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Are current photometric tests for incandescent lights valid for LEDs?

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Project Sponsor: Federal Aviation Administration

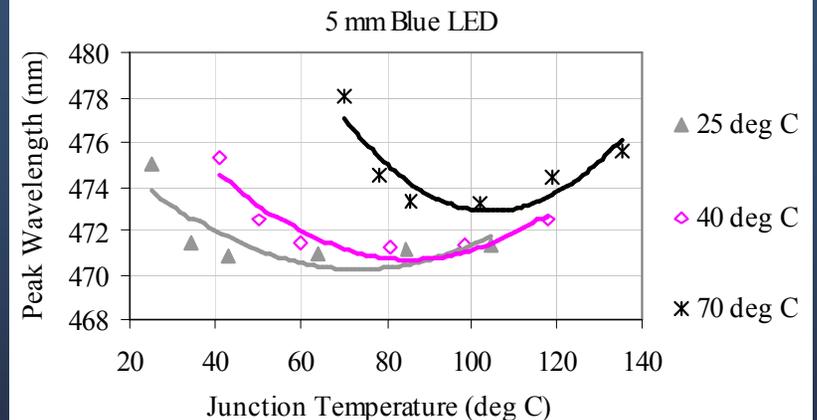
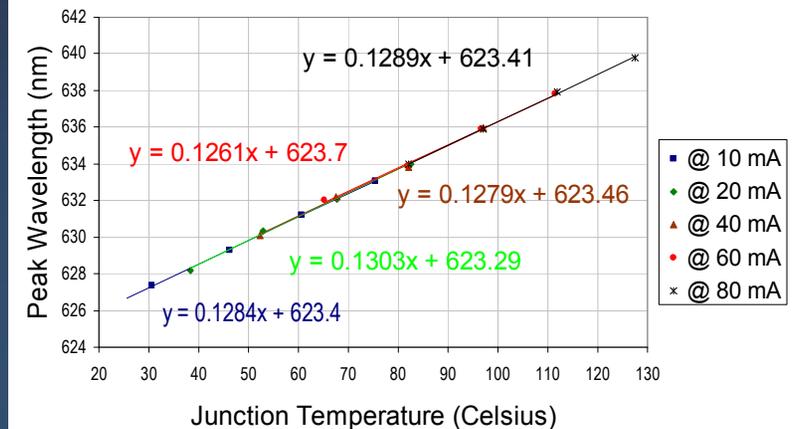
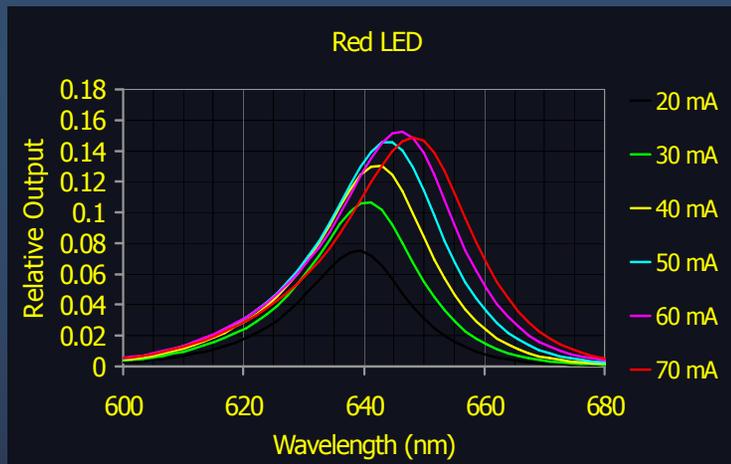
Cooperative Agreements Number: FAA/05-C-AT-RPI, 10-G-013
and 13-G-009

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.**

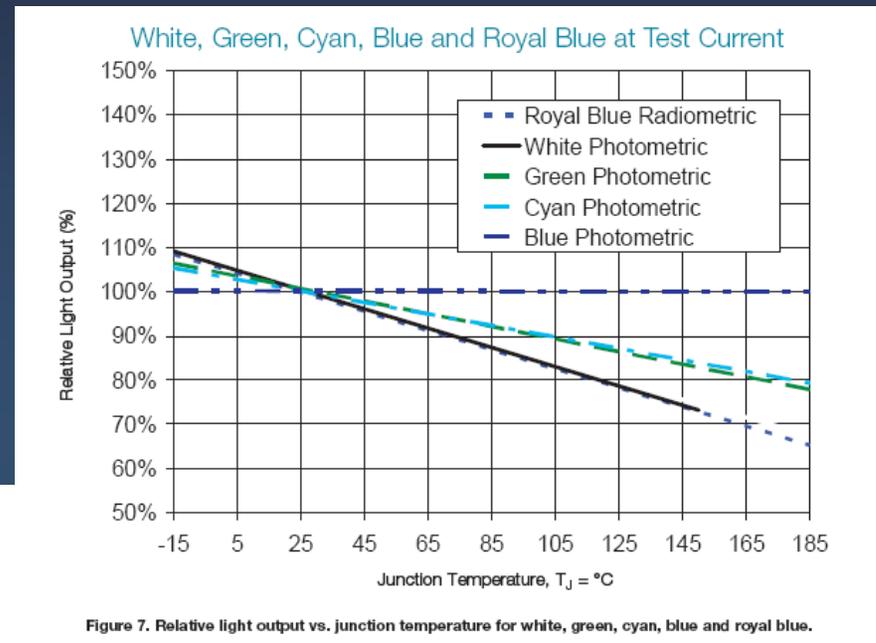
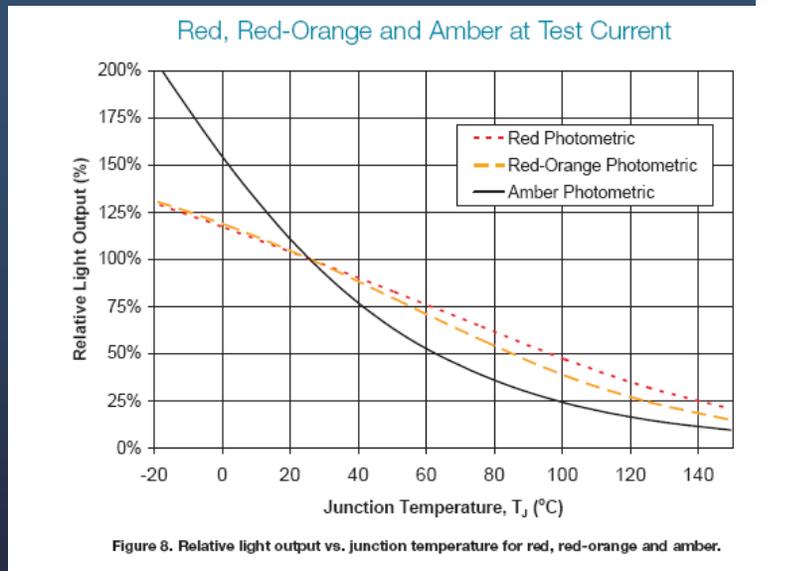
Short-term effect of heat at the junction

- ◆ Peak wavelength shifts with changes in junction temperature



Short-term effect of heat at the junction

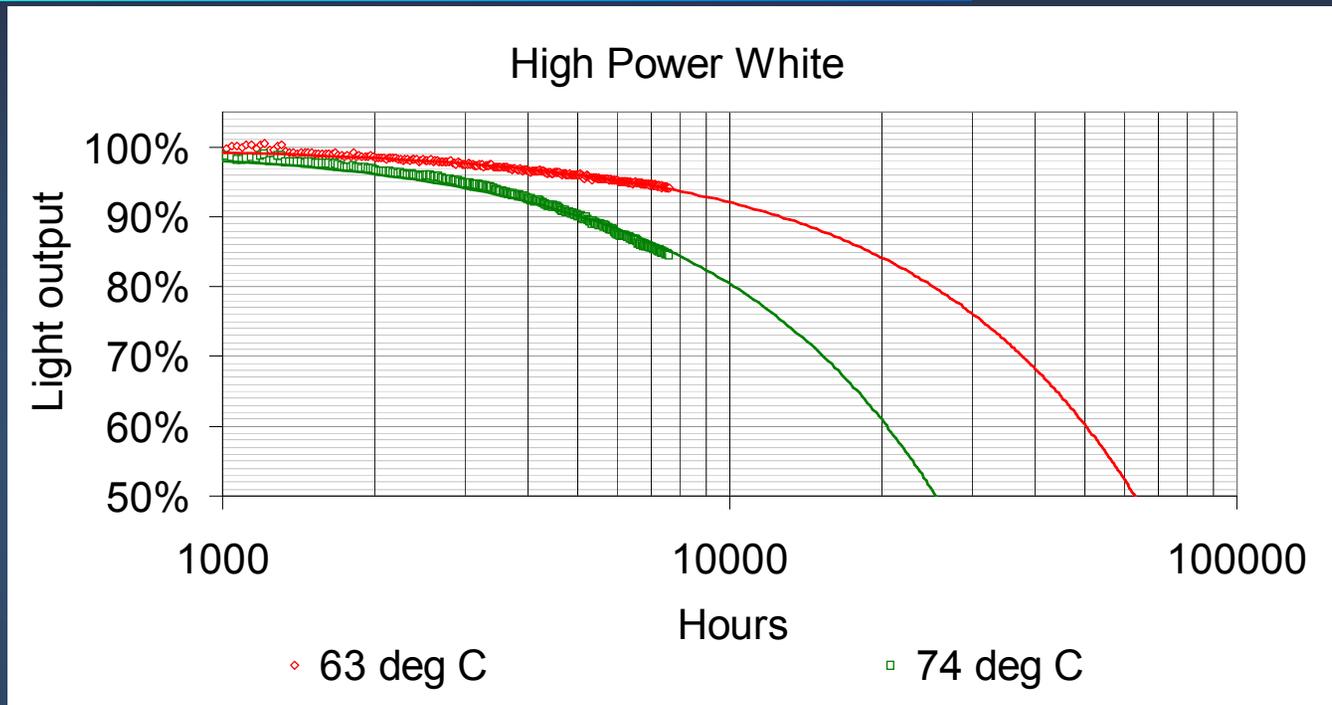
- ◆ Light output decreases with increasing temperature
- ◆ Different types of LEDs have different temperature sensitivity



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

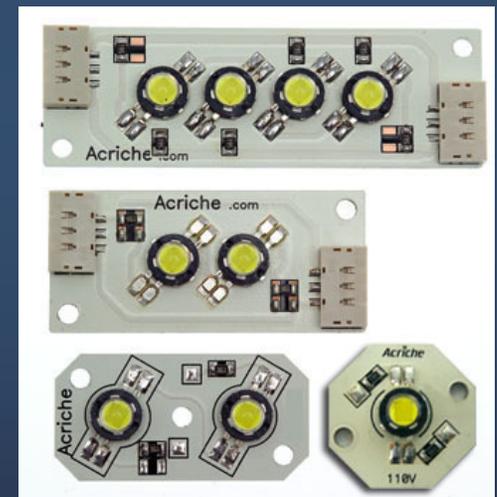
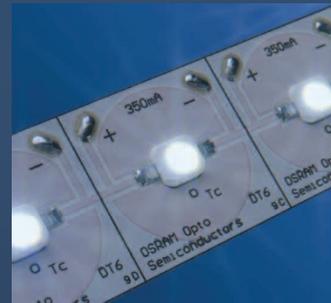
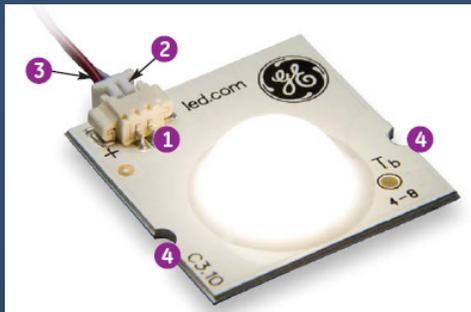
- ◆ Relevant Advisory Circulars reviewed
 - > EB 67
 - > SAE 25050 I50/5340-30 I50/5345-43F I50/5210-5B
 - > I50/5345-46C I50/5345-47B I50/5345-51A I50/5345-54A
 - > I50/5345-53C I50/5345-56 I50/5345-54A I50/5345-120C
- ◆ Relevant topics within Advisory Circulars
 - > General specifications, life, photometric,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

Topics for Investigation

- ◆ Effects of temperature
 - > warm-up time
 - > test temperature range
 - > 'ambient temperature' definition and recommendations for sensor location
- ◆ 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



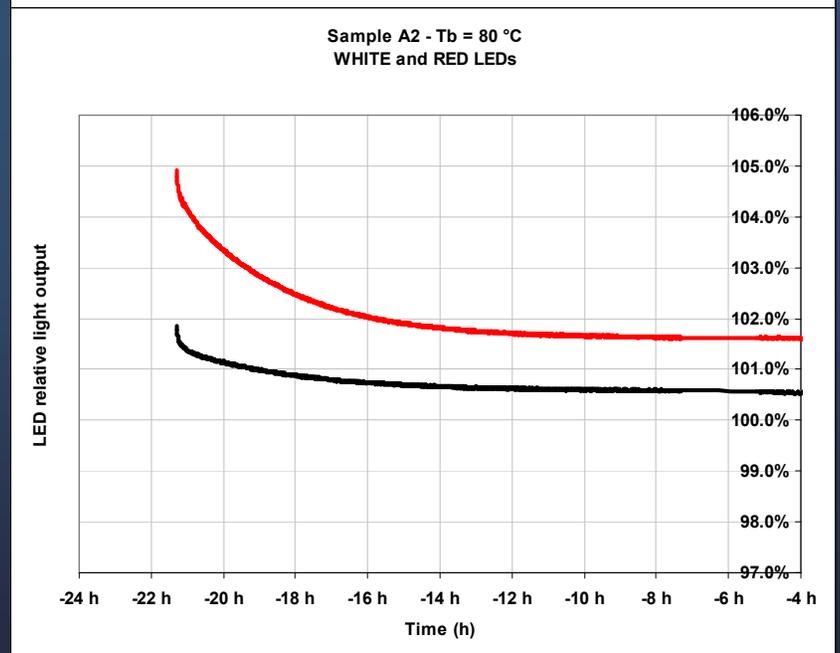
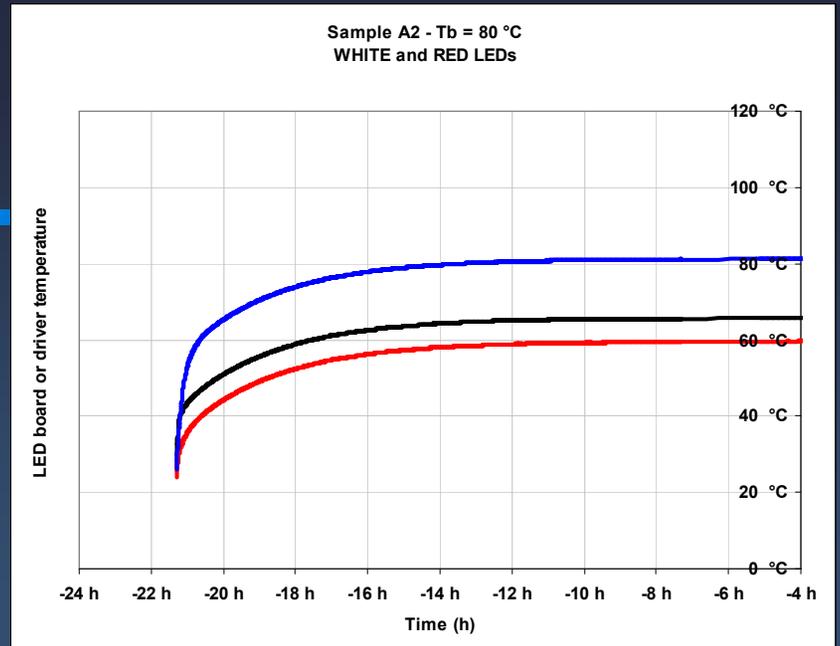
http://www.lumination.com/literature/VioDataSheetWEB8_7_07.pdf

<http://www.cree.com/products/pdf/XLamp7090XR-E.pdf>

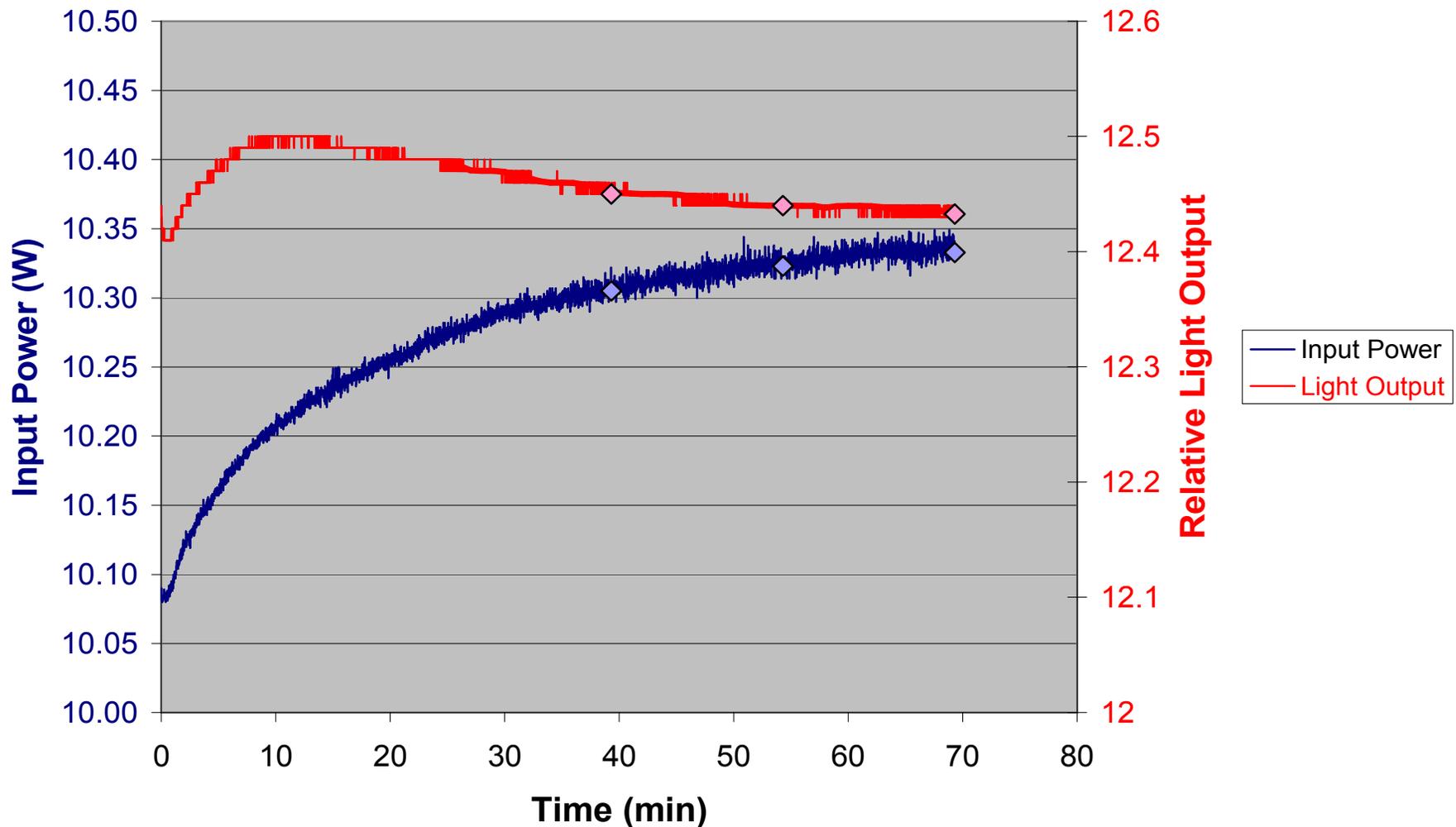
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Effects of Temperature: Warm-up Time

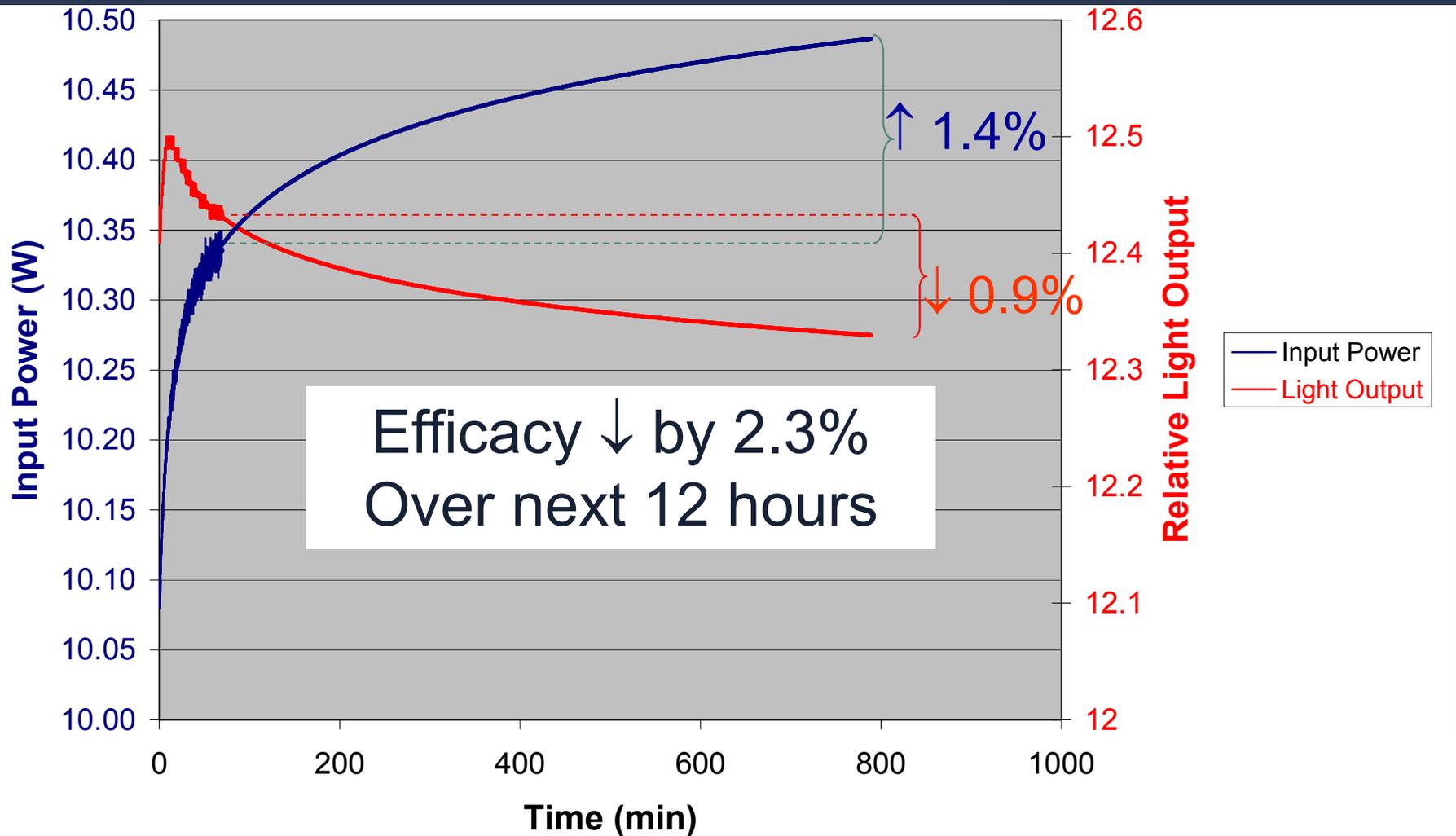
- ◆ Stabilization time of LED systems can take several hours
- ◆ Photometric and electrical characteristics depend on the junction temperature (T_j)



Test of an SSL Downlight Product

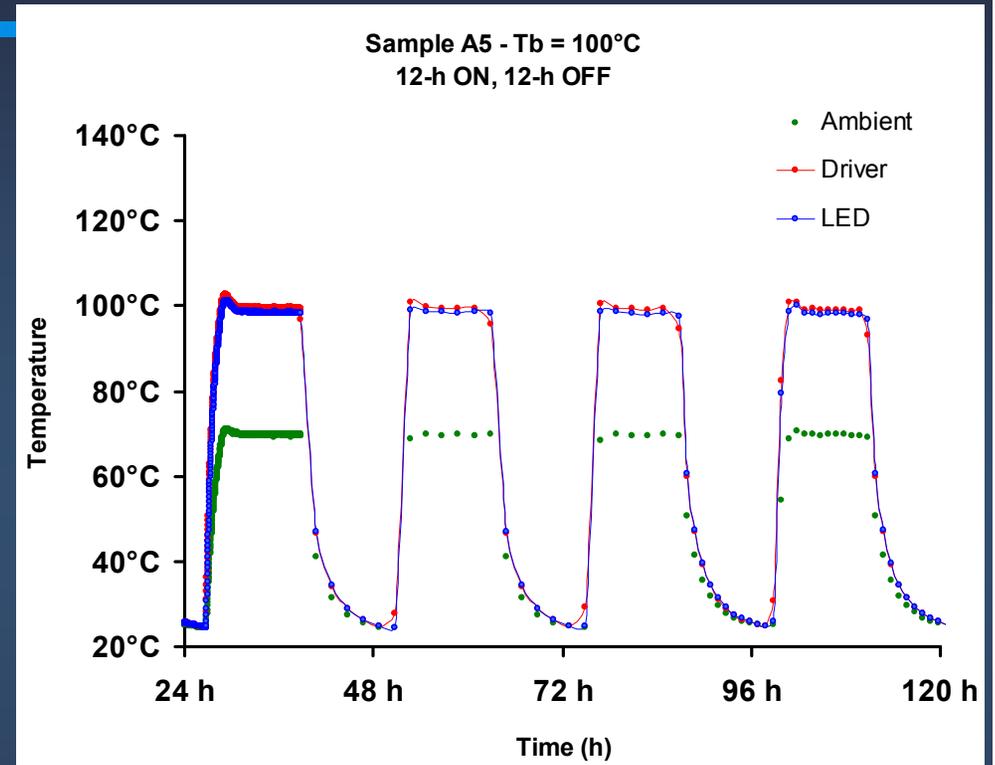


Test of an SSL Downlight Product



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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 - › Lalith Jayasinghe, Yimin Gu, Andrew Bierman, Yiting Zhu, Yi-wei Liu, Terry Klein, Martin Overington, Howard Ohlhous

Directional lighting test method

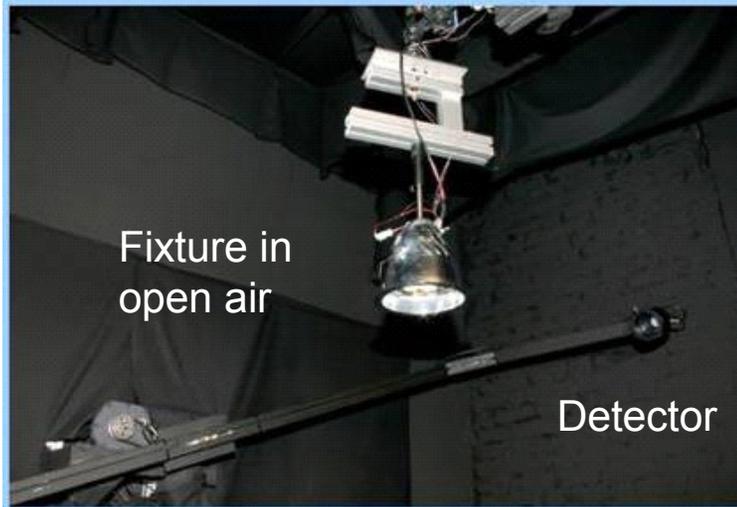
- ◆ ASSIST proposal:

- Use board temperature instead of ambient temperature and measure luminaire performance in conditions similar to application environment
- Conditions to test fixtures:
 - Open air: the light source and the driver have plenty of ventilation around them
 - Semi-ventilated: the light source and the driver have limited ventilation around them (similar to non-IC)
 - Enclosed: the light source and the driver have almost no ventilation around them (similar to IC)



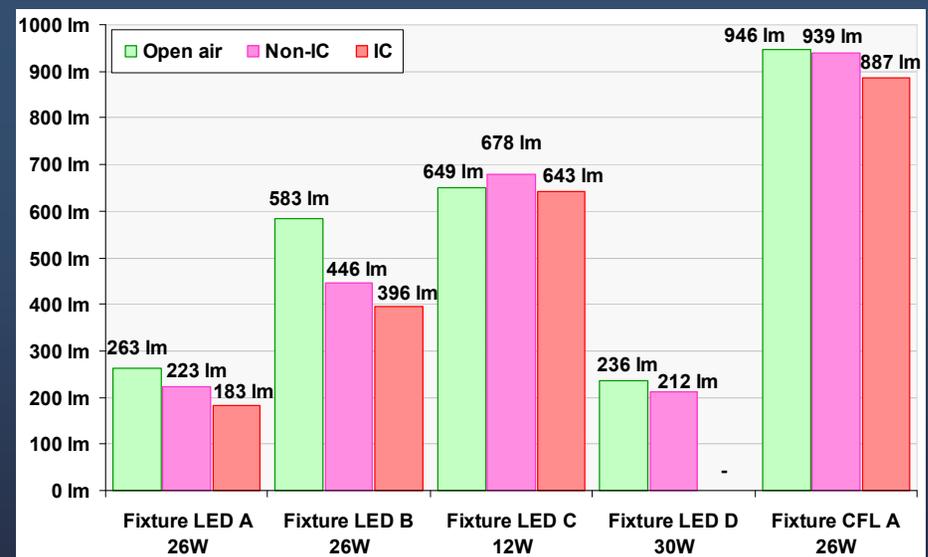
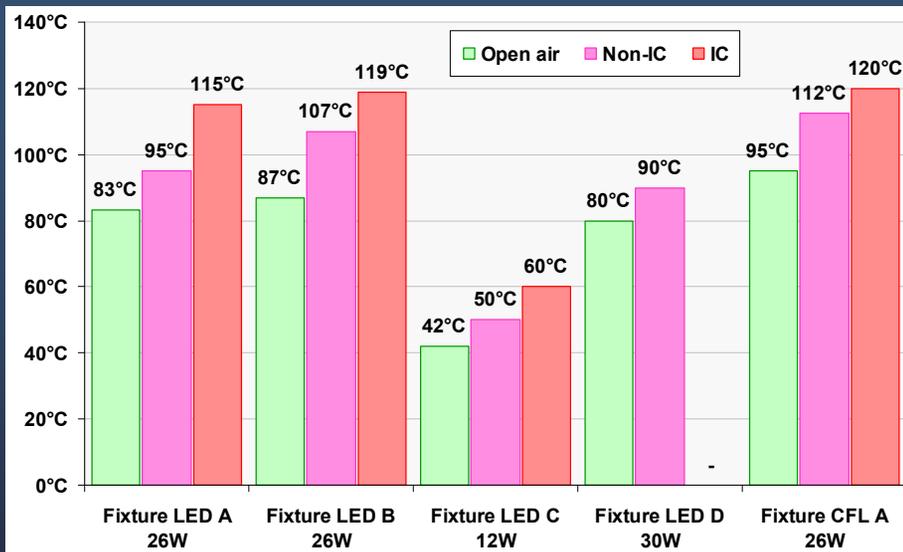
Goniophotometry

- ◆ Downlight inside UL Test Box or the heated chamber
- ◆ Data gathered once the board temperature, T_s , reaches application temperature



Luminous flux (lm)

- ◆ Well-designed luminaires maintain light output even in hot environments. However, poorly designed luminaires have significantly lower light output (more than 30%) in IC-condition.
- ◆ Traditional test methods would not have provided this information.



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

