XLamp® LEDs
Testing and Characterization

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INTRODUCTION

This document is a tutorial on Cree LED's test conditions for LEDs and shows how differences in test conditions can lead to measurement discrepancies between Cree LED's results and those of our customers.

Customers may ask Cree LED, "What did you send to me?" when customer LED or luminaire testing finds that LED luminous flux or color point are different than expected. The time and resources needed to resolve such a situation increases development costs.

Correlation samples from Cree LED can help alleviate this situation and remove this unnecessary delay in customers' development time.

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FLUX AND CHROMATICITY

XLamp® LEDs are provided in specific luminous flux ranges and defined color regions as shown in the examples in Table 1 and Figure 1. These luminous flux ranges and color regions, known in the LED industry as bins, can be found on the Cree LED website (www.cree-led.com) in the data sheet document for each of the XLamp LED products.

Table 1: XP family luminous flux ranges or bins

Group Code	Minimum Luminous Flux	Maximum Luminous Flux
J	23.5	30.6
K2	30.6	35.2
K3	35.2	39.8
M2	39.8	45.7
M3	45.7	51.7
N2	51.7	56.8
N3	56.8	62.0
N4	62.0	67.2
P2	67.2	73.9
P3	73.9	80.6
P4	80.6	87.4
Q2	87.4	93.9
Q3	93.9	100
Q4	100	107
Q5	107	114
R2	114	122
R3	122	130
R4	130	139
R5	139	148
S2	148	156
S3	156	164
S4	164	172
S5	172	182
S6	182	200

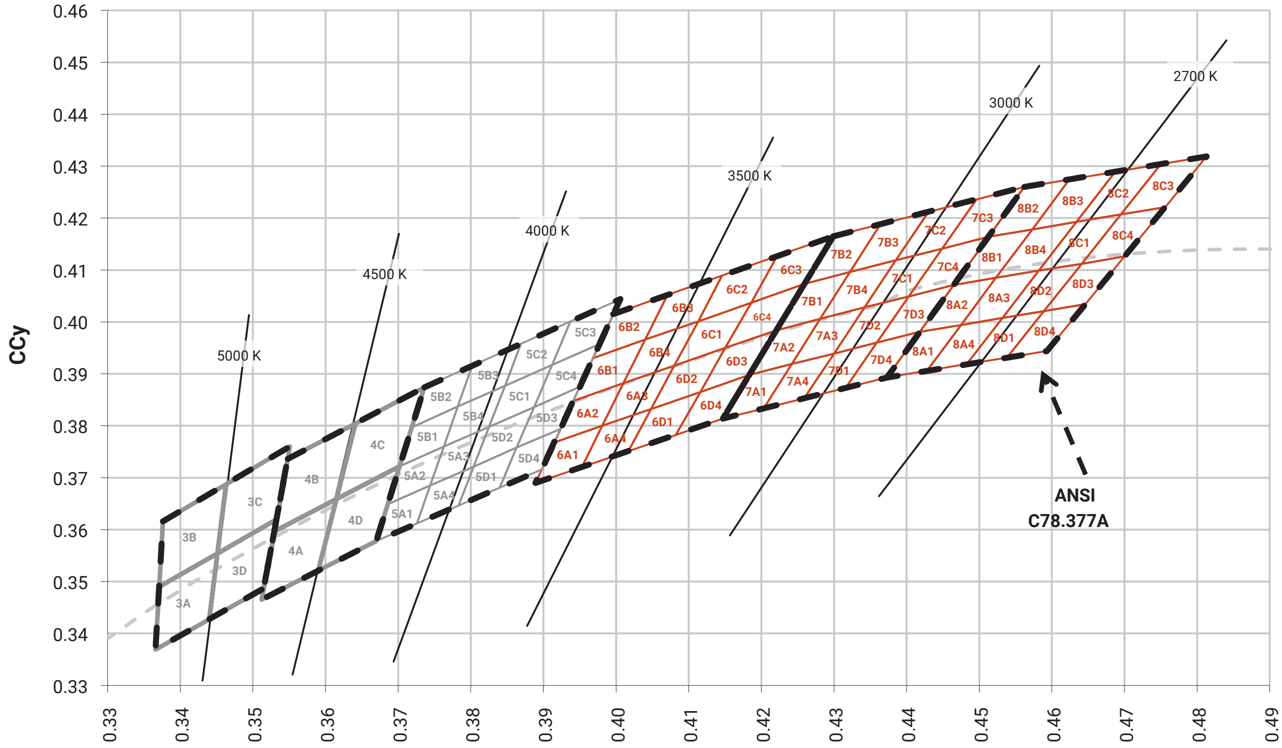


Figure 1: Chromaticity regions or bins for XP family XLamp LEDs

XLAMP® LED TEST CONDITIONS

During XLamp LED testing in its manufacturing facilities, Cree LED measures the photometric properties of each LED and sorts the LEDs into the appropriate chromaticity and flux bins. Cree LED calibrates its production test systems worldwide to United States National Institute of Standards and Technology (NIST) standards and performs production testing under specific and exacting conditions. During testing, LEDs have historically been operated at a drive current of 350 mA and a nominal ambient temperature of 25 °C. The actual measurement time of the light emitted by the LED, known as the integration time, is 25 msec. Because the integration time is so short, the LED junction temperature does not exceed the 25 °C ambient temperature. Beginning in 2011, Cree LED started binning select products at a higher temperature, 85 °C. This hot binning process helps customers reduce development cost by simulating LED operating temperatures.

After testing, the LEDs are placed into carrier tape on a reel and shipped to the customer. All the LEDs on a single reel are from a single flux bin and chromaticity bin that is part of the kit the customer has ordered.

If LEDs are operated at drive currents or temperatures that are not equal to the test current or test temperature, the resulting photometric data may not match that of the specific ordered bin. This is due to the well known fact that both temperature and drive current affect LED light output. Graphs in Figures 2 and 3 show the effects of temperature and drive current on luminous flux. Data sheets on the Cree LED website make these graphs available for each LED product.

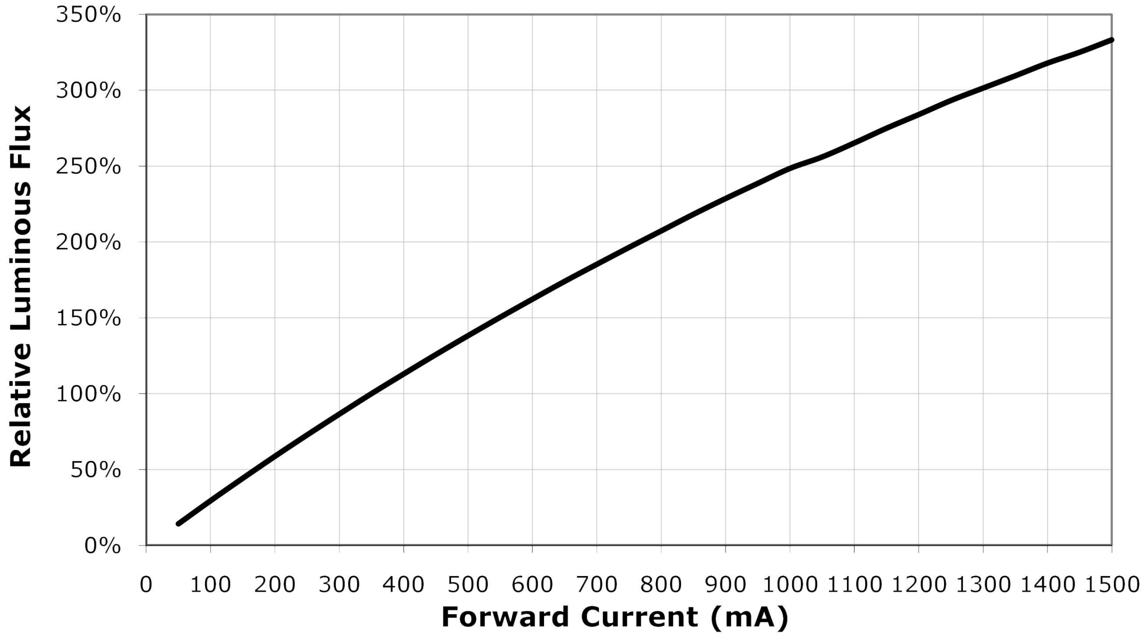


Figure 2: XLamp XP-G LED luminous flux vs. forward current.
The forward current used during XP-G testing is 350 mA (100% LF).

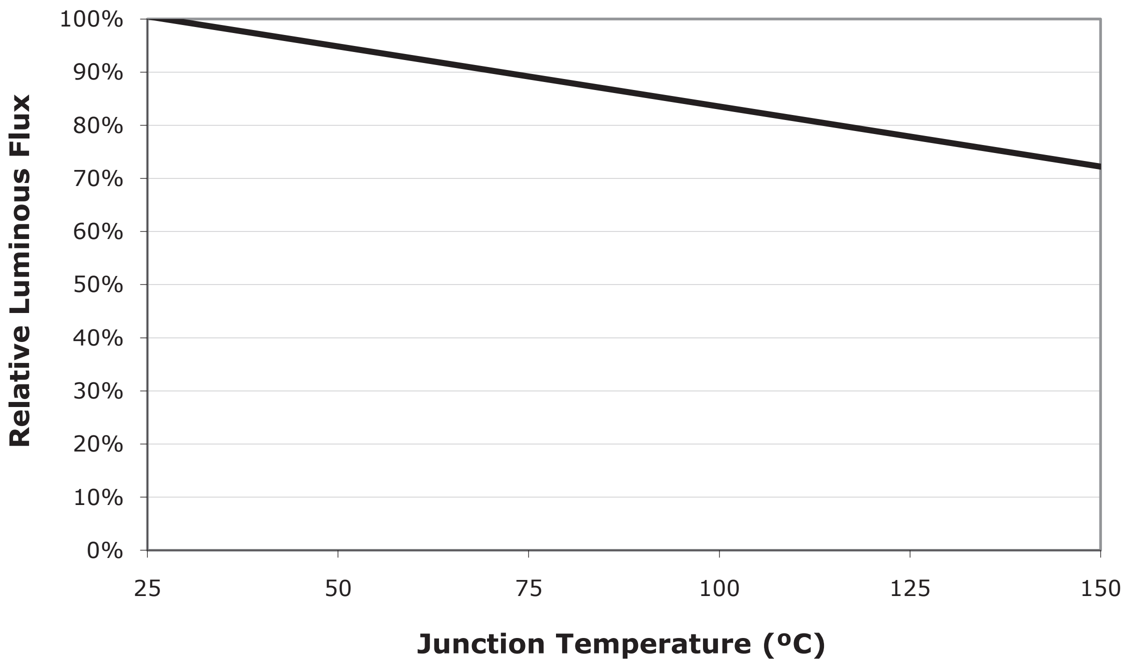
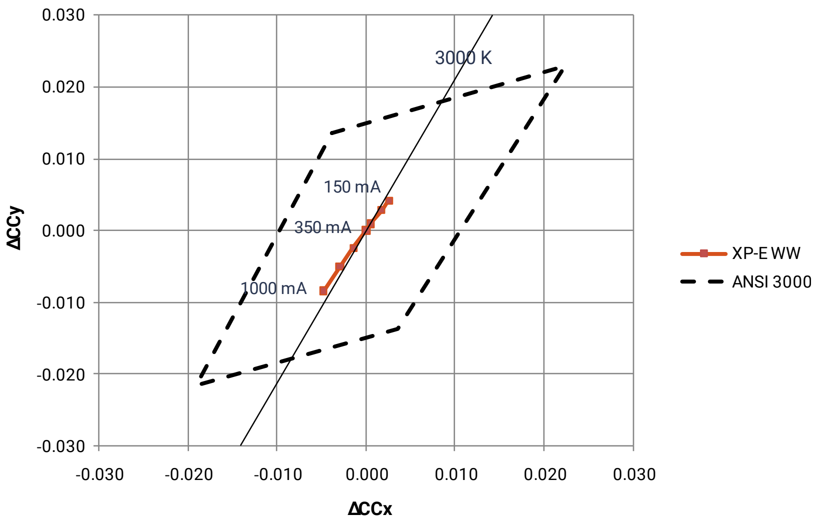


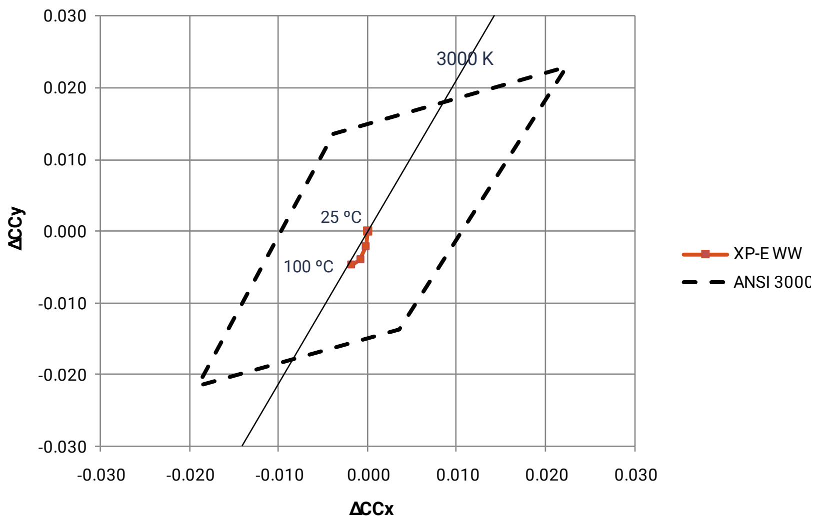
Figure 3: XLamp XP-G LED luminous flux vs. junction temperature.
The junction temperature during XP-G testing is 25 °C (100% LF).

In much the same way that luminous flux is affected by drive current and temperature, it is well known that chromaticity is also affected by drive current and temperature. Figures 4 and 5 show the typical color shift of the warm white XP-E LED as drive current and temperature increase.



Current (mA)	150	200	300	350	500	700	1000
ΔCCx	0.0026	0.0017	0.0005	---	-0.0014	-0.0030	-0.048
ΔCCy	0.0042	0.0028	0.0009	---	-0.0024	-0.0050	-0.0084
ΔCCT	-10	-6	-1	---	5	9	13

Figure 4: Color shift vs. drive current for 3000 K warm white XP-E LED



Tsp (°C)	25	50	80	100
ΔCCx	---	-0.0002	-0.0008	-0.0018
ΔCCy	---	0.0001	-0.0002	-0.0008
ΔCCT	---	-14	-18	-8

Figure 5: Color shift vs. temperature for 3000 K warm white XP-E LED

MEASUREMENT DISCREPANCIES

Upon measuring individual LEDs or assembled lighting products, XLamp LED customers occasionally find that the luminous flux does not meet their expectations or that the color point is not in the expected bin. This is invariably due to the use of a different test protocol than that used by Cree LED. Studying these issues has most often found that the junction temperature of the LEDs during customer testing is higher than the 25 °C/85 °C used by Cree LED. Operating the LEDs for more than 25 msec will cause the junction temperature to quickly increase above 25 °C/85 °C and result in lower than expected luminous flux measurements.

Using measurement tools that are not correctly calibrated has also been found to be a source of discrepancy.

TO AVOID DISCREPANCIES

To help avoid measurement discrepancies, Cree LED can provide correlation samples to XLamp LED customers. Upon request, Cree LED measures multiple LEDs using the standard Cree LED test parameters and calibrated equipment and records the test results. Cree LED ships the LEDs and results to the requester to be used as correlation samples. This ensures that XLamp LEDs are tested under consistent conditions and eliminates the need to resolve measurement discrepancies, streamlining customers' development processes.

Please contact your Cree LED sales representative if you are interested in receiving correlation samples from Cree LED.