

LumeLEX™ 2000 Series  
Reliability Datasheet: IS-0112 E

# Reliability Data

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## INTRODUCTION:

This datasheet summarizes the reliability performance of the specification grade LumeLEX™ 2000 series fixtures.

As with all Solid-State Lighting Fixtures, the overall product reliability is determined by the integration of packaging and assembly of LED components into a final product, ensuring that each of the Original Equipment Manufacturers (OEM) guidelines on drive conditions and assembly practices are adhered to. The LumeLEX™ 2000 series of products use Xicato XSM and XLM Led Modules that can typically contain Philips Lumileds LUXEON Royal-Blue Rebel LEDs.

Therefore, to fully demonstrate the reliability of the fixture, the reliability of the LED and of the Xicato Module must be detailed and tested within context to each other and to the fixture.

Most LEDs experience a gradual reduction in light output over the lifetime of 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 package, module or fixture. The ability of a light source to maintain its original color properties over time is referred to as Maintained Color Consistency, and is detailed in LSI's LumeLEX™ 2000 Color Consistency Datasheet IS-0122.

The Xicato product uses remote-phosphor technology to keep the phosphor layer cold during operation, therefore retaining its light transmission and color properties throughout the life of the product. There is a multitude of optics available for the LumeLEX™ 2000 fixtures, made from either optical grade Acrylic Lenses or Aluminum coated polycarbonate reflectors. These materials do not degrade over time, as the heat of the fixture and the wavelength of light do not impact the Aluminum coating or the acrylic material.

The most important drive conditions of the fixture are current applied and operating temperature, as these are the key factors on establishing performance and reliability. Therefore, Lumen Maintenance will be provided at specific current and temperature points for the LED, the Module and the Fixture. These three composite data points provide objective evidence to establish compliance with LM-80-08.

The maximum ambient operating temperature for the LumeLEX 2000 is 35°C/95°F.

Xicato has also performed an independent LM-80-08 test of the module to validate both Lumen Maintenance and Color Maintenance.

## REFERENCES:

- IESNA Testing Procedures Committee. IESNA LM-79-08 *Approved Method for Lumen Maintenance Testing of LED Light Sources*, New York: Illuminating Engineering Society of North America, 2008.
- IESNA Testing Procedures Committee. IESNA LM-80-08 *Approved Method for Lumen Maintenance Testing of LED Light Sources*, New York: Illuminating Engineering Society of North America, 2008.
- IESNA Testing Procedures Committee. IESNA TM-21-11 *Projecting Long Term Lumen Maintenance of LED Light Sources*, New York: Illuminating Engineering Society of North America, 2008.
- Lumileds. RD07 Reliability Datasheet RD07 *LUXEON Rebel Reliability Data*, Philips 2007.
- Bay Area Compliance Laboratories Corp. *LM-80-08 TEST AND MEASUREMENT REPORT (9100 HRS) For Xicato Inc. Model: XSM8030-1300-B*, SunnyVale CA: Report Number R1209208A-9100Hrs Final. March 22, 2013
- Next Generation Lighting Industry Alliance with the U. S. Department of Energy. Solid-State Lighting Product Quality Initiative *LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting: First Edition* May 2010.

## DEFINITIONS:

- Lumen Maintenance** – Lumen maintenance is the remaining luminous flux output (typically expressed as a percentage of the maximum output) at any selected elapsed operating time.
- Rated Lumen Maintenance Life, ( $L_p$ )** – The elapsed operating time over which the LED light source will maintain the percentage, p% (e.g. 70%), of its initial light output e.g.  $L_{70}$ (hours).
- Lumen Maintenance Lifetime, ( $B_{xx}$ )** – The elapsed operating time over which xx% (e.g. 50%) of the products light output falls below 70% of the nominal initial value e.g.  $B_{50}$ (hours).
- Electrical Failure Time ( $F_{yy}$ )** – The elapsed operating time over which yy% (e.g. 25%) of the population has experienced conventional lights-out failure e.g.  $F_{25}$ (hours).
- Product Lifetime ( $L_{70}/B_{xx}/F_{yy}$ )** – 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; e.g.  $L_{70}/B_{50}/F_{25}$  (hours).
- Case Temperature, ( $T_x$ )** –  $T_x$  is the temperature of the thermocouple attachment point on the LED light source package (x) as defined by the manufacturer of the package (OEM or x).

**CONSTRUCTION OF LumeLEX™ 2000 SERIES FIXTURES:**

The LumeLEX™ 2000 series of products, as shown in Figure 1, are Composite Fixtures that start with Philips Lumileds LUXEON Rebel LEDs which are then packaged into both the Xicato XSM and XLM LED Modules and then integrated by Lighting Services Inc into our LumeLEX™ 2000 series fixtures.



Figure 1 – the Composite Fixture – LSI, Xicato, and Philips

The specific Philips Lumileds LUXEON Rebel, is the Royal-Blue Indium Gallium Nitride (InGaN) LED. Figure 2 illustrates the internal construction of the Royal-Blue InGaN LUXEON Rebel package. Note that the LED chip is mounted on top of the metalized ceramic substrate using gold-to-gold interconnects. A separate InGaN chip is then mounted on the metalized ceramic substrate, with a clear silicone lens molded over the LED package and InGaN chips.

The driver, LED module and optical components (lenses or reflectors) are all key aspects of the product reliability and lumen maintenance. LumeLEX 2000 fixtures all have electronic drivers that have been critically selected due to their performance. The fixture design also ensures that the electronic driver meets the thermal requirements that the driver manufacturer requires to ensure that a conventional “lights out” failure is not caused by driver failure, and that the driver operates inside of its tolerances for supplying power to the LED module. The reflector suppliers are also under constant surveillance by LSI for optical coating quality and efficiency.

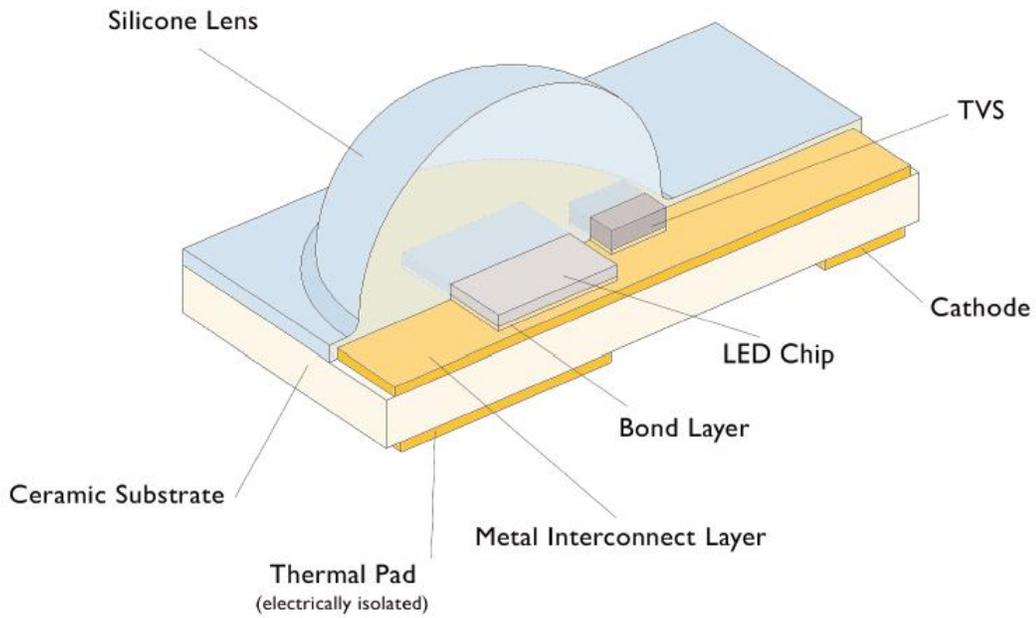


Figure 2 – Philips Lumileds LUXEON Rebel Construction

The Xicato XSM LED module, Figure 3, packages the LUXEON Rebel LEDs. Utilizing remote phosphor technology the XSM keeps the phosphor colder than other solid state products that have the phosphor directly applied to the top of the LED InGaN chip.



Figure 3 – Xicato XSM led module packages several Lumileds LUXEON Rebels

DRIVE CURRENT:

The LumeLEX™ 2000 operates the XSM and XLM modules and Rebel LEDs at 1050mA and below – depending on the fixture, module and application.

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” which is equivalent to the “heart” of the LED. The LM-80-08 and TM-21-11 protocols defined Case Temperature to be the temperature at the thermocouple attachment point on the LED light source package as defined by the manufacturer of the package. The Case Temperature is therefore the quintessential factor for ensuring product lifetime, as that is how the LM-80-08 testing is performed.

Philips and Xicato have published specifications for all of their case temperatures:

- Tc = XSM Module Case Temperature
- Tj = LED Junction Case Temperature
- Tp = LED Thermal / solder pad Temperature

These specifications are verified by measurements in the module and in the fixture. The combined Drive Currents and Temperatures are shown in Table 1, as both Specifications and as verified Measurements.

*Ambient Operating Temperature 35°C /95°F – Customer Maximum Ambient* *SPECIFICATION*

<u>Component</u>	<u>Drive Current</u>	<u>Case Temperature</u>	<u>SPECIFICATION / VERIFICATION</u>
LumeLEX™ 2000	1050mA	Tc 90°C – Xicato Module Case Temp - Measured	Measurement
Xicato XSM	1050mA	Tc 90°C - Xicato Module Case Temp - Maximum	SPECIFICATION
	1050mA	Tj 116°C - Junction Temp - Measured	Measurement
	1050mA	Tp 95°C - Thermal / solder pad Temp - Measured	Measurement
LUXEON Rebel	1050mA	Tj 125°C - Junction Temp – Figure 4	SPECIFICATION
	1050mA	Tj 135°C - Junction Temp – Figure 5	SPECIFICATION
	1050mA	Tp 111°C - Thermal / solder pad – Figure 6	SPECIFICATION

Table 1 – Specification and Measurement Summary of Case Temperatures of LumeLEX™ 2000

In order to ensure long life of this product, each manufacturer has a factor of safety already built into the design elements. For example, Philips specifies their Tj (LED Junction Case Temperature) to not exceed 125°C at 1000mA, and Xicato’s Module has a measured Tj = 116°C at 700mA. Philips specifies their Tp (LED Thermal / solder pad Temperature) to not exceed 111°C, and Xicato Module has a measured Tp = 95°C. Xicato achieves these temperatures by specifying their Tc (Xicato Module case temperature) not to exceed 90°C. This is consistent with the LSI LumeLEX™ fixture led Module Tc measuring below 90°C, when tested in an ambient environment that does not exceed 35°C /95°F.

## RELIABILITY TESTING:

With the Construction, Drive Current and Case Temperatures defined, it is now possible to demonstrate the LumeLEX™ 2000 series reliability to IESNA LM-80-08 (Lxx) and per the LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting (L70/Bxx/Fyy).

Starting with the Royal-Blue LUXEON Rebel LED, Figure 4 shows the long-term lumen maintenance of the royal-blue LUXEON Rebel at Tj (LED Junction Case Temperature) of Tj = 125°C.

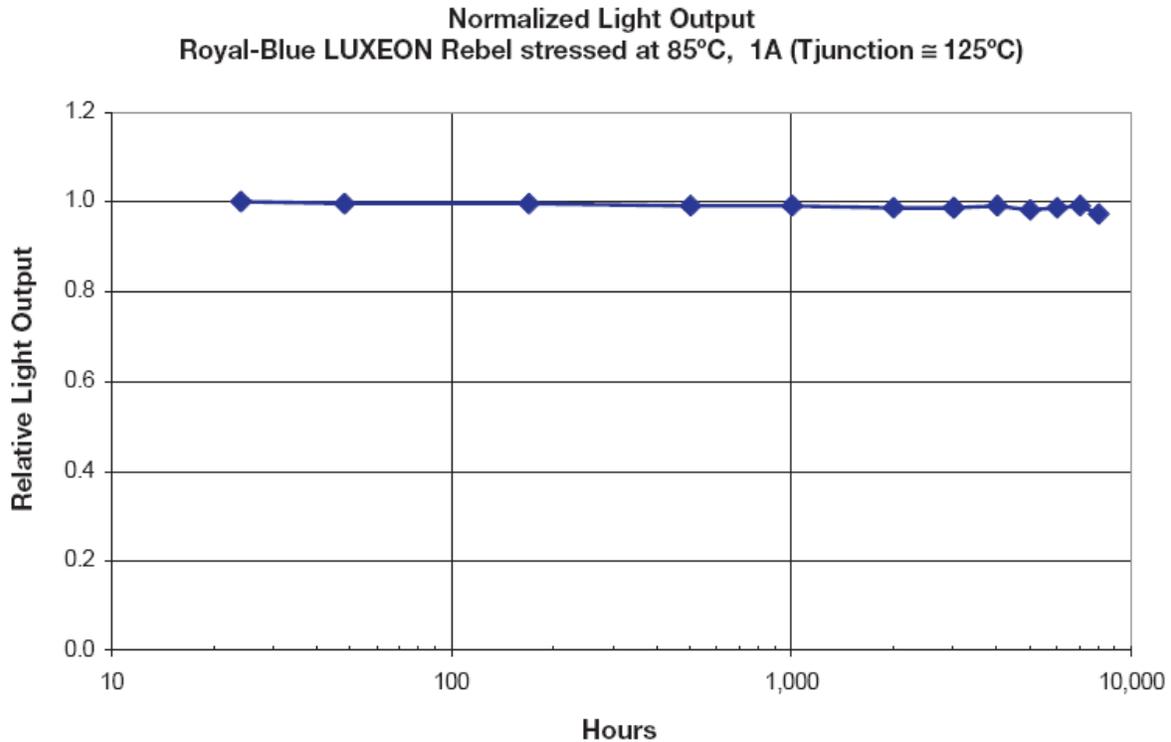


Figure 4 – Lumen maintenance of royal-blue LUXEON Rebel.

As you can see in Figure 4, there is less than 5% drop in lumen maintenance in the first 10,000 hours of life. The following is per Lumileds RD07 - “The LUXEON Rebel product family was stressed over a wide range of drive currents and junction temperatures in order to predict useful lifetimes under various operating conditions. To aid understanding, these predictions incorporate the same terminology applied to conventional lighting technologies. For example, many light sources display little change in light output as the lamp is stressed, until the unit fails catastrophically. As a result, failure rates are often expressed in terms of the time by which a certain percentage of the population is expected to have failed. For example, a B10 value for any given lamp denotes the time by which 10% of the population is expected to fail.” Note – this B10 value is a 0% light output failure, as defined by Philips.

“However, noting that the light output of an LED tends to degrade gradually as the device is stressed, its efficacy may fall to an unacceptable level long before total failure occurs. Such a condition may be described as lumen maintenance failure. To facilitate comparison of the LUXEON Rebel family with

other lighting devices using conventional technologies and other LEDs Philips Lumileds also expresses LUXEON reliability with reference to a threshold for lumen maintenance failure. For example, L70 defines a lumen maintenance failure as any unit producing less than 70% of its initial output. Since light output degradation is defined as  $(1 - \text{lumen maintenance})$ , a failure criteria of L70 means that any unit with more than 30% light output degradation would be classified as a failure.”

“Using this terminology, Philips Lumileds has estimated the expected lifetimes of the LUXEON Rebel product family as a function of drive current and junction temperature. For example, the lifetime at (B10, L70) is the expected stress time at which 10% of the population is expected to have either failed catastrophically (i.e. opens or shorts) or has degraded by more than 30% from the initial light output.”

Figure 5 and 6 show the expected (B50, L70) lifetimes at a 90% confidence interval for the InGaN LUXEON Rebel as a function of the T<sub>j</sub> (junction temperature of LED) and the T<sub>p</sub> (Thermal / solder pad temperature LED), respectively. Note the blue arrows that indicate the actual MEASURED operating temperatures for the T<sub>j</sub> and T<sub>p</sub> values in the Xicato Modules in the LumeLEX 2000.

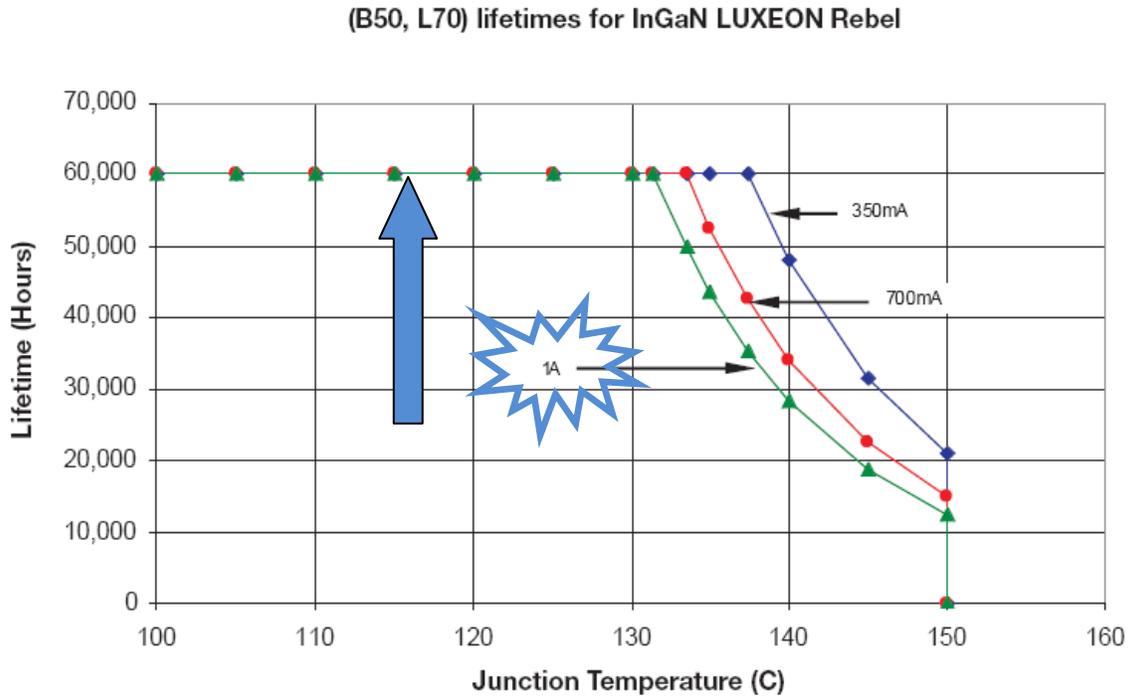


Figure 5 – Expected (B50, L70) lifetimes for InGaN LUXEON Rebel

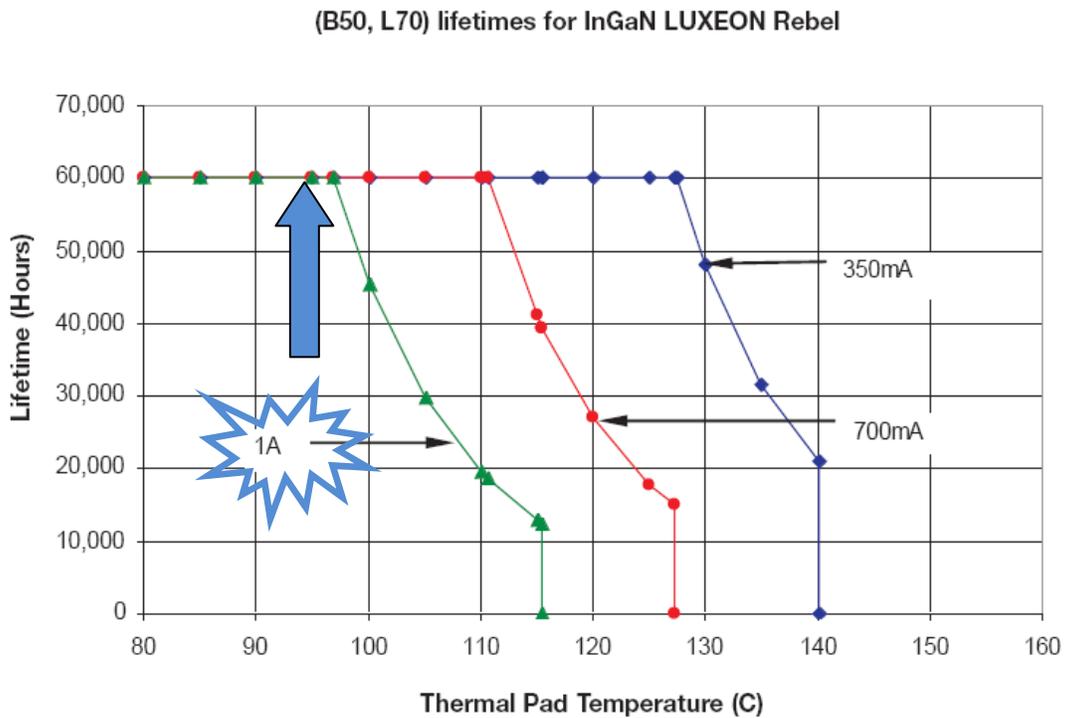


Figure 6 – Expected (B50, L70) lifetimes for InGaN LUXEON Rebel

## PRODUCT LIFETIME

Nomenclature in this report in the format of (Bxx, Lyy) was taken directly from Philips 2007 Lumileds LUXEON Rebel *Reliability Data*, which pre-dates the May 2010 *LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting* that recommends the more comprehensive use of Product Lifetime expressed as (L70/B<sub>xx</sub>/F<sub>yy</sub>) – which is a 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 experience a conventional lights-out failure; e.g. L70/B50/F10 (hours).

Note that the May 2010 *LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting* has not yet been adopted by any Standards making bodies, as it is only a guide by which LSI is reporting the LumeLEX™ 2000 reliability information on as well.

Per the recommendation report, this comprehensive “Product Lifetime” figure is to address both the complexity and ambiguity between a single luminaire’s lumen maintenance and the median lumen maintenance of an installation group. This “Product Lifetime” is a comprehensive expression of gradual lumen depreciation, accelerated degradation and catastrophic failures – as this figure covers some of the following conditions as an example:

1. All LEDs light up but at a reduced light level (defined by time to B<sub>xx</sub>)
2. A single catastrophic LED failure occurs but other LEDs in the Modules are still functional, perhaps running at a reduced light level (defined by time to B<sub>xx</sub>)
3. Multiple catastrophic failures but other LEDs are still functional, perhaps running at a reduced light level (defined by time to B<sub>xx</sub>) – defined by time to F<sub>25</sub> if 25% of the LED Modules or the output of the Driver has reduce drive current.
4. No LEDs light up, due to system failure (defined by time to F<sub>100</sub> as an example)

## LM-80-08 TESTING

LM-80-08 testing of the Xicato XSM module has been performed by Bay Area Compliance Laboratories Corp (a 3<sup>rd</sup> Party DOE approved facility) to 9,100 total actual hours.

As a point of reference the Energy Star requirements for Commercial Luminaires is L70= 35,000 hours.

Test report R1209208A-9100Hrs dated March 22, 2013 contains Lumen Maintenance data shown in Figure 7 below at a Case Temperature of Tc=85°C.

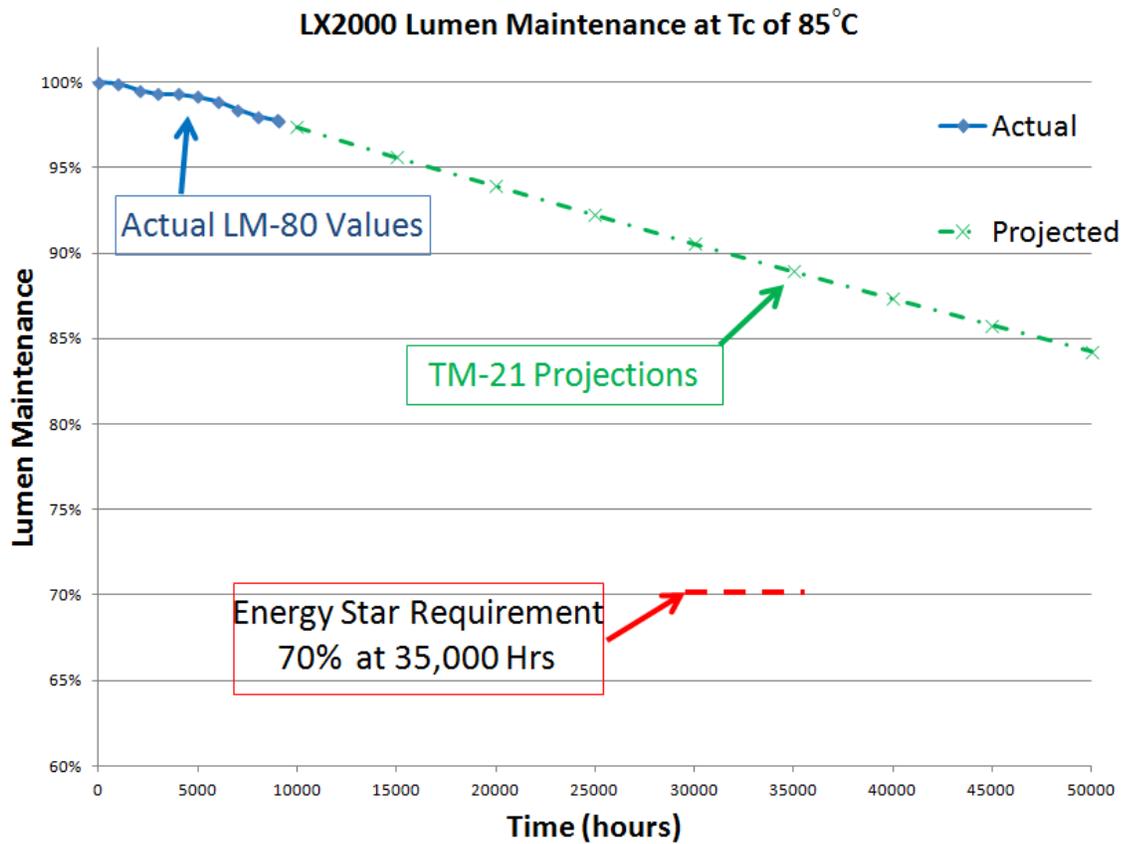


Figure 7 – Lumen Maintenance of Xicato 3<sup>rd</sup> Party LM-80-08 Test

TM-21-11 provides recommendations for projecting the long term lumen maintenance of LED light sources. The TM-21-11 rationale was determined using statistically significant long-term tests to produce mathematical models that predict lumen maintenance. The maximum limitation making a “Reported L70 Claim” by using the TM-21-11 formulas, can only be a maximum of six (6) times the total test duration. In order to claim 50,000 hours, data would be required at a minimum of 8,333 hours, however these models can “interpolate” a theoretical life as well. Per the LM-80-08 protocol, three groups of modules are to be tested at three different Case temperatures: the first is a Tc=100°C (this is selected by the manufacturer, and was selected as a condition representing 15°C beyond the maximum Ambient fixture operating temperature), the second is a Tc=85°C (a case temperature mandated by LM-80-08, and represents 5°C below the maximum case Temperature in Xicato spec) and the third is a Tc=55°C (another case temperature mandated by LM-80-08 protocol to use in the TM-21-11 formulas). Using the TM-21-11 formula the L70 “interpolation” the time to reach 70% lumen maintenance is between 69,000 hours and 159,000 hours, with 101,000 hours being most realistic, as detailed in Figure 8 below (taken directly from the Xicato LM-80 report).

Table 1: Report at each LM-80 Test Condition					
Description of LED Light Source Tested (manufacturer, model, catalog number)		Manufacturer: XICATO, Inc.; Model: XSM-8030-1300			
Test Condition 1 - 100 C Case Temp		Test Condition 2 - 85 C Case Temp		Test Condition 3 - 55 C Case Temp	
Sample size	11	Sample size	11	Sample size	11
Number of failures	0	Number of failures	0	Number of failures	0
DUT drive current used in the test (mA)	1000	DUT drive current used in the test (mA)	1000	DUT drive current used in the test (mA)	1000
Test duration (hours)	9,100	Test duration (hours)	9,100	Test duration (hours)	9,100
Test duration used for projection (hour to hour)	5,000 - 9,100	Test duration used for projection (hour to hour)	5,000 - 9,100	Test duration used for projection (hour to hour)	5,000 - 9,100
Tested case temperature ( C)	100	Tested case temperature ( C)	85	Tested case temperature ( C)	55
α	5.232E-06	α	3.624E-06	α	2.249E-06
B	1.003	B	1.010	B	1.000
Calculated L70(9k) (hours)	69,000	Calculated L70(9k) (hours)	101,000	Calculated L70(9k) (hours)	159,000
Reported L70(9k) (hours)	>50000	Reported L70(9k) (hours)	>50000	Reported L70(9k) (hours)	>50000

Figure 8 – TM-21-11 Projections from LM-80-08 Xicato test

Contact LSI if more details are required.

ROUTINE PRODUCTION TESTING:

Per the CALiPER program and per recommendation of the *LED LUMINAIRE LIFETIME: Recommendations for Testing and Reporting* Lighting Services Inc performs routine production Burn-In testing to at least 1000 hours of a small number of products continuously to ensure our product quality.

CONCLUSION:

Based on the above data and testing, the LumeLEX™ 2000 series fixtures **shall exceed a Rated Lumen Maintenance Life of L70 = 50,000** Hours (time to 70% Lumen Maintenance).

Lighting Services Inc is projecting that the LumeLEX™ 2000 series fixtures will have a **Product Lifetime of (L70/B50/F10) > 60,000 Hours** at which time 50% of the population will fall below 70% of the nominal initial value, and less than 10% will have experienced conventional lights-out failure.

WARRANTY:

LSI has a full 5 year warranty to ensure customer satisfaction with our product.

This is backed up by the addition of Xicato's 5-year color consistency and lumen maintenance warranty.