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Are current photometric tests for incandescent lights valid for LEDs?

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and 13-G-009

LRC and Aviation Lighting Research



Aviation Lighting Research at the LRC

Human Factors

- Color Vision Status and LED Identification
- Signal Light Brightness
- Perception of Linear Lighting
- Effective Intensity of Flashing Lights
- Stroboscopic Effect Perception
- Requirements for LED Runway Guard Lights
- Specifications for Remote Airfield Lighting

Solid State Lighting Technology

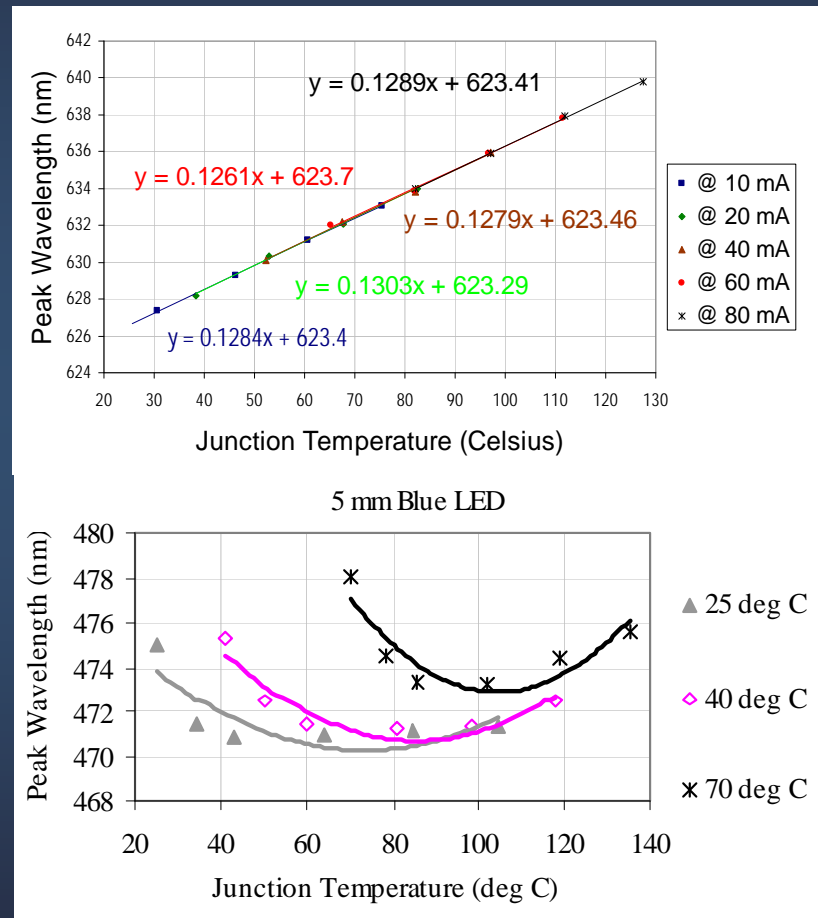
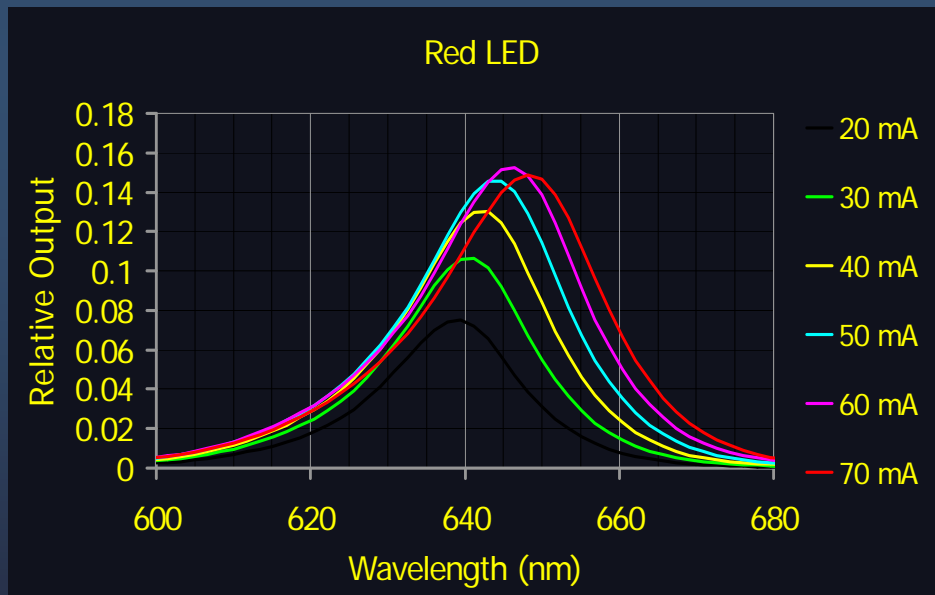
- Heat Transfer in Taxiway Edge Lights
- Life Testing for Airfield Lighting Fixtures
- Solar-Powered LED Fixtures
- Volatile Organic Compound Effects in LEDs
- LED Driving Circuitry and Flicker
- Photometric Testing for LED Fixtures
- Electrical Infrastructure Research Team Support
- Phosphor-Converted Amber LEDs
- Evaluation of Alternating-Current LEDs
- LED Electrical and Thermal Parameters Under Stress

Background

- ◆ LED aviation signal lights are being increasingly considered for airfield lighting applications. Photometric tests of LED based systems are conducted using existing test procedures that were developed for incandescent lamp based systems.
- ◆ But, are these photometric test methods appropriate for LED as well?
- ◆ Funded by the Federal Aviation Administration the Lighting Research Center (LRC) reviewed several Advisory Circulars and have proposed several recommendations for changes when testing LED systems. These changes were mainly in three sections: **life testing, test temperatures and temperature measurement points, and photometric test procedures.**

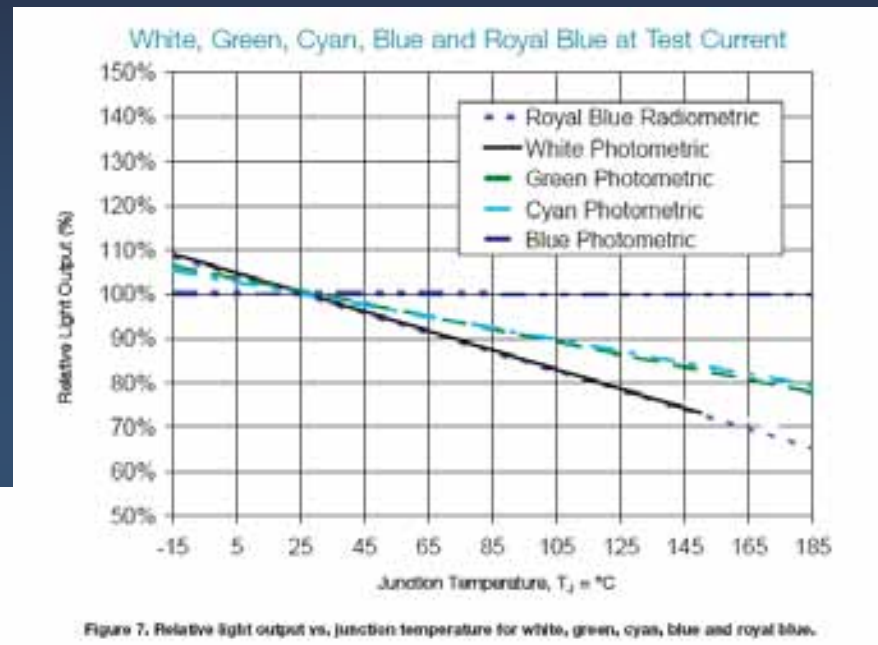
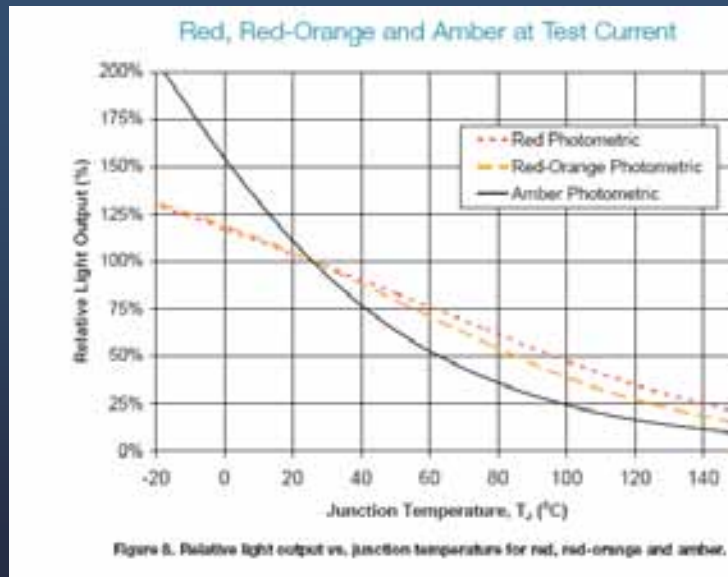
Short-term effect of heat at the junction

- ◆ Peak wavelength shifts with changes in junction temperature



Short-term effect of heat at the junction

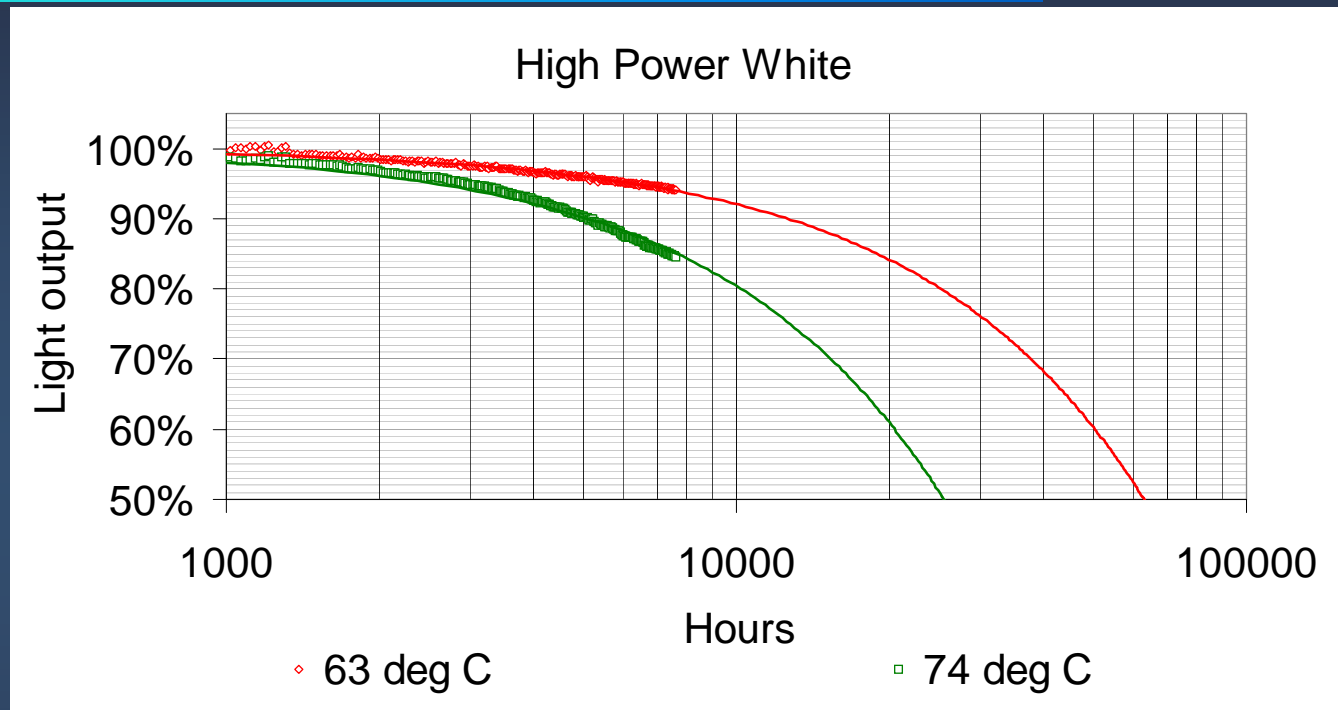
- ◆ Light output decreases with increasing temperature
- ◆ Different types of LEDs have different temperature sensitivity



Red	~ 0.8	% per °C
Green	~ 0.3	% per °C
Blue	~ 0.06	% per °C

courtesy of Lumileds

Long-term effect of heat at the junction



Junction temperature effects

L_{70} from 38,000 hrs to 14,000 hrs

L_{50} from 62,000 hrs to 24,000 hrs

Background: Scope of Work

- ◆ Task 1: Review of FAA Advisory Circulars to understand
 - › lighting and system performance requirements
 - › how testing procedures relate to LED systems
- ◆ Task 2: Conduct laboratory tests of existing LED fixtures to develop and verify appropriate metrics and methodologies
 - › methodology should cover colored and white airport lighting luminaires for all light source technologies

Background: Task I

- ◆ Relevant Advisory Circulars reviewed
 - › EB 67
 - › SAE 25050 I50/5340-30 I50/5345-43F I50/5210-5B
 - › I50/5345-46C I50/5345-47B I50/5345-51A I50/5345-54A
 - › I50/5345-53C I50/5345-56 I50/5345-54A I50/5345-120C
- ◆ Relevant topics within Advisory Circulars
 - › General specifications, life, photometric, thermal, and electrical requirements
- ◆ Overlap between test methods for general lighting fixtures and airport fixtures

Topics for Investigation

- ◆ Effects of temperature
 - › ‘ambient temperature’ definition and recommendations for sensor location
 - › test temperature range
 - › warm-up time
- ◆ Location of temperature sensor of arctic kit
- ◆ Definition of life and life-test methods
- ◆ Dimming methods and associated issues
- ◆ Seasoning

Where to measure LED temperature?

- ◆ T_j cannot be measured directly
 - › T_s (or T_b or T_{pin}) is related to T_j and can be measured using a thermal sensor



http://www.lumination.com/literature/VioDataSheetWEB8_7_07.pdf

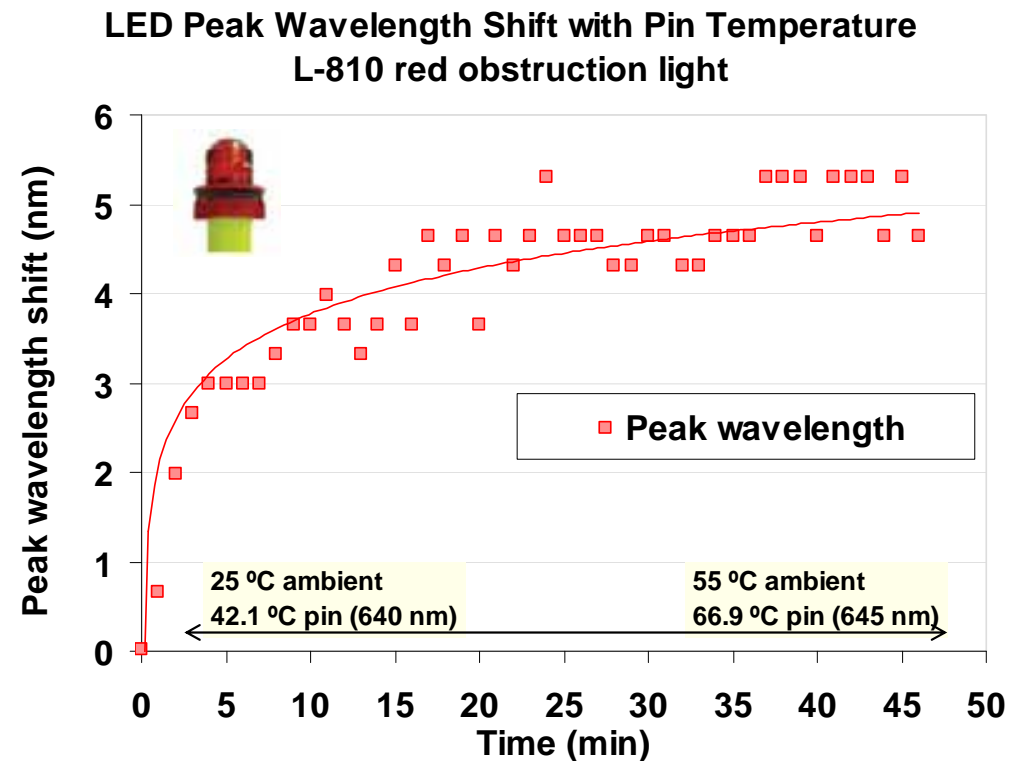
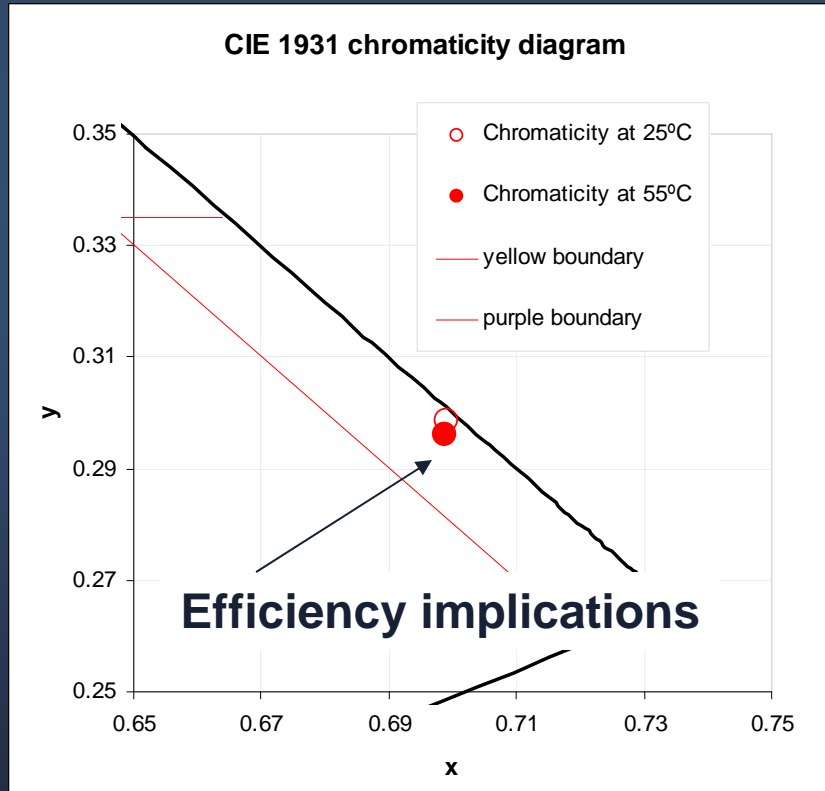
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Effects of Temperature: Test Range

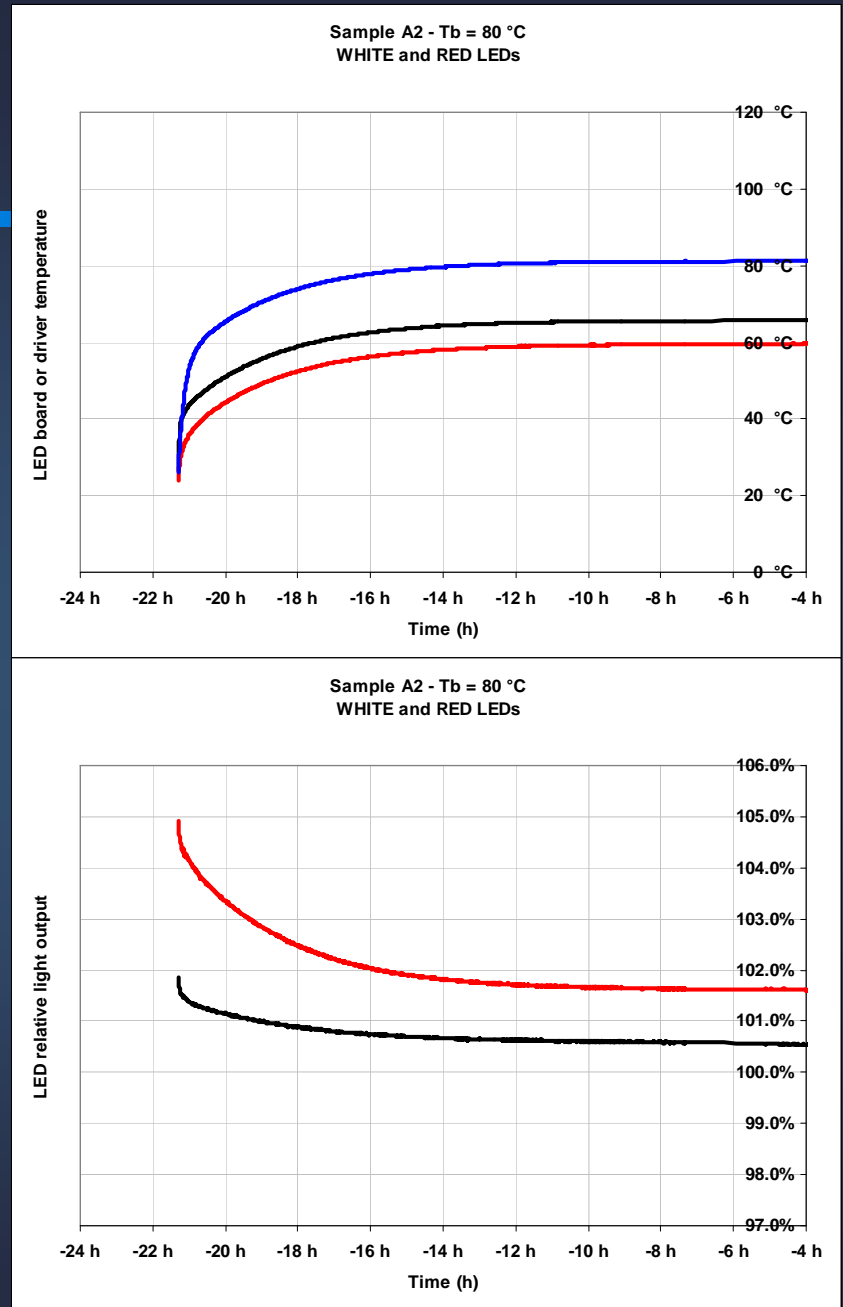
FAA specification requirements: Perform tests at -40 °C and +55 °C.

- ♦ Measured peak wavelength shift over the range 25 to 55 °C
 - › L-810 Red Obstruction Light



Effects of Temperature: Warm-up Time

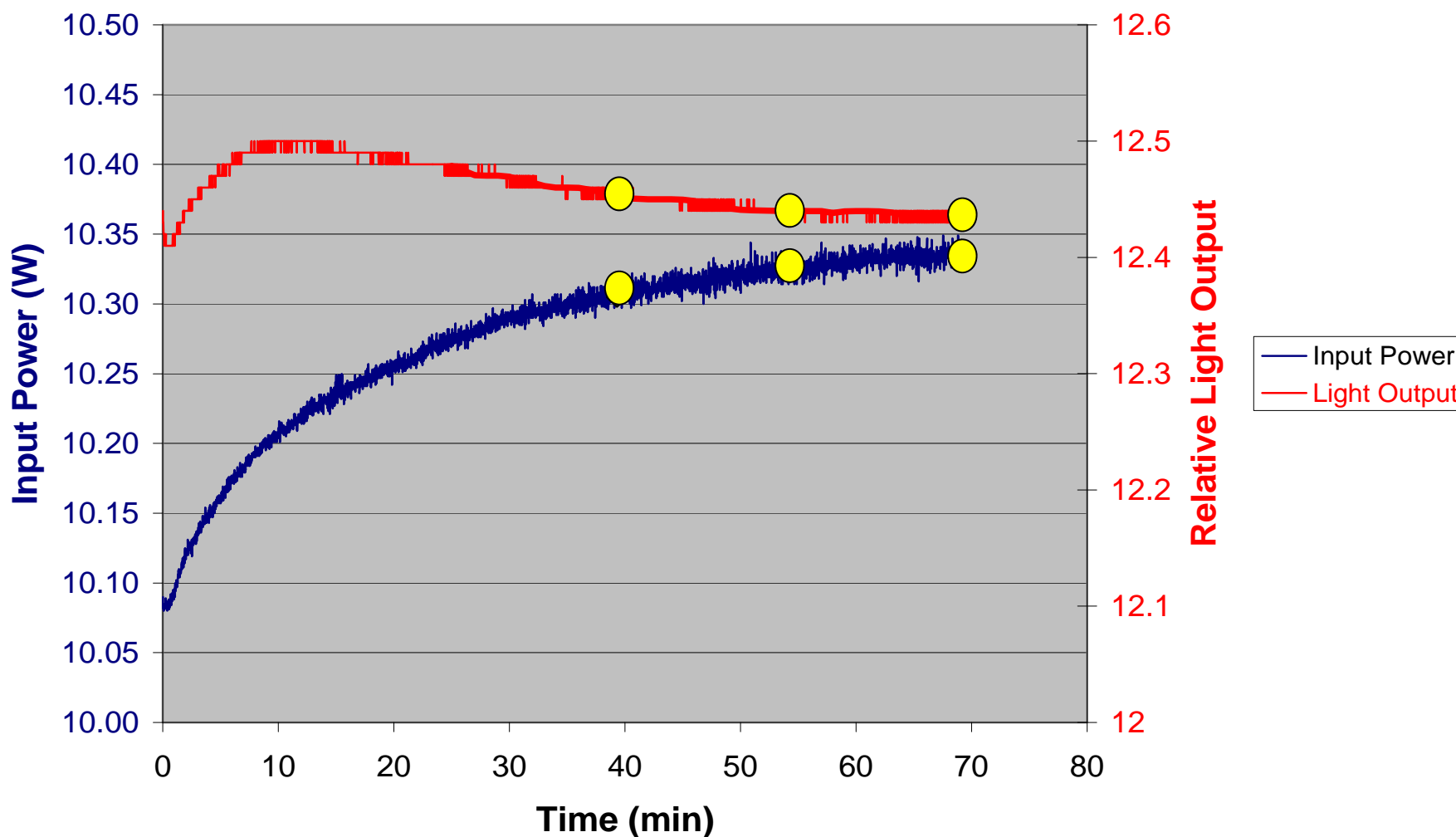
- ◆ Stabilization time of LED systems can take several hours
- ◆ Photometric and electrical characteristics depend on the junction temperature (T_j)



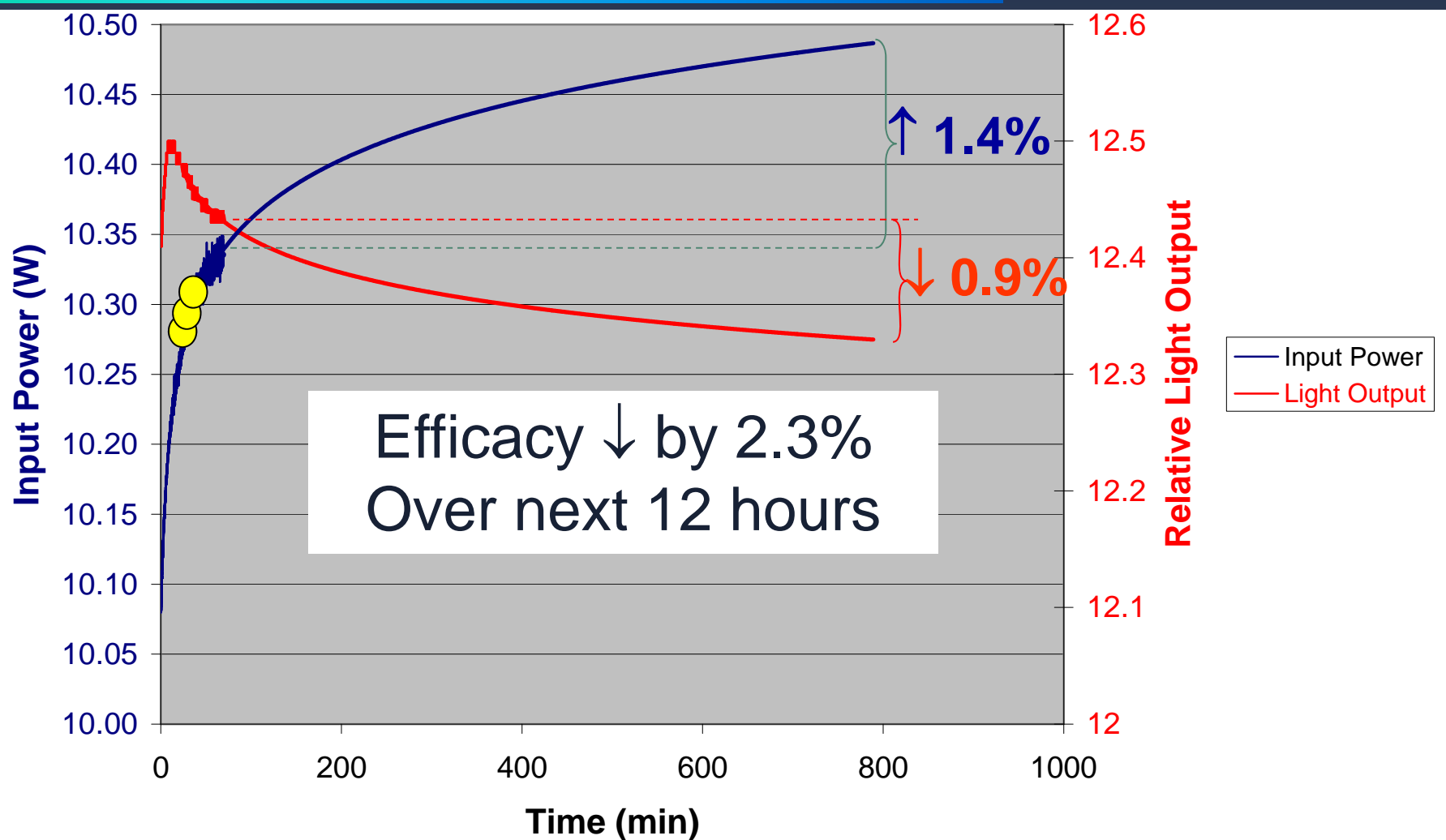
Stabilization of SSL Products (according to IES LM-79)

- ◆ Stability based on both input power and light output
- ◆ Stability is when the variation of at least 3 readings over a period of 30 min, taken 15 min apart, is less than 0.5 %

Test of an SSL Downlight Product

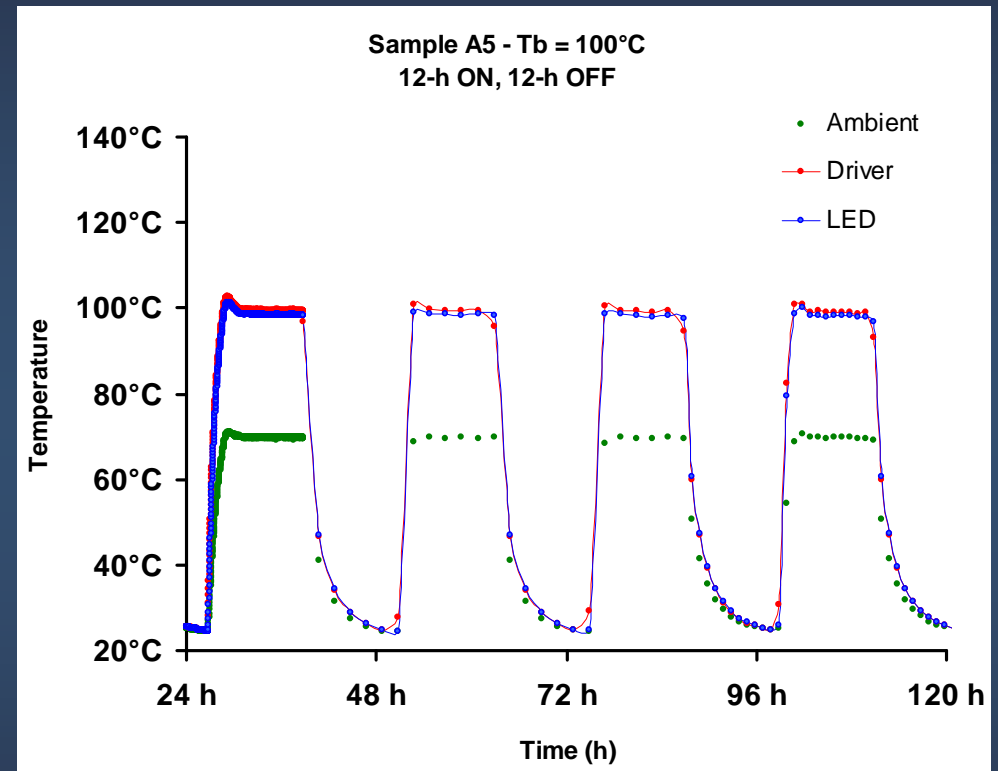


Test of an SSL Downlight Product



Effects of Temperature: Accelerated life test

- ◆ Presently, the accelerated life test calls for a 20-h on and 4-h off cycle
- ◆ Stabilization time of LED systems can take several hours



Conclusions

- ◆ Existing specifications and test procedures do not cover all the potential problems with LED products.
- ◆ Different LED technologies can present various challenges that need to be addressed.
- ◆ Ongoing research is addressing the definition of life and a methodology for testing.

Acknowledgments

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Seasoning of SSL Products (according to IES LM-79)

- ◆ No seasoning of samples prior to testing
 - › The test committee determined this method would produce the most repeatable results
- ◆ Other light sources
 - › Incandescent lamps: 0.5% of rated life
 - › Fluorescent lamps: 100 hrs with 3-hr on and 20-min off cycle
 - › HID: 100 hrs with 11-hr on and 1-hr off operating cycle

Initial lumen
maintenance of LEDs

