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LED System Life

How is the Operational Failure of LED Fixtures Identified?

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Cooperative Agreements Number: 10-G-013 and 13-G-009

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Background

- LED-based solutions offer many potential benefits for airfield applications
  - Long life is one commonly claimed benefit
    - More reliable operation
    - Reduced maintenance costs
- However, LED systems are relatively new in airfield applications
  - Insufficient long-term performance data.
- Knowing the useful life of a luminaire allows planning and execution of preventive maintenance without disruption of airport operations.

Background: Photometric performance

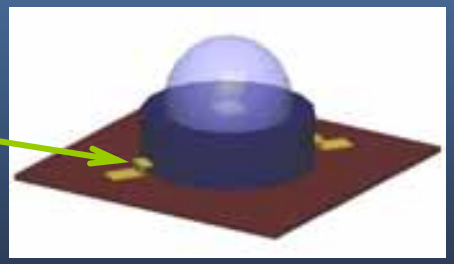
- A functional definition of life is needed for LED airfield luminaires
  - Life of incandescent luminaires is well understood due to the predictable nature of the technology
    - Light output depreciation relatively small before lamp fails
  - LED-based solutions will have differing performance depending on the system integration and the application environmental conditions

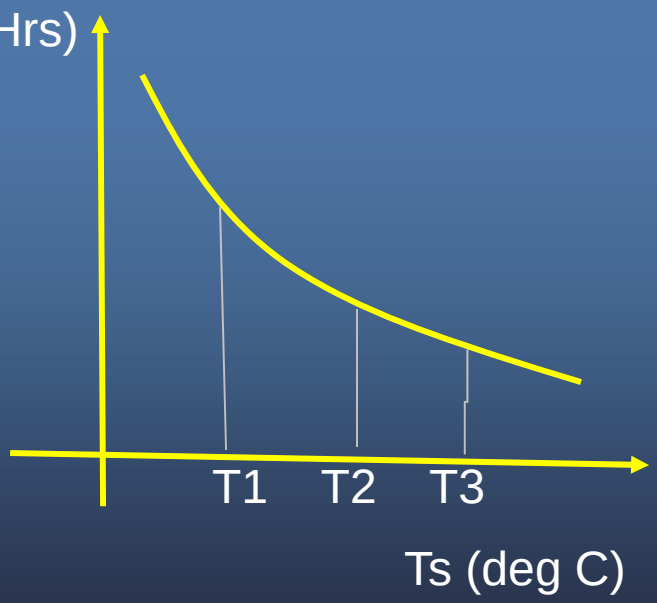
- Safe airport operations depend on the adequate photometric performance of luminaires at all times

Background

- Lighting Industry LED Life Standard: IES LM-80-08
  - ASSIST Recommends 2005
- Operation at three case temperatures: 55°C, 85°C, and a 3rd value specified by the manufacturer, all at the same drive current
- Determine time for L_{70} in hours.

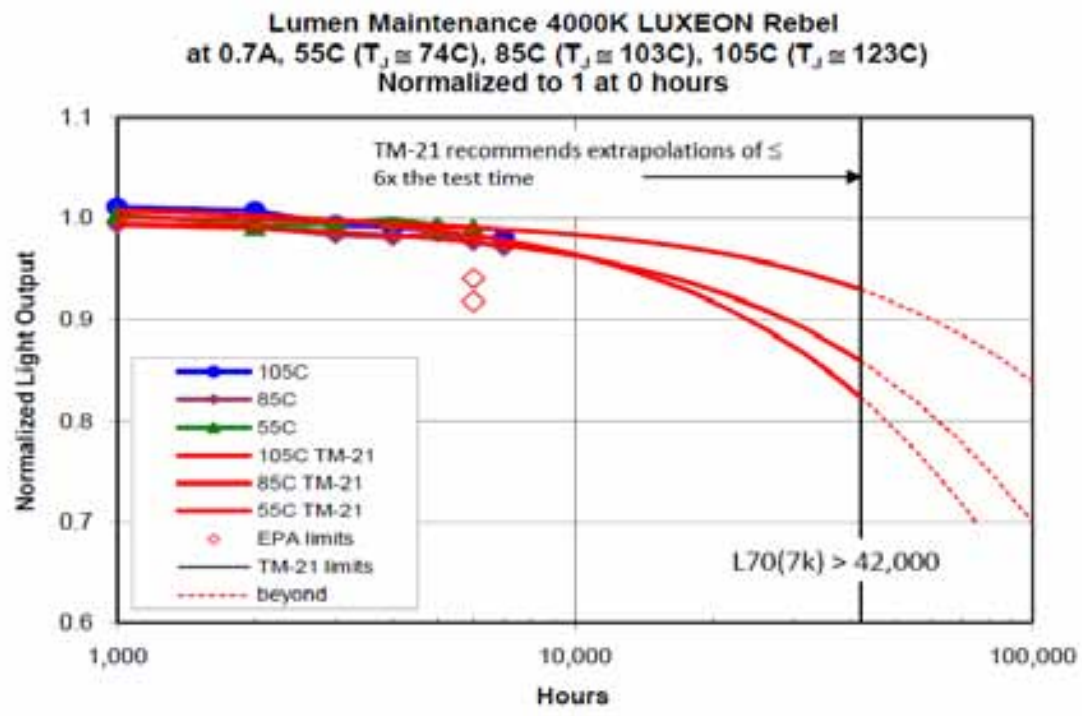
Ts, thermocouple at the test point specified by LED manufacturer





Background

- IES LM-80-08 + TM-21
- Data collection period 6000 hours



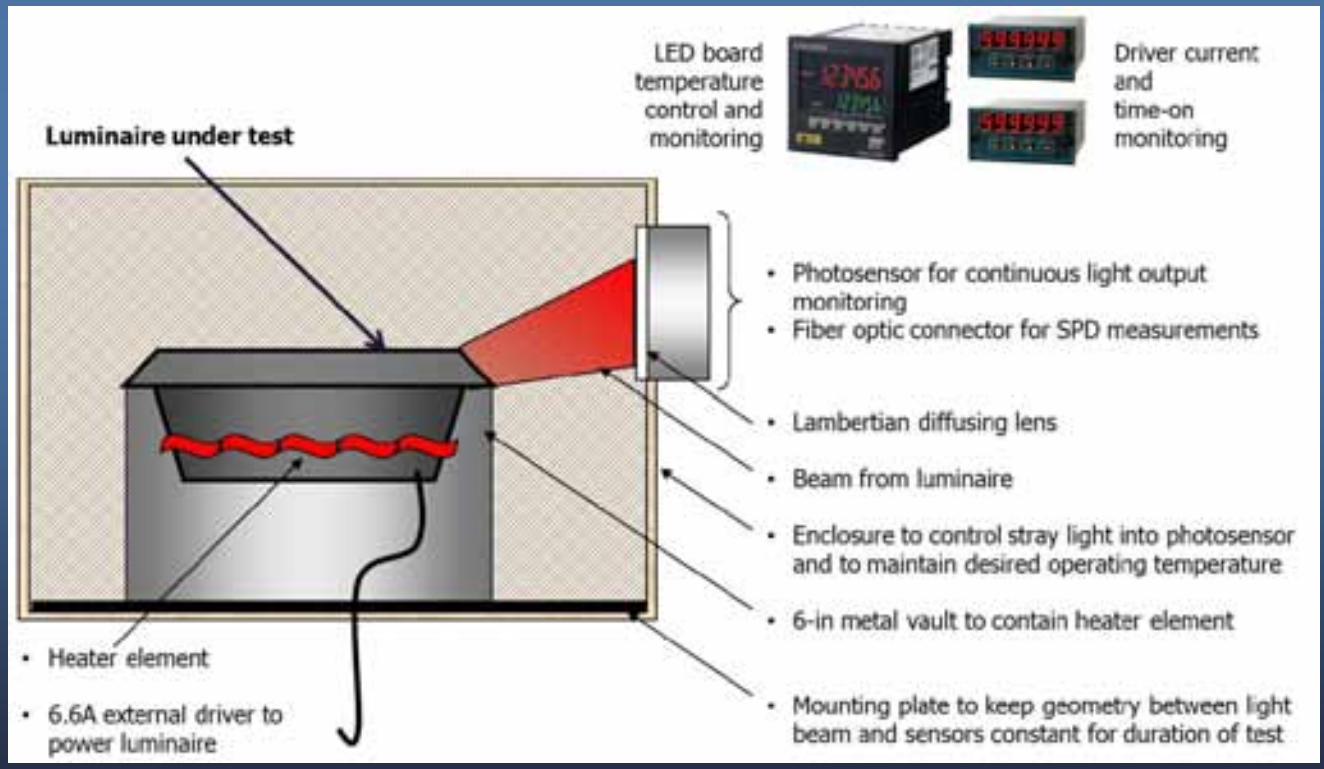
http://www.philipslumileds.com/technology/lumenmaintenance

Study Objective

- The objective of this study is to gather long-term light output and color shift data for airfield luminaires under continuous and cycled operations
  - To develop a suitable life testing method for airfield light fixtures.

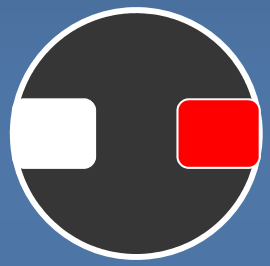
Life testing of airfield luminaires

- Life testing (2012-2013)
  - Testing at 3 temperatures allows for identifying system life at any ambient temperature

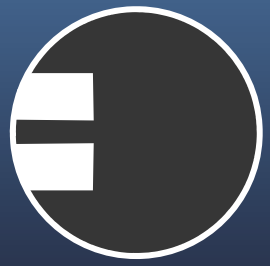


Samples tested

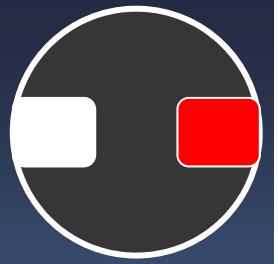
- Three red/white directional Runway Centerline luminaires



- Three white Touchdown Zone luminaires

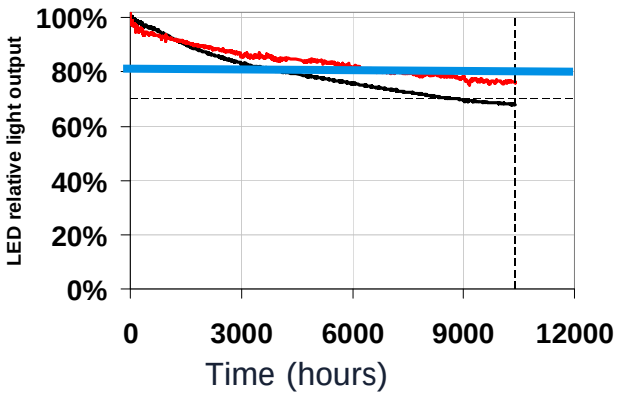


Runway Centerline luminaires
Light output depreciation

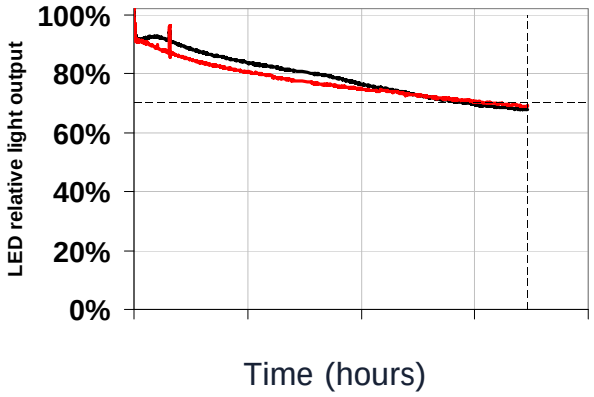


- Lumen depreciation was rapid even at room temperature
- Catastrophic failures were due to driver failure

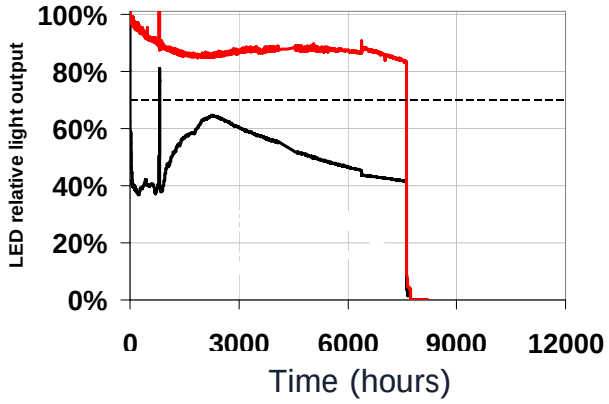
A0 (59 °C)



A2 (80 °C)



A3 (100 °C)



Driver temperature:
A0 (90 °C)

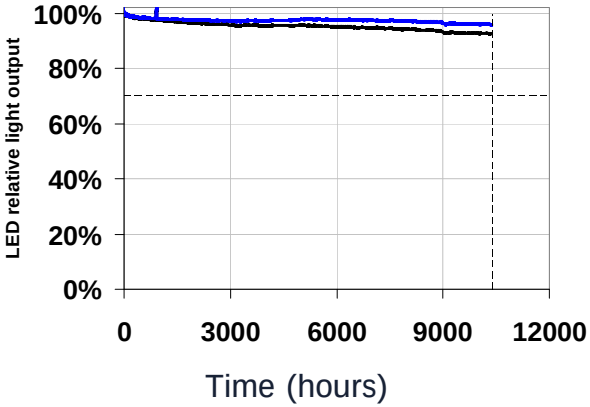
A2 (100 °C)

A3 (130 °C)

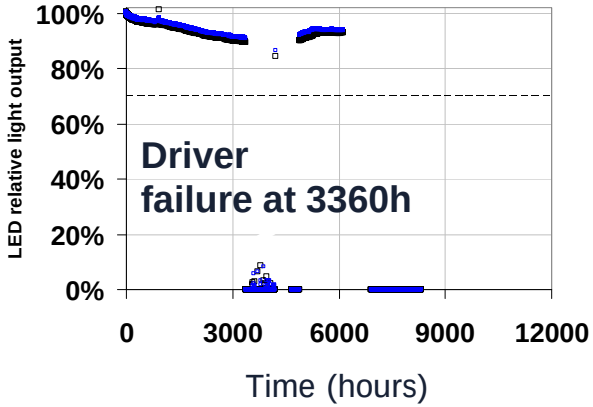
Touchdown Zone luminaires
Light output depreciation

- Lumen depreciation was rapid at higher temperatures
- Catastrophic failures were due to driver failure

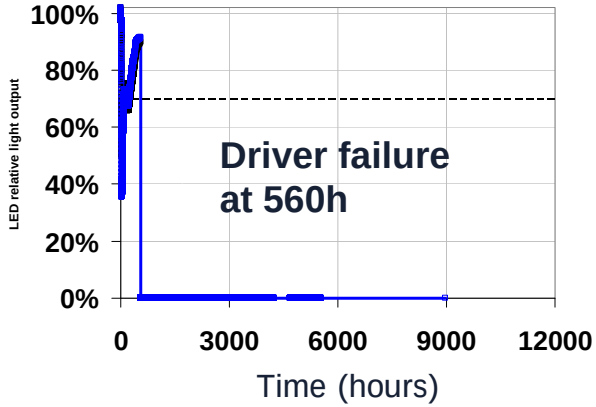
B1 (55 °C)



B2 (80 °C)



B3 (100 °C)



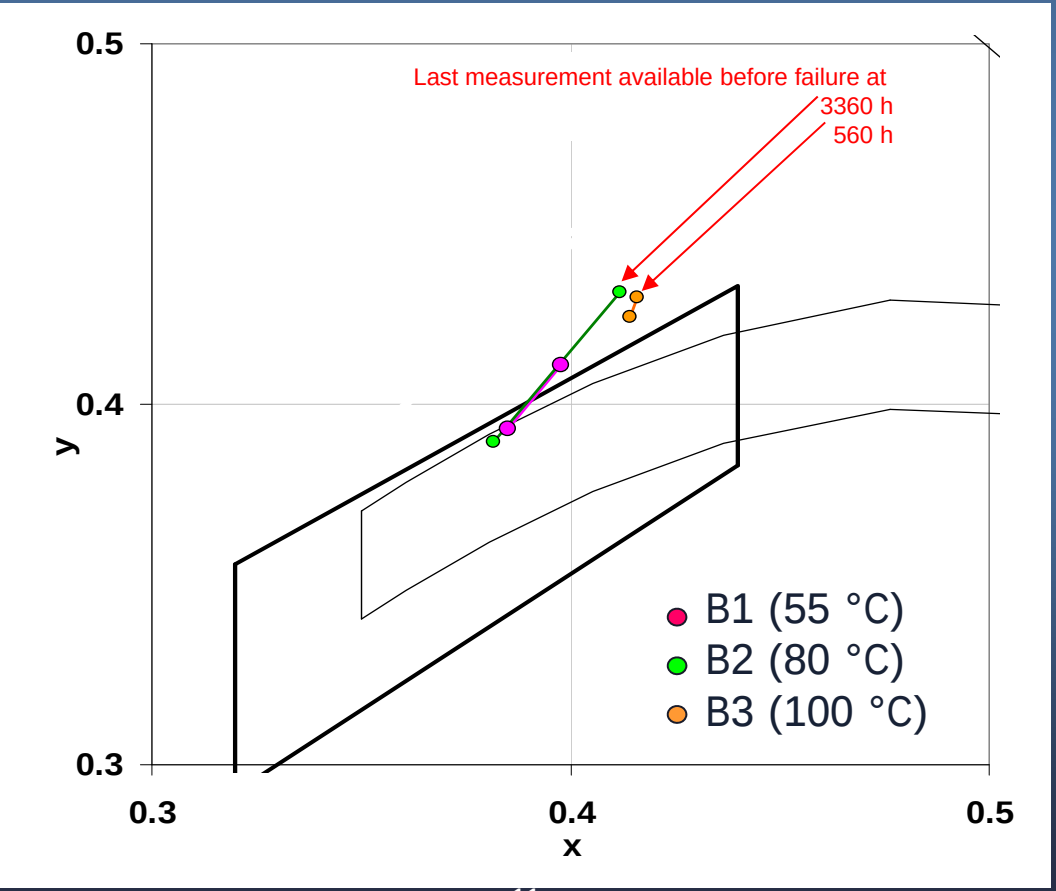
Driver temperature:
B1 (58 °C)

B2 (82 °C)

B3 (104 °C)

Touchdown zone luminaires

- Significant color shift
  - Crossed color boundary in few hundred hours



A Parallel Study Sponsored by ASSIST

An accelerated test method for estimating LED system life

Narendran and Yi Wei, 14th International Symposium on the Science and Technology of Lighting June 22-27, Como - Italy

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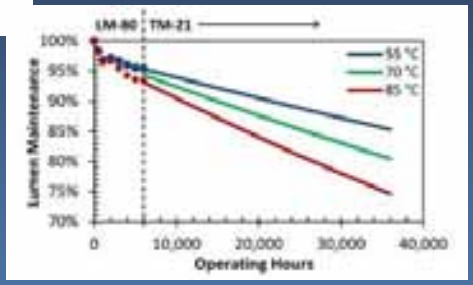
Background



- Failures can be parametric (lumen depreciation) or catastrophic (complete failure)
- LED system life
  - Presently, LED lighting product life is rated based on LED lumen maintenance (LM80/TM21)
- A lighting system has many components
  - Failure of any component can cause system failure
- Therefore, whole system has be tested to obtain reasonable life estimate

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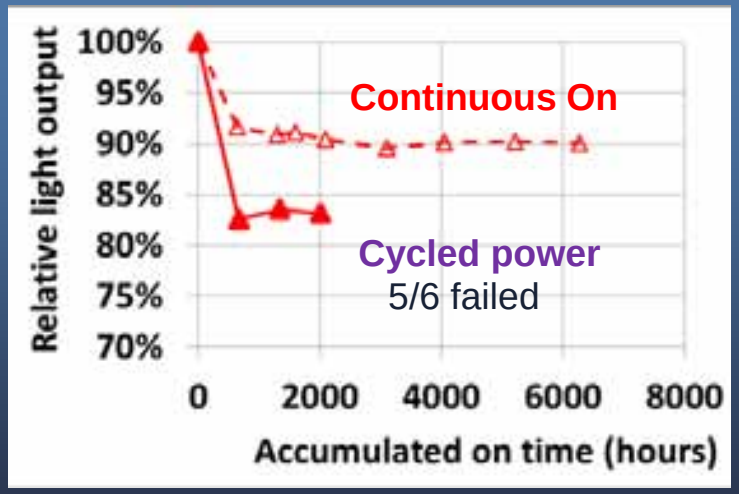
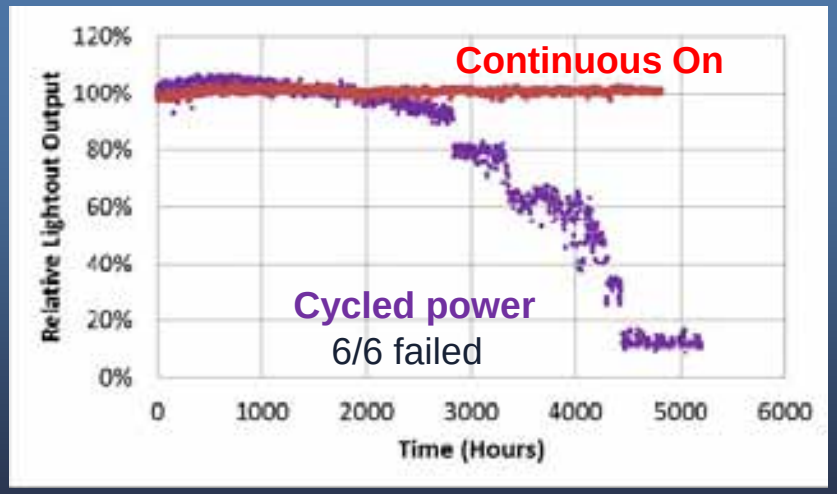
Background

- IESNA LM84-14 standard:
  - First attempt towards developing a system life test method
  - Test method is based on continuous operation.

- Power cycling can cause component/system catastrophic failure

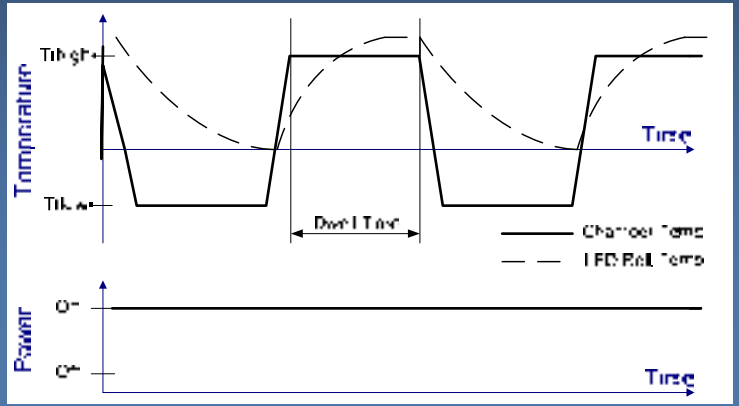




Background

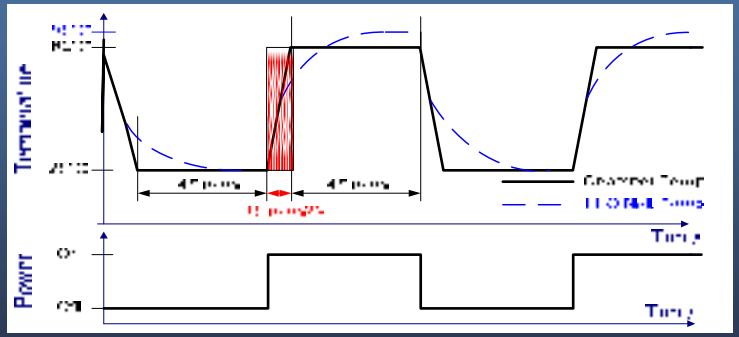
- The electronic industry has several rapid cycle test methods for failure testing
  - › Example:
    - IEC 60068-2-14
    - Strife
- Some manufacturers have adopted similar methods for LED reliability testing
  - › Test for 1000 cycles
  - › Usually a pass/fail test (helps to identify early failures)

IEC 60068-2-14 Method



IEC 60068-2-14 : Test the ability to withstand rapid changes of ambient temperature."

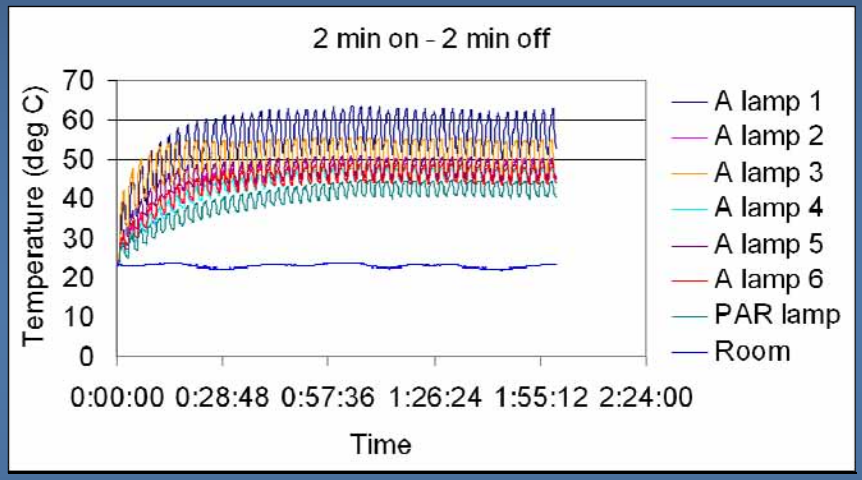
Strife method



STRIFE method is the most destructive among test method.

Background

- Some standards have very fast cycling of LED products to test for failures.
  - Very small delta T
  - May not cause damage



- Generally there are two types of failures:
  - Parametric
    - Lumen depreciation or color shift
  - Catastrophic

Study Objective

- None of the test procedures presently available are designed to project system life based on the environment temperature and the use pattern (on-off)

- Objective - To develop an accelerated test method that can predict failure of LED system based on factors such as
  - Environment temperature (Tpin)
  - On-off cycling.

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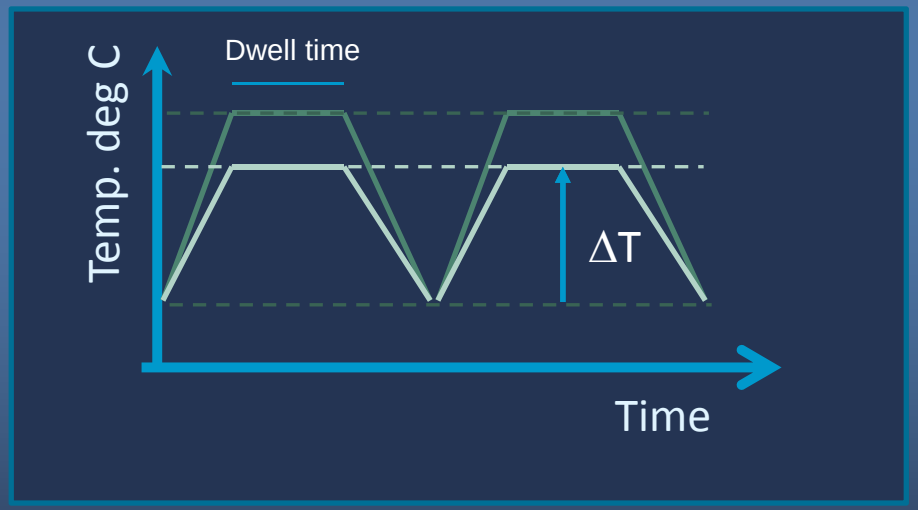
ASSIST Study Objective

- To understand the effect of different delta temperate and dwell times on failure time
  - Lamp used: A 60W equivalent LED lamp



ΔT	60°C	70°C	80°C	90°C

Dwell time – 1, 2, 3, 4, 5, 7 hours

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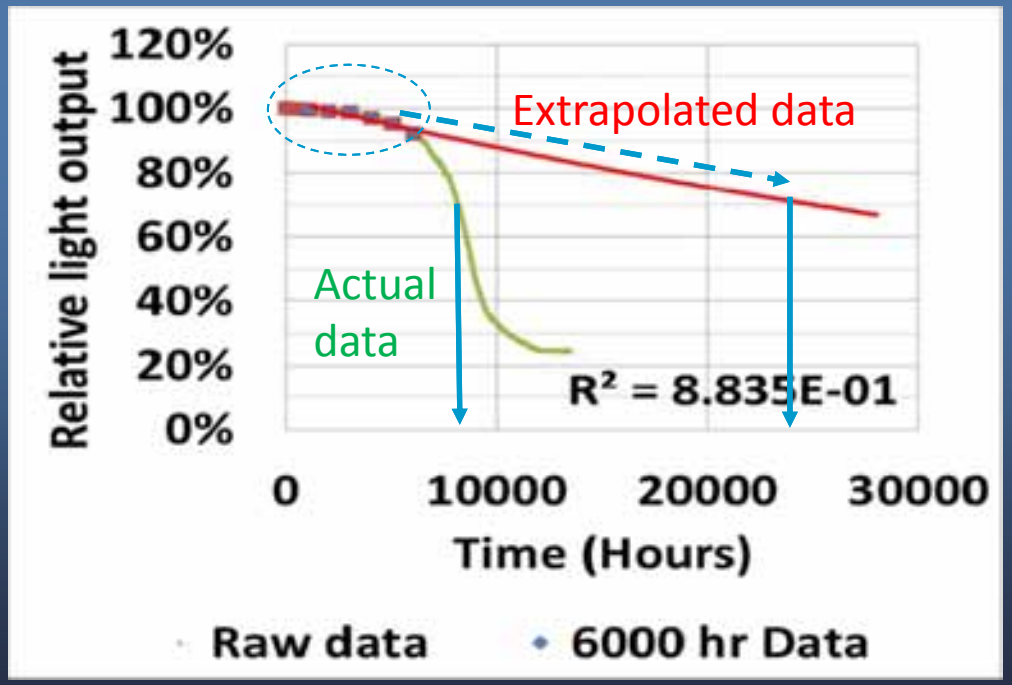
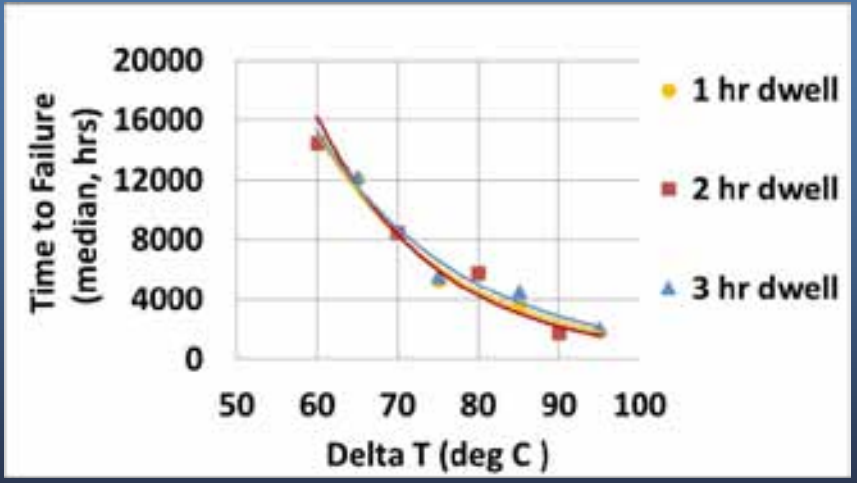
Results

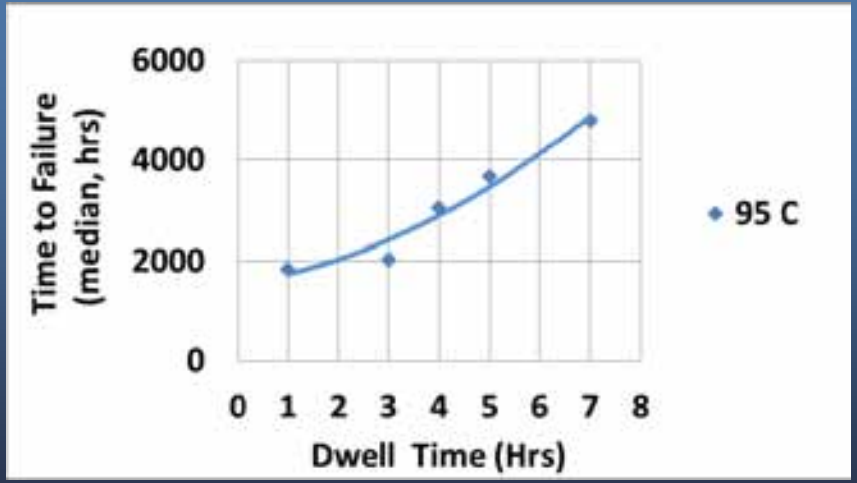
- Extrapolating the 6000 hr data can lead to erroneous results
  - Projected life = 25,000 hrs
  - Actual life = 8,000 hrs



Results

- For the system tested
  - Delta temperature increase results in shorter TTF
    - Catastrophic failure
  - Dwell time increase
    - Results in longer time to failure at delta T 95 C
    - Data is still being collected at other delta T temperature





ASSIST Study Summary

- Life testing of LED systems must include on-off cycling
  - Very fast cycling may not show failure
- LED system lumen depreciation can be due to several factors (Electrical and optical)
  - Simple function extrapolation for systems may lead to erroneous results
- Failure acceleration using delta T and dwell time is showing promise in predicting the failure of LED systems under different operating conditions

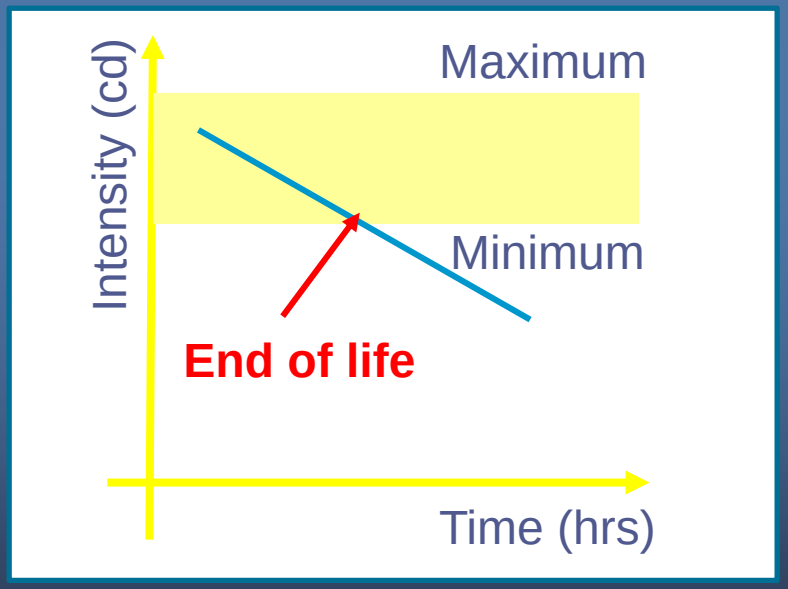
Follow up study – started 12/2013

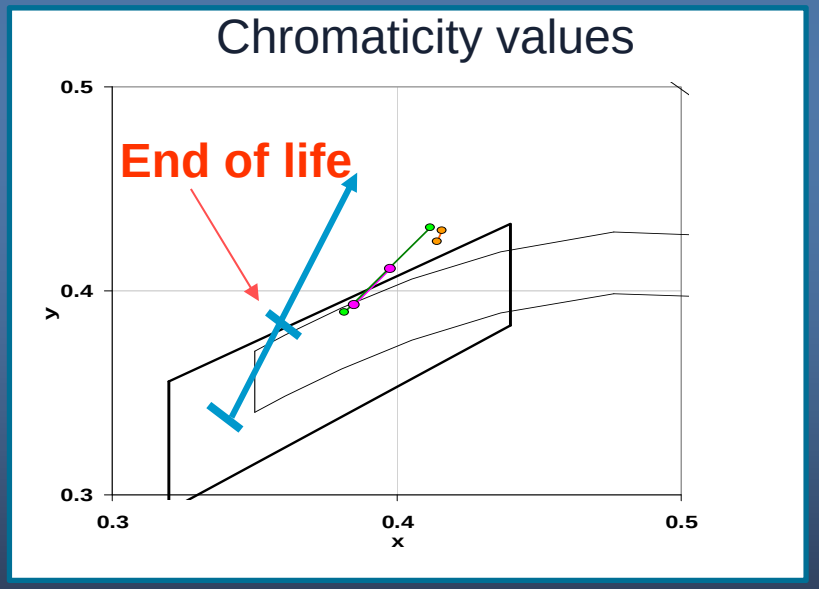
- Objective: To understand performance of LED airfield fixtures under continuous and cycled operations

- Test conditions
  - In all cases, the ambient temperature was set such that the LED pin temperature = 100°C
  - For each sample type, one is operated continuously and the other is cycled 12-hours on and 12-hours off

Discussion

- Life definition should be based on absolute light level and maintenance of chromaticity values within the prescribed boundary





Discussion

Useful life: A definition

- Luminaires should provide the required photometric characteristics for the length of their useful life, thus:
  - Useful life is the time until a given luminaire falls out of photometric specifications in terms of intensity and color.

- Light intensity requirements must include upper and lower limits.

Acknowledgements

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