XLamp® LED Reliability Overview

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INTRODUCTION

This application note describes the qualification process Cree LED applies to ensure long-term reliability for XLamp® LEDs and details Cree LED's pre-release qualification testing for XLamp LEDs.

PRE-RELEASE QUALIFICATION TESTING

Before releasing XLamp LEDs to production, Cree LED puts a representative product sample set through an entire suite of pre-release qualification tests. There is no unified standard for qualification testing in the high-power LED industry. Each LED company must decide what tests and conditions to use to qualify new products.

Cree LED's pre-release qualification test suite is based on standard semiconductor pre-release qualification test conditions and methods defined by the Joint Electron Device Engineering Council (JEDEC) and the Illuminating Engineering Society (IES).

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QUALIFICATION TEST LIST (OPERATING LIFE)

The table below applies to all XLamp LEDs, except XFL LEDs:

Test	Applicable Standards	Test Conditions & Failure Criteria
Room Temperature Operating Life Test (RTOL) [6]	IES LM-80-2008	**Test Conditions:** • Ambient Temperature : 55 °C • Forward Current : Maximum in data sheet • Test Period [7] : 1008 hours **Failure Criteria [1]:** • Forward Voltage shift [2] : > 5% • Luminous Flux degradation [2] - InGaN LEDs [3] : > 15% - PC Color LEDs : > 25% - AlInGaP LEDs [4] : > 25% • Catastrophic failure [5]
High Temperature Operating Life Test (HTOL)	IES LM-80-2008	**Test Conditions:** • Ambient Temperature : 85 °C • Forward Current : Maximum in data sheet • Test Period [7] : 1008 hours **Failure Criteria [1]:** • Forward Voltage shift [2] : > 5% • Luminous Flux degradation [2] - InGaN LEDs [3] : > 15% - PC Color LEDs : > 25% - AlInGaP LEDs [4] : > 25% • Catastrophic failure [5]
Wet High Temperature Operating Life Test (WHTOL)	For 85 °C/85% RH testing: JESD22 Method A101-C	**Test Conditions:** • Forward Current: : Maximum in data sheet • All color XR-C & XR-E LEDs • XR-C & XR-E Cool White (>5000K CCT) LEDs • XP White (chromaticity bins WA-WP & 0A-1U) & XP Color - Ambient Temperature : 85 °C - Humidity : 85% RH • All other XLamp LEDs - Ambient Temperature : 60 °C - Humidity : 90% RH • Test Period [7] : 1008 hours (cycled) **Failure Criteria [1]:** • Forward Voltage shift [2] : > 5% • Luminous Flux degradation [2] - InGaN LEDs [3] : > 15% - PC Color LEDs : > 25% - AlInGaP LEDs [4] : > 25% • Catastrophic failure [5]
Low Temperature Operating Life Test (LTOL)	JESD22 Method A108-C	**Test Conditions:** • Ambient Temperature : -40 °C • Forward Current : Nominal in data sheet • Test Period [7] : 1008 hours **Failure Criteria [1]:** • Forward Voltage shift [2] : > 5% • Luminous Flux degradation [2] - InGaN LEDs [3] : > 15% - PC Color LEDs : > 25% - AlInGaP LEDs [4] : > 25% • Catastrophic failure [5]

Notes:

1. The entire test has failed if at least one LED from the sample set satisfies the listed failure criteria. If no LED satisfies the listed failure criteria, the test is successful.
2. Comparison is made between [value at time 0] and [value at the end of the test period].
3. InGaN LEDs are white, blue, violet, cyan, and green LEDs.
4. AlInGaP LEDs are red, red-orange and amber LEDs.
5. A catastrophic failure causes the LED to become non-functional, i.e., open or short.
6. RTOL testing was not performed on XLamp LEDs released after October 1, 2015.
7. LED packages in the violet wavelength range (400 nm–435 nm) have a test period of 504 hours for all pre-release operating qualification tests.

QUALIFICATION TEST LIST (OPERATING LIFE) - CONTINUED

The table below applies to XLamp XFL LEDs:

Test	Test Condition	Forward Current	Test Period	Failure Criteria [1]
High Temperature Operating Life Test (HTOL) #1	• Ambient Temperature: 85 °C	XFL05K: 3.5A XFL08K: 6.3A XFL10K: 8.4A	500 hrs	• Forward Voltage shift [2] : > 5% • Luminous Flux degradation [2] : > 15% • Catastrophic failure [3]
High Temperature Operating Life Test (HTOL) #2	• Ambient Temperature: 85 °C	XFL05K: 8.75A XFL08K: 15.75A XFL10K: 21.00A	48 hrs	
Wet High Temperature Operating Life Test (WHTOL) #1	• Ambient Temperature: 60 °C • Humidity: 90% RH	XFL05K: 3.5A XFL08K: 6.3A XFL10K: 8.4A	500 hrs	
Wet High Temperature Operating Life Test (WHTOL) #2	• Ambient Temperature: 60 °C • Humidity: 90% RH	XFL05K: 8.75A XFL08K: 15.75A XFL10K: 21.00A	48 hrs	

Notes:

1. The entire test has failed if at least one LED from the sample set satisfies the listed failure criteria. If no LED satisfies the listed failure criteria, the test is successful.
2. Comparison is made between [value at time 0] and [value at the end of the test period].
3. A catastrophic failure causes the LED to become non-functional, i.e., open or short.

PROCEDURES FOR OPERATING LIFE TESTS

The following procedures are followed for RTOL, HTOL and WHTOL tests:

- XLamp LEDs are reflow soldered onto metal-core printed circuit (PC) boards.
- PC boards are mounted onto heat sinks within reliability test chambers.
- For RTOL, HTOL and WHTOL tests, solder point temperature (case temperature) is maintained equal to the ambient temperature during the test.
- Power is applied to the lamps. In the WHTOL test, power is applied in one-hour intervals that are followed by one-hour intervals without power to let moisture penetrate the package as much as possible. This procedure results in a test that is more rigorous than one that calls for applying continuous power.
- At regular intervals power is turned off and the sample boards are removed from the tester according to JEDEC testing protocol.
    - ◊ The lamps are characterized according to reliability test criteria.
    - ◊ The boards are placed back into the test chambers and the procedure is repeated until the test has concluded.
- Test period hours are true operating hours, i.e., any time the test chamber is turned off during a test is not counted. This is in compliance with LM-80 procedures.

QUALIFICATION TEST LIST (NON-OPERATING LIFE)

Test	Applicable Standards	Test Conditions & Failure Criteria
Thermal Shock	JESD22 Method A104-E Condition G	**Test Conditions:** • Temperature Range : -40 °C to 125 °C • Transfer Time : < 20 seconds • Cycles : 200 cycles **Failure Criteria [1]:** • LED no longer lights up after test
Mechanical Shock	JESD22 Method B104-C Condition B	**Test Conditions:** • Shock : 1500 G • Pulse Width : 0.5 ms • Test Period : 5 each, 6 axis (30 total) **Failure Criteria [1]:** • LED no longer lights up after test
Salt Atmosphere (Corrosion Test)	ASTM B117	**Test Conditions:** • Ambient Temperature : 35 °C • Salt Deposit : 1-2 ml/hr/80 cm^2 horizontal collection area • Test Period : 48 hours **Failure Criteria [1]:** • LED no longer lights up after test

Note:

1. The entire test has failed if at least one LED from the sample set satisfies the listed failure criteria. If no LED satisfies the listed failure criteria, the test is successful.