

LED Chips Reliability Overview

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INTRODUCTION

This application note outlines the Cree LED pre-release qualification testing used to ensure long-term reliability for Cree LED Chips.

PRE-RELEASE QUALIFICATION TESTING

Before releasing LED Chips to production, Cree LED exposes a representative set of product samples to a suite of pre-release qualification tests. There is no unified standard for qualification testing in the LED industry. Each LED company decides what tests and conditions are used to qualify new products.

Cree LED's pre-release qualification test suite, shown on page 2, is based on standard semiconductor pre-release qualification test conditions and practices. Test methods are defined by the Joint Electron Device Engineering Council (JEDEC), the Illuminating Engineering Society (IES) and MIL-STD-883.

PRE-RELEASE QUALIFICATION TEST LIST (OPERATING LIFE TESTS)

Test Environment	Applicable Standards	Test Conditions & Failure Criteria
High Temperature Operating Life Test (HTOL)	IES LM-80-2008	Test Conditions: <ul style="list-style-type: none"> • Ambient Temperature : 85 °C • Forward Current : Maximum in data sheet • Test Period : 1008 hours Failure Criteria ²: <ul style="list-style-type: none"> • Forward Voltage shift ³ : > 10% • Flux degradation ³ : > 15% • Catastrophic failure ⁴
Wet High Temperature Operating Life Test (WHTOL) ⁵ 85 °C/85% RH or 60 °C/90% RH	JESD22 Method A101-C	Test Conditions: <ul style="list-style-type: none"> • Forward Current: : Maximum in data sheet • Ambient Temperature⁶: <ul style="list-style-type: none"> • 85 °C/85% RH : 85 °C • 60 °C/90% RH : 60 °C • Humidity⁶: <ul style="list-style-type: none"> • 85 °C/85% RH : 85% RH • 60 °C/90% RH : 90% RH • Test Period : 1008 hours (cycled) Failure Criteria ²: <ul style="list-style-type: none"> • Forward Voltage shift ³ : > 10% • Flux degradation ³ : > 15% • Catastrophic failure ⁴
Low Temperature Operating Life Test (LTOL)	JESD22 Method A104-H	Test Conditions: <ul style="list-style-type: none"> • Ambient Temperature : -40 °C • Forward Current : Nominal in data sheet • Test Period : 1008 hours Failure Criteria ²: <ul style="list-style-type: none"> • Forward Voltage shift ³ : > 10% • Flux degradation ³ : > 15% • Catastrophic failure ⁴

Notes:

1. This Test List is a guideline for LED chips pre-release qualification. A product-specific Qualification Plan is defined for each product release and may include modified or additional tests, test conditions and/or failure criteria.
2. A test typically fails if one or more LED chip samples exceed the listed Failure Criteria. A failed sample may be discounted and the test considered to pass if the failure mode is unrelated to the chip design under qualification.
3. Comparison is made between the [value at time 0] and the [value at the end of the test period].
4. A catastrophic failure causes the LED to become non-functional, i.e., open or short.
5. The WHTOL environment for an LED chip qualification is 85 °C/85% RH or 60 °C/90% RH. Power LED chips are typically qualified using WHTOL 85/85 conditions. Low power LED chips are more commonly qualified using WHTOL 60/90 conditions.
6. Room Temperature Operating Life (RTOL) testing is not typically included in an LED Chips Qualification Plan.

PROCEDURES FOR OPERATING LIFE TESTS

The following procedures apply for LTOL, HTOL and WHTOL tests:

- All LED Chips are packaged with encapsulant for testing.
- Packaged LED chips are reflow-soldered onto metal-core printed circuit (PC) boards.
- PC boards are mounted onto heat sinks within reliability test chambers.
- Solder point temperature (case temperature) is maintained at or above the chamber's ambient temperature during the test.
- Power is applied to the packaged LED Chips. In WHTOL testing, power is cycled (one-hour on / one-hour off) to encourage moisture penetration. This procedure is more rigorous than a test with only power on.
- At regular intervals, the sample boards are removed from the test environment according to JEDEC protocol.
 - ◊ The packaged LED chips 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.

PRE-RELEASE QUALIFICATION TEST LIST (NON-OPERATING LIFE TESTS)

Test	Applicable Standards	Test Conditions & Failure Criteria
Thermal Shock ²	JESD22 Method A104-E Condition G	Test Conditions: <ul style="list-style-type: none"> • Temperature Range : -40 °C to 125 °C • Dwell Time : 15 minutes • Transfer Time : < 20 seconds • Cycles : 200 cycles Failure Criteria ¹: <ul style="list-style-type: none"> • LED no longer lights up after test
Electrostatic Discharge (ESD) ³	MIL-STD-883K HBM (Human Body Model)	Test Conditions: <ul style="list-style-type: none"> • Class Rating : As specified in data sheet • Pulses per voltage condition : 3 Forward + 3 Reverse • Voltage conditions tested : Multiple Failure Criteria ¹: <ul style="list-style-type: none"> • LED no longer lights up after test

Notes:

1. A test typically fails if one or more LED chip samples exceed the listed Failure Criteria. A failed sample may be discounted and the test considered to pass if the failure mode is unrelated to the chip design under qualification.
2. Thermal Shock testing is not included in all LED chip qualifications
3. ESD test requirements vary by chip size and are defined in each product-specific Qualification Plan when required.