Lighting Services Inc

CREE X-Lamps CMA2550 & CXB1310 White Light LED Series
Reliability Datasheet IS-0333 Rev. A

Reliability Data

INTRODUCTION

This Technical Datasheet summarizes the Reliability performance of the specification grade CREE X Lamp® White Light LED fixtures and High-Density LED Luminaires (CMA2550 & CXB1310 series, respectively).

As with all Solid-State Lighting Fixtures, the overall product reliability is determined by the integration of packaging and assembly of LED components, also defined as a Luminaire(s) into a fully integrated products. Reliability documentation ensures that each of the Original Equipment Manufacturers (OEM) guidelines on operating conditions and Certificate of Product Compliance are adhered to. The BPM, LP4, & LZ Zoom series of LSI Brand name products integrates with CREE's X Lamps LED Array modules. Therefore, to fully demonstrate the reliability of the fixture, the reliability of the LED package must be detailed, tested within context to each related integrated component and to the specified configuration of the Luminaire fixture(s).

Most LED components experience a gradual reduction in light output during operation, known as Lumen Depreciation. The reliability of the LED to maintain its light output during operation is known as Lumen Maintenance. As such, any degradation can be either from a reduction in the light-emitting efficiency of the LED chip or a reduction in the light transmission of the optical path within the LED component, package module, or integrated fixture. Other factors that play a critical role in Lumen Maintenance and Lumen Depreciation are: temperature conditions, phosphor quality, driver failure, other electrical conditions such as operating voltage, current, or wattage.

The CREE X Lamp product family is fitted for application in track, downlight, and outdoor use in Luminaire designs. All BPM, LP4, & LZ Zoom fixtures integrates CREE X Lamps to cover various performance requirements: lumen output, efficacy, and reliability in high drive current application.

Key factors establishing performance and reliability in operating conditions of the fixture are: time, current applied, and sustained temperatures. Therefore, Lumen Maintenance will be provided at specific current and temperature points for LED component, LED Array, and/or Luminaire Fixture. These three composite data points provide a practical manner to establish compliance with testing for LM-80-08 testing and TM-21 calculation standards.

The ambient temperature for all LM80-08 testing conditions conducted for Manufacturers LED modules, arrays, and components were at 25°C (77°F). However, Lighting Services Inc. conducts specified tests of X Lamp Array LEDs at the specified Case Temperature of the LED component(s)to ensure sustained product performance and reliability confidence from the rated maximum operating temperature(s) of 85°C (185°F). *CREE has performed an independent LM80-08 test of the X Lamp Array Module externally with a 3rd Party Laboratory to validate these parameters (LED Lumen Maintenance, Color Consistency, etc.).*

DEFINITIONS

Lumen Maintenance
Lumen maintenance is the luminous flux output remaining (typically expressed as a percentage of the maximum output) at any selected elapsed operating time.

Rated Lumen Maintenance Life, (L_{70})
The elapsed operating time over which the LED light source will maintain the percentage of 70% of its initial light output. Lifetime measurement criteria (developed by IESNA) of solid-state lighting source degrading past 70% of its initial lighting source output during useful operational hours of LED Module package. Units of measurement is in hours.

Product Lifetime (L_{70}, B_{50}, F_{YY},)
The combined metric of the elapsed operating time when the average light source will reach 70% lumen maintenance (reference value) and where XX% of the population have reached 70% lumen maintenance and where YY% of the population have experienced a conventional lights-out failure, i.e. -
$L_{70}/B_{50}/F_{25}$ (in units of hours). Industry metric standard of two nomenclature to description of the minimum of 80% Luminous Flux for a specified period in Maximum Ambient Temperature.
Industry metric standard of two nomenclature to description of the minimum of 90% Luminaire to the level of maintenance defining the Luminous flux (B_{50},)

Ambient Temperature, T_{AMB}
The Temperature immediate surrounding air that Luminaire equipment is exposed to for the purpose of testing

Case Temperature, T_C
The Temperature of the casing within the LED light source package defined by the OEM Manufacture

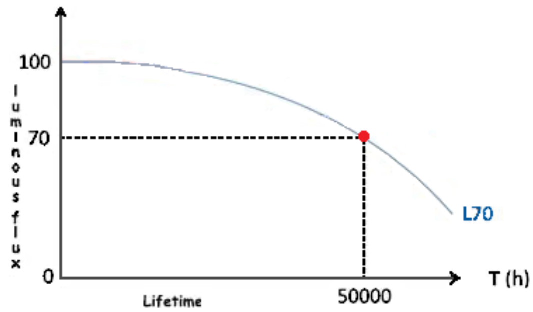


Figure 1 - L_{70} , Actual Lifetime of LED Luminaire – Luminous Flux Description (*Refer to Reliability – Product Lifetime section*)

Mean-Time Between Failure, MTBF

A defined period of elapsed time between failures of an individual electronic component or system specific to LED Luminaires

$$MTBF \equiv \frac{Hours\ of\ Operation}{Number\ of\ Failures} = \frac{\Sigma(\text{Start}_{DOWNTIME} - \text{Start}_{UPTIME})}{Number\ of\ Failures}$$

Lifetime Lumen Maintenance Projection

$$L_p(Dk) = \frac{ln(100 \times \frac{B}{p})}{\alpha} \cong \frac{ln(\frac{B}{0.7})}{\alpha}$$

$L_p \equiv Lumen\ maintenance\ output\ expressed\ in\ hours, where\ p\ is\ in\ \%\ of\ initial\ lumen\ output\ maintained$

$D \equiv Total\ duration\ of\ time\ divided\ by\ 1000$

Normalized Luminous Flux

Luminous Flux output at time, t, operating hours which derives a decay rate constant of when the calculated output reaches 70% Lumens

$$\Phi(t) = Be^{-\alpha t}$$

$t \equiv operating\ time, (hours)$
$\Phi(t) \equiv Average\ Normalized\ Luminous\ Flux\ output, (\%)$
$B \equiv projected\ intital\ constant, derived\ from\ the\ least\ squared\ curved\ fit$
$\alpha \equiv decay\ rate\ constant\ derived\ from\ the\ least\ squared\ curved\ fit$

LM80-08, Testing Protocol

IES standard that utilizes a test method to measure lumen depreciation of operated solid-state lighting source such as LED integrated component, modules, and auxiliary current drivers. Results recorded details clarifications for better understanding of LED Product Lifetime and product performance over time.

Technical Memorandum – TM-21-11 Test Method Report
Technical Memorandum IES recommended Industry metric standard, by IESNA, to specify how to extrapolate data generated from internal LM-80 Protocol lumen maintenance tests results conducted by LED manufacturers.

DRIVE CURRENT (IP)

The BPM, LP4, & LZ Zoom series operates the CREE CMA/CXB models at $I_{LM-80,\ Test} = 1900\ and\ 950\ mA$, respectively, depending on the LED package module and Lighting application. Supported documentation on qualifying components used in BPM, LP4, and LZ Zoom Series are available for viewing within the parameter scope of specification required by CREE X Lamp LED modules. The driver, LED module, and optical reflectors components are all key criteria of the Luminaire's Overall Product Reliability and lifetime Lumen Maintenance. BPM, LP4, & LZ Zoom series luminaires all have electronic drivers that have been critically selected due to their performance requirements and specified component compatibility.

The fixture design also ensures that the electronic driver meets the electric, thermal requirements that the driver manufacturer sets to prevent the possibility of unexpected malfunction. Test results from samples tested of Luminaire having a 70% Lumen Maintenance to yield an output result(s) to TM-21 calculations. The reflector suppliers are also under constant surveillance by LSI for optical coating quality and efficiency.

LSI BPM, LP4, & LZ Zoom series uses MAGTECH. Drivers integrated into our Luminaire units are ROAL series (**RSLP070-48 @ 1500mA**), MAGTECH M-series (**MD42-U42-0950-XP @ 950mA**) for LP4 integrated with CREE X Lamp CMA2550 LEDs; and finally, MAGTECH M-Series (**MD22-U24-0950-XP @ 950mA**) and PermLight (**PS25-48V-UNV @ constant voltage**) for LZ Zoom integrated with CREE X Lamp CXB1310 LEDs. The MTBF (referenced in the definition section) of which LED Drivers' operating specification >100,000 Hrs. at full load and $T_{AMB} = 25°C$ conditions. (TELC3, Telcordia SR-332, Issue 3 references results documented on MAGTech LED Drivers Datasheet.

CASE TEMPERATURES

Drive current and operating temperature are the two most important variables affecting long-term lumen maintenance of high-power LED's. These two variables have the most influence on the "Junction Temperature". The LM-80-08 and TM-21-11 protocols define T_{CASE} to be the temperature at the thermocouple attachment point on the LED light source package as defined by the manufacturer. Case Temperature is therefore the most critical factor for ensuring sustained performance and product lifetime as that is how the LM-80-08 testing is performed.

Specifications for driver current and T_{CASE} will be detailed in reported results.

RELIABILITY TESTING

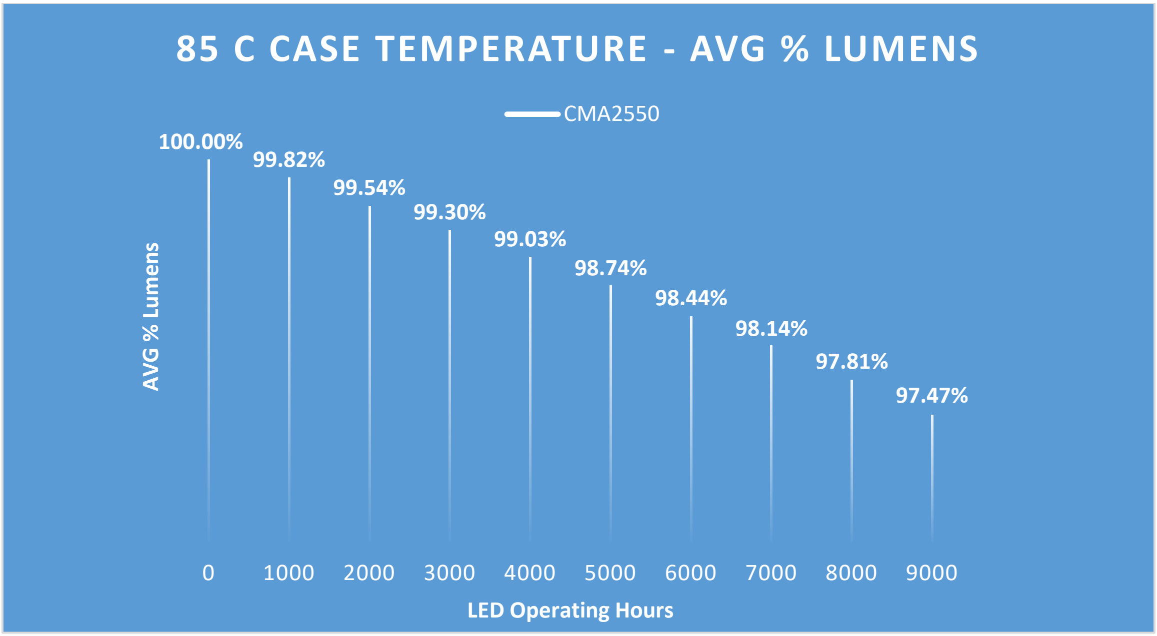
LM80-08 STANDARDIZED TESTING

The scope of focus is CREE XLamp® White Light LEDs under LM80-08 testing on CMA2550 & CXB1310 series assembled into modules design allows a variety of lenses and heatsinks to integrate into different configurations of Luminaire design options. LM-80-08 testing is an industry wide testing standard that measures Lumen Maintenance and Color Consistency of an LED lighting source or a Luminaire. National Voluntary Laboratory Accreditation Program (NVLAP®) is the 3rd Party responsible for facilitating testing capacity for CREE products lines testing their LED Modules by CREE LED's SSL Testing Laboratory (**Lab Code: 500041-0**). Testing is performed for IES LM-80-2008 and LM-80-2015. The report that documents the findings of data recorded in LM-80-08 testing are listed below:

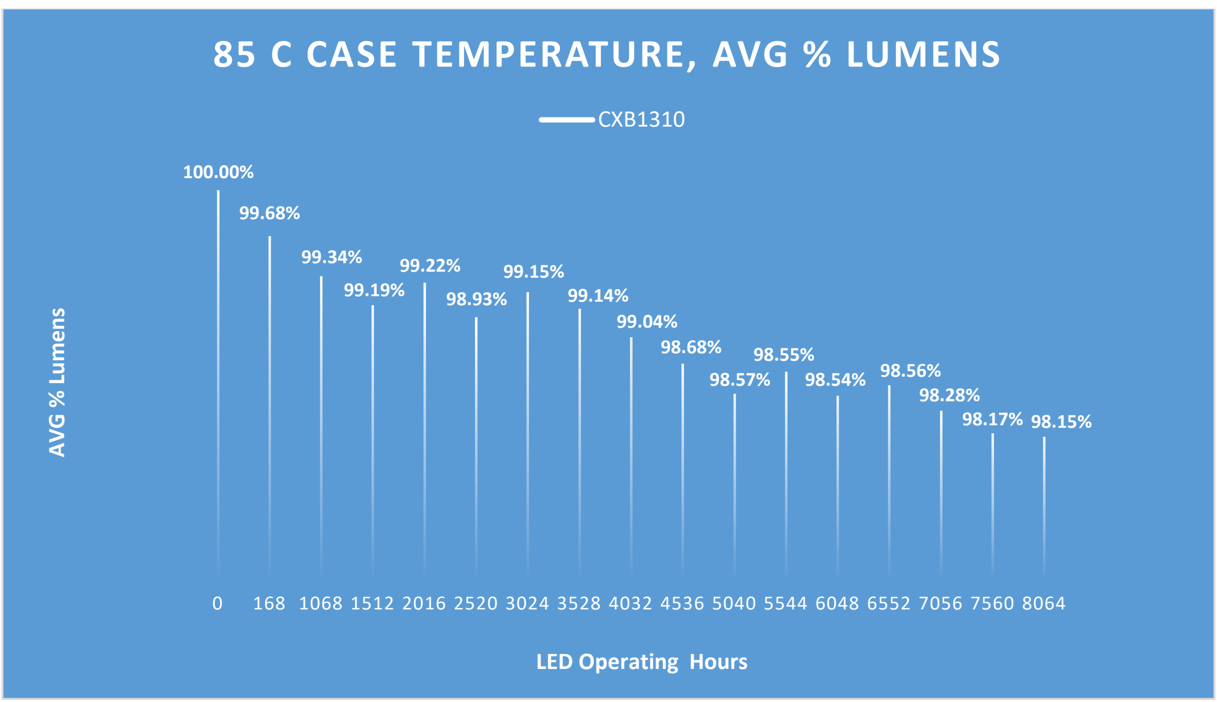
1. *CREE, LM-80-08 Report –* ***9,000 hrs.***
    a. Lab Report Code Number: 500041-01
    b. Report Date: December 13th, 2021 (Rev. 12)
    c. Product Type: LED Array
    d. LED Model: CMA2550
    e. Test Duration: 0 – 9,000 hours, in increments of 1000 hours
2. *CREE, LM-80-08 Report –* ***12,000 hrs.***
    a. Lab Report Code Number: 500041-01
    b. Report Date: June 20th, 2018 (Rev. 5)
    c. Product Type: LED Array
    d. LED Model: CXB1310
    e. Test Duration: 0 – 12,000 hours, in increments of 1000 hours

Each LM-80-08 reports are the standard test results published most recent to date.

The format of testing is that each LED Array is operating in $T_{AMB} = 25°C$. The internal operating temperature of each LED Lighting source is 85°C. Lumen output is measured in percentage from the beginning operating hours to the end. The average Lumen (%) is then measured every 1000 hours to check for Lumen Depreciation over the course of time tested. Testing temperatures point should never exceed temperature point(s) stated above for testing at operating condition to avoid system damage in Luminaires. Below is a graph illustrating LM-80-08 testing results obtained from CREE CMA2550 and CXB1310 Array at each operating temperature(s):



Graph 1 – 85°C Case Temperature, Lumens Maintenance (Tested at 9,000 Hours)



Graph 2 – 85°C Case Temperature, Lumens Maintenance (Tested at 12,000 Hours)

The Graphs above display the Lumen Depreciation (%) overtime of operating test conditions, which is running 13 and 15 LED samples at one Case Temperatures, $T_{C,\ CMA2550} = T_{C,\ CXB1310} \equiv 85\ °C$. From the data sample populated over the course of 9,000 hrs for the CMA2550 LED Model and of 12,000 hrs for the CXB1310 LED Model, the product lifetime of each LED Module(s) was found by extrapolating the measured data recorded in the LM-80-08 testing from the TM-21-11 Calculator. **DISCLAIMER**: No Failure were discovered during tests conducted.

TM-21-11 Test Report

TM-21-11 provides recommendations for projecting the long-term lumen maintenance of LED light sources to estimated product longevity. Lumen Depreciation is the key factor being calculated to give a predictive measure of Lumen Maintenance over the lifecycle of the Luminaire. The TM-21 rationale was determined using statistically significant long-term tests to produce mathematical models that predict lumen maintenance. The maximum limitation making a “Reported L_{70}” data claim by using the TM-21-11 formulas, is only six (6) times the total test duration (Max. Hours).

Therefore, to claim 50,000 hrs., data would be required at a minimum of 8,333 testing hours, however these models can “interpolate” a theoretical life as well.

From the reported date(s) mentioned in the LM80-08 section, CREE has achieved 9,000 hours and 12,000 hours of LM-80-08 testing in which Table No. 1 and Table No. 2 displays results of the projected Lumen Maintenance and at what period the Lumen output will reach

$$L_P \equiv Projected\ Lumen\ Maintenance\ output.\ (\%)$$

Resulted calculations are extrapolated values from LM80-08 inserted into TM-21 formula for the CREE X Lamp LED Array Module testing to substantiate a reported claim of 6 x 9,000 = 54,000 hours & 6 x 12,000 = 72,000 hours, in which LSI cannot make claims of the quality of Lumen Maintenance past the hours calculated. Under these Testing condition(s) L_P ≥ 70%, not past 6 × (Test Hours). Calculations tabulated in results recorded are projected lifecycle hours. Projected calculations can be made utilizing TM-21 formula to “interpolate” data from documented LM80-08 results reported. TM-21-11 projected results are displayed in Table No. 1 at 85°C where the CMA2550 CREE LED Array will reach a projected Lumen Maintenance output (L_P) at an estimate 84.55% at 54,000 hrs from the 9,000 hrs LM-80-08 Test Conditions. Results from CXB1310 CREE LED Array tested at 12,000 hrs LM-80-08 Test Conditions were calculated to be as follows for Lumen Maintenance $L_P = 98.97\%$ at 72,000 hrs. (Displayed on Table No. 2)

Report LM-80 Test Condition, CMA2550	
Case Temperature, CMA2550	
Temperature (°C)	85
Temperature (°K)	358.15
Calculated Lumen Maintenance (% @ 54,000)	84.55
Reported L70 (hrs), @ 9,000 hrs	> 50,000

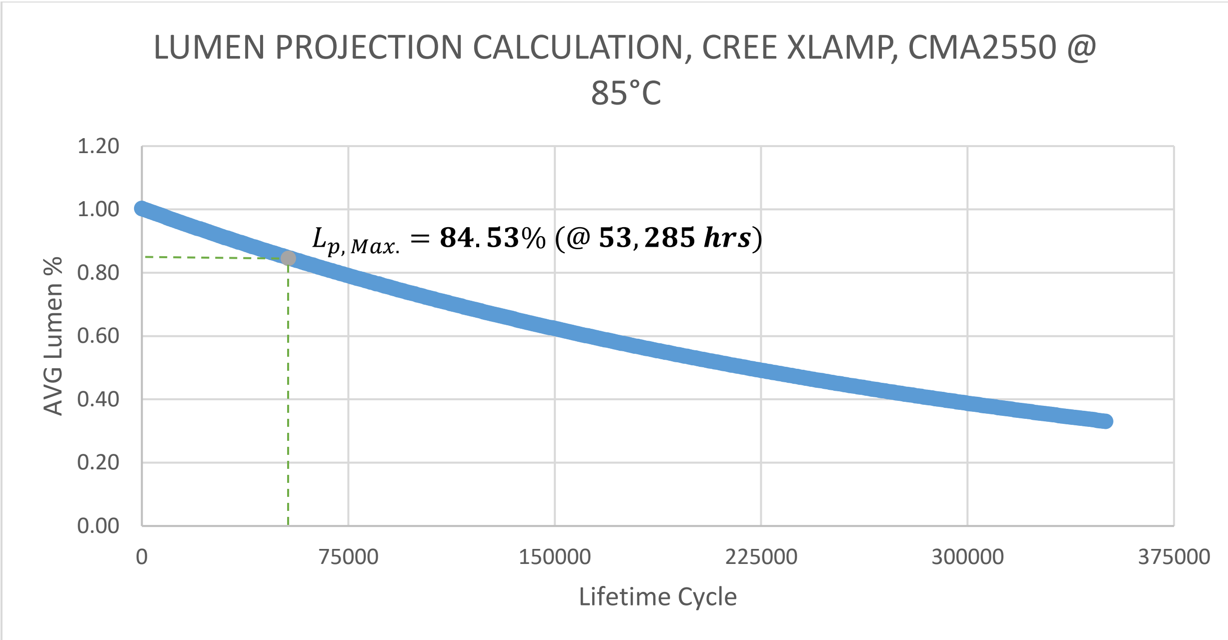
Table 1 – TM-21-11 Reported Projections of 9,000 Hrs. Test from LM-80-08 CREE test

Report LM-80 Test Condition, CXB1310	
Case Temperature, CXB1310	
Temperature (°C)	85
Temperature (°K)	358.15
Calculated Lumen Maintenance (% @ 72,000)	98.97
Reported L70 (hrs), @ 12,000 hrs	> 67,000

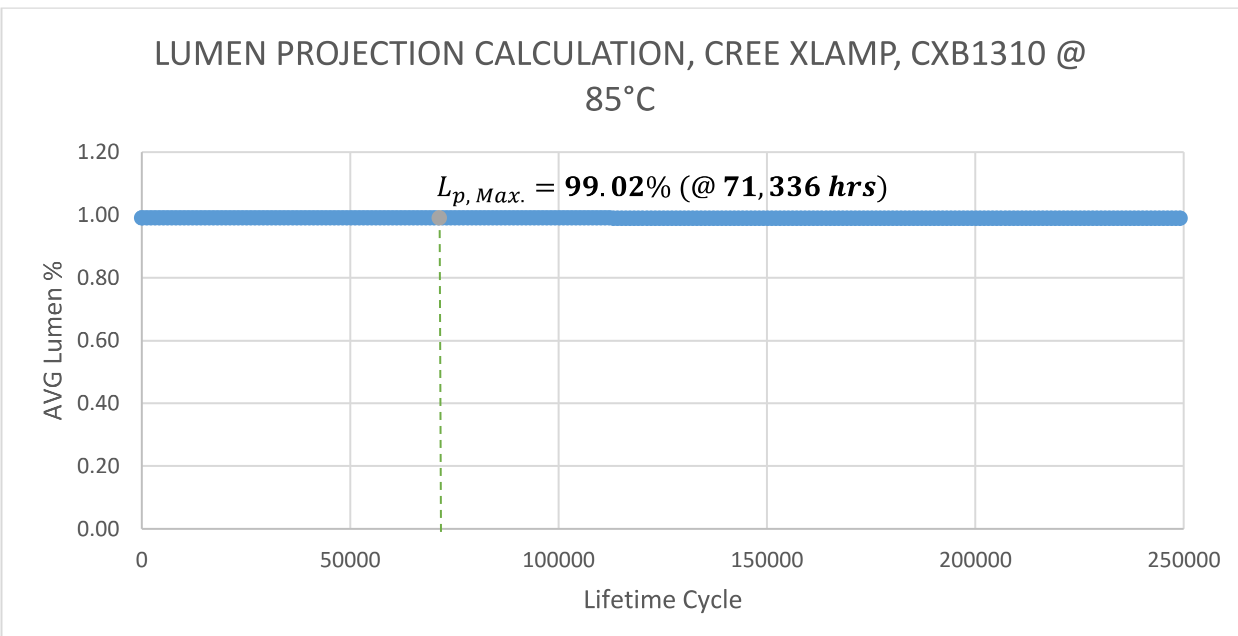
Table 2 – TM-21-11 Reported Projections of 12,000 Hrs. Test from LM-80-08 CREE test

PRODUCT LIFETIME

Below are graphs detailing test results from Reported L_P claims from LM80-08 Testing collected, and from said data gathered, using them to calculate Operating Hours of Luminaire fixtures will maintain a 70% or greater Lumen Maintenance quality over the course of its Lifetime below 6 × (Test Hours). The data also illustrates over the course of a Luminaires Lifetime what the degradation of the LED Array from CREE CMA/CXB models will be over the period of time observed from LM80-08 Test Conditions and calculated in TM-21 standard, approximately. The intervals of the operating hours used to calculate project Lumen Maintenance, L_P, were in increments of $t = 1{,}000\ hrs$. (Starting at t = 0 hrs)



Graph 3 – CREE X Lamp LED Array (CMA2550), @ $T_{Case\ Temp.}$ = 85°C Lumen Maintenance Calculation



Graph 4 – CREE X Lamp LED Array (CXB1310), @ $T_{Case\ Temp.}$ = 85°C Lumen Maintenance Calculation

CONCLUSION

Based on the above data and testing, the CREE X Lamp series Luminaires is expected to exceed a Rating Lumen Maintenance of

- $L_{P,\ @\,85°C\ and\ 9{,}000\ hrs} \equiv\ 84.53\%$ (CMA2550, Graph 3)
- $L_{P,\ @\,85°C\ and\ 12{,}000\ hrs} \equiv\ 99.02\%$ (CXB1310, Graph 4)

Lighting Services Inc. is projecting that the CREE X Lamp series will have a **Lumen Maintenance** of 84.53% (CMA2550) and 99.02% (CXB1310) during the period of $t_{Lumen\ Maintenance} \leq$ 72,000 Hours.