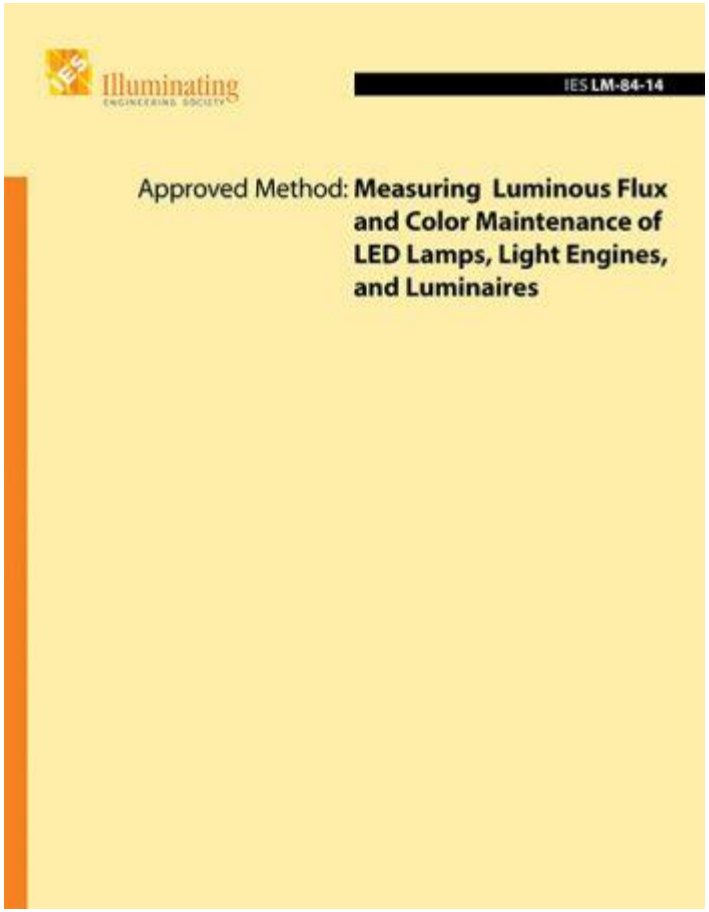
- Now an ANSI Standard
- Incorporated Addendum A
  - Must have consistent measurement intervals
  - May impact usability of some manufacturers LM-80
- Reduced to 2 required case temperatures
- Addresses PWM, DC, and AC



IES Documents: REVISION IN DEVELOPMENT

IES LM-84 – Lumen and Color Maintenance of LED Lamps, Light Engines, Luminaires

- Been around for a few years
- Mainly an option for products w/o LM-80
- Considering revision to:
  - Perform minor updates and revisions
  - Include radiant / photon flux references



IES Documents: IN DEVELOPMENT

IES LM-87 / TM-3x: LED Robustness Testing

- Potential document
- Differs from LM-80 as addresses overall robustness, not lumen maintenance
- Started as an LM, re-written as a TM
- Early in the development phase

IES LM-89: LED Lamp/Luminaire Robustness Testing

- Similar to IES LM-87 / TM-3x but for end use products

Why?

- Is Lumen Maintenance the only failure mechanism?

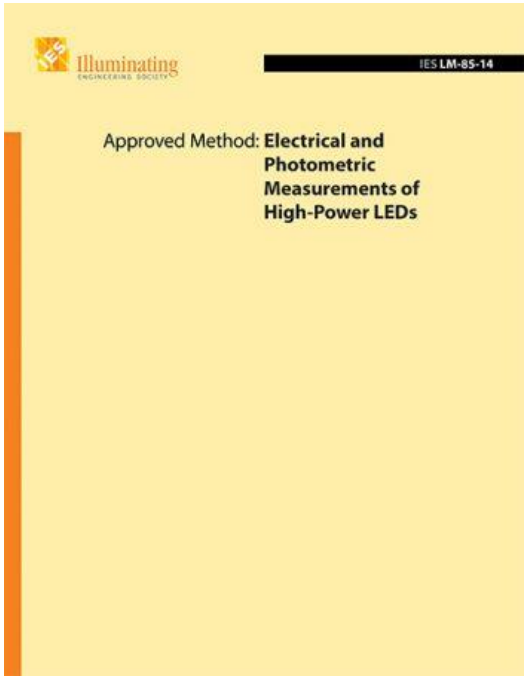
IES Documents: IN DEVELOPMENT

IES LM-85: High Power LED Measurements:

- Published in 2014
- Modification to add LED Arrays into the scope
  - Likely an Addendum

IES LM-88: AC LED Measurements:

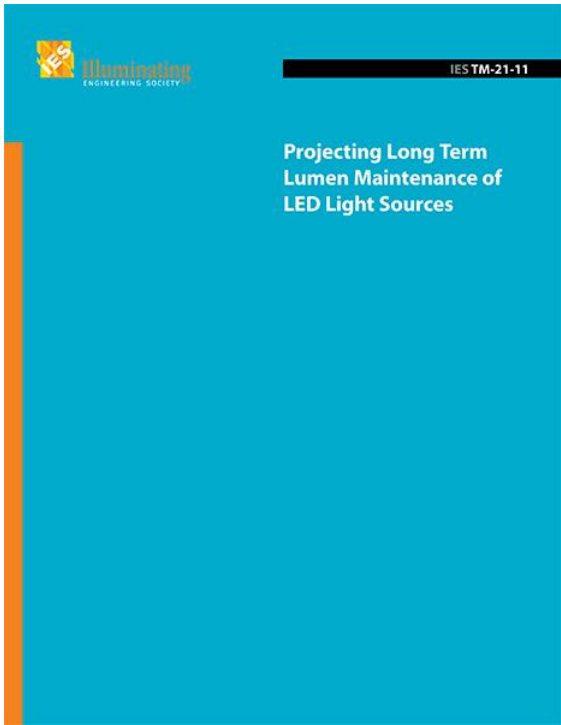
- Similar to LM-85 (High Power LED Measurements)
- LED Package / Array level measurements
- Repeatability of AC LED measurements
  - Temperature
  - Time
  - Wave



IES Documents: Revision

IES TM-21 – Lumen Maintenance Projection of LED Packages / Arrays / Modules

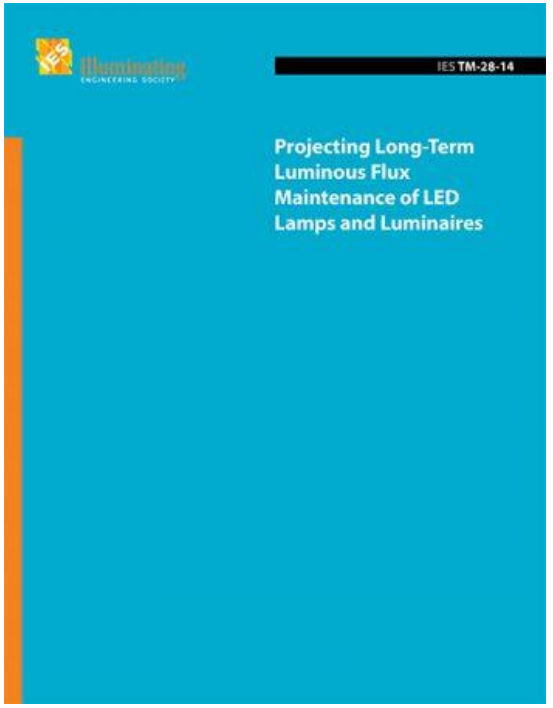
- Very important document to industry
- Working on major revisions
- Potential for current interpolation in addition to temperature
  - In mathematical model development
- Annex with methodology possible



IES Documents: Revision:

IES TM-28 – Lumen Maintenance Projection of LED Lamps / Luminaires

- LED Light Engines not currently in scope
  - Not significantly different than a lamp in definition
- Revision being considered for scope expansion



IES Documents: Published

IES TM-30 – Light Source Color Rendition

- Published a few years ago (2015)
- Attempts to improve on CRI
  - Uses more color samples for comparison
  - Includes graphical representations of color space and hue

- Dual Metric rather than a single metric
  - Rf – A fidelity metric which refers to how closely colors are rendered
  - Rg – A metric considering the gamut area that a product can generate.

- NOT directly comparable to CRI

IES Documents: IN DEVELOPMENT

IES TM-31 – Color Maintenance Projection

- Acknowledging additional failure criteria
  - If a product still produces the right lumens, but the light has shifted CCT significantly… is this a failure?
- **YES**
- Color shift is a problem, and can make a product unsuitable while still having reasonable lumen maintenance
- Models attempting to account for 2 major deteriorations:
  - Die Shift Mechanisms
  - Phosphor Shift Mechanisms

IES Documents: DRAFT

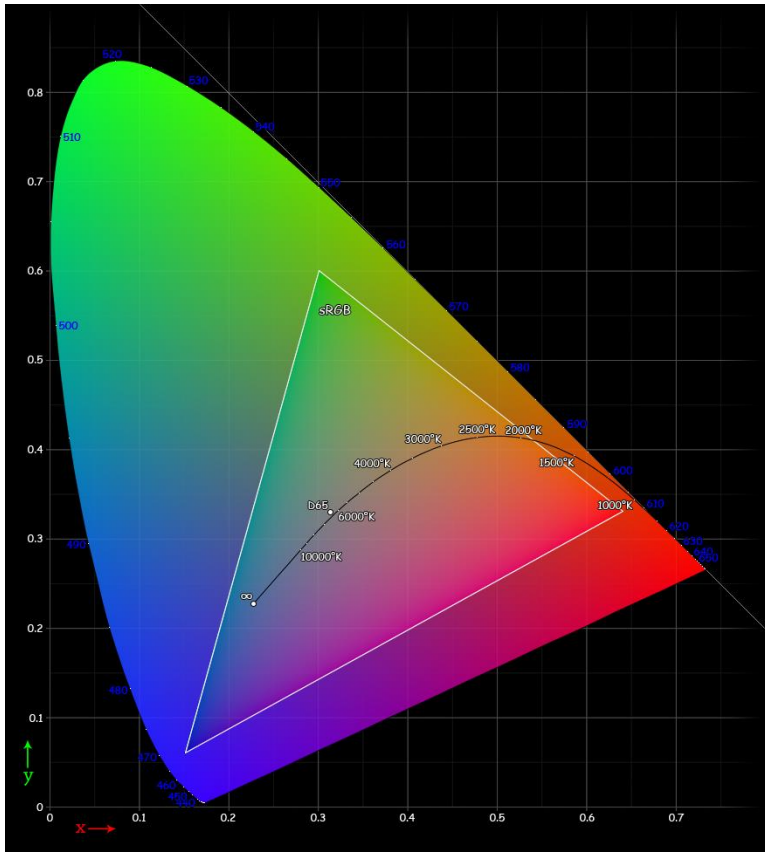
IES TM-32 – Variations in LED Packages, Arrays and Modules Know to Affect Flux and Color Maintenance

- Recently approved by Board of Directors as TM-32
- Intent is similar to the ENERGY STAR Lumen Maintenance Guidance
- Applies to LED packages, arrays and modules
- In depth exploration from die to package to phosphors
- Intended as a guide to LED manufacturers, end use product manufacturers, and specifiers to determine when LM-80 data should apply (e.g. when an LED used in a product should have the same or better performance than the tested model)

IES Documents: DRAFT

IES S0416 – Recommendations for Testing Color Tunable SSL Products

- In the early stages
- Challenge with Color Tunable LEDs: How to describe what they can do?
  - RGB color tuning
  - RGBA color tuning
  - RGBW color tuning
  - CW-WW color tuning
- Other challenge: What points do you test?
  - Infinitely tunable = infinite number of test points
  - Nobody wants to test infinitely



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IES Documents : Flicker / TLA

IES S0421 – Method of Measuring and Quantifying TLA

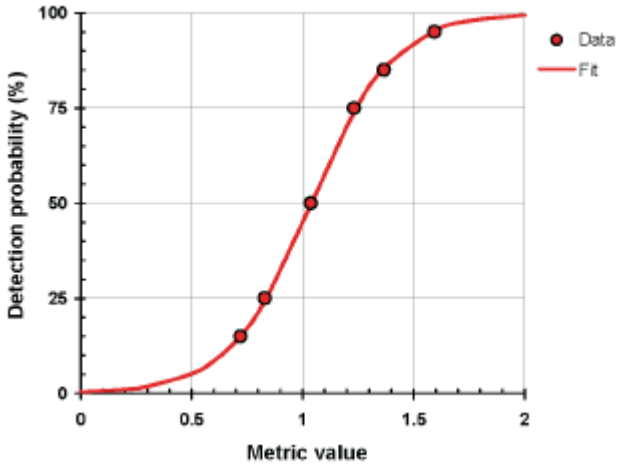
- Currently in Working Group
- Progress is moving quickly
- Scope: Measuring between 1Hz and 3000Hz
- Currently includes:
  - Definitions
  - Test Conditions
  - Test Equipment
  - Data Calculations
  - Reporting Requirements
  - Uncertainty
- Acknowledges current documents regarding flicker…

Flicker Metrics and Test Methods…
So many efforts…

Flicker: ASSIST Recommends Flicker Metric

ASSIST Recommends Flicker Metric:

- Developed by Lighting Research Center
- Applies to direct perception (only)…
  - Up to 100Hz only
  - Does NOT account for stroboscopic effects
- Accounts for Frequency and Modulation (Percent Flicker)
  - Ideal sampling is 10x oversampling, so 1000Hz sampling rate is recommended
  - 2 second minimum sampling record
  - Frequency interval of 0.5 Hz
- Uses multiple functions:
  - Fourier Transform
  - Applies Weber Temporal Contrast
  - Applies Perceptual Sensitivity Weighting
  - Combines frequency components.
- **Provides a Probability % of Detection**



From ASSIST Recommends Flicker Metric

Flicker: NEMA 77

NEMA 77: Temporal Light Artifacts: Test Methods and Guidance

- Developed by lighting manufacturers
- Includes:
  - Definitions
  - Background
  - Comparison of existing metrics and technologies (including ASSIST)
- Similar (but not identical) to ASSIST in 0-80Hz range
- Adds higher frequency to address stroboscopic effect
- References NEMA SSL-7
  - Includes Maximum (130), Minimum (40) and Intermediate (90) conduction angles
- Includes Matlab / Octave software to help calculation consistency
- Does not recommend levels

Flicker: California JA10

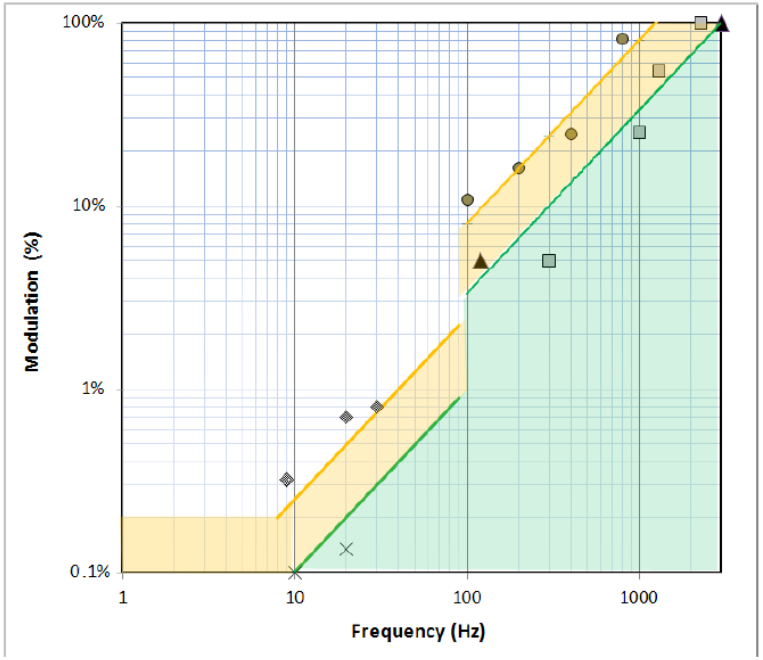
California JA10: Test Method for Measuring Flicker of Lighting Systems

- Includes equipment requirements
- Requires pairing of products with dimmers
- References NEMA SSL-7 for dimmers
- Includes any ballast or transformer if necessary
- Tested at
  - 100% output
  - 20% output
  - Minimum dimming level
- Evaluated at 40Hz, 90Hz, 200Hz, 400Hz, and 1000Hz cutoff frequencies

Flicker: IEEE 1789

IEEE 1789: Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

- Based on evaluation of research documents
- Focused on the health risks, not visibility
  - Does a fair job of avoiding visible flicker as well
- 2 different levels specified:
  - Low Risk
  - No Effect
- Conservative approach to flicker
  - Some controversy
    - Incandescent may not meet
  - References percent flicker



Flicker: IEC Efforts

IEC 61000-3-3:

- “Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems”
- Obviously focused on power quality first…

IEC / TS 61000-4-5: From 2012… but referenced in more recent docs

- Testing and Measurement Techniques – Flickermeter – Functional and Design Specifications
- Describes flickermeter measuring apparatus and flicker peception level (Pst and Plt)
- Focuses on Voltage Fluctuation Immunity
- No tolerance levels for severity

Flicker: IEC Efforts

IEC TR 61547-1:

An objective voltage fluctuation immunity test method

- Describes flicker meter use for immunity against voltage fluctuations
- Eliminates the incandescent bulb, uses equations for eye-brain model, but still compares flicker equivalency to that of incandescent
- No tolerance levels for severity
- Edition 2 under development, to include testing with dimmer

IEC/TR 61XXX: (In Development)

- Equipment for general lighting purposes - Objective Test Method for Stroboscopic Effects of Lighting Equipment
- Does not intend to set any limits
- Testing to be performed at 100% of light output and 50% of light output
- NEMA SSL7A and IEC TR 63036/63037 considered applicable

Flicker: CIE TN 006:2016

Visual Aspects of Time-Modulated Lighting Systems – Definitions and Measurement Models

Published as a Technical Note:

- Short summary technical paper
  - High Level
- Includes:
  - Terms / Definitions
  - Capturing Waveforms
  - Example Embodiments (ways to represent):
    - Stroboscopic Visibility Metric
    - Phantom Array Effect Visibility Metric
    - Short Term Flicker Severity
  - Recommendations for future work
    - Additional sensitivity work
    - Quantification of phantom array effect
    - Repeatability / reproducibility

Other Standards and Research Works of Interest

IOT Ready Alliance

Alliance of Organizations Creating Standard for IOT Luminaires

- IoT – Internet of Things
  - AKA Connected
  - AKA Smart
- Includes:
  - Lighting Manufacturers
  - Building Management
  - IoT Companies and Organizations
- Why?
  - Need for consistent sensor interface
  - Allows for easier integration of sensors and systems
  - Ability to upgrade or change sensors
    - Future proofing

Non-Visual Effects of Lighting

- Research being published on light effect on humans:
  - Intrinsically Photoreceptive Retinal Ganglion Cells
    - Cells not tied to visual system
  - Circadian Rhythm Effects
    - Melanopsin Suppression
    - Impact on Alertness
  - Standards far off
  - Moral Implications of this:
    - Just because we can impact behavior with lighting, should we?

Conclusions and Questions

- Standards and Test Method Development Continues at a Rapid Pace
- Attention turning towards different areas:
  - Non-Visual Aspects
  - Wider Systems Compatibility
  - Remote Control and Monitoring