



Great One Global Certification Co., Ltd.

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Lumen Maintenance of LED Light Source Test Report



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to the joint ISO-ILAC-IAF Communiqué dated January 2009).

Standard used :	IESNA LM-80-15 Approved Method for Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
Date of test :	November 30, 2016 to March 2, 2018
Date of issue :	August 12, 2019 (Original : April 30, 2018)
Report number :	GO17080303-101-R1 (Original : GO17080303-101)

Reviewed by :

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*Joint IAF-ILAC-ISO Communiqué
on the
Management Systems Requirements of ISO/IEC 17025:2005,
General requirements for the competence of testing and calibration
laboratories*

A laboratory's fulfilment of the requirements of ISO/IEC 17025:2005 means the laboratory meets both the technical competence requirements and **management system requirements** that are necessary for it to consistently deliver technically valid test results and calibrations. The **management system requirements** in ISO/IEC 17025:2005 (Section 4) are written in language relevant to laboratory operations and meet the principles of ISO 9001:2008 **Quality Management Systems — Requirements** and are aligned with its pertinent requirements.

IAF Chair

ILAC Chair

ISO Secretary General

January 2009



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www.ilac.org



International Laboratory Accreditation Cooperation

Joint ISO-ILAC-IAF Communiqué

8 January 2009

ILAC members will be aware that many of their accredited laboratories have been experiencing difficulty convincing their customers they should be asking laboratories to be accredited to ISO/IEC 17025, (prior to 1999 ISO Guide 25) rather than be certified (registered) to ISO 9001. The situation became more acute with the publication of ISO 9001:2008, as some customers continually asked laboratories to be certified, when they really meant accredited. The confusion is caused by the perception that accredited laboratories do not operate a recognised quality management system.

To address this problem the ILAC Laboratory Committee asked that a statement be put on accreditation (attestation) certificates, issued by their accreditation body, stating that an accredited laboratory's management system meets the principles of ISO 9001:2008. The same statement could also be used by accredited laboratories on their calibration certificates and test reports.

Working through the ISO-ILAC-IAF Joint Working Group (JWG), ILAC is pleased to be able to advise its member accreditation bodies that the problem raised by the Laboratory Committee may now be addressed as follows:-

On accreditation (attestation) certificates, accreditation bodies may add the following:

"This laboratory is accredited in accordance with the recognised International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communiqué dated January 2009)"

Accreditation Bodies choosing to use the above statement on their accreditation certificates should either supply, or provide access to (via a website), the Joint ISO-ILAC-IAF Communiqué as part of the package. (It may be convenient for accreditation bodies to do this when they issue new accreditation certificates for ISO/IEC 17025:2005 to their accredited laboratories.)

Accredited laboratories choosing to use the above statement on their test reports and calibration certificates should also either supply, or provide access to (via a website), the Joint ISO-ILAC-IAF Communiqué as part of the package for their laboratory customers.

The Joint Communiqué is available on the ILAC website at www.ilac.org on the publications and resources page.

The ILAC Laboratory Committee thanks the members of the ILAC and IAF Executive Committees and the ISO-ILAC-IAF JWG, for developing a solution to a critical market issue facing some accredited laboratories.

Daniel Pierre, ILAC Chair

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Lumen Maintenance of LED Light Sources TEST REPORT

Report number.....: GO17080303-101-R1 (Original : GO17080303-101)

Date of issue.....: August 12, 2019 (Original : April 30, 2018)

Tested by.....: Johnson Wang

Reported by.....: Johnson Wang / Julie Hsu

Approved by.....: David Yuan


Testing laboratory.....: Great One Global Certification Co., Ltd.

Address.....: 9F-2, No. 120, Qiaohe Rd., Zhonghe Dist., New Taipei City
235, Taiwan (R.O.C.)

Applicant's name.....: Bridgelux Inc.

Address.....: 46430 Fremont Boulevard Fremont, CA 94538 USA

Standard used.....: IESNA LM-80-15 Approved Method for Measuring Luminous
Flux and Color Maintenance of LED Packages, Arrays and
Modules

Brand name.....: 

Test item description:

Product Name.....: LED Package

Model/Type reference.....: BXEN-(A)(B)-13H-9(C)
BXEN-(A)(B)-12M-6(C)

Classification.....: Package

Ratings.....: 9 Vdc, 100 mA, 1 W



Summary of testing:

Tests performed

The test samples were configured for continuous emission and powered by 100 mA constant current.

Model BXEN-27E-13H-99 was subjected to the following test and was considered representative of the whole series.

The LED input power was measured under normal conditions noted in details of measurement procedure and measurement results.

Measurement results: See Appendix A.

Testing location:

Great One Global Certification Co., Ltd.

Address:

9F-2, No.120, Qiaoh Rd., Zhonghe Dist., New Taipei City 235, Taiwan (R.O.C.)

Testing

Date of receipt of test item: November 1, 2016

Date(s) of performance of tests: November 30, 2016 to March 2, 2018

Number of LED light sources tested: 25 pcs per case temperature

Test duration: 10,000 hrs

Operating cycle: Constant direct current

Air flow.....: < 0.1 m/s

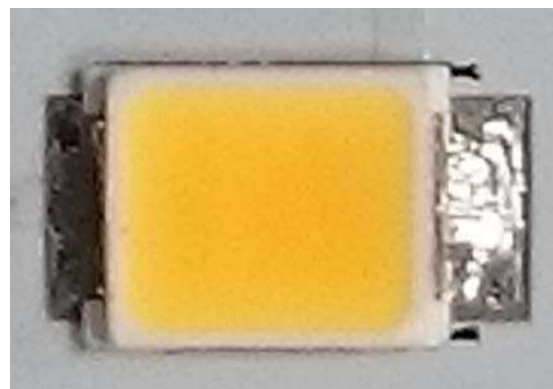
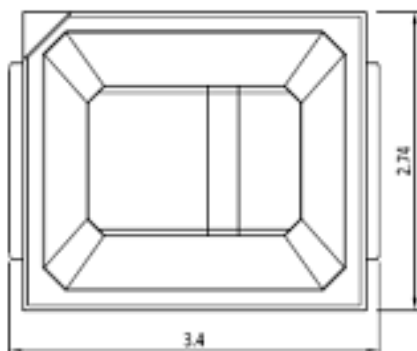
Relative humidity.....: < 45%

Photometric measurement uncertainty

Flux measurement: 2.2 % (k=2)

CCT measurement.....: 0.48 % (k=2)

General product information:





Description of model series:

Tests conducted on Model: BXEN-27E-13H-99 is considered representative of the following series.

BXEN-(A)(B)-13H-9(C) and BXEN-(A)(B)-12M-6(C)

(A): CCT variation, can be 27 for 2700K, 30 for 3000K, 35 for 3500K, 40 for 4000K, 50 for 5000K, 57 for 5700K, 65 for 6500K.

(B): CRI variation, can be C for 70, E for 80, G for 90, H for 95..

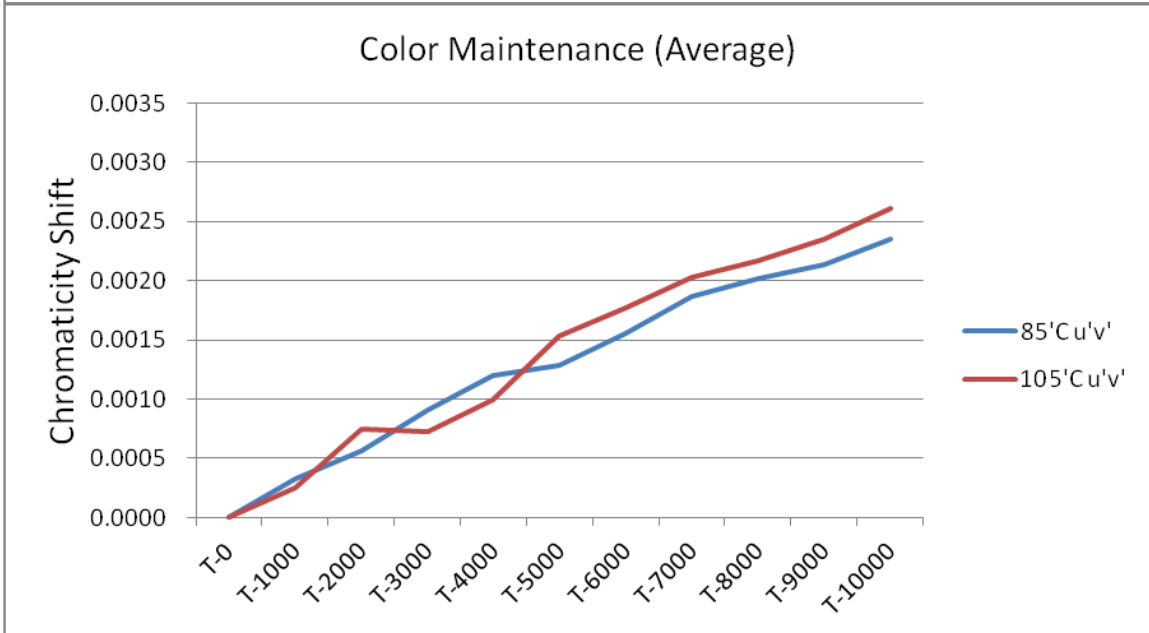
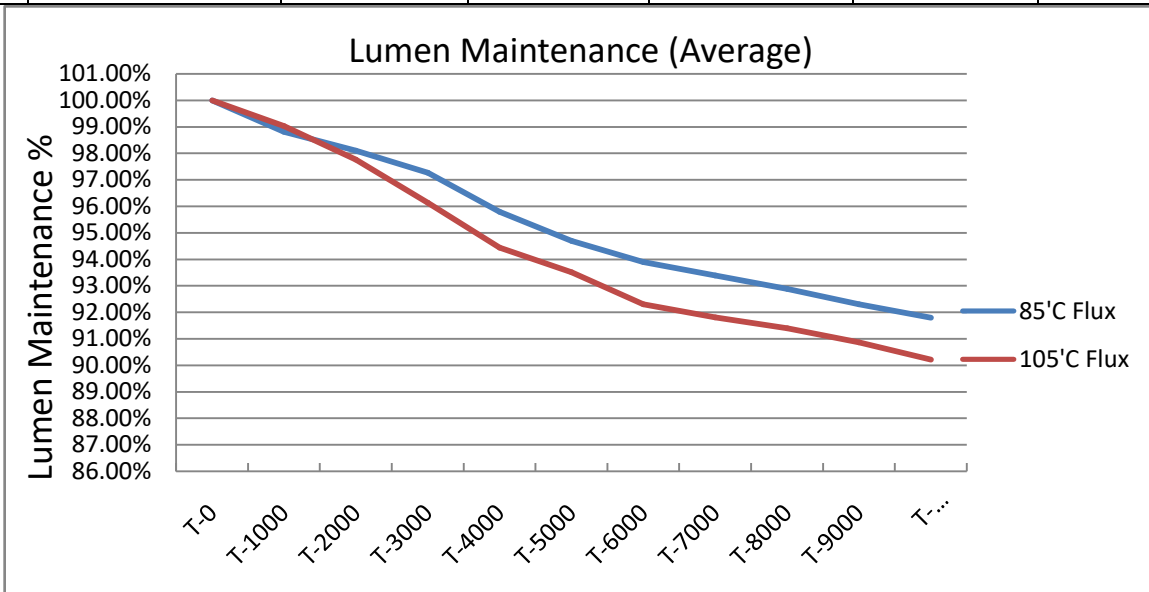
(C): Customer code, can be 0-ZZ

Device under test is LED package with model number: BXEN-27E-13H-99, Nominal CCT 2700K CRI 80.



Summary of results

Data Set	Case Temperature [Ts] °C	Ambient Temperature [Ta] °C	Drive Current [If] mA	Lumen Maintenance at 10000 hrs	Chromaticity Shift ($\Delta u'v'$) at 10000 hrs	TM-21 Projection L70 (10000 hrs)
1	85	>80	100	91.80%	0.0024	55,000
2	105	>100	100	90.22 %	0.0026	48,000



Observation of LED light sources failures, including the failure conditions and time of failure: No failure observed



Revision Summary			
Date	Proj#	Page	Description of Change
August 1 2019	GO17080303-101-R1	Cover	Revise Date of issue, Report number
August 1 2019	GO17080303-101-R1	1	Revise Date of issue, Report number
August 1 2019	GO17080303-101-R1	2	Revise Test duration 6,000hrs to 10,000hrs

~ End of Report ~



Appendix A

LM-80-15

Approved Method for Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

Report No. :	GO17080303-101	Test Initiation Date :	2016-11-30
Model No. :	BXEN-27E-13H-99	Test Completion Date :	2018-3-2
Tested By :	Johnson Wang		
Manufacturer's Name:	Bridgelux Inc.		
Rated Voltage :	9 V	Temperature Selected by manufacturer:	105 °C
Rated Current :	100 mA	Number of LED Light Sources tested:	25
Rated CCT	2700 K		

EQUIPMENT USED:					
Inst. ID No.	Instrument Type	Function /Range	Pre Cal. Date	Cal. Date	Due Date
L401	LED current source 1(16 channel)	0~48 V dc, 0~5 A	2017/03/27	2018/03/26	-
L402	LED current source 2(8 channel)	0~48 V dc, 0~5 A	2017/03/27	2018/03/26	-
L430	LED current source 3(8 channel)	0~48 V dc, 0~5 A	2017/02/21	2018/02/20	2019/02/19
L431	LED current source 4(8 channel)	0~48 V dc, 0~5 A	2017/02/21	2018/02/20	2019/02/19
L403	Thermal Plate Controller	0°C to 95°C	-	-	-
L404	Environment Oven	-	2017/03/27	2018/03/26	2019/03/25
L405	PC Controller	-	-	-	-
L406 to L411	Temperature Data Recorder	0°C to 300°C	2017/02/21	2018/02/20	2019/02/19
L419 to L420	Auxiliary Thermal Plate Controller 1 to 2	0°C to 95°C	-	-	-
L238	Thermal Plate Cooler	0°C to 95°C	-	-	-
L240	Integrating Sphere	0.5 M	-	-	-
L244	Standard Lamp	-	2017/01/03	2017/12/29	2018/12/28
L247	Digital CC & CV DC Power Supply	0~150Vdc,0~5A	2016/12/01	2017/11/30	2018/11/29

TEST SAMPLE IDENTIFICATION		
Date Received	Data Set No.	Sample No.
2016-11-30	1	16110903-1 to 16110903-25
2016-11-30	2	16110903-26 to 16110903-50



Appendix A

TEST METHOD

The samples were tested according to the IES LM-80-2015. Lumen maintenance data for each individual LED light source along with median value, standard deviation, minimum and maximum lumen maintenance value for all of the LED light sources were recorded in the following table.

Temperature and Humidity

The two case temperatures, T_s , was 85 °C with a temperatures 105 °C selected by the manufacturer. The case temperature and drive current selected by the manufacturer represented their expectation for customers applications and was within their recommended operating temperature range. Case temperature was controlled to -2 °C during life testing. The temperature of the surrounding air was maintained to within -5 °C of the case temperature during testing.

Humidity was maintained to less the 65 RH throughout the life test.

Airflow was minimized (Air flow : < 0.1m/s) for proper light source starting and operation.

Photometry Measurement

For information on the photometry of the LED light source, see Reference 2.1.2, LM-79.

A Spectroradiometer and Integrating Sphere were used to measure correlated color temperature, chromaticity coordinates, and the luminous flux for each LED light sources. Chromaticity coordinates, correlated color temperature and color rendering index were calculated from the spectral radiant flux measurements taken at 5 nm intervals over the range of 380 to 780 nm.

Luminous flux was measured at the drive current used during life testing.

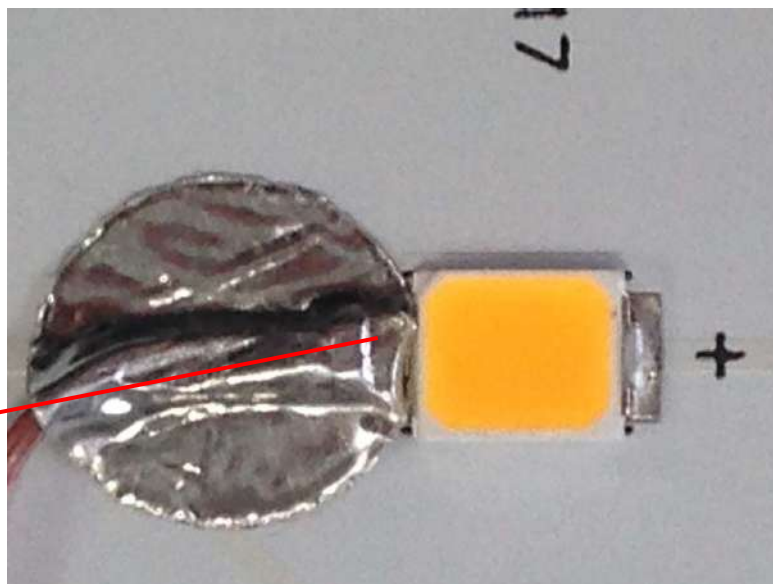
The ambient temperature during lumen and chromaticity measurements was set to 25 °C +/- 2 °C.

Recording failures

Checking for LED light source failures either by visual observation or automatic monitoring was done at every measurement interval.

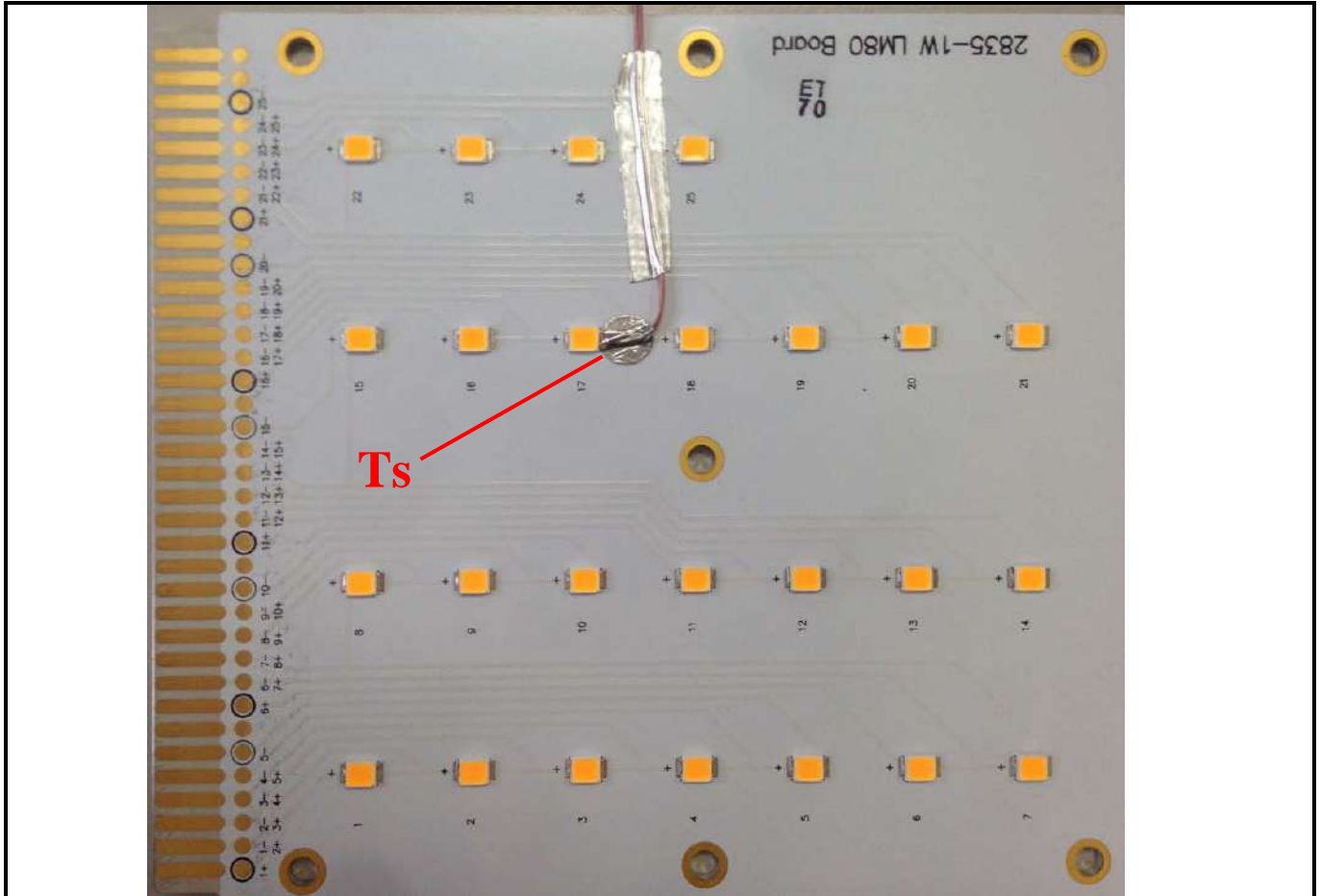
CASE TEMPERATURE, (T_s) ATTACMENT POINT, CASE SIZE

T_s





Appendix A





Appendix A

Data Set 1	
Case Temperature	85 °C
Measurement Current	100 mA

**Table 1-1
Initial Characteristics**

Sample No.	Luminous Flux (lm)	Forward Voltage	CCT(K)	CIE-1931		CIE-1976	
16110903-1	124.40	9.50	2718	0.4600	0.4100	0.2600	0.5300
16110903-2	121.80	9.62	2734	0.4602	0.4156	0.2605	0.5293
16110903-3	127.20	9.59	2697	0.4633	0.4164	0.2621	0.5301
16110903-4	127.00	9.89	2768	0.4588	0.4175	0.2588	0.5298
16110903-5	124.80	9.80	2727	0.4632	0.4201	0.2604	0.5314
16110903-6	128.30	9.85	2692	0.4633	0.4157	0.2624	0.5298
16110903-7	125.20	9.62	2725	0.4616	0.4171	0.2608	0.5301
16110903-8	119.90	9.68	2695	0.4641	0.4175	0.2621	0.5306
16110903-9	125.30	9.43	2709	0.4618	0.4151	0.2617	0.5294
16110903-10	126.00	9.82	2741	0.4612	0.4184	0.2599	0.5305
16110903-11	126.20	9.62	2691	0.4647	0.4181	0.2623	0.5309
16110903-12	126.70	9.81	2693	0.4647	0.4184	0.2622	0.5310
16110903-13	125.50	9.48	2691	0.4636	0.4161	0.2624	0.5300
16110903-14	124.40	9.63	2718	0.4609	0.4148	0.2613	0.5291
16110903-15	109.80	9.45	2688	0.4628	0.4143	0.2627	0.5292
16110903-16	125.60	9.51	2714	0.4620	0.4163	0.2613	0.5298
16110903-17	123.90	9.90	2717	0.4591	0.4115	0.2616	0.5276
16110903-18	125.90	9.62	2705	0.4619	0.4150	0.2619	0.5293
16110903-19	126.60	9.66	2689	0.4630	0.4149	0.2626	0.5295
16110903-20	126.70	9.53	2702	0.4622	0.4150	0.2620	0.5294
16110903-21	125.20	9.71	2701	0.4619	0.4144	0.2621	0.5291
16110903-22	110.40	9.41	2697	0.4627	0.4154	0.2622	0.5296
16110903-23	124.40	9.90	2743	0.4591	0.4147	0.2602	0.5288
16110903-24	123.70	9.50	2701	0.4605	0.4118	0.2624	0.5279
16110903-25	123.70	9.54	2754	0.4550	0.4086	0.2602	0.5258
Avg.	123.95	9.65	2711	0.4620	0.4157	0.2616	0.5296
Med.	125.25	9.62	2704	0.4620	0.4155	0.2620	0.5296
σ	4.36	0.15	22.61	0.0017	0.0017	0.0011	0.0008
Min.	109.80	9.41	2688	0.4588	0.4115	0.2588	0.5276
Max.	128.30	9.90	2768	0.4647	0.4201	0.2627	0.5314



Appendix A

**Table 1-2
Lumen Maintenance**

Sample No.	Lumen Maintenance% (Normalized to 100% at Initial)										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-1	100.0%	98.7%	98.9%	95.8%	95.8%	95.2%	94.5%	93.8%	93.5%	92.7%	92.4%
16110903-2	100.0%	98.8%	97.2%	98.6%	96.6%	94.1%	93.4%	92.8%	92.3%	92.1%	91.7%
16110903-3	100.0%	99.0%	98.5%	97.9%	96.1%	94.3%	93.4%	93.2%	92.8%	92.4%	91.9%
16110903-4	100.0%	98.0%	97.4%	97.3%	95.2%	94.6%	93.9%	93.3%	92.9%	92.6%	92.2%
16110903-5	100.0%	98.8%	97.8%	97.1%	95.2%	94.7%	94.4%	93.8%	93.2%	92.4%	92.1%
16110903-6	100.0%	98.5%	97.3%	97.7%	95.2%	95.2%	94.5%	93.9%	92.4%	91.8%	91.4%
16110903-7	100.0%	99.0%	98.5%	96.9%	97.5%	95.8%	94.9%	93.5%	93.1%	93.0%	92.4%
16110903-8	100.0%	99.6%	97.9%	97.0%	93.9%	93.9%	92.8%	92.5%	92.0%	91.6%	91.2%
16110903-9	100.0%	98.8%	98.3%	98.3%	96.1%	94.0%	93.7%	92.6%	90.9%	90.7%	90.0%
16110903-10	100.0%	99.1%	98.4%	96.7%	95.2%	95.8%	94.4%	94.2%	93.5%	93.0%	92.6%
16110903-11	100.0%	99.6%	97.1%	97.2%	95.3%	95.6%	94.7%	94.3%	93.8%	93.3%	92.7%
16110903-12	100.0%	99.1%	97.9%	97.7%	97.6%	93.8%	93.1%	92.7%	92.6%	92.1%	91.7%
16110903-13	100.0%	98.5%	98.0%	96.6%	95.3%	93.3%	93.2%	92.5%	92.2%	91.7%	91.4%
16110903-14	100.0%	98.9%	98.2%	97.4%	95.8%	93.4%	92.4%	91.8%	91.5%	91.1%	90.7%
16110903-15	100.0%	99.0%	98.9%	96.4%	95.3%	94.3%	93.7%	93.4%	92.9%	92.3%	91.7%
16110903-16	100.0%	98.9%	98.4%	98.0%	95.3%	95.8%	94.7%	94.4%	94.1%	93.7%	93.2%
16110903-17	100.0%	98.7%	98.2%	96.3%	96.6%	95.2%	94.4%	93.9%	93.7%	93.3%	92.9%
16110903-18	100.0%	98.6%	97.8%	97.5%	97.1%	94.6%	93.6%	93.2%	92.8%	92.3%	91.8%
16110903-19	100.0%	98.6%	97.7%	96.3%	95.4%	94.4%	93.9%	93.5%	93.1%	92.7%	92.1%
16110903-20	100.0%	98.0%	97.7%	97.1%	97.4%	96.0%	95.1%	94.9%	94.3%	91.5%	91.0%
16110903-21	100.0%	98.7%	98.6%	97.9%	95.1%	95.3%	94.6%	94.2%	93.9%	92.3%	91.7%
16110903-22	100.0%	99.4%	99.3%	97.9%	95.8%	94.4%	93.1%	92.7%	92.3%	91.7%	91.4%
16110903-23	100.0%	98.7%	97.8%	97.4%	95.2%	95.3%	94.6%	94.4%	93.8%	93.4%	92.5%
16110903-24	100.0%	98.0%	98.3%	97.8%	95.7%	94.3%	92.9%	92.3%	92.1%	91.8%	91.0%
16110903-25	100.0%	99.3%	98.5%	96.9%	95.1%	94.2%	93.6%	93.1%	92.6%	92.1%	91.4%
Avg.	100.0%	98.8%	98.1%	97.3%	95.8%	94.7%	93.9%	93.4%	92.9%	92.3%	91.8%
Med.	100.0%	98.8%	98.2%	97.3%	95.4%	94.6%	93.9%	93.4%	92.9%	92.3%	91.7%
σ	0.0000	0.0043	0.0055	0.0069	0.0090	0.0078	0.0074	0.0078	0.0083	0.0074	0.0073
Min.	100.0%	99.6%	99.3%	98.6%	97.6%	96.0%	95.1%	94.9%	94.3%	93.7%	93.2%
Max.	100.0%	98.0%	97.1%	95.8%	93.9%	93.3%	92.4%	91.8%	90.9%	90.7%	90.0%

TM-21 Projection

Time	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
ln (Avg.)	0.0000	-0.0120	-0.0191	-0.0277	-0.0430	-0.0545	-0.0629	-0.0683	-0.0737	-0.0801	-0.0855

Test duration used	10,000 hrs	Calculated L70 (10,000 hrs)	55,000 hrs
B	0.975	Report L70 (10,000 hrs)	55,000 hrs
α	6.073E-06		



Appendix A

**Table 1-3
Forward Voltage**

Sample No.	Relative Forward Voltage % (Normalized to 100% at Initial)										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-1	100.0%	100.2%	101.5%	100.1%	101.1%	103.3%	102.4%	100.4%	100.6%	101.4%	101.5%
16110903-2	100.0%	100.6%	101.2%	101.4%	101.6%	101.9%	102.5%	101.4%	101.8%	100.7%	101.5%
16110903-3	100.0%	101.0%	101.0%	101.3%	101.5%	102.7%	102.2%	102.3%	102.1%	102.7%	102.5%
16110903-4	100.0%	100.3%	100.0%	101.7%	101.6%	101.6%	101.1%	101.3%	101.5%	100.9%	100.9%
16110903-5	100.0%	100.2%	100.4%	101.0%	100.8%	102.0%	100.5%	100.8%	101.3%	101.5%	100.3%
16110903-6	100.0%	100.8%	101.4%	100.6%	101.4%	102.6%	103.2%	101.5%	102.5%	101.5%	101.3%
16110903-7	100.0%	101.0%	101.0%	100.8%	101.2%	101.5%	102.6%	101.8%	101.2%	101.8%	102.6%
16110903-8	100.0%	101.0%	100.7%	101.1%	100.0%	102.3%	100.7%	102.6%	101.6%	101.2%	101.9%
16110903-9	100.0%	100.3%	100.3%	100.2%	101.4%	101.1%	100.6%	100.4%	102.1%	101.3%	101.1%
16110903-10	100.0%	100.6%	101.7%	101.5%	101.7%	102.7%	101.8%	100.8%	101.1%	101.8%	100.7%
16110903-11	100.0%	100.1%	100.7%	100.5%	100.6%	102.1%	101.6%	101.4%	100.6%	100.8%	100.6%
16110903-12	100.0%	101.5%	101.6%	100.6%	100.3%	102.7%	103.0%	101.6%	102.4%	102.9%	102.3%
16110903-13	100.0%	100.4%	100.9%	101.2%	100.4%	101.9%	101.9%	101.8%	100.9%	101.7%	101.3%
16110903-14	100.0%	100.2%	101.6%	101.8%	101.7%	102.2%	103.2%	100.9%	102.0%	102.0%	101.2%
16110903-15	100.0%	100.6%	101.0%	100.1%	101.1%	102.2%	102.0%	101.3%	100.6%	101.4%	100.9%
16110903-16	100.0%	101.3%	100.9%	100.4%	101.7%	101.1%	101.8%	101.7%	102.1%	101.5%	101.8%
16110903-17	100.0%	101.1%	100.8%	100.0%	100.9%	102.5%	102.1%	102.1%	102.4%	101.3%	102.3%
16110903-18	100.0%	100.7%	100.9%	101.0%	100.1%	102.3%	101.3%	101.8%	101.9%	101.2%	101.7%
16110903-19	100.0%	101.1%	101.7%	100.2%	100.2%	103.3%	102.5%	102.4%	101.3%	101.4%	102.0%
16110903-20	100.0%	100.5%	100.3%	101.1%	100.8%	101.4%	101.6%	100.9%	101.7%	101.4%	100.8%
16110903-21	100.0%	101.8%	100.9%	100.6%	100.1%	101.9%	101.6%	103.1%	102.0%	103.4%	103.2%
16110903-22	100.0%	100.3%	101.4%	101.2%	101.2%	102.8%	102.8%	100.3%	100.8%	101.1%	101.2%
16110903-23	100.0%	101.2%	101.4%	100.4%	101.6%	102.7%	103.1%	102.0%	101.3%	101.6%	102.3%
16110903-24	100.0%	101.1%	100.8%	100.4%	101.3%	102.4%	102.0%	102.2%	102.1%	101.6%	101.3%
16110903-25	100.0%	100.1%	100.6%	100.1%	100.9%	101.8%	101.1%	100.7%	101.9%	100.7%	100.5%
Avg.	100.0%	100.7%	101.0%	100.8%	101.0%	102.2%	102.0%	101.5%	101.6%	101.6%	101.5%
Med.	100.0%	100.6%	100.9%	100.6%	101.1%	102.2%	102.0%	101.5%	101.7%	101.4%	101.3%
σ	0.0000	0.0047	0.0047	0.0055	0.0058	0.0059	0.0080	0.0073	0.0059	0.0065	0.0075
Min.	100.0%	101.8%	101.7%	101.8%	101.7%	103.3%	103.2%	103.1%	102.5%	103.4%	103.2%
Max.	100.0%	100.1%	100.0%	100.0%	100.0%	101.1%	100.5%	100.3%	100.6%	100.7%	100.3%



Appendix A

Table 1-4 Chromaticity Shift

Sample No.	Chromaticity Shift $\Delta u'v'$										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-1	0.0000	0.0003	0.0005	0.0009	0.0015	0.0016	0.0020	0.0018	0.0020	0.0017	0.0028
16110903-2	0.0000	0.0002	0.0006	0.0007	0.0011	0.0010	0.0012	0.0025	0.0023	0.0022	0.0019
16110903-3	0.0000	0.0002	0.0005	0.0007	0.0011	0.0016	0.0017	0.0018	0.0022	0.0023	0.0018
16110903-4	0.0000	0.0002	0.0005	0.0009	0.0010	0.0014	0.0015	0.0022	0.0022	0.0021	0.0022
16110903-5	0.0000	0.0005	0.0006	0.001	0.0012	0.0009	0.0011	0.0020	0.0020	0.0022	0.0024
16110903-6	0.0000	0.0002	0.0004	0.0007	0.0012	0.0009	0.0012	0.0012	0.0018	0.0022	0.0022
16110903-7	0.0000	0.0004	0.0007	0.0012	0.0014	0.0015	0.0019	0.0020	0.0019	0.0017	0.0032
16110903-8	0.0000	0.0002	0.0004	0.0008	0.0008	0.0013	0.0015	0.0014	0.0018	0.0018	0.0021
16110903-9	0.0000	0.0001	0.0002	0.0006	0.0008	0.0013	0.0015	0.0014	0.0018	0.0019	0.0022
16110903-10	0.0000	0.0004	0.0005	0.0009	0.0011	0.0012	0.0015	0.0024	0.0024	0.0017	0.0023
16110903-11	0.0000	0.0003	0.0007	0.0010	0.0010	0.0012	0.0014	0.0027	0.0025	0.0025	0.0022
16110903-12	0.0000	0.0003	0.0007	0.0010	0.0014	0.0015	0.0019	0.0018	0.0020	0.0027	0.0028
16110903-13	0.0000	0.0005	0.0009	0.0013	0.0018	0.0011	0.0015	0.0024	0.0024	0.0025	0.0025
16110903-14	0.0000	0.0004	0.0007	0.0011	0.0015	0.0013	0.0014	0.0020	0.0020	0.0019	0.0024
16110903-15	0.0000	0.0002	0.0004	0.0008	0.0012	0.0014	0.0015	0.0018	0.0019	0.0022	0.0025
16110903-16	0.0000	0.0004	0.0004	0.0006	0.0008	0.0011	0.0014	0.0016	0.0018	0.0017	0.0021
16110903-17	0.0000	0.0002	0.0003	0.0006	0.0008	0.0009	0.0011	0.0013	0.0017	0.0022	0.0026
16110903-18	0.0000	0.0005	0.0008	0.0009	0.0013	0.0013	0.0016	0.0018	0.0020	0.0019	0.0024
16110903-19	0.0000	0.0005	0.0006	0.0009	0.0014	0.0010	0.0011	0.0019	0.0020	0.0021	0.0028
16110903-20	0.0000	0.0003	0.0005	0.0010	0.0010	0.0012	0.0015	0.0017	0.0020	0.0021	0.0025
16110903-21	0.0000	0.0004	0.0007	0.0011	0.0015	0.0018	0.0022	0.0017	0.0019	0.0027	0.0021
16110903-22	0.0000	0.0005	0.0006	0.0009	0.0013	0.0014	0.0017	0.0015	0.0017	0.0017	0.0024
16110903-23	0.0000	0.0001	0.0005	0.0011	0.0014	0.0014	0.0016	0.0020	0.0021	0.0024	0.0020
16110903-24	0.0000	0.0003	0.0004	0.0008	0.0011	0.0015	0.0020	0.0017	0.0020	0.0027	0.0022
16110903-25	0.0000	0.0003	0.0006	0.0010	0.0013	0.0014	0.0016	0.0019	0.0020	0.0021	0.0024
Avg.	0.0000	0.0003	0.0005	0.0009	0.0012	0.0013	0.0015	0.0019	0.0020	0.0021	0.0024
Med.	0.0000	0.0003	0.0005	0.0009	0.0012	0.0013	0.0015	0.0018	0.0020	0.0021	0.0024
σ	0.0000	0.0001	0.0002	0.0002	0.0003	0.0002	0.0003	0.0004	0.0002	0.0003	0.0003
Min.	0.0000	0.0001	0.0002	0.0006	0.0008	0.0009	0.0011	0.0012	0.0017	0.0017	0.0018
Max.	0.0000	0.0005	0.0009	0.0013	0.0018	0.0018	0.0022	0.0027	0.0025	0.0027	0.0032



Appendix A

Data Set 2	
Case Temperature	105 °C
Measurement Current	100 mA

**Table 2-1
Initial Characteristics**

Sample No.	Luminous Flux (lm)	Forward Voltage	CCT(K)	CIE-1931		CIE-1976	
16110903-26	122.70	9.42	2709	0.4609	0.4136	0.2618	0.5286
16110903-27	125.90	9.58	2722	0.4638	0.4207	0.2606	0.5317
16110903-28	125.00	9.54	2716	0.4603	0.4135	0.2615	0.5285
16110903-29	124.40	9.79	2721	0.4628	0.4186	0.2608	0.5308
16110903-30	126.70	9.60	2710	0.4623	0.4163	0.2615	0.5299
16110903-31	126.10	9.53	2740	0.4611	0.4181	0.2600	0.5304
16110903-32	124.90	9.40	2706	0.4628	0.4167	0.2617	0.5301
16110903-33	123.90	9.49	2737	0.4614	0.4181	0.2601	0.5304
16110903-34	125.10	9.45	2698	0.4627	0.4153	0.2622	0.5296
16110903-35	126.30	9.59	2689	0.4639	0.4164	0.2625	0.5301
16110903-36	125.30	9.53	2695	0.4630	0.4155	0.2623	0.5297
16110903-37	125.50	9.76	2717	0.4619	0.4166	0.2612	0.5299
16110903-38	126.70	9.49	2708	0.4615	0.4146	0.2618	0.5291
16110903-39	127.10	9.62	2755	0.4597	0.4174	0.2593	0.5299
16110903-40	121.90	9.52	2683	0.4624	0.4128	0.2631	0.5286
16110903-41	125.10	9.38	2699	0.4627	0.4155	0.2621	0.5296
16110903-42	119.50	1.00	2700	0.4620	0.4144	0.2622	0.5291
16110903-43	125.60	9.69	2727	0.4605	0.4152	0.2608	0.5292
16110903-44	123.70	9.63	2757	0.4550	0.4089	0.2601	0.5260
16110903-45	127.00	9.63	2719	0.4624	0.4176	0.2610	0.5304
16110903-46	126.90	9.68	2702	0.4632	0.4168	0.2619	0.5302
16110903-47	122.20	9.36	2705	0.4645	0.4195	0.2615	0.5314
16110903-48	125.10	9.62	2690	0.4628	0.4145	0.2626	0.5292
16110903-49	126.70	9.48	2703	0.4627	0.4162	0.2619	0.5299
16110903-50	126.70	9.50	2679	0.4643	0.4157	0.2630	0.5300
Avg.	124.97	9.20	2713	0.4619	0.4160	0.2614	0.5297
Med.	125.20	9.53	2709	0.4624	0.4163	0.2616	0.5299
σ	1.88	1.75	19.46	0.0019	0.0024	0.0009	0.0011
Min.	119.50	1.00	2683	0.4550	0.4089	0.2593	0.5260
Max.	127.10	9.79	2757	0.4645	0.4207	0.2631	0.5317



Appendix A

**Table 2-2
Lumen Maintenance**

Sample No.	Lumen Maintenance% (Normalized to 100% at Initial)										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-26	100.0%	98.3%	98.0%	96.9%	94.8%	95.2%	93.9%	93.2%	93.1%	92.8%	91.3%
16110903-27	100.0%	98.8%	98.1%	95.4%	94.1%	94.1%	92.9%	93.0%	92.7%	92.1%	91.7%
16110903-28	100.0%	98.8%	96.7%	95.6%	94.6%	92.0%	91.5%	91.2%	91.7%	91.4%	90.4%
16110903-29	100.0%	99.4%	98.2%	95.3%	93.6%	92.9%	92.0%	91.4%	91.2%	90.6%	89.8%
16110903-30	100.0%	99.6%	99.3%	97.1%	95.3%	94.8%	94.3%	93.8%	93.5%	92.8%	92.4%
16110903-31	100.0%	99.7%	97.7%	95.7%	93.6%	93.8%	93.1%	92.6%	90.7%	90.6%	90.3%
16110903-32	100.0%	99.3%	98.5%	96.3%	95.1%	93.3%	91.7%	91.2%	90.7%	90.1%	89.6%
16110903-33	100.0%	98.9%	96.9%	95.7%	93.8%	92.4%	91.1%	90.8%	90.2%	89.9%	90.1%
16110903-34	100.0%	99.3%	98.2%	97.1%	94.4%	93.9%	92.2%	91.9%	91.7%	91.9%	91.4%
16110903-35	100.0%	98.4%	98.1%	96.6%	95.2%	93.8%	93.2%	93.0%	92.2%	92.0%	91.7%
16110903-36	100.0%	99.6%	98.0%	95.3%	93.9%	91.7%	90.9%	90.1%	89.5%	89.1%	89.2%
16110903-37	100.0%	98.8%	98.0%	96.7%	95.6%	93.6%	92.1%	91.7%	91.4%	91.3%	90.7%
16110903-38	100.0%	98.9%	97.7%	95.8%	94.3%	93.1%	92.0%	91.7%	91.0%	90.8%	90.1%
16110903-39	100.0%	99.7%	98.2%	96.4%	94.2%	93.3%	91.3%	90.8%	90.3%	90.1%	89.4%
16110903-40	100.0%	99.6%	96.6%	95.3%	93.3%	91.8%	90.4%	90.6%	90.1%	89.9%	88.5%
16110903-41	100.0%	99.1%	97.3%	96.2%	94.4%	93.9%	92.4%	92.9%	92.4%	91.4%	90.7%
16110903-42	100.0%	98.5%	97.8%	95.9%	93.6%	94.0%	92.4%	92.4%	92.2%	91.9%	91.4%
16110903-43	100.0%	98.8%	97.3%	95.4%	93.1%	93.1%	92.0%	92.0%	91.5%	90.6%	89.8%
16110903-44	100.0%	99.4%	97.9%	96.8%	95.6%	94.2%	92.6%	91.7%	91.0%	90.7%	90.4%
16110903-45	100.0%	99.1%	97.3%	95.9%	94.2%	93.5%	92.2%	91.1%	91.9%	91.5%	91.1%
16110903-46	100.0%	98.6%	96.4%	95.2%	93.7%	93.2%	91.9%	90.4%	90.2%	90.8%	89.9%
16110903-47	100.0%	99.2%	98.1%	96.4%	94.7%	94.1%	93.2%	91.2%	90.7%	89.5%	88.1%
16110903-48	100.0%	98.6%	98.6%	97.8%	96.2%	95.2%	93.3%	92.5%	91.9%	89.6%	89.3%
16110903-49	100.0%	98.9%	97.8%	97.0%	95.5%	93.7%	93.0%	92.1%	91.8%	89.2%	87.8%
16110903-50	100.0%	98.4%	97.4%	95.6%	94.2%	93.2%	92.1%	92.0%	91.6%	91.1%	90.3%
Avg.	100.0%	99.0%	97.8%	96.1%	94.4%	93.5%	92.3%	91.8%	91.4%	90.9%	90.2%
Med.	100.0%	98.9%	97.9%	95.9%	94.3%	93.6%	92.2%	91.7%	91.5%	90.8%	90.3%
σ	0.0000	0.0044	0.0066	0.0072	0.0081	0.0091	0.0092	0.0095	0.0099	0.0105	0.0114
Min.	100.0%	99.7%	99.3%	97.8%	96.2%	95.2%	94.3%	93.8%	93.5%	92.8%	92.4%
Max.	100.0%	98.3%	96.4%	95.2%	93.1%	91.7%	90.4%	90.1%	89.5%	89.1%	87.8%

TM-21 Projection

Time	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
ln (Avg.)	0.0000	-0.0098	-0.0226	-0.0394	-0.0572	-0.0671	-0.0800	-0.0854	-0.0898	-0.0958	-0.1030

Test duration used	10,000 hrs	Calculated L70 (10,000 hrs)	48,000 hrs
B	0.963	Report L70 (10,000 hrs)	48,000 hrs
α	6.588E-06		



Appendix A

Table 2-3 Forward Voltage

Sample No.	Relative Forward Voltage % (Normalized to 100% at Initial)										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-26	100.0%	101.1%	101.5%	100.8%	101.4%	100.6%	101.3%	101.3%	101.2%	100.1%	100.3%
16110903-27	100.0%	100.8%	100.3%	100.2%	100.4%	100.8%	100.0%	100.2%	101.0%	100.8%	100.8%
16110903-28	100.0%	101.6%	100.1%	101.7%	100.4%	101.4%	100.9%	100.3%	101.7%	101.0%	100.5%
16110903-29	100.0%	101.3%	101.7%	100.6%	100.1%	101.5%	101.2%	101.5%	101.2%	100.0%	100.7%
16110903-30	100.0%	101.4%	100.1%	101.6%	100.4%	100.8%	100.8%	101.7%	101.6%	101.8%	101.8%
16110903-31	100.0%	100.3%	100.3%	101.8%	100.7%	101.4%	100.9%	101.0%	100.3%	101.2%	101.2%
16110903-32	100.0%	101.1%	101.1%	101.3%	101.4%	100.7%	100.8%	100.9%	101.5%	100.8%	101.6%
16110903-33	100.0%	101.5%	100.6%	101.4%	100.9%	100.5%	101.7%	101.2%	100.1%	101.0%	101.2%
16110903-34	100.0%	100.4%	101.6%	101.2%	100.7%	100.0%	100.0%	101.1%	101.4%	100.7%	100.6%
16110903-35	100.0%	100.5%	101.4%	101.3%	101.2%	101.0%	100.0%	101.4%	100.4%	100.8%	100.2%
16110903-36	100.0%	101.6%	101.6%	100.7%	101.0%	100.7%	101.5%	100.9%	101.1%	101.3%	101.5%
16110903-37	100.0%	101.5%	100.2%	101.3%	100.1%	100.3%	101.6%	101.2%	100.9%	100.5%	100.3%
16110903-38	100.0%	100.2%	101.0%	101.7%	101.4%	101.6%	100.1%	101.7%	100.5%	101.3%	101.5%
16110903-39	100.0%	101.0%	101.5%	100.3%	100.4%	101.5%	100.3%	100.1%	101.7%	100.4%	100.4%
16110903-40	100.0%	100.6%	101.2%	100.9%	100.7%	101.4%	100.9%	101.0%	100.5%	100.5%	100.8%
16110903-41	100.0%	100.2%	100.5%	101.2%	100.4%	101.3%	101.4%	100.6%	100.5%	100.3%	101.7%
16110903-42	100.0%	100.1%	99.8%	100.4%	99.7%	100.1%	100.5%	100.1%	100.6%	100.5%	100.0%
16110903-43	100.0%	101.4%	101.2%	100.3%	101.2%	100.8%	100.6%	101.3%	101.4%	100.6%	100.6%
16110903-44	100.0%	101.5%	100.4%	100.1%	100.6%	101.8%	100.2%	100.6%	100.7%	100.3%	100.6%
16110903-45	100.0%	101.1%	100.6%	100.5%	101.1%	100.9%	100.8%	101.0%	100.2%	101.1%	101.2%
16110903-46	100.0%	100.3%	101.3%	101.1%	100.5%	100.3%	100.8%	100.2%	100.3%	100.9%	101.7%
16110903-47	100.0%	100.8%	100.2%	101.3%	101.3%	100.2%	100.1%	100.6%	101.3%	101.5%	101.2%
16110903-48	100.0%	101.2%	100.4%	100.3%	100.5%	101.3%	101.0%	101.0%	100.2%	100.6%	100.6%
16110903-49	100.0%	100.0%	100.7%	101.6%	100.6%	100.5%	100.6%	101.3%	100.1%	100.1%	101.6%
16110903-50	100.0%	101.7%	101.1%	101.3%	100.5%	100.7%	100.4%	101.5%	101.1%	100.7%	100.3%
Avg.	100.0%	100.9%	100.8%	101.0%	100.7%	100.9%	100.7%	101.0%	100.9%	100.8%	100.9%
Med.	100.0%	101.1%	100.7%	101.2%	100.6%	100.8%	100.8%	101.0%	100.9%	100.7%	100.8%
σ	0.0000	0.0055	0.0057	0.0053	0.0045	0.0051	0.0053	0.0050	0.0053	0.0045	0.0055
Min.	100.0%	101.7%	101.7%	101.8%	101.4%	101.8%	101.7%	101.7%	101.7%	101.8%	101.8%
Max.	100.0%	100.0%	99.8%	100.1%	99.7%	100.0%	100.0%	100.1%	100.1%	100.0%	100.0%



Appendix A

Table 2-4 Chromaticity Shift

Sample No.	Chromaticity Shift $\Delta u'v'$										
	0 h	1000 h	2000 h	3000 h	4000 h	5000 h	6000 h	7000 h	8000 h	9000 h	10000 h
16110903-26	0.0000	0.0004	0.0011	0.0002	0.0005	0.0009	0.0014	0.0018	0.0021	0.0021	0.0024
16110903-27	0.0000	0.0004	0.0006	0.0009	0.0012	0.0017	0.0018	0.0019	0.0022	0.0024	0.0026
16110903-28	0.0000	0.0001	0.0004	0.0007	0.0011	0.0017	0.0022	0.0024	0.0025	0.0027	0.0028
16110903-29	0.0000	0.0004	0.0010	0.0007	0.0012	0.0017	0.0020	0.0021	0.0022	0.0024	0.0025
16110903-30	0.0000	0.0002	0.0007	0.0009	0.0012	0.0020	0.0017	0.0022	0.0022	0.0025	0.0027
16110903-31	0.0000	0.0002	0.0004	0.0007	0.0009	0.0015	0.0014	0.0018	0.0019	0.0020	0.0022
16110903-32	0.0000	0.0003	0.0009	0.0006	0.0011	0.0016	0.0017	0.0020	0.0021	0.0023	0.0025
16110903-33	0.0000	0.0003	0.0006	0.0007	0.0010	0.0017	0.0016	0.0021	0.0023	0.0023	0.0026
16110903-34	0.0000	0.0003	0.0006	0.0008	0.0011	0.0017	0.0019	0.0022	0.0023	0.0025	0.0027
16110903-35	0.0000	0.0003	0.0007	0.0009	0.0010	0.0013	0.0015	0.0018	0.0020	0.0021	0.0024
16110903-36	0.0000	0.0004	0.0010	0.0004	0.0006	0.0012	0.0015	0.0018	0.0023	0.0025	0.0027
16110903-37	0.0000	0.0001	0.0005	0.0009	0.0011	0.0017	0.0021	0.0022	0.0023	0.0022	0.0026
16110903-38	0.0000	0.0001	0.0006	0.0011	0.0015	0.0018	0.0022	0.0022	0.0023	0.0025	0.0029
16110903-39	0.0000	0.0001	0.0006	0.0005	0.0009	0.0014	0.0016	0.0020	0.0023	0.0026	0.0028
16110903-40	0.0000	0.0005	0.0006	0.0006	0.0006	0.0013	0.0019	0.0020	0.0021	0.0021	0.0024
16110903-41	0.0000	0.0001	0.0009	0.0010	0.0012	0.0017	0.0017	0.0018	0.0019	0.0023	0.0026
16110903-42	0.0000	0.0002	0.0008	0.0012	0.0012	0.0013	0.0018	0.0019	0.0020	0.0024	0.0025
16110903-43	0.0000	0.0001	0.0007	0.0010	0.0010	0.0015	0.0018	0.0023	0.0022	0.0025	0.0028
16110903-44	0.0000	0.0001	0.0008	0.0008	0.0010	0.0020	0.0018	0.0021	0.0023	0.0026	0.0029
16110903-45	0.0000	0.0003	0.0006	0.0007	0.0009	0.0015	0.0020	0.0024	0.0024	0.0025	0.0027
16110903-46	0.0000	0.0004	0.0008	0.0005	0.0007	0.0012	0.0017	0.0019	0.0023	0.0026	0.0030
16110903-47	0.0000	0.0004	0.0006	0.0004	0.0006	0.0014	0.0018	0.0020	0.0020	0.0024	0.0027
16110903-48	0.0000	0.0000	0.0008	0.0007	0.0009	0.0016	0.0017	0.0018	0.0020	0.0021	0.0024
16110903-49	0.0000	0.0001	0.0008	0.0006	0.0010	0.0014	0.0017	0.0019	0.0019	0.0021	0.0021
16110903-50	0.0000	0.0001	0.0013	0.0005	0.0010	0.0015	0.0018	0.0021	0.0020	0.0023	0.0028
Avg.	0.0000	0.0002	0.0007	0.0007	0.0010	0.0015	0.0018	0.0020	0.0022	0.0024	0.0026
Med.	0.0000	0.0002	0.0007	0.0007	0.0010	0.0015	0.0018	0.0020	0.0022	0.0024	0.0026
σ	0.0000	0.0001	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002
Min.	0.0000	0.0000	0.0004	0.0002	0.0005	0.0009	0.0014	0.0018	0.0019	0.0020	0.0021
Max.	0.0000	0.0005	0.0013	0.0012	0.0015	0.0020	0.0022	0.0024	0.0025	0.0027	0.0030



Appendix B



INTERNATIONAL
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has met the requirements of the IAS Accreditation Criteria for Testing Laboratories (AC89), has demonstrated compliance with ISO/IEC Standard 17025:2005, *General requirements for the competence of testing and calibration laboratories*, and has been accredited, commencing January 13, 2016, for the test methods listed in the approved scope of accreditation.

(see laboratory's scope of accreditation for fields of testing and accredited test methods)

*This accreditation certificate supersedes any IAS accreditation bearing an earlier effective date. The certificate becomes invalid upon suspension, cancellation or revocation of accreditation.
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C.P. Ramani

C.P. Ramani, P.E., C.B.O.
President



Appendix B



SCOPE OF ACCREDITATION

FIELDS OF TESTING	ACCREDITED TEST METHODS
ENERGY STAR Program Requirements for Lighting (except Electromagnetic and Radio Frequency Interference, Air Tight for Restricted Air Flow, and Mercury Content) (continued)	<p>IES LM-49-2001: Approved Method of Life Testing for Incandescent Filament Lamps</p> <p>IES LM-49-2011: Approved Method of Life Testing for Incandescent Filament Lamps</p> <p>IES LM-49-12: Life Testing of Incandescent Filament Lamps</p> <p>IES LM-51-00: Approved Method for the Electrical and Photometric Measurements of High Intensity Discharge Lamps</p> <p>IES LM-54-99 /12: IESNA Guide to Lamp Seasoning</p> <p>IES LM-58-94: Guide to Spectroradiometric Measurements</p> <p>IES LM-65-01: Approved Method for Life Testing of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-65-10: Approved Method for Life Testing of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-65-14: Approved Method for Life Testing of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-66-00: Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-66-11: Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-66-14: Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps</p> <p>IES LM-79-08: Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products, Sections 9, 10 and 12</p> <p>IES LM-80-08: Measuring Lumen Maintenance of LED Light Sources</p> <p>IES LM-80-15: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays, and Modules</p> <p>IES LM-82-12: Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature</p> <p>IES LM-84-14: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires</p>



Appendix B





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