

## LM-79-08 TEST REPORT

for

### GREEN CREATIVE LTD

Room 3603, Level 36, Tower 1, Enterprise Square Five, 38 Wang Chiu Road, Kowloon Bay, KL,  
Hong Kong

### LED Tube

**Model: 12T8/3F/830/UEB**

#### Laboratory: Leading Testing Laboratories

**NVLAP CODE: 200960-0**

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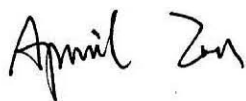
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Report No.: HZ23030039p

The laboratory that conducted the testing detailed in this report has been accredited for SSL by NVLAP.

Review by:



Engineer: April Zou  
Apr. 06, 2023

Approved by:



Manager: Jim Zhang  
Apr. 06, 2023

Government.

## TEST SUMMARY

Sample Tested: 12T8/3F/830/UEB

Luminous Efficacy (Lumens /Watt)	Total Luminous Flux (Lumens)	Power (Watts)	Power Factor
122.0	1480.2	12.13	0.9806
CCT (K)	CRI	Stabilization Time (Light & Power)	
3087	82.1	60	

Table 1: Executive Data Summary

Note: The above results are recorded/ derived from measurements made using an Integrating Sphere.

### Test specifications:

<b>Date of Receipt</b>	: Nov. 09, 2020
<b>Date of Test</b>	: Nov. 13, 2020
<b>Test item</b>	: Total Luminous Flux, Luminous Distribution Intensity, Luminous Efficacy, Correlated Color Temperature, Color Rendering Index, Chromaticity Coordinate, Electrical parameters
<b>Reference Standard</b>	: IESNA LM-79-2008 Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products ANSI/IES TM-30-18 IES Method for Evaluating Light Source Color Rendition

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## SAMPLE PHOTO



Figure 1- Overview of the sample

### Equipment Under Test(EUT)

<b>Name</b>	: LED Tube
<b>Model</b>	: 12T8/3F/830/UEB
<b>Electrical Ratings</b>	: 120-277V, 50/60Hz, 12W
<b>Product Description</b>	: 3000K

## TEST RESULTS

Test ambient temperature was 24.9 °C.

Base orientation was horizontal. Test was conducted without a dimmer in the circuit.

The stabilization time of the sample was 60 minutes, and the total operating time including stabilization was 65 minutes.

### Sphere-Spectroradiometer Method

Parameter	Result	
Test Voltage (V)	120.0	277.0
Voltage frequency (Hz)	60	60
Test Current (A)	0.103	0.048
Power Factor	0.9806	0.9224
Test Power (W)	12.13	12.13
THD A%	17.79	18.20
Luminous Efficacy (lm/W)	122.0	120.9
Total Luminous Flux (lm)	1480.2	1466.7
Color Rendering Index (CRI)	82.1	
R9	5.4	
Correlated Color Temperature (CCT)(K)	3087	
Chromaticity Chroma x	0.4298	
Chromaticity Chroma y	0.3998	
Chromaticity Chroma u	0.2478	
Chromaticity Chroma v	0.3457	
Duv	-0.0007	
Chromaticity Chroma u'	0.2478	
Chromaticity Chroma v'	0.5186	

Special Color Rendering Indices	
R1	80.5
R2	90.8
R3	96
R4	79.6
R5	80.7
R6	88.4
R7	82.4
R8	58.5
R9	5.4
R10	78.9
R11	78.6
R12	69.5
R13	83
R14	98.5

Table 2: Test data per Sphere-Spectroradiometer Method

Note: According to CIE 1976 (u',v') diagram,  $u' = u = 4x/(-2x+12y+3)$ ,  $v' = 3v/2 = 9y/(-2x+12y+3)$ .

### Goniophotometer Method

Test ambient temperature was 24.8 °C.

The photometric distance is 30 m.

Luminous data was taken at 0.5 vertical intervals and 10 horizontal intervals.

Parameter	Result
Test Voltage (V)	120.0
Voltage frequency (Hz)	60
Test Current (A)	0.103
Power Factor	0.9809
Power (W)	12.15
Luminous Efficacy (lm/W)	120.1
Total Luminous Flux (lm)	1459.4
Beam Angle ( ° )	108.7 (0°-180°) / 202.4 (90°-270°)
Center Beam Candle Power (cd)	265
Maximum Beam Candle Power (cd)	264.8 (At: C=190.0, Gamma=1.0)
Spacing Criteria	1.24 (0°-180°) / 1.40 (90°-270°)
Zonal Lumens in the 0 °-60 °Zone	45.01%
Zonal Lumens in the 60 °-90 °Zone	26.49%
Zonal Lumens in the 90 °-120 °Zone	16.58%
Zonal Lumens in the 120 °-180 °Zone	11.92%

Table 3: Test data per Goniophotometer Method

## Spectral Power Distribution - Sphere Spectroradiometer Method

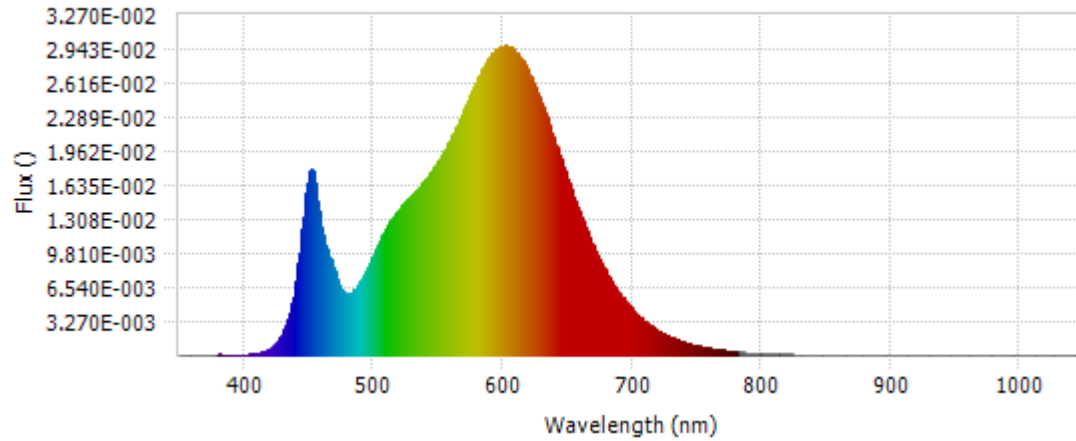
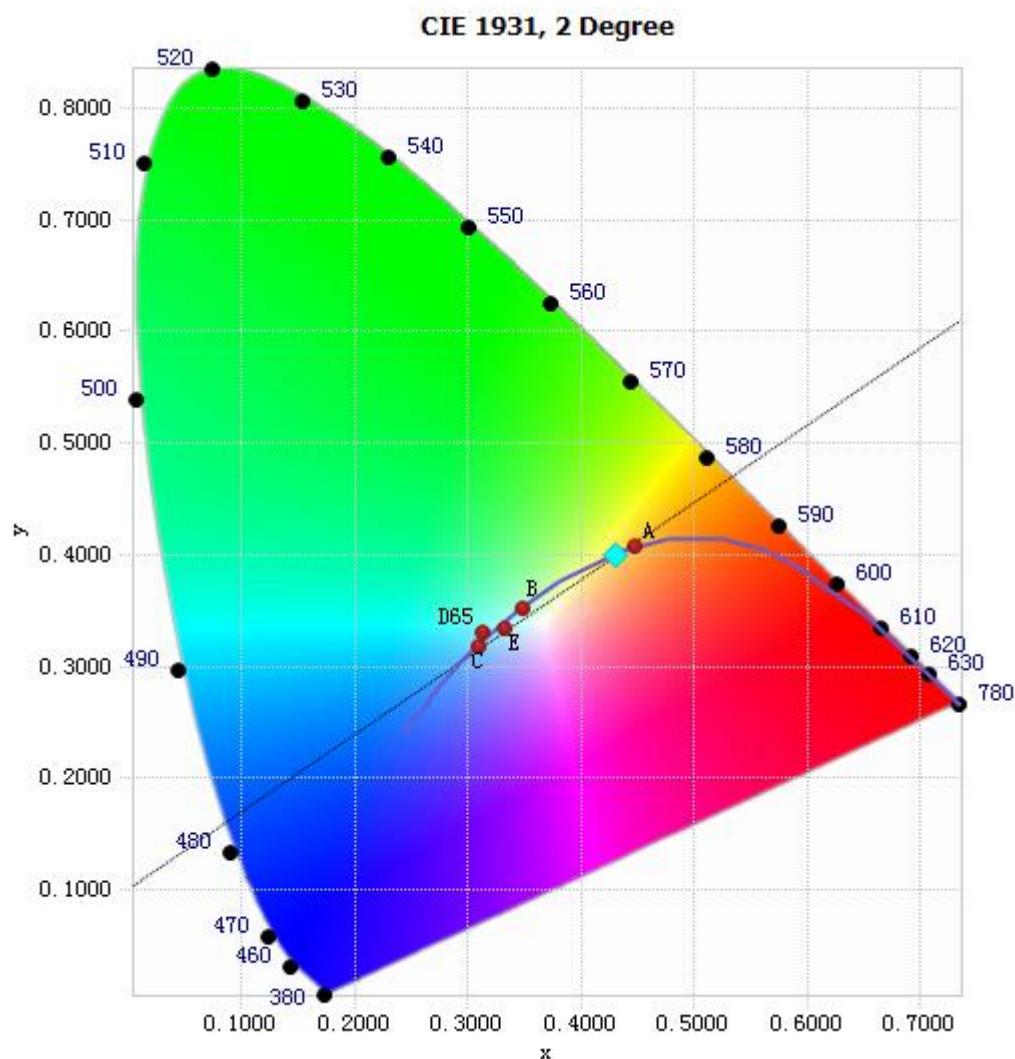


Chart 1: Spectral Power Distribution

Spectral Distribution over Visible Wavelength							
WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)
380	1.03E-04	485	6.26E-03	590	2.87E-02	695	5.18E-03
385	9.58E-05	490	7.04E-03	595	2.94E-02	700	4.46E-03
390	9.54E-05	495	8.28E-03	600	2.96E-02	705	3.83E-03
395	9.57E-05	500	9.70E-03	605	2.96E-02	710	3.27E-03
400	9.15E-05	505	1.10E-02	610	2.91E-02	715	2.81E-03
405	1.20E-04	510	1.22E-02	615	2.84E-02	720	2.41E-03
410	1.81E-04	515	1.33E-02	620	2.72E-02	725	2.07E-03
415	3.49E-04	520	1.41E-02	625	2.58E-02	730	1.77E-03
420	6.52E-04	525	1.48E-02	630	2.42E-02	735	1.50E-03
425	1.19E-03	530	1.55E-02	635	2.25E-02	740	1.29E-03
430	2.20E-03	535	1.61E-02	640	2.07E-02	745	1.10E-03
435	4.00E-03	540	1.69E-02	645	1.89E-02	750	9.42E-04
440	7.04E-03	545	1.77E-02	650	1.70E-02	755	8.08E-04
445	1.21E-02	550	1.86E-02	655	1.52E-02	760	6.93E-04
450	1.72E-02	555	1.97E-02	660	1.35E-02	765	5.93E-04
455	1.66E-02	560	2.08E-02	665	1.20E-02	770	5.10E-04
460	1.22E-02	565	2.22E-02	670	1.05E-02	775	4.34E-04
465	9.86E-03	570	2.36E-02	675	9.20E-03	780	3.74E-04
470	8.06E-03	575	2.50E-02	680	8.02E-03		
475	6.40E-03	580	2.64E-02	685	6.95E-03		
480	5.91E-03	585	2.77E-02	690	6.01E-03		

Table 4: Spectral Power Distribution Numerical Data per Sphere - Spectroradiometer Method

# Chromaticity Diagram - Sphere Spectroradiometer Method



Tristimulus values(x, y): (0.4298, 0.3998)

Chart 2: Chromaticity Diagram per Sphere - Spectroradiometer Method

Note: The location on the diagram of the tristimulus coordinates are indicated by the blue diamond.



# Nominal CCT Quadrangles – Sphere Spectroradiometer Method

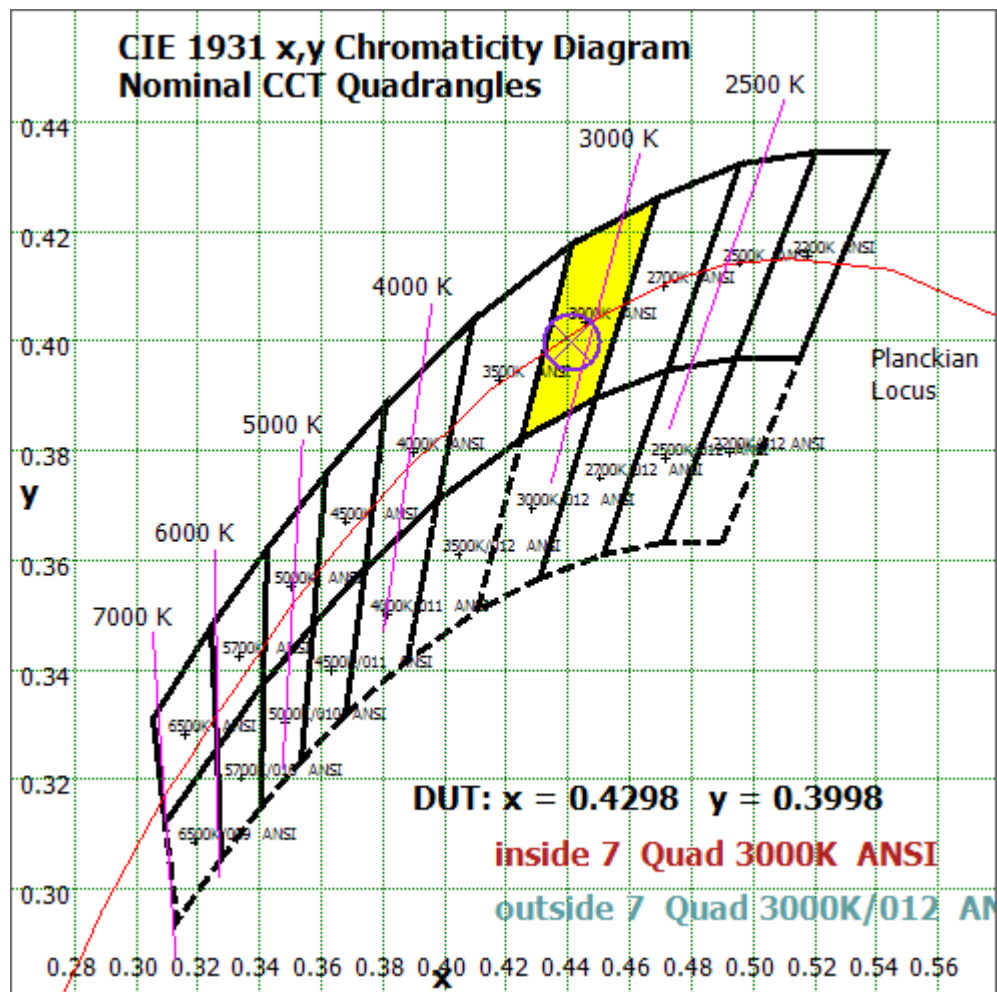


Chart 3: Plot of Lamp x/y coordinates on CIE 1931 Chromaticity Diagram

# Color Rendition Report – Sphere Spectroradiometer Method

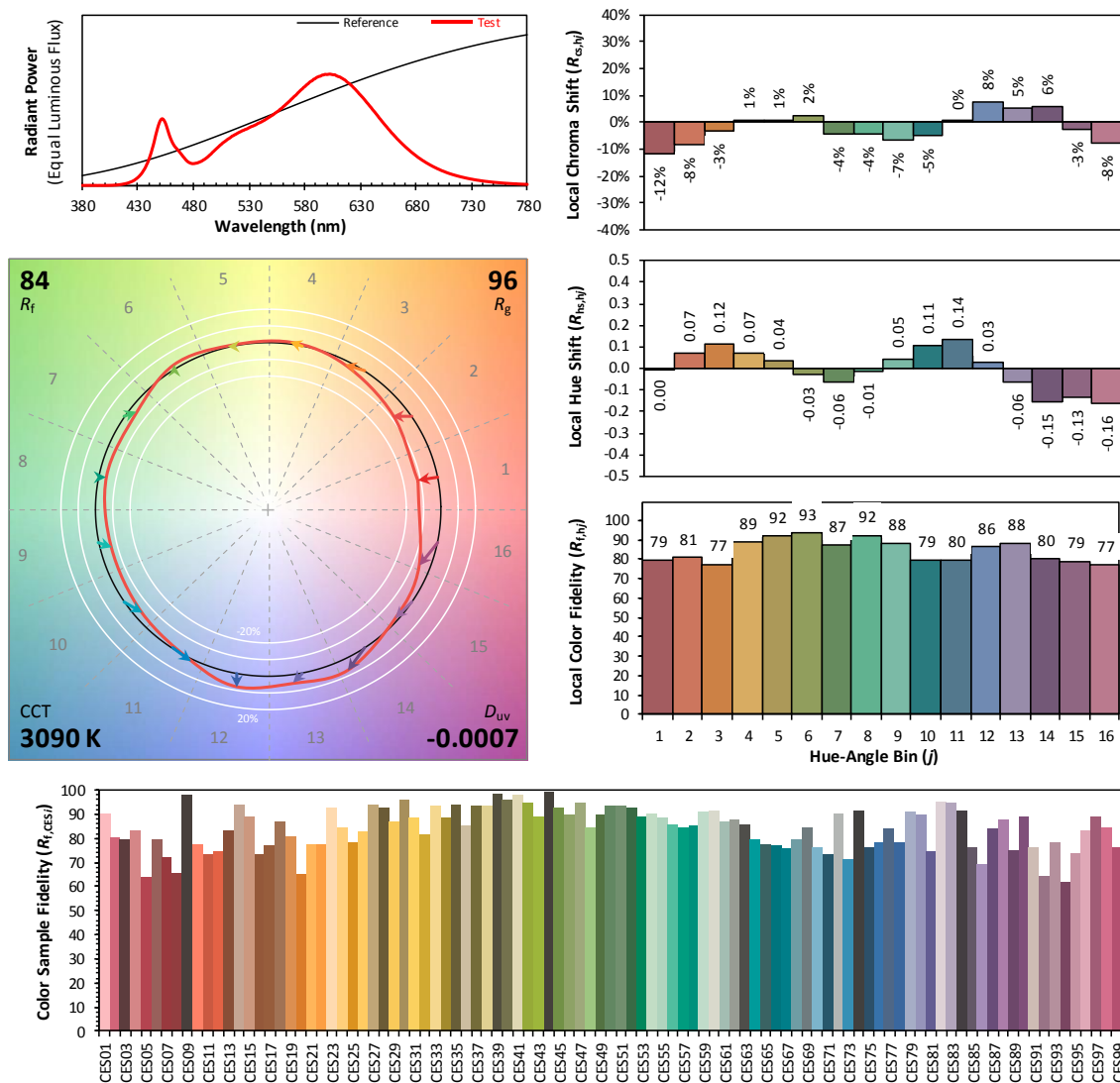
## ANSI/IES TM-30-18 Color Rendition Report

Source: LED

Manufacturer: GREEN CREATIVE LTD

Date: 2020/11/13

Model: 12T8/3F/830/UEB



**Notes:** This is a recommended method for displaying ANSI/IES TM-30-18 information.

$x$  0.4298  
 $y$  0.3998  
 $u'$  0.2478  
 $v'$  0.5186

CIE 13.3-1995  
(CRI)  
 $R_a$  82  
 $R_g$  6

Colors are for visual orientation purposes only. Created with the ANSI/IES TM-30-18 Calculator Version 2.00.

Chart 4: Full Report Created with the IES TM-30 Calculator

Note: The values in this diagram might be a little different from the values in Table 2 due to rounding.

### Zonal Lumen Tabulation- Goniophotometer Method

$\gamma(^{\circ})$	Lumens	% Total
0- 10	25.084	1.72%
10- 20	72.389	4.96%
20- 30	111.665	7.65%
30- 40	139.239	9.54%
40- 50	153.51	10.52%
50- 60	154.999	10.62%
60- 70	145.774	9.99%
70- 80	129.524	8.88%
80- 90	111.252	7.62%
90-100	95.249	6.53%
100-110	80.229	5.50%
110-120	66.544	4.56%
120-130	54.54	3.74%
130-140	44.109	3.02%
140-150	34.071	2.33%
150-160	23.983	1.64%
160-170	13.36	0.92%
170-180	3.853	0.26%
Total	1459.4	100%

$\gamma(^{\circ})$	Lumens	% Total
0- 60	656.886	45.01%
60- 90	386.55	26.49%
0-90	1043.436	71.50%
90- 180	415.938	28.50%
0- 180	1459.4	100%

Table 5: Zonal Lumen

## Illuminance Plots- Goniophotometer Method

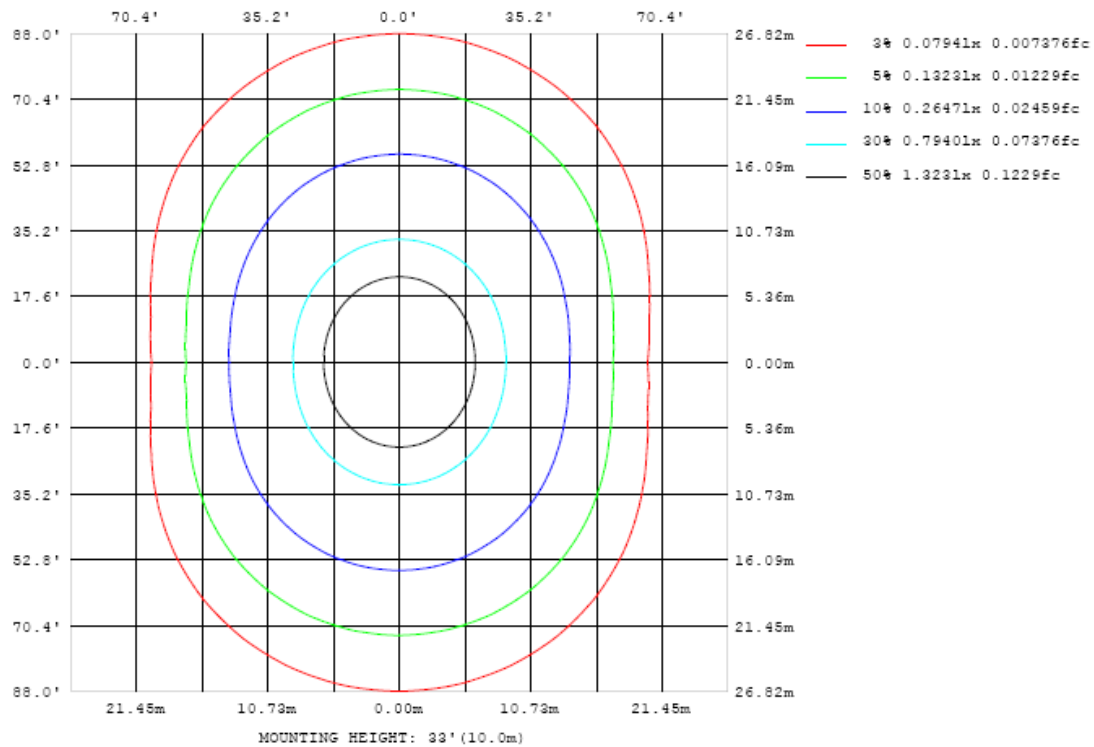


Chart 5: Illuminance Plot (Footcandles)

## Luminous Intensity Distribution Plots- Goniophotometer Method

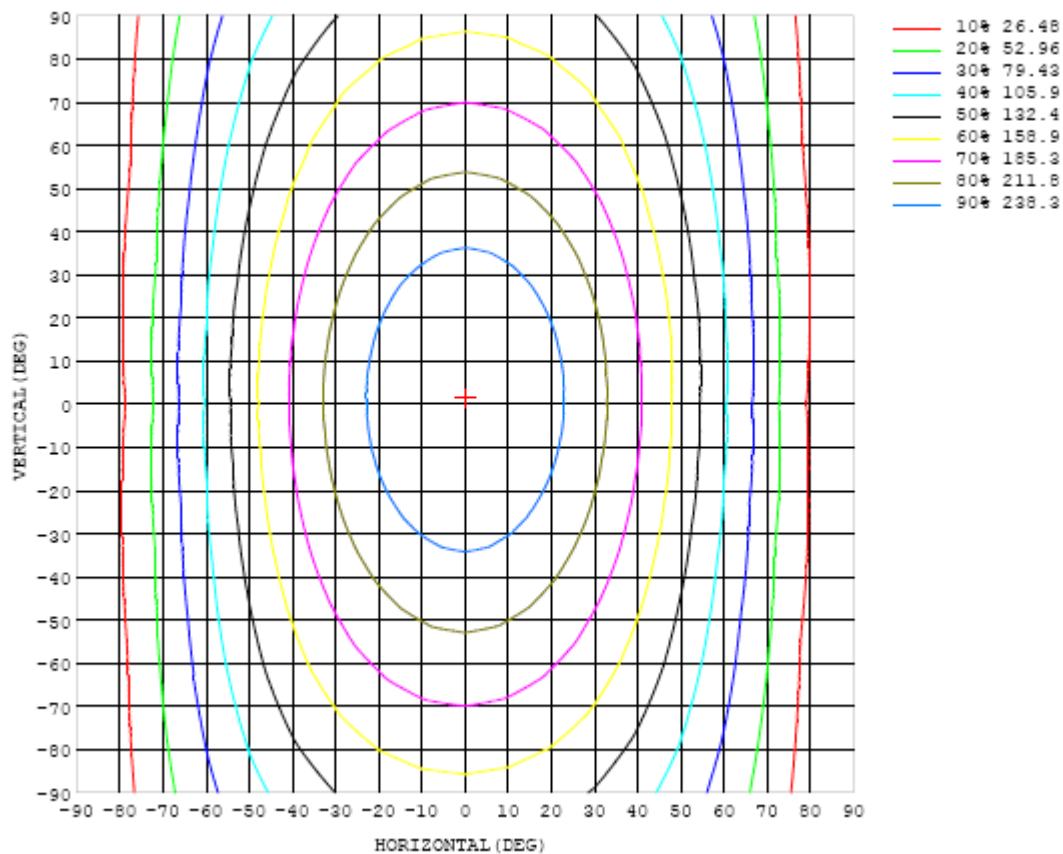


Chart 6: Isocandela Plot

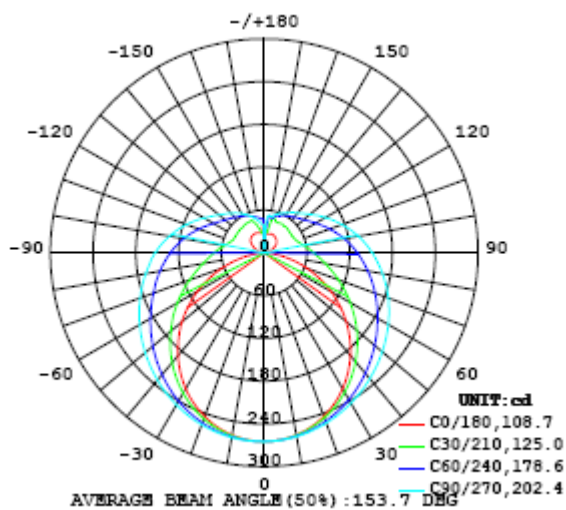


Chart 7: Polar Candela Distribution

## Luminous Intensity Data- Goniophotometer Method

Table--1

UNIT: cd

C (DEG) y (DEG)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
0	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265
5	263	263	263	263	263	263	264	264	264	264	264	264	264	264	264	263	263	263	263
10	259	260	260	260	260	260	261	261	262	262	262	261	261	261	260	260	260	260	260
15	253	253	254	254	255	256	257	258	258	258	258	258	257	256	255	254	254	253	253
20	244	245	245	246	248	250	252	253	254	254	254	253	252	250	248	247	245	244	244
25	233	234	235	237	240	242	245	247	249	249	249	247	245	243	240	237	235	234	233
30	220	221	222	226	230	234	238	241	243	243	243	241	238	234	230	226	223	221	220
35	205	206	209	213	219	224	229	233	236	237	236	234	230	225	219	214	209	206	205
40	188	189	193	199	207	214	221	226	229	231	229	226	221	215	207	200	194	189	188
45	170	172	177	185	194	203	212	218	222	223	222	218	212	204	195	186	177	171	170
50	150	152	159	170	181	193	202	210	214	216	215	210	203	193	182	171	160	152	151
55	129	132	141	154	169	182	193	201	207	209	207	202	194	183	170	155	142	132	130
60	108	112	123	139	156	171	184	193	199	201	199	194	185	172	157	141	124	112	108
65	86.0	91.2	106	125	144	161	175	185	191	193	192	186	176	162	146	126	107	91.2	85.4
70	64.3	70.9	88.8	111	132	151	165	176	183	185	183	177	167	153	134	113	90.3	70.8	63.0
75	42.9	51.8	73.2	98.3	121	141	157	167	175	177	175	169	158	143	124	101	75.4	52.5	41.3
80	23.1	34.5	60.3	87.1	111	132	148	159	166	169	167	160	149	134	114	90.0	63.3	36.1	22.1
85	7.73	21.5	49.5	77.3	102	123	139	151	157	160	158	152	141	125	105	80.6	52.8	24.0	7.00
90	0.64	14.1	41.6	69.7	94.1	115	131	142	149	152	150	143	133	117	97.2	72.8	45.3	17.2	0.60
95	1.55	11.1	36.1	63.0	86.6	107	122	134	141	143	141	135	124	109	89.8	66.7	40.0	14.3	1.73
100	3.75	11.4	32.3	57.0	79.5	98.7	114	125	132	134	132	126	116	102	82.8	60.8	36.1	14.4	4.17
105	6.67	13.5	30.6	52.2	73.0	91.2	106	116	123	125	124	118	108	93.9	76.3	56.0	34.2	16.6	7.42
110	9.98	16.6	30.5	49.0	67.9	84.2	97.9	108	114	116	115	109	99.9	86.8	70.9	52.4	34.0	19.7	10.9
115	13.3	19.7	31.5	46.9	63.3	77.8	90.4	99.6	105	107	106	101	92.3	80.4	66.2	50.2	35.1	23.3	14.5
120	17.0	23.0	33.2	46.0	59.8	72.2	83.5	91.9	97.2	99.1	97.8	93.1	85.3	74.6	62.5	49.0	36.7	26.1	18.3
125	20.3	24.9	35.3	45.9	57.3	68.3	77.4	84.7	89.5	91.3	90.1	85.9	78.9	70.5	59.9	48.9	38.8	29.1	21.8
130	22.9	28.8	37.0	46.2	55.7	64.8	72.3	78.6	82.6	84.1	83.2	79.7	74.1	67.0	58.2	49.2	40.8	31.2	25.0
135	24.6	32.6	38.5	46.9	54.6	62.2	68.7	73.4	76.7	78.0	77.3	74.3	70.1	63.9	56.9	49.6	42.3	35.1	27.0
140	25.9	35.9	40.2	47.4	53.9	59.9	65.4	69.7	71.9	72.8	72.2	70.4	66.6	61.6	55.9	50.1	44.1	36.9	28.4
145	26.9	37.4	40.1	46.9	53.4	58.1	62.5	65.8	68.1	68.9	68.5	66.6	63.5	59.6	55.1	50.6	44.0	39.7	29.2
150	27.6	38.4	42.0	47.7	51.5	56.8	60.0	62.6	64.2	64.9	64.6	63.1	60.8	57.9	54.5	49.8	44.7	41.8	29.8
155	28.3	40.8	46.4	46.6	51.8	54.0	57.5	59.8	61.0	61.5	61.2	60.2	58.6	56.5	54.1	49.6	46.2	43.2	30.1
160	28.3	37.9	46.8	47.6	49.5	53.1	55.2	56.4	57.3	58.0	58.0	57.5	56.5	55.1	51.1	48.5	46.3	42.3	29.8
165	27.7	32.5	36.9	50.3	49.8	49.6	51.7	53.5	54.5	55.0	55.2	54.7	54.0	51.0	46.4	41.9	37.9	35.5	29.0
170	27.1	27.5	28.6	34.8	47.4	51.8	52.1	51.8	51.7	51.8	52.2	52.5	47.2	40.3	36.7	34.0	31.3	30.1	28.4
175	32.2	31.6	30.4	30.3	34.0	33.7	36.5	44.4	48.0	49.7	40.8	28.9	28.1	32.2	31.5	33.7	31.7	32.3	32.6
180	3.65	3.65	3.65	3.65	3.64	3.63	3.62	3.61	3.60	3.59	3.59	3.60	3.61	3.62	3.62	3.63	3.63	3.64	3.64

Table 6: Luminous Intensity Data



Table--2

UNIT: cd

C (DEG) y (DEG)	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350		
0	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265	265		
5	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	263		
10	260	260	261	261	262	262	263	263	263	263	262	262	262	261	261	260	260		
15	254	254	255	256	257	259	260	260	260	260	260	259	258	256	255	254	253		
20	245	246	248	250	252	254	255	256	257	256	255	254	252	250	248	246	245		
25	234	236	238	241	245	248	250	251	252	251	250	248	245	242	239	236	234		
30	221	224	227	232	236	240	243	246	246	246	243	240	236	232	228	224	221		
35	207	210	215	221	226	232	236	239	240	239	236	232	227	221	215	210	207		
40	190	194	201	208	216	223	228	232	233	232	228	223	217	209	202	195	190		
45	172	178	186	196	205	214	220	224	226	224	220	214	206	197	187	179	173		
50	154	161	171	183	194	204	211	216	218	216	212	205	195	184	172	162	154		
55	134	143	156	169	183	194	203	208	210	208	203	195	184	171	157	144	135		
60	113	125	141	157	172	184	194	200	202	200	194	185	173	159	142	126	114		
65	91.5	106	126	145	161	175	185	191	194	192	186	176	162	146	128	109	93.2		
70	70.6	89.2	111	133	151	165	176	183	185	183	177	167	153	135	114	91.6	72.8		
75	51.1	73.4	98.5	122	142	157	168	175	177	175	168	158	143	124	101	76.1	53.6		
80	34.2	60.0	87.2	112	132	148	160	166	169	167	160	150	134	114	89.7	62.7	36.8		
85	21.7	49.7	77.9	103	124	140	152	159	161	159	153	141	125	105	80.2	52.1	24.0		
90	15.0	42.4	70.2	95.0	116	132	143	150	153	151	144	133	117	96.9	72.4	44.6	16.8		
95	11.7	36.7	63.4	87.4	108	123	135	142	144	142	136	125	109	89.4	65.7	39.0	13.4		
100	12.2	32.7	57.2	80.0	99.4	115	126	133	135	133	127	116	101	82.1	59.5	34.7	13.4		
105	14.8	30.8	52.1	73.2	91.4	106	117	123	126	124	118	108	93.3	75.3	54.2	32.6	15.6		
110	18.3	31.4	48.7	67.1	84.0	97.7	108	114	116	114	109	99.1	85.8	69.1	50.5	32.2	18.9		
115	22.0	32.9	46.9	62.5	77.1	89.6	98.8	105	107	105	99.8	91.0	78.7	64.1	48.1	32.9	22.4		
120	25.5	34.7	46.7	59.0	71.7	82.5	90.4	95.7	97.7	96.2	91.3	83.5	73.1	60.4	47.1	34.9	25.9		
125	28.4	36.6	46.7	57.4	67.3	76.5	83.5	88.0	89.6	88.4	84.3	77.6	68.6	58.1	46.8	37.2	28.9		
130	31.6	38.6	46.9	55.9	64.6	71.9	77.3	81.3	82.8	81.7	78.2	72.8	65.5	56.4	47.2	39.5	32.4		
135	34.1	40.6	47.3	54.8	62.0	68.1	73.0	76.1	77.4	76.5	73.6	69.0	62.7	55.3	48.0	41.8	35.1		
140	35.9	41.9	47.0	53.9	59.8	64.9	68.8	71.6	72.5	71.7	69.3	65.4	60.3	54.6	49.0	43.9	37.6		
145	38.5	43.1	47.9	51.6	57.9	62.0	65.2	67.3	68.0	67.4	65.6	62.2	58.1	53.9	50.1	46.0	40.2		
150	39.8	44.9	48.2	51.3	55.8	59.5	61.9	63.1	63.5	63.0	62.0	58.9	55.8	53.3	51.2	48.1	42.7		
155	41.1	46.3	48.6	50.6	52.3	57.1	58.7	59.0	59.0	58.6	58.4	55.6	53.6	52.6	52.3	50.2	45.2		
160	36.4	45.4	47.5	49.4	52.6	54.8	55.5	54.8	54.5	54.2	54.8	52.4	51.3	52.0	53.4	52.3	47.7		
165	31.5	36.6	40.8	42.5	52.7	52.5	52.3	50.7	49.9	49.8	51.2	49.1	49.1	51.3	54.5	54.5	50.2		
170	28.6	30.4	32.3	34.8	52.9	50.2	49.1	46.6	45.4	45.4	47.6	45.8	46.8	50.7	55.6	56.6	52.7		
175	32.5	26.9	27.0	27.2	53.0	47.9	45.9	42.4	40.9	41.0	44.0	42.6	44.6	50.1	56.7	58.7	55.2		
180	3.64	3.63	3.63	3.62	3.62	3.61	3.60	3.59	3.59	3.60	3.61	3.62	3.63	3.64	3.65	3.65	3.65		

Table 7: Luminous Intensity Data

## EQUIPMENT LIST

Test Equipment	Model	Equipment No.	Calibration Date	Calibration Due date
Goniophotometer system	GO-R5000	HZTE011-01	Aug. 05, 2020	Aug. 04, 2021
Digital Power Meter	PF2010A	HZTE028-01	Aug. 05, 2020	Aug. 04, 2021
AC Power Supply	DPS1060	HZTE001-06	Aug. 05, 2020	Aug. 04, 2021
DC Power Supply	WY12010	HZTE004-03	Aug. 05, 2020	Aug. 04, 2021
Temperature recorder	JM624U	HZTE018-08	Aug. 05, 2020	Aug. 04, 2021
Temperature and humidity recorder	JR900	HZTE018-01	Aug. 05, 2020	Aug. 04, 2021
Standard source	D908	HZTE012-01	Aug. 05, 2020	Aug. 04, 2021
Integrate Sphere system	3M	HZTE015-04	Aug. 05, 2020	Aug. 04, 2021
Digital Power Meter	WT210	HZTE008-01	Aug. 05, 2020	Aug. 04, 2021
AC Power Supply	PCR 500L	HZTE001-07	Aug. 05, 2020	Aug. 04, 2021
DC Power Supply	IT6154	HZTE004-04	Aug. 05, 2020	Aug. 04, 2021
Standard source	SCL-1400	HZTE012-02	Aug. 05, 2020	Aug. 04, 2021
Temperature and humidity recorder	JR900	HZTE018-02	Aug. 05, 2020	Aug. 04, 2021
Temperature Meter	TES1310	HZTE017-01	Aug. 05, 2020	Aug. 04, 2021

Table 8: Test Equipment List

## TEST METHODS

### Seasoning of SSL Product

For the purpose of rating new SSL products, SSL products shall be tested with no seasoning. Therefore, no seasoning was performed.

### Sphere-Spectroradiometer Method- Photometric and Electrical Measurements

A Labsphere Model CDS 2100 Spectroradiometer and Two Meter Sphere was used to measure correlated color temperature, chromaticity coordinates, and the color rendering index for each SSL unit. The coating reflectance of each sphere is 98%. The measure geometry is  $4\pi$ . Self-absorption correction is conducted in testing. Bandwidth of spectroradiometer is 350nm-1050nm.

Ambient temperature was measured at a position inside the sphere. Each SSL unit was operated on the client provided driver at the rated input voltage in its designated orientation.

The stabilization time typically ranges from 30 min (small integrated LED lamps) to 2 or more hours for large SSL luminaires). It can be judged that stability is reached when the variation (maximum – minimum) of at least 3 readings of the light output and electrical power over a period of 30 min, taken 15 minutes apart, is less than 0.5 %.

Electrical measurements including voltage, current, and power were measured using the Yokogawa Power Analyzer.

The standard reference of the integrated sphere system is halogen incandescent lamp, the intensity distribution type is omni-directional, and is traceable to the National Institute of Standards and Technology.



The uncertainty of integrating sphere system reported in this document is expanded uncertainty is 2.1% with a coverage factor  $k=2$ .

## **Goniophotometer Method**

### **Photometric and Electrical Measurements**

An EVERFINE Type C Model GO-R5000 Goniophotometer was used to measure the intensity at each angle of distribution for each sample. The photometric distance is 2.475m for near-field measurement or 30m for far-field measurement. Bandwidth of spectroradiometer is 380nm-780nm.

Ambient temperature was measured at the same height of the sample mounted on the Goniophotometer equipment. Each SSL unit was operated on the client provided driver at the rated input voltage in its designated orientation.

The stabilization time typically ranges from 30 min (small integrated LED lamps) to 2 or more hours for large SSL luminaires). It can be judged that stability is reached when the variation (maximum – minimum) of at least 3 readings of the light output and electrical power over a period of 30 min, taken 15 minutes apart, is less than 0.5 %.

Electrical measurements including voltage, current, and power were measured using the Everfine Digital Power Meter.

Some graphics were created with Photometric Plus software.

The standard reference of the Goniophotometer system is halogen incandescent lamp, the intensity distribution type is omni-directional, and is traceable to the National Institute of Metrology P.R. China.

The uncertainty of goniophotometer system reported in this document is expanded uncertainty is 2.3% with a coverage factor  $k=2$ .

### **Color Characteristics Measurements**

The color characteristics of SSL products include chromaticity coordinates, correlated color temperature, and color rendering index. These characteristics of SSL products may be spatially non-uniform, and thus, in order that they can be specified accurately, the color quantities shall be measured as values that are spatially average, weighted to intensity, over the angular range where light is intentionally emitted from the SSL product. The color characteristics measurements are using gonio-spectroradiometer.

### **Color Spatial Uniformity**

The characteristics of SSL products may be spatially non-uniform, the chromaticity coordinate shall be measured at two vertical planes ( $C=0^\circ/180^\circ$  and  $C=90^\circ/270^\circ$ ) and at  $10^\circ$  or less intervals for vertical angle until the light output dropped to below 10% of the peak intensity. The averaged weighted chromaticity coordinate

was calculated from these points. The data was then analyzed to check for delta color differences of the  $u'$ ,  $v'$  chromaticity coordinates. The spatial non-uniformity of chromaticity,  $\Delta u'v'$ , is determined as the maximum deviation (distance on the CIE ( $u'$ ,  $v'$ ) diagram) among all measured points from the spatially averaged chromaticity coordinate.

The geometry for the chromaticity measurement using gonio-spectroradiometer is shown as following.



\*\*\* End of Report \*\*\*

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