

# LM-80 Test Report

## COB-A, COB-B Series

<b>Issue Date:</b>	August 25, 2015	<b>Revision Date:</b>	-
<b>Test Initiation Date:</b>	October 25, 2012	<b>Test Completion Date:</b>	January 6, 2014
<b>Test Duration:</b>	10,000 hours	<b>Report Number:</b>	SQETMMJ79601

**Customer Information:**

Company Name: Nichia Corporation  
 Address: 491-100, Oka, Kaminaka-cho, Anan-shi, Tokushima, 774-8601, JAPAN

**Description of Test Samples:**

Classification: LED Array  
 Model Name: COB  
 Model Number: NSCLL180A (Nominal CCT: 2700 K, Array size: 180 dies)

**Test Summary:**

Data Set	Case Temperature [T <sub>s</sub> ]	Ambient Temperature [T <sub>A</sub> ]	Drive Current [I <sub>F</sub> ]	Average Current per Die	Lumen Maintenance at 10,000 hours	Chromaticity Shift (Δu'v') at 10,000 hours	TM-21 Projection L <sub>70</sub> (10K)
1	55 °C	> 50 °C	1500 mA	100 mA	97.3 %	0.0017	> 56100 hours
2	85 °C	> 80 °C	1140 mA	76 mA	96.0 %	0.0019	> 56000 hours
3	85 °C	> 80 °C	1500 mA	100 mA	95.9 %	0.0020	> 56100 hours
4	105 °C	> 100 °C	1140 mA	76 mA	94.2 %	0.0020	> 56000 hours

Approved Signatory:



Hitoshi TOHYAMA, Lab Manager

**Nichia Corporation LED Testing Laboratory**  
 1-1, Tatsumi-Cho, Anan-Shi, TOKUSHIMA 774-0001, JAPAN

**Applicable Model Numbers:**

This LM-80 test report applies to the following models:

Series	Model Number	Case Temperature [°C]	Forward Current [mA]	Nominal CCT [K]	Data Set Number
COB	NSCLL036A	55	300	≥ 2700	1
		85	228	≥ 2700	2
		85	300	≥ 2700	3
		105	228	≥ 2700	4
COB	NSCWL036A	55	300	≥ 5000	1
		85	228	≥ 5000	2
		85	300	≥ 5000	3
		105	228	≥ 5000	4
COB	NSBLL066A	55	600	≥ 2700	1
		85	456	≥ 2700	2
		85	600	≥ 2700	3
		105	456	≥ 2700	4
COB	NSBWL066A	55	600	≥ 5000	1
		85	456	≥ 5000	2
		85	600	≥ 5000	3
		105	456	≥ 5000	4
COB	NSBLL121A	55	1100	≥ 2700	1
		85	836	≥ 2700	2
		85	1100	≥ 2700	3
		105	836	≥ 2700	4
COB	NSBWL121A	55	1100	≥ 5000	1
		85	836	≥ 5000	2
		85	1100	≥ 5000	3
		105	836	≥ 5000	4
COB	NTCLS024B	55	300	≥ 2700	1
		85	228	≥ 2700	2
		85	300	≥ 2700	3
		105	228	≥ 2700	4
COB	NTCWS024B	55	300	≥ 5000	1
		85	228	≥ 5000	2
		85	300	≥ 5000	3
		105	228	≥ 5000	4
COB	NFCLL036B	55	540	≥ 2700	1
		85	477	≥ 2700	2
		85	540	≥ 2700	3
		105	477	≥ 2700	4
COB	NFCWL036B	55	540	≥ 5000	1
		85	477	≥ 5000	2
		85	540	≥ 5000	3
		105	477	≥ 5000	4
COB	NFCLL060B	55	900	≥ 2700	1
		85	796	≥ 2700	2
		85	900	≥ 2700	3
		105	796	≥ 2700	4
COB	NFCWL060B	55	900	≥ 5000	1
		85	796	≥ 5000	2
		85	900	≥ 5000	3
		105	796	≥ 5000	4

**Applicable Model Numbers:**

This LM-80 test report applies to the following models:

Series	Model Number	Case Temperature [°C]	Forward Current [mA]	Nominal CCT [K]	Data Set Number
COB	NTCLS024B-V1	55	300	≥ 2700	1
		85	228	≥ 2700	2
		85	300	≥ 2700	3
		105	228	≥ 2700	4
COB	NTCWS024B-V1	55	300	≥ 5000	1
		85	228	≥ 5000	2
		85	300	≥ 5000	3
		105	228	≥ 5000	4
COB	NFCLL036B-V1	55	540	≥ 2700	1
		85	477	≥ 2700	2
		85	540	≥ 2700	3
		105	477	≥ 2700	4
COB	NFCWL036B-V1	55	540	≥ 5000	1
		85	477	≥ 5000	2
		85	540	≥ 5000	3
		105	477	≥ 5000	4
COB	NFCLL060B-V1	55	900	≥ 2700	1
		85	796	≥ 2700	2
		85	900	≥ 2700	3
		105	796	≥ 2700	4
COB	NFCWL060B-V1	55	900	≥ 5000	1
		85	796	≥ 5000	2
		85	900	≥ 5000	3
		105	796	≥ 5000	4

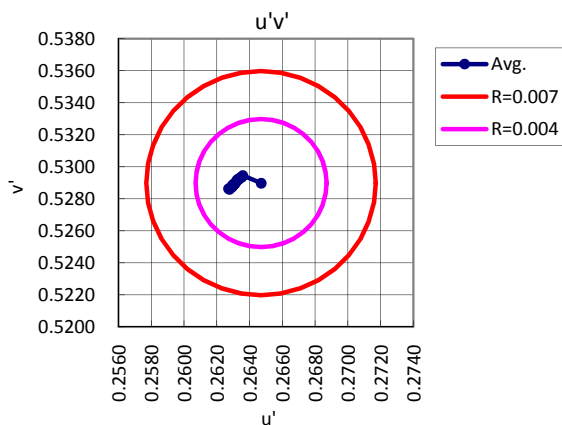
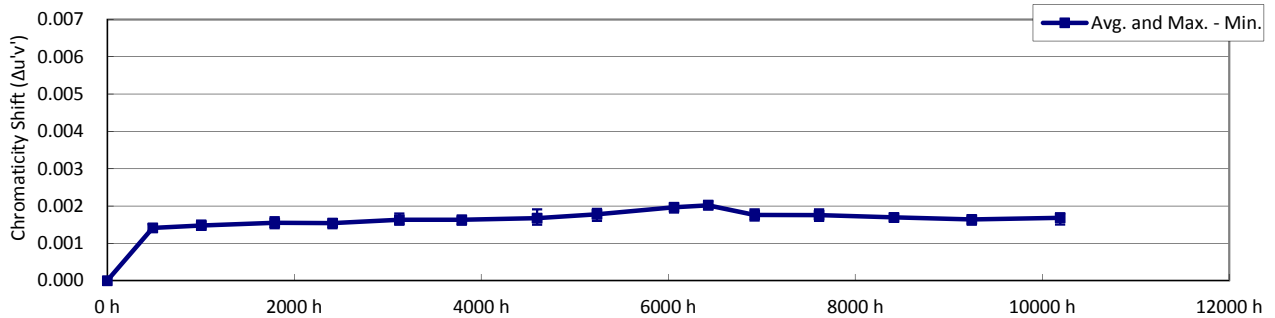
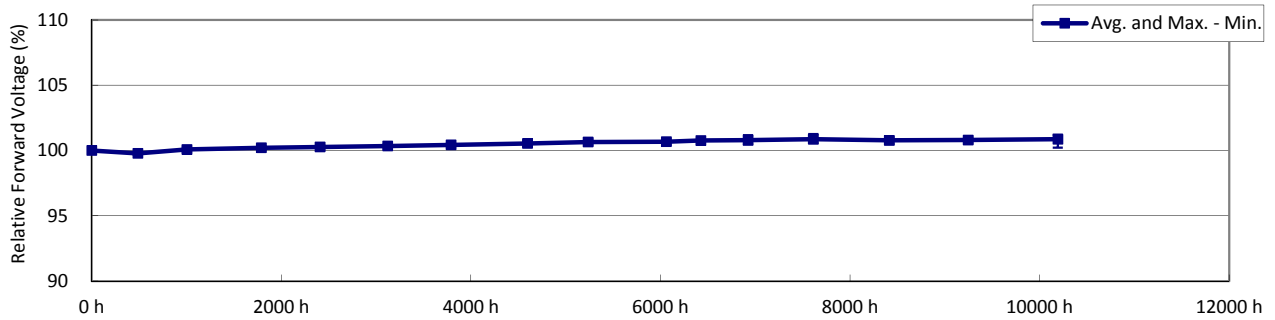
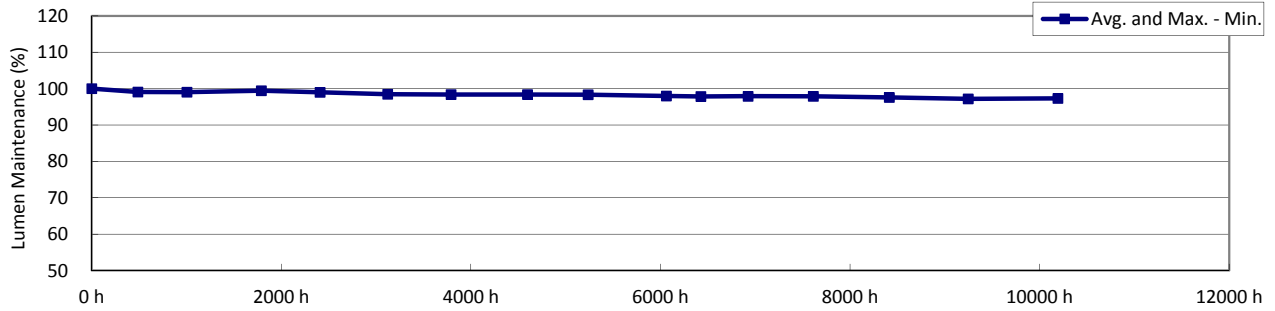
**IES LM-80-08 Test Report Requirement :**

1. **Number of LED light sources tested**  
See tables.
  2. **Description of LED light sources**  
See Description of Test Samples
  3. **Description of auxiliary equipment**  
Active cooling life test system  
Consisting of small boxes, in which each box contains a reliability test board, and a water-cooled heat sink or a heater to control device temperature.  
LED Tester  
Consisting of an integrating sphere, a programmable current-source meter, and a spectroradiometer.
  4. **Operating cycle**  
Constant direct current (DC).
  5. **Ambient conditions including airflow, temperature, and relative humidity**  
Ambient Temperature ( $T_A$ ) : See tables  
Ambient temperature is the temperature of the air at a distance of 1.5 mm above the reliability test board.  
Air flow : < 0.1 m/s  
Relative Humidity : < 45 %
  6. **Case temperature (test point temperature)**  
See tables.  
For the case temperature ( $T_S$ ) measurement point, see the figure below.
- 
7. **Drive current of the LED light sources during lifetime test**  
See tables.
  8. **Initial luminous flux and forward voltage at photometric measurement current**  
See tables.
  9. **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.**  
See tables.
  10. **Observation of LED light sources failures including the failure conditions and time of failure.**  
No failure observed
  11. **LED light source monitoring interval**  
See tables.
  12. **Photometric measurement uncertainty**  
Flux measurement: 4.2 % ( $k=2$ )  
Lumen maintenance: 1.8 % ( $k=2$ )
  13. **Chromaticity shift reported over the measurement time.**  
See tables.

**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [ $T_S$ ]	57.0 °C
Actual Ambient Temperature [ $T_A$ ]	57.3 °C
Drive Current [ $I_F$ ]	1500 mA
Measurement Current	1500 mA

NOTES:  
 $T_S$  and  $T_A$  were measured during initial setup.



**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

 T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-1**  
Initial Characteristics

LED No.	Luminous flux	Forward voltage	CCT	CIE1931		CIE1976							
	$\Phi_V$ [lm]	V <sub>F</sub> [V]	T <sub>CP</sub> [K]	x	y	u'	v'						
1	5760	39.0	2665	0.463	0.412	0.264	0.528						
2	5654	38.8	2655	0.465	0.414	0.264	0.529						
3	5782	39.0	2671	0.463	0.412	0.264	0.528						
4	5834	39.0	2639	0.466	0.414	0.265	0.530						
5	5702	38.8	2649	0.465	0.413	0.265	0.529						
6	5819	38.9	2639	0.466	0.413	0.265	0.529						
7	5826	39.0	2654	0.464	0.412	0.265	0.529						
8	5724	38.8	2632	0.466	0.413	0.266	0.529						
9	5846	39.0	2661	0.464	0.412	0.264	0.529						
10	5802	38.9	2630	0.467	0.414	0.266	0.530						
n	10	10	10	10	10	10	10						
Avg.	5775	38.9	2650	0.465	0.413	0.265	0.529						
Med.	5792	38.9	2651	0.465	0.413	0.265	0.529						
$\sigma$	63.6	0.08	14.1	0.0014	0.0007	0.0006	0.0005						
Min.	5654	38.8	2630	0.463	0.412	0.264	0.528						
Max.	5846	39.0	2671	0.467	0.414	0.266	0.530						

Data Set 1 : 55 °C, 1500 mA

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:  
T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

TABLE 1-2  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3791 h	4597 h	5237 h	6062 h	6427 h	6924 h	7613 h	8414 h	9246 h
1	100.0	99.1	99.1	99.6	99.2	98.5	98.4	98.5	98.5	98.2	98.1	98.0	97.9	97.6	97.1
2	100.0	99.1	99.0	99.3	98.9	98.2	98.0	98.1	98.1	97.7	97.5	97.7	97.6	97.1	96.7
3	100.0	99.0	99.0	99.5	99.0	98.5	98.4	98.4	98.4	98.0	98.0	98.1	98.1	97.9	97.4
4	100.0	99.2	99.2	99.6	99.3	98.8	98.7	98.8	98.8	98.4	98.3	98.4	98.4	98.1	97.8
5	100.0	99.0	98.9	99.2	98.8	98.2	98.1	98.1	98.0	97.6	97.5	97.5	97.4	97.1	96.8
6	100.0	99.1	99.2	99.5	99.0	98.6	98.4	98.4	98.3	98.0	97.9	98.0	98.0	97.6	97.3
7	100.0	98.9	98.9	99.3	98.9	98.4	98.4	98.3	98.3	98.0	97.7	97.8	97.8	97.4	97.1
8	100.0	99.0	98.9	99.2	98.8	98.2	98.1	98.1	98.0	97.7	97.5	97.6	97.4	97.2	96.8
9	100.0	99.2	99.1	99.6	99.2	98.7	98.6	98.6	98.6	98.2	98.1	98.2	98.2	98.0	97.6
10	100.0	99.1	99.1	99.5	99.1	98.6	98.5	98.5	98.5	98.2	97.9	98.0	97.9	97.7	97.4
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	99.1	99.0	99.4	99.0	98.5	98.4	98.4	98.3	98.0	97.9	97.9	97.9	97.6	97.2
Med.	100.0	99.1	99.1	99.5	99.0	98.5	98.4	98.4	98.3	98.0	97.9	98.0	97.9	97.6	97.2
σ	0.00	0.10	0.14	0.15	0.19	0.22	0.23	0.24	0.27	0.27	0.29	0.29	0.32	0.35	0.37
Min.	100.0	98.9	98.9	99.2	98.8	98.2	98.0	98.1	98.0	97.6	97.5	97.5	97.4	97.1	96.7
Max.	100.0	99.2	99.2	99.6	99.3	98.8	98.7	98.8	98.8	98.4	98.3	98.4	98.4	98.1	97.8

TM-21 Projection

Time	4597 h	5237 h	6062 h	6427 h	6924 h	7613 h	8414 h	9246 h	10192 h						
ln(Avg.)	-0.0165	-0.0167	-0.0203	-0.0217	-0.0210	-0.0213	-0.0246	-0.0285	-0.0272						

Test duration used	4597 h	to	10192 h
B	0.9935		
α	2.1456E-06		
R <sup>2</sup>	0.9126		
Calculated L <sub>70</sub> (10K)	163000	hours	
Reported L <sub>70</sub> (10K)	> 56100	hours	

Curve-fit equation:  
 $\Phi(t)=Bexp(-at)$

Lumen maintenance life equation:  
 $L_{70}=\ln(B/0.7)/\alpha$

**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-2 (Continued)**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )													
	10192 h													
1	97.4													
2	97.0													
3	97.6													
4	97.8													
5	96.9													
6	97.4													
7	97.2													
8	96.9													
9	97.7													
10	97.3													
n	10													
Avg.	97.3													
Med.	97.3													
σ	0.33													
Min.	96.9													
Max.	97.8													



**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-3**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3791 h	4597 h	5237 h	6062 h	6427 h	6924 h	7613 h	8414 h	9246 h
1	100.0	99.7	100.1	100.2	100.3	100.4	100.4	100.6	100.7	100.7	100.8	100.9	100.9	100.9	100.8
2	100.0	99.7	99.9	100.1	100.1	100.2	100.2	100.3	100.4	100.4	100.5	100.5	100.6	100.5	100.6
3	100.0	99.8	100.2	100.3	100.4	100.4	100.5	100.7	100.9	100.9	100.9	101.2	101.3	101.0	101.0
4	100.0	99.8	100.1	100.2	100.3	100.4	100.5	100.6	100.7	100.7	100.8	100.8	100.9	100.8	100.8
5	100.0	99.7	100.0	100.0	100.1	100.1	100.3	100.4	100.4	100.5	100.7	100.7	100.6	100.5	100.6
6	100.0	99.9	100.2	100.3	100.4	100.5	100.6	100.7	100.8	100.8	100.9	100.9	101.0	100.9	100.9
7	100.0	99.8	100.1	100.2	100.2	100.3	100.4	100.5	100.6	100.6	100.7	100.7	100.8	100.7	100.7
8	100.0	99.8	100.1	100.2	100.3	100.4	100.4	100.6	100.7	100.7	100.9	100.9	100.9	100.8	100.9
9	100.0	99.8	100.1	100.2	100.3	100.4	100.5	100.6	100.7	100.7	100.7	100.8	100.9	100.8	100.8
10	100.0	99.8	100.1	100.3	100.3	100.4	100.5	100.6	100.7	100.7	100.8	100.9	101.0	100.9	100.9
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	99.8	100.1	100.2	100.3	100.3	100.4	100.5	100.6	100.7	100.8	100.8	100.9	100.8	100.8
Med.	100.0	99.8	100.1	100.2	100.3	100.4	100.5	100.6	100.7	100.7	100.8	100.8	100.9	100.8	100.8
σ	0.00	0.06	0.09	0.10	0.11	0.11	0.11	0.11	0.14	0.13	0.13	0.19	0.20	0.17	0.14
Min.	100.0	99.7	99.9	100.0	100.1	100.1	100.2	100.3	100.4	100.4	100.5	100.5	100.6	100.5	100.6
Max.	100.0	99.9	100.2	100.3	100.4	100.5	100.6	100.7	100.9	100.9	100.9	101.2	101.3	101.0	101.0

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The laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005.



**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-3 (Continued)**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )													
	10192 h													
1	100.9													
2	100.6													
3	101.1													
4	100.9													
5	101.1													
6	101.2													
7	100.8													
8	101.2													
9	100.6													
10	100.2													
n	10													
Avg.	100.9													
Med.	100.9													
σ	0.31													
Min.	100.2													
Max.	101.2													

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**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-4**  
Chromaticity Shift

LED No.	Chromaticity Shift Δu'v'														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3791 h	4597 h	5237 h	6062 h	6427 h	6924 h	7613 h	8414 h	9246 h
1	0.0000	0.0014	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016	0.0017	0.0019	0.0020	0.0018	0.0018	0.0018	0.0016
2	0.0000	0.0013	0.0014	0.0015	0.0015	0.0016	0.0016	0.0015	0.0016	0.0018	0.0020	0.0017	0.0017	0.0016	0.0015
3	0.0000	0.0013	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0019	0.0020	0.0016	0.0017	0.0017	0.0017
4	0.0000	0.0014	0.0014	0.0016	0.0015	0.0016	0.0016	0.0017	0.0017	0.0019	0.0019	0.0017	0.0016	0.0017	0.0016
5	0.0000	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015	0.0016	0.0017	0.0018	0.0019	0.0017	0.0017	0.0016	0.0016
6	0.0000	0.0015	0.0016	0.0017	0.0016	0.0018	0.0017	0.0019	0.0018	0.0021	0.0020	0.0019	0.0018	0.0017	0.0017
7	0.0000	0.0014	0.0015	0.0016	0.0016	0.0017	0.0016	0.0017	0.0018	0.0021	0.0020	0.0018	0.0018	0.0017	0.0017
8	0.0000	0.0014	0.0015	0.0016	0.0016	0.0017	0.0017	0.0017	0.0018	0.0020	0.0021	0.0018	0.0019	0.0017	0.0017
9	0.0000	0.0014	0.0014	0.0016	0.0015	0.0016	0.0017	0.0016	0.0019	0.0020	0.0020	0.0017	0.0017	0.0017	0.0016
10	0.0000	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0017	0.0018	0.0020	0.0020	0.0018	0.0018	0.0017	0.0017
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	0.0000	0.0014	0.0015	0.0016	0.0015	0.0016	0.0016	0.0017	0.0018	0.0020	0.0020	0.0018	0.0018	0.0017	0.0016
Med.	0.0000	0.0014	0.0015	0.0016	0.0016	0.0016	0.0016	0.0017	0.0018	0.0020	0.0020	0.0018	0.0018	0.0017	0.0017
σ	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Min.	0.0000	0.0013	0.0014	0.0014	0.0014	0.0015	0.0015	0.0015	0.0016	0.0018	0.0019	0.0016	0.0016	0.0016	0.0015
Max.	0.0000	0.0015	0.0016	0.0017	0.0016	0.0018	0.0017	0.0019	0.0019	0.0021	0.0021	0.0019	0.0019	0.0018	0.0017

**Data Set 1 : 55 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	57.0 °C
Actual Ambient Temperature [T <sub>A</sub> ]	57.3 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:  
T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 1-4 (Continued)**  
Chromaticity Shift

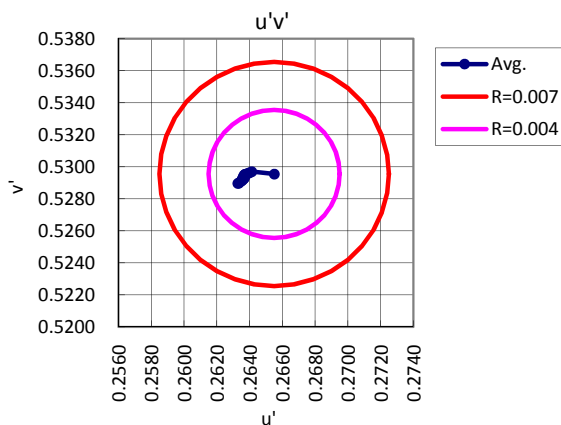
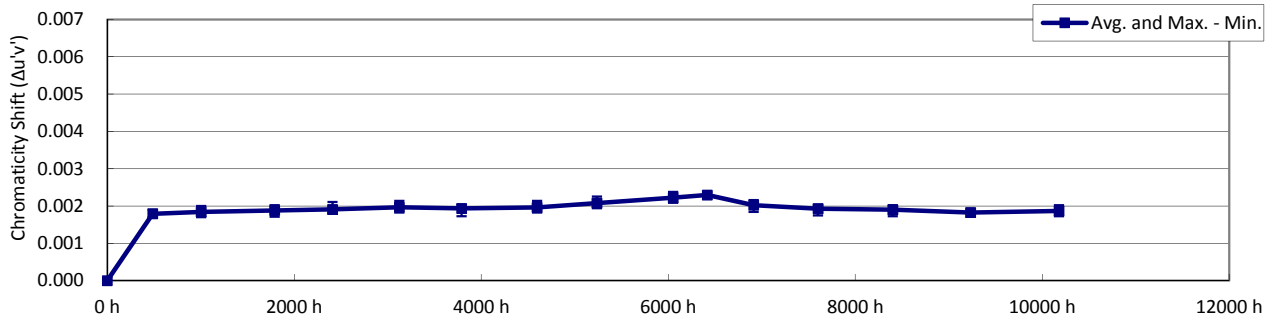
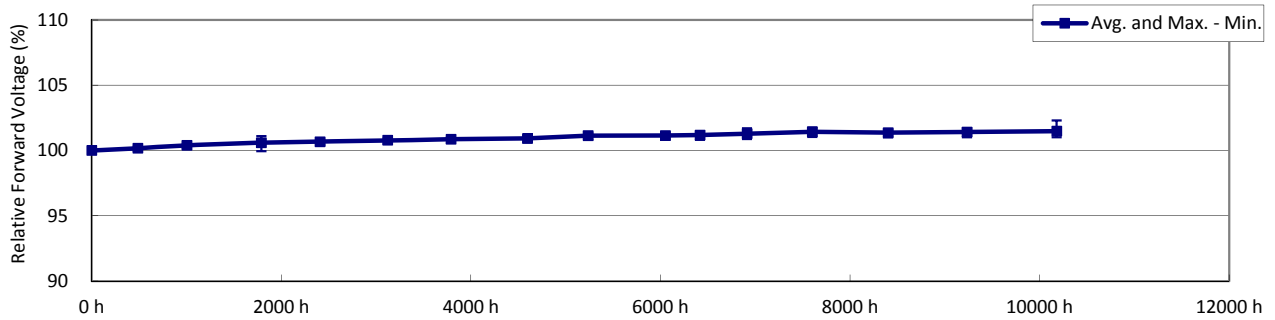
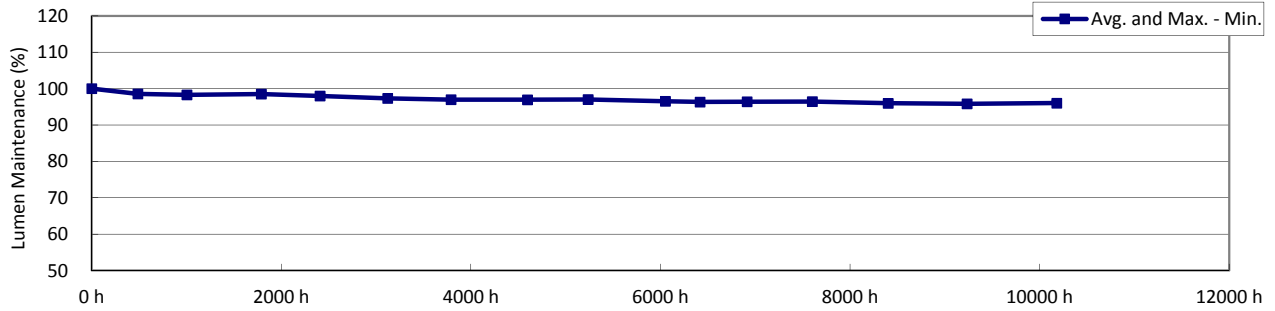
LED No.	Chromaticity Shift Δu'v'													
	10192 h													
1	0.0017													
2	0.0017													
3	0.0016													
4	0.0017													
5	0.0015													
6	0.0017													
7	0.0018													
8	0.0017													
9	0.0017													
10	0.0017													
n	10													
Avg.	0.0017													
Med.	0.0017													
σ	0.0001													
Min.	0.0015													
Max.	0.0018													

**Data Set 2 : 85 °C, 1140 mA**

Actual Case Temperature [ $T_S$ ]	85.6 °C
Actual Ambient Temperature [ $T_A$ ]	87.4 °C
Drive Current [ $I_F$ ]	1140 mA
Measurement Current	1140 mA

NOTES:

$T_S$  and  $T_A$  were measured during initial setup.



**Data Set 2 : 85 °C, 1140 mA**

Actual Case Temperature [T <sub>S</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:

 T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-1**  
 Initial Characteristics

LED No.	Luminous flux	Forward voltage	CCT	CIE1931		CIE1976							
	$\Phi_V$ [lm]	V <sub>F</sub> [V]	T <sub>CP</sub> [K]	x	y	u'	v'						
1	4624	37.6	2638	0.466	0.413	0.265	0.529						
2	4590	37.5	2627	0.467	0.414	0.266	0.530						
3	4592	37.6	2619	0.468	0.415	0.266	0.530						
4	4591	37.5	2631	0.467	0.414	0.266	0.530						
5	4493	37.5	2634	0.466	0.412	0.266	0.529						
6	4541	37.4	2618	0.468	0.414	0.266	0.530						
7	4480	37.5	2633	0.467	0.414	0.265	0.530						
8	4537	37.4	2645	0.465	0.413	0.265	0.529						
9	4581	37.6	2642	0.466	0.413	0.265	0.529						
10	4510	37.5	2627	0.467	0.414	0.266	0.530						
n	10	10	10	10	10	10	10						
Avg.	4554	37.5	2631	0.467	0.414	0.266	0.530						
Med.	4561	37.5	2632	0.467	0.414	0.266	0.530						
σ	48.7	0.07	8.8	0.0010	0.0008	0.0004	0.0004						
Min.	4480	37.4	2618	0.465	0.412	0.265	0.529						
Max.	4624	37.6	2645	0.468	0.415	0.266	0.530						

### Data Set 2 : 85 °C, 1140 mA

Actual Case Temperature [T <sub>S</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-2**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6052 h	6417 h	6913 h	7602 h	8402 h	9234 h
1	100.0	99.0	98.7	99.0	98.4	97.6	97.2	97.3	97.6	96.9	96.8	96.9	96.9	96.3	96.3
2	100.0	98.6	98.3	98.5	98.0	97.1	96.7	96.7	97.0	96.4	96.2	96.3	96.3	95.7	95.7
3	100.0	98.7	98.5	98.7	98.2	97.6	97.2	97.1	97.2	96.7	96.5	96.6	96.7	96.2	96.1
4	100.0	98.3	98.0	98.3	97.7	97.2	96.9	96.8	96.8	96.4	96.2	96.3	96.3	95.9	95.7
5	100.0	98.6	98.3	98.5	98.0	97.4	97.0	97.0	97.0	96.6	96.3	96.4	96.3	95.9	95.8
6	100.0	98.5	98.3	98.5	97.9	97.3	96.9	96.9	96.9	96.5	96.3	96.4	96.4	96.0	95.8
7	100.0	98.4	98.2	98.4	97.8	97.2	96.8	96.7	96.8	96.3	96.1	96.2	96.2	95.7	95.6
8	100.0	98.4	98.2	98.4	97.9	97.4	97.1	97.0	97.1	96.7	96.4	96.5	96.5	96.1	95.9
9	100.0	98.5	98.3	98.5	98.0	97.4	97.0	96.9	97.0	96.6	96.3	96.4	96.5	96.0	95.8
10	100.0	98.6	98.2	98.5	97.9	97.3	96.9	96.9	96.9	96.4	96.2	96.2	96.3	95.9	95.7
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	98.6	98.3	98.5	98.0	97.3	97.0	96.9	97.0	96.5	96.3	96.4	96.4	96.0	95.8
Med.	100.0	98.6	98.3	98.5	97.9	97.3	97.0	96.9	97.0	96.5	96.3	96.4	96.4	96.0	95.8
σ	0.00	0.19	0.20	0.19	0.21	0.18	0.18	0.18	0.22	0.19	0.19	0.21	0.23	0.20	0.21
Min.	100.0	98.3	98.0	98.3	97.7	97.1	96.7	96.7	96.8	96.3	96.1	96.2	96.2	95.7	95.6
Max.	100.0	99.0	98.7	99.0	98.4	97.6	97.2	97.3	97.6	96.9	96.8	96.9	96.9	96.3	96.3

#### TM-21 Projection

Time	4597 h	5237 h	6052 h	6417 h	6913 h	7602 h	8402 h	9234 h	10180 h							
ln(Avg.)	-0.0310	-0.0303	-0.0352	-0.0374	-0.0367	-0.0363	-0.0410	-0.0427	-0.0405							

Test duration used	4597 h	to	10180 h
B	0.9785		
α	2.0929E-06		
R <sup>2</sup>	0.8245		
Calculated L <sub>70</sub> (10K)	160000	hours	
Reported L <sub>70</sub> (10K)	> 56000	hours	

Curve-fit equation:  
 $\Phi(t) = B \exp(-at)$

Lumen maintenance life equation:  
 $L_{70} = \ln(B/0.7) / \alpha$

Data Set 2 : 85 °C, 1140 mA

Actual Case Temperature [T <sub>s</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

TABLE 2-2 (Continued)  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )													
	10180 h													
1	96.7													
2	96.1													
3	96.3													
4	95.9													
5	95.9													
6	96.0													
7	95.7													
8	96.1													
9	96.0													
10	95.8													
n	10													
Avg.	96.0													
Med.	96.0													
σ	0.28													
Min.	95.7													
Max.	96.7													



**Data Set 2 : 85 °C, 1140 mA**

Actual Case Temperature [T <sub>s</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

## NOTES:

 T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-3**  
 Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6052 h	6417 h	6913 h	7602 h	8402 h	9234 h
1	100.0	100.1	100.4	100.6	100.6	100.8	100.9	101.0	101.3	101.2	101.4	101.7	101.8	101.6	101.7
2	100.0	100.2	100.4	101.1	100.7	100.8	100.9	101.0	101.2	101.2	101.2	101.3	101.4	101.4	101.4
3	100.0	100.2	100.4	100.3	100.7	100.9	101.0	101.1	101.2	101.3	101.3	101.3	101.5	101.4	101.5
4	100.0	100.3	100.5	101.0	100.8	100.9	101.0	101.1	101.3	101.3	101.3	101.4	101.6	101.5	101.5
5	100.0	100.1	100.2	100.6	100.5	100.6	100.7	100.7	100.9	100.9	100.9	101.0	101.1	101.2	101.1
6	100.0	100.3	100.5	100.9	100.8	100.9	101.0	101.1	101.2	101.3	101.3	101.4	101.5	101.4	101.5
7	100.0	100.2	100.4	100.5	100.6	100.8	100.8	100.9	101.1	101.1	101.1	101.2	101.3	101.2	101.4
8	100.0	100.2	100.4	100.8	100.6	100.8	100.8	100.9	101.1	101.1	101.2	101.2	101.4	101.3	101.4
9	100.0	100.3	100.5	100.0	100.8	100.9	101.0	101.1	101.3	101.3	101.3	101.4	101.6	101.6	101.7
10	100.0	100.0	100.2	100.3	100.4	100.5	100.6	100.6	100.8	100.8	100.8	100.9	101.0	101.0	101.0
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	100.2	100.4	100.6	100.7	100.8	100.9	100.9	101.1	101.1	101.2	101.3	101.4	101.4	101.4
Med.	100.0	100.2	100.4	100.6	100.7	100.8	100.9	101.0	101.2	101.2	101.2	101.3	101.5	101.4	101.4
σ	0.00	0.09	0.10	0.35	0.14	0.14	0.15	0.16	0.17	0.17	0.19	0.22	0.22	0.19	0.22
Min.	100.0	100.0	100.2	100.0	100.4	100.5	100.6	100.6	100.8	100.8	100.8	100.9	101.0	101.0	101.0
Max.	100.0	100.3	100.5	101.1	100.8	100.9	101.0	101.1	101.3	101.3	101.4	101.7	101.8	101.6	101.7

### Data Set 2 : 85 °C, 1140 mA

Actual Case Temperature [T <sub>s</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-3 (Continued)**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	10180 h														
1	101.9														
2	101.2														
3	101.6														
4	101.0														
5	101.3														
6	102.3														
7	101.2														
8	101.9														
9	101.1														
10	101.4														
n	10														
Avg.	101.5														
Med.	101.3														
σ	0.43														
Min.	101.0														
Max.	102.3														

**Data Set 2 : 85 °C, 1140 mA**

Actual Case Temperature [T <sub>s</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-4**  
Chromaticity Shift

LED No.	Chromaticity Shift Δu'v'														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6052 h	6417 h	6913 h	7602 h	8402 h	9234 h
1	0.0000	0.0018	0.0017	0.0018	0.0018	0.0019	0.0019	0.0019	0.0020	0.0022	0.0022	0.0019	0.0019	0.0018	0.0018
2	0.0000	0.0017	0.0017	0.0017	0.0018	0.0019	0.0018	0.0018	0.0019	0.0022	0.0022	0.0019	0.0017	0.0018	0.0017
3	0.0000	0.0017	0.0018	0.0018	0.0018	0.0018	0.0019	0.0019	0.0019	0.0021	0.0022	0.0020	0.0019	0.0019	0.0017
4	0.0000	0.0018	0.0019	0.0019	0.0019	0.0020	0.0020	0.0019	0.0020	0.0022	0.0024	0.0020	0.0019	0.0020	0.0019
5	0.0000	0.0019	0.0019	0.0020	0.0020	0.0020	0.0020	0.0020	0.0022	0.0023	0.0024	0.0020	0.0020	0.0020	0.0019
6	0.0000	0.0019	0.0020	0.0020	0.0021	0.0021	0.0020	0.0021	0.0023	0.0024	0.0024	0.0022	0.0020	0.0020	0.0019
7	0.0000	0.0018	0.0019	0.0019	0.0019	0.0019	0.0019	0.0020	0.0022	0.0022	0.0024	0.0020	0.0019	0.0018	0.0018
8	0.0000	0.0018	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0022	0.0024	0.0024	0.0022	0.0020	0.0019	0.0019
9	0.0000	0.0017	0.0017	0.0018	0.0018	0.0018	0.0017	0.0018	0.0019	0.0022	0.0022	0.0018	0.0018	0.0017	0.0017
10	0.0000	0.0018	0.0018	0.0018	0.0019	0.0020	0.0019	0.0020	0.0021	0.0023	0.0024	0.0020	0.0019	0.0019	0.0018
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	0.0000	0.0018	0.0018	0.0019	0.0019	0.0020	0.0019	0.0020	0.0021	0.0022	0.0023	0.0020	0.0019	0.0019	0.0018
Med.	0.0000	0.0018	0.0019	0.0019	0.0019	0.0020	0.0019	0.0020	0.0021	0.0022	0.0024	0.0020	0.0019	0.0019	0.0018
σ	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Min.	0.0000	0.0017	0.0017	0.0017	0.0018	0.0018	0.0017	0.0018	0.0019	0.0021	0.0022	0.0018	0.0017	0.0017	0.0017
Max.	0.0000	0.0019	0.0020	0.0020	0.0021	0.0021	0.0020	0.0021	0.0023	0.0024	0.0024	0.0022	0.0020	0.0020	0.0019

**Data Set 2 : 85 °C, 1140 mA**

Actual Case Temperature [T <sub>S</sub> ]	85.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.4 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 2-4 (Continued)**  
Chromaticity Shift

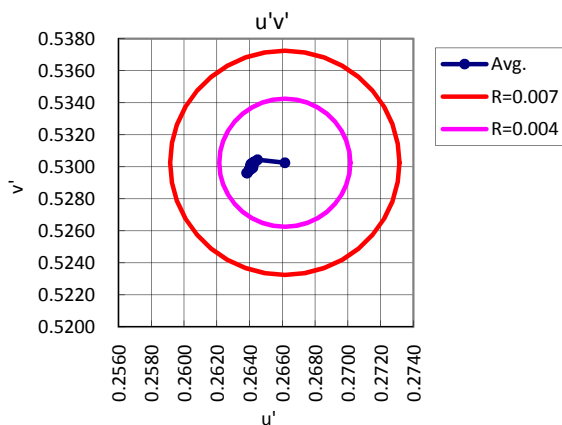
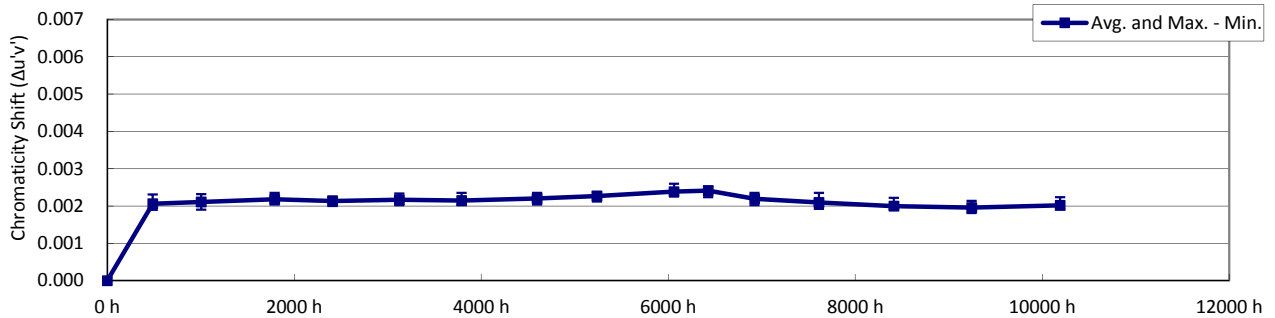
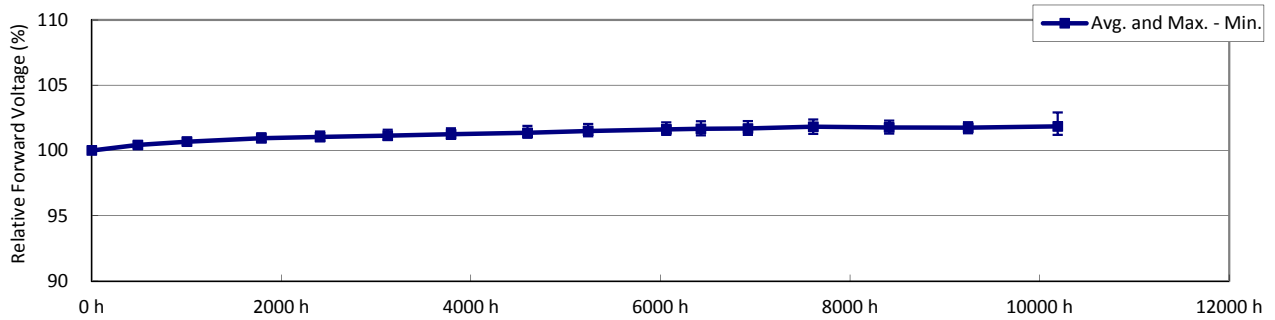
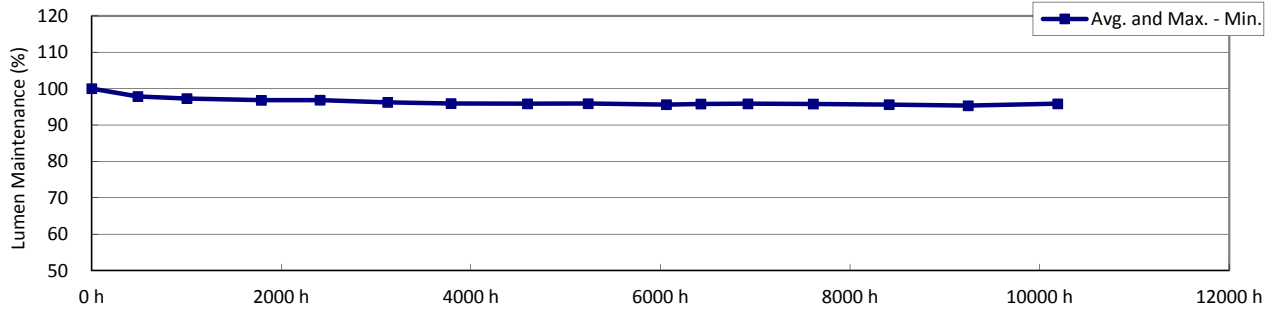
LED No.	Chromaticity Shift Δu'v'													
	10180 h													
1	0.0018													
2	0.0018													
3	0.0018													
4	0.0019													
5	0.0019													
6	0.0019													
7	0.0019													
8	0.0020													
9	0.0017													
10	0.0018													
n	10													
Avg.	0.0019													
Med.	0.0019													
σ	0.0001													
Min.	0.0017													
Max.	0.0020													

**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [ $T_S$ ]	86.2 °C
Actual Ambient Temperature [ $T_A$ ]	87.5 °C
Drive Current [ $I_F$ ]	1500 mA
Measurement Current	1500 mA

NOTES:

$T_S$  and  $T_A$  were measured during initial setup.



Data Set 3 : 85 °C, 1500 mA

Actual Case Temperature [T <sub>s</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 3-1**  
Initial Characteristics

LED No.	Luminous flux	Forward voltage	CCT	CIE1931		CIE1976						
	Φ <sub>V</sub> [lm]	V <sub>F</sub> [V]	T <sub>CP</sub> [K]	x	y	u'	v'					
1	5836	39.1	2611	0.469	0.415	0.266	0.531					
2	5775	38.9	2619	0.468	0.415	0.266	0.530					
3	5680	38.9	2601	0.470	0.416	0.267	0.531					
4	5664	38.8	2615	0.468	0.414	0.266	0.530					
5	5763	38.8	2621	0.468	0.414	0.266	0.530					
6	5812	38.9	2640	0.466	0.413	0.265	0.529					
7	5754	38.9	2630	0.467	0.414	0.266	0.530					
8	5604	38.8	2600	0.471	0.416	0.267	0.531					
9	5799	39.1	2624	0.467	0.414	0.266	0.530					
10	5726	38.9	2595	0.471	0.416	0.267	0.531					
n	10	10	10	10	10	10	10					
Avg.	5741	38.9	2616	0.469	0.415	0.266	0.530					
Med.	5759	38.9	2617	0.468	0.414	0.266	0.530					
σ	73.1	0.10	14.2	0.0017	0.0010	0.0006	0.0006					
Min.	5604	38.8	2595	0.466	0.413	0.265	0.529					
Max.	5836	39.1	2640	0.471	0.416	0.267	0.531					

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### Data Set 3 : 85 °C, 1500 mA

Actual Case Temperature [T <sub>s</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 3-2**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6062 h	6427 h	6923 h	7612 h	8413 h	9245 h
1	100.0	98.1	97.5	96.7	97.1	96.4	96.1	96.0	96.2	95.9	96.1	96.1	96.0	95.8	95.4
2	100.0	98.1	97.6	96.8	97.1	96.4	96.0	96.0	96.1	95.8	95.8	95.9	95.7	95.4	95.1
3	100.0	97.9	97.3	96.6	96.6	96.0	95.6	95.5	95.5	95.2	95.4	95.5	95.5	95.3	94.9
4	100.0	97.8	97.2	96.8	96.7	96.2	95.9	95.7	95.7	95.4	95.6	95.7	95.6	95.5	95.2
5	100.0	98.1	97.5	97.3	97.2	96.6	96.3	96.3	96.3	95.9	96.1	96.1	96.1	95.9	95.6
6	100.0	97.8	97.3	97.0	96.8	96.2	96.0	95.9	96.0	95.8	96.0	96.1	96.1	95.9	95.7
7	100.0	97.8	97.2	96.8	96.8	96.2	96.0	95.9	95.9	95.7	95.8	95.9	95.9	95.7	95.5
8	100.0	97.8	97.2	96.9	96.8	96.1	95.9	95.7	95.8	95.4	95.6	95.6	95.5	95.4	95.1
9	100.0	97.5	96.8	96.3	96.3	95.7	95.5	95.5	95.5	95.4	95.5	95.5	95.6	95.4	95.1
10	100.0	97.7	97.2	96.8	96.8	96.2	96.0	95.9	96.0	95.8	95.9	96.0	95.9	95.9	95.5
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	97.9	97.3	96.8	96.8	96.2	95.9	95.8	95.9	95.6	95.8	95.9	95.8	95.6	95.3
Med.	100.0	97.8	97.3	96.8	96.8	96.2	96.0	95.9	95.9	95.7	95.8	95.9	95.8	95.6	95.3
σ	0.00	0.18	0.22	0.24	0.29	0.25	0.22	0.25	0.27	0.26	0.24	0.24	0.24	0.25	0.25
Min.	100.0	97.5	96.8	96.3	96.3	95.7	95.5	95.5	95.5	95.2	95.4	95.5	95.5	95.3	94.9
Max.	100.0	98.1	97.6	97.3	97.2	96.6	96.3	96.3	96.3	95.9	96.1	96.1	96.1	95.9	95.7

### TM-21 Projection

Time	4597 h	5237 h	6062 h	6427 h	6923 h	7612 h	8413 h	9245 h	10191 h						
ln(Avg.)	-0.0424	-0.0420	-0.0447	-0.0432	-0.0424	-0.0430	-0.0448	-0.0480	-0.0424						

Test duration used	4597 h	to	10191 h
B	0.9603		
α	4.4094E-07		
R <sup>2</sup>	0.1814		
Calculated L <sub>70</sub> (10K)	717000	hours	
Reported L <sub>70</sub> (10K)	> 56100	hours	

Curve-fit equation:  

$$\Phi(t) = B \exp(-\alpha t)$$

Lumen maintenance life equation:  

$$L_{70} = \ln(B/0.7) / \alpha$$

**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

## NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.**TABLE 3-2 (Continued)**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	10191 h														
1	96.5														
2	96.2														
3	95.5														
4	95.6														
5	96.1														
6	96.0														
7	95.8														
8	95.4														
9	95.6														
10	96.0														
n	10														
Avg.	95.9														
Med.	95.9														
σ	0.34														
Min.	95.4														
Max.	96.5														



**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 3-3**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6062 h	6427 h	6923 h	7612 h	8413 h	9245 h
1	100.0	100.5	100.7	101.0	101.2	101.3	101.4	101.5	101.7	101.8	101.9	101.7	102.2	102.3	102.2
2	100.0	100.5	100.7	101.0	101.0	101.1	101.2	101.3	101.5	101.6	101.5	101.6	101.7	101.6	101.7
3	100.0	100.4	100.6	100.8	100.9	101.0	101.1	101.3	101.5	101.7	101.9	101.8	102.0	102.0	101.8
4	100.0	100.3	100.5	100.7	100.8	100.9	101.0	101.1	101.2	101.3	101.6	101.7	101.7	101.4	101.4
5	100.0	100.4	100.6	100.9	101.0	101.1	101.2	101.3	101.4	101.5	101.6	101.7	101.7	101.7	101.8
6	100.0	100.5	100.8	101.0	101.1	101.2	101.4	101.5	101.6	101.7	101.7	101.7	101.9	101.8	101.8
7	100.0	100.5	100.8	101.0	101.1	101.2	101.3	101.4	101.5	101.6	101.6	101.6	101.8	101.7	101.8
8	100.0	100.2	100.4	100.6	100.7	100.8	100.9	101.0	101.1	101.2	101.2	101.2	101.3	101.3	101.3
9	100.0	100.7	101.0	101.3	101.5	101.6	101.7	101.9	102.0	102.2	102.2	102.2	102.4	102.3	102.1
10	100.0	100.4	100.7	100.9	101.0	101.1	101.2	101.3	101.4	101.5	101.5	101.5	101.6	101.6	101.6
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	100.4	100.7	100.9	101.0	101.1	101.2	101.4	101.5	101.6	101.7	101.7	101.8	101.8	101.7
Med.	100.0	100.4	100.7	100.9	101.0	101.1	101.2	101.3	101.5	101.6	101.6	101.7	101.8	101.7	101.8
σ	0.00	0.13	0.16	0.19	0.21	0.22	0.23	0.25	0.26	0.27	0.28	0.26	0.32	0.34	0.27
Min.	100.0	100.2	100.4	100.6	100.7	100.8	100.9	101.0	101.1	101.2	101.2	101.2	101.3	101.3	101.3
Max.	100.0	100.7	101.0	101.3	101.5	101.6	101.7	101.9	102.0	102.2	102.2	102.2	102.4	102.3	102.2

**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [ $T_S$ ]	86.2 °C
Actual Ambient Temperature [ $T_A$ ]	87.5 °C
Drive Current [ $I_F$ ]	1500 mA
Measurement Current	1500 mA

**NOTES:**

$T_S$  and  $T_A$  were measured during initial setup.

**TABLE 3-3 (Continued)**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )													
	10191 h													
1	102.5													
2	101.6													
3	102.1													
4	102.0													
5	101.5													
6	102.9													
7	101.9													
8	101.4													
9	101.2													
10	101.4													
n	10													
Avg.	101.8													
Med.	101.7													
$\sigma$	0.54													
Min.	101.2													
Max.	102.9													

**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [T <sub>s</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 3-4**  
Chromaticity Shift

LED No.	Chromaticity Shift Δu'v'														
	0 h	486 h	1004 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6062 h	6427 h	6923 h	7612 h	8413 h	9245 h
1	0.0000	0.0019	0.0019	0.0020	0.0021	0.0020	0.0020	0.0021	0.0022	0.0023	0.0023	0.0020	0.0019	0.0019	0.0018
2	0.0000	0.0021	0.0022	0.0022	0.0022	0.0021	0.0023	0.0024	0.0023	0.0025	0.0025	0.0023	0.0022	0.0019	0.0020
3	0.0000	0.0021	0.0021	0.0021	0.0020	0.0021	0.0021	0.0021	0.0021	0.0023	0.0022	0.0021	0.0021	0.0019	0.0019
4	0.0000	0.0020	0.0020	0.0022	0.0021	0.0022	0.0022	0.0022	0.0023	0.0023	0.0025	0.0022	0.0020	0.0019	0.0020
5	0.0000	0.0020	0.0021	0.0021	0.0020	0.0021	0.0020	0.0021	0.0023	0.0023	0.0024	0.0022	0.0020	0.0019	0.0019
6	0.0000	0.0021	0.0021	0.0021	0.0022	0.0022	0.0023	0.0023	0.0024	0.0024	0.0025	0.0023	0.0022	0.0020	0.0019
7	0.0000	0.0022	0.0022	0.0023	0.0022	0.0022	0.0021	0.0023	0.0023	0.0025	0.0025	0.0023	0.0021	0.0020	0.0020
8	0.0000	0.0019	0.0020	0.0021	0.0020	0.0021	0.0020	0.0020	0.0022	0.0024	0.0024	0.0021	0.0019	0.0020	0.0019
9	0.0000	0.0023	0.0023	0.0024	0.0023	0.0023	0.0024	0.0024	0.0024	0.0026	0.0025	0.0024	0.0024	0.0022	0.0021
10	0.0000	0.0020	0.0021	0.0022	0.0021	0.0022	0.0020	0.0022	0.0023	0.0024	0.0024	0.0022	0.0021	0.0020	0.0019
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	0.0000	0.0021	0.0021	0.0022	0.0021	0.0022	0.0021	0.0022	0.0023	0.0024	0.0024	0.0022	0.0021	0.0020	0.0020
Med.	0.0000	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0022	0.0023	0.0024	0.0024	0.0022	0.0021	0.0020	0.0019
σ	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Min.	0.0000	0.0019	0.0019	0.0020	0.0020	0.0020	0.0020	0.0020	0.0021	0.0023	0.0022	0.0020	0.0019	0.0019	0.0018
Max.	0.0000	0.0023	0.0023	0.0024	0.0023	0.0023	0.0024	0.0024	0.0024	0.0026	0.0025	0.0024	0.0024	0.0022	0.0021

**Data Set 3 : 85 °C, 1500 mA**

Actual Case Temperature [T <sub>S</sub> ]	86.2 °C
Actual Ambient Temperature [T <sub>A</sub> ]	87.5 °C
Drive Current [I <sub>F</sub> ]	1500 mA
Measurement Current	1500 mA

NOTES:  
T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 3-4 (Continued)**  
Chromaticity Shift

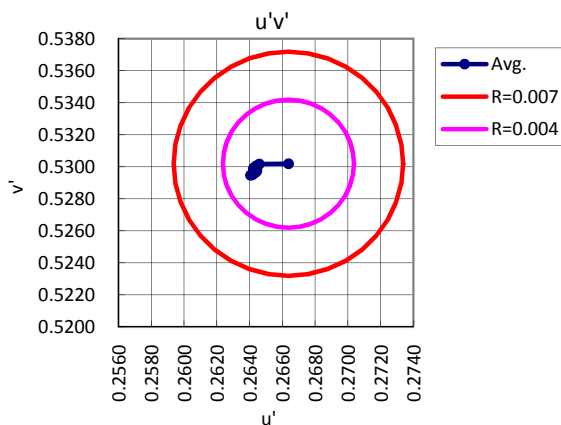
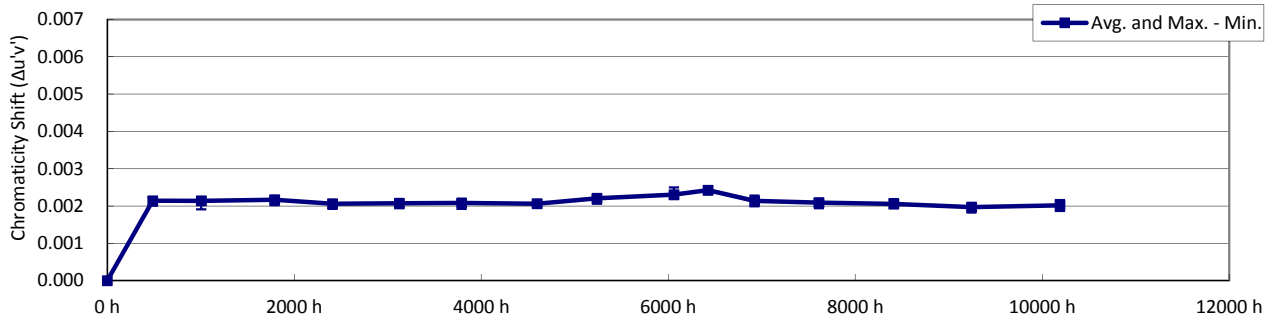
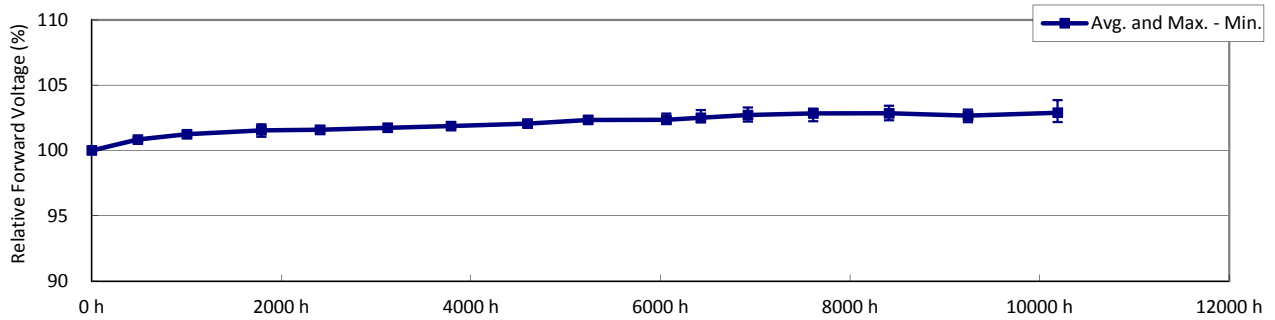
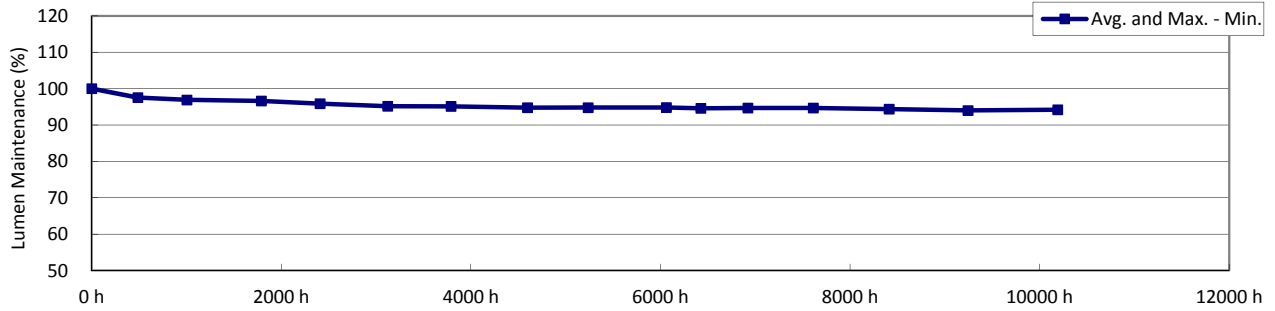
LED No.	Chromaticity Shift Δu'v'													
	10191 h													
1	0.0019													
2	0.0021													
3	0.0020													
4	0.0020													
5	0.0019													
6	0.0020													
7	0.0020													
8	0.0019													
9	0.0022													
10	0.0020													
n	10													
Avg.	0.0020													
Med.	0.0020													
σ	0.0001													
Min.	0.0019													
Max.	0.0022													

**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [ $T_S$ ]	106.6 °C
Actual Ambient Temperature [ $T_A$ ]	105.5 °C
Drive Current [ $I_F$ ]	1140 mA
Measurement Current	1140 mA

NOTES:

$T_S$  and  $T_A$  were measured during initial setup.





**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [T <sub>s</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-2**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6061 h	6426 h	6923 h	7612 h	8412 h	9244 h
1	100.0	97.7	97.2	97.0	96.2	95.2	95.4	94.7	94.9	95.0	94.7	94.9	94.8	94.4	93.9
2	100.0	97.6	97.1	96.8	96.0	95.0	95.1	94.6	94.7	94.8	94.5	94.6	94.6	94.2	93.7
3	100.0	97.4	96.6	96.3	95.5	94.8	94.7	94.4	94.3	94.3	94.2	94.2	94.2	94.0	93.5
4	100.0	97.6	97.0	96.8	96.0	95.4	95.4	95.1	95.1	95.1	95.0	95.0	95.1	94.8	94.5
5	100.0	97.6	97.0	96.5	96.0	95.3	95.3	95.0	95.1	95.1	94.9	95.0	95.0	94.7	94.4
6	100.0	97.5	96.8	96.5	95.8	95.3	95.2	94.9	95.0	95.0	94.8	94.9	94.9	94.7	94.3
7	100.0	97.6	97.0	96.8	96.1	95.4	95.3	95.0	95.0	95.0	94.9	94.9	95.0	94.7	94.3
8	100.0	97.3	96.5	96.1	95.3	94.6	94.5	94.1	94.1	94.1	93.8	93.8	93.8	93.5	93.1
9	100.0	97.5	96.9	96.7	95.9	95.3	95.3	95.0	95.0	95.1	94.6	94.7	94.8	94.5	94.2
10	100.0	97.6	97.0	96.7	95.9	95.2	95.1	94.8	94.8	94.8	94.5	94.6	94.6	94.4	94.0
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	97.5	96.9	96.6	95.9	95.2	95.1	94.8	94.8	94.8	94.6	94.7	94.7	94.4	94.0
Med.	100.0	97.6	97.0	96.7	96.0	95.3	95.3	94.8	94.9	95.0	94.7	94.8	94.8	94.5	94.1
σ	0.00	0.13	0.21	0.26	0.27	0.28	0.30	0.32	0.34	0.34	0.36	0.37	0.39	0.41	0.43
Min.	100.0	97.3	96.5	96.1	95.3	94.6	94.5	94.1	94.1	94.1	93.8	93.8	93.8	93.5	93.1
Max.	100.0	97.7	97.2	97.0	96.2	95.4	95.4	95.1	95.1	95.1	95.0	95.0	95.1	94.8	94.5

**TM-21 Projection**

Time	4597 h	5237 h	6061 h	6426 h	6923 h	7612 h	8412 h	9244 h	10190 h						
ln(Avg.)	-0.0538	-0.0535	-0.0531	-0.0556	-0.0547	-0.0547	-0.0578	-0.0619	-0.0596						

Test duration used	4597 h	to	10190 h
B	0.9553		
α	1.4324E-06		
R <sup>2</sup>	0.7562		
Calculated L <sub>70</sub> (10K)	217000	hours	
Reported L <sub>70</sub> (10K)	> 56000	hours	

Curve-fit equation:  

$$\Phi(t)=Bexp(-at)$$
Lumen maintenance life equation:  

$$L_{70}=\ln(B/0.7)/\alpha$$

**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [T <sub>S</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-2 (Continued)**  
Lumen Maintenance

LED No.	Lumen Maintenance % ( Normalized to 100 % at 0 hours )														
	10190 h														
1	94.3														
2	94.1														
3	93.7														
4	94.6														
5	94.6														
6	94.6														
7	94.6														
8	93.3														
9	94.4														
10	94.1														
n	10														
Avg.	94.2														
Med.	94.3														
σ	0.44														
Min.	93.3														
Max.	94.6														



**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [T <sub>s</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-3**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6061 h	6426 h	6923 h	7612 h	8412 h	9244 h
1	100.0	100.8	101.2	101.5	101.6	101.7	101.8	101.9	102.3	102.7	102.3	102.7	103.2	103.2	103.0
2	100.0	100.9	101.3	101.6	101.6	101.7	101.8	102.0	102.6	102.3	102.4	102.8	102.9	102.9	102.2
3	100.0	100.8	101.2	102.0	101.5	101.6	101.8	102.0	102.4	102.2	102.4	102.5	102.9	102.9	102.3
4	100.0	100.9	101.3	102.0	101.6	101.8	101.8	102.0	102.2	102.1	102.2	102.2	102.2	102.3	102.3
5	100.0	100.9	101.3	101.1	101.7	101.9	102.0	102.1	102.4	102.4	102.4	103.1	103.1	102.5	102.5
6	100.0	101.0	101.5	101.3	101.9	102.0	102.1	102.2	102.4	102.5	102.7	102.8	102.9	103.0	102.8
7	100.0	100.8	101.2	101.6	101.6	101.7	101.9	102.1	102.4	102.1	102.8	103.0	103.0	102.7	102.6
8	100.0	100.6	101.0	101.6	101.3	101.4	101.7	102.1	102.2	102.3	102.4	102.5	102.7	102.9	102.9
9	100.0	100.8	101.2	101.7	101.6	101.7	101.9	102.0	102.3	102.8	103.1	103.3	103.2	103.4	103.0
10	100.0	100.9	101.3	101.0	101.6	101.7	101.9	102.1	102.3	102.1	102.4	102.2	102.3	102.6	103.1
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	100.0	100.8	101.2	101.5	101.6	101.7	101.9	102.1	102.3	102.3	102.5	102.7	102.8	102.8	102.7
Med.	100.0	100.8	101.2	101.6	101.6	101.7	101.9	102.1	102.3	102.3	102.4	102.7	102.9	102.9	102.7
σ	0.00	0.10	0.13	0.32	0.16	0.15	0.12	0.09	0.14	0.25	0.27	0.35	0.35	0.33	0.35
Min.	100.0	100.6	101.0	101.0	101.3	101.4	101.7	101.9	102.2	102.1	102.2	102.2	102.2	102.3	102.2
Max.	100.0	101.0	101.5	102.0	101.9	102.0	102.1	102.2	102.6	102.8	103.1	103.3	103.2	103.4	103.1

**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [T <sub>s</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-3 (Continued)**  
Forward Voltage

LED No.	Relative Forward Voltage % ( Normalized to 100 % at 0 hours )														
	10190 h														
1	103.1														
2	103.9														
3	102.6														
4	103.2														
5	102.2														
6	103.0														
7	103.5														
8	102.6														
9	102.6														
10	102.3														
n	10														
Avg.	102.9														
Med.	102.8														
σ	0.53														
Min.	102.2														
Max.	103.9														

### Data Set 4 : 105 °C, 1140 mA

Actual Case Temperature [T <sub>s</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:

T<sub>s</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-4**  
Chromaticity Shift

LED No.	Chromaticity Shift Δu'v'														
	0 h	486 h	1005 h	1790 h	2409 h	3123 h	3790 h	4597 h	5237 h	6061 h	6426 h	6923 h	7612 h	8412 h	9244 h
1	0.0000	0.0020	0.0019	0.0020	0.0020	0.0020	0.0020	0.0020	0.0022	0.0022	0.0023	0.0020	0.0020	0.0020	0.0020
2	0.0000	0.0022	0.0022	0.0023	0.0022	0.0021	0.0022	0.0021	0.0023	0.0023	0.0025	0.0022	0.0022	0.0022	0.0021
3	0.0000	0.0020	0.0021	0.0020	0.0019	0.0020	0.0019	0.0020	0.0021	0.0022	0.0023	0.0021	0.0021	0.0020	0.0019
4	0.0000	0.0021	0.0022	0.0022	0.0020	0.0021	0.0021	0.0020	0.0022	0.0023	0.0025	0.0022	0.0021	0.0021	0.0019
5	0.0000	0.0021	0.0021	0.0023	0.0021	0.0022	0.0021	0.0021	0.0023	0.0023	0.0024	0.0022	0.0021	0.0021	0.0019
6	0.0000	0.0022	0.0022	0.0021	0.0021	0.0022	0.0022	0.0021	0.0023	0.0024	0.0024	0.0021	0.0022	0.0021	0.0020
7	0.0000	0.0022	0.0022	0.0022	0.0021	0.0022	0.0022	0.0022	0.0023	0.0023	0.0025	0.0023	0.0022	0.0022	0.0020
8	0.0000	0.0022	0.0022	0.0022	0.0021	0.0021	0.0020	0.0020	0.0022	0.0023	0.0024	0.0021	0.0021	0.0020	0.0019
9	0.0000	0.0022	0.0021	0.0022	0.0020	0.0021	0.0021	0.0022	0.0023	0.0025	0.0025	0.0022	0.0022	0.0021	0.0020
10	0.0000	0.0020	0.0020	0.0020	0.0019	0.0019	0.0019	0.0020	0.0021	0.0022	0.0024	0.0021	0.0019	0.0019	0.0018
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Avg.	0.0000	0.0021	0.0021	0.0022	0.0021	0.0021	0.0021	0.0021	0.0022	0.0023	0.0024	0.0021	0.0021	0.0021	0.0020
Med.	0.0000	0.0022	0.0022	0.0022	0.0021	0.0021	0.0021	0.0021	0.0022	0.0023	0.0024	0.0021	0.0021	0.0021	0.0020
σ	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Min.	0.0000	0.0020	0.0019	0.0020	0.0019	0.0019	0.0019	0.0020	0.0021	0.0022	0.0023	0.0020	0.0019	0.0019	0.0018
Max.	0.0000	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0022	0.0023	0.0025	0.0025	0.0023	0.0022	0.0022	0.0021

**Data Set 4 : 105 °C, 1140 mA**

Actual Case Temperature [T <sub>S</sub> ]	106.6 °C
Actual Ambient Temperature [T <sub>A</sub> ]	105.5 °C
Drive Current [I <sub>F</sub> ]	1140 mA
Measurement Current	1140 mA

NOTES:  
T<sub>S</sub> and T<sub>A</sub> were measured during initial setup.

**TABLE 4-4 (Continued)**  
Chromaticity Shift

LED No.	Chromaticity Shift Δu'v'												
	10190 h												
1	0.0021												
2	0.0021												
3	0.0020												
4	0.0020												
5	0.0020												
6	0.0021												
7	0.0022												
8	0.0019												
9	0.0021												
10	0.0019												
n	10												
Avg.	0.0020												
Med.	0.0021												
σ	0.0001												
Min.	0.0019												
Max.	0.0022												