



LM-79-08 Test Report

for

Revolution Lighting Technologies, Inc.

2280 Ward Ave. Simi Valley, CA 93065

LED Tube

Model: 202100-115

Laboratory: Leading Testing Laboratories

NVLAP CODE: 200960-0

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Report No.: HZ18110016ap

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

Review by:

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Nov. 30, 2018

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Nov. 30, 2018

Note: This report does not imply product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

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TEST RESULTS

Test ambient temperature was 25.1 °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
Voltage frequency (Hz)	60	60
Test Current (A)	0.079	0.038
Power Factor	0.9846	0.9194
Test Power (W)	9.31	9.67
THD A%	14.91	28.33
Luminous Efficacy (lm/W)	137.3	131.6
Total Luminous Flux (lm)	1278.0	1273.0
Color Rendering Index (CRI)	82.1	
R9	2.2	
Correlated Color Temperature (CCT)(K)	4926	
Chromaticity Chroma x	0.3481	
Chromaticity Chroma y	0.3629	
Chromaticity Chroma u	0.2091	
Chromaticity Chroma v	0.3270	
Duv	0.0043	
Chromaticity Chroma u'	0.2091	
Chromaticity Chroma v'	0.4905	

Special Color Rendering Indices	
R1	79.5
R2	87.7
R3	93.8
R4	80.6
R5	79.8
R6	82.7
R7	87.4
R8	65.4
R9	2.2
R10	71
R11	79.4
R12	56.1
R13	81.7
R14	96.8

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 25.0 °C.

The photometric distance is 2.47 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)	0.079
Power Factor	0.9848
Power (W)	9.34
Luminous Efficacy (lm/W)	135.0
Total Luminous Flux (lm)	1260.5
Beam Angle (°)	102.9 (0°-180°) /129.6(90°-270°)
Center Beam Candle Power (cd)	359
Maximum Beam Candle Power (cd)	359.1 (At: C=40.0, Gamma=1.0)
Spacing Criteria	1.19 (0°-180°) /1.31 (90°-270°)
Zonal Lumens in the 0 °-60 °Zone	64.63%
Zonal Lumens in the 60 °-90 °Zone	25.54%
Zonal Lumens in the 90 °-120 °Zone	7.56%
Zonal Lumens in the 120 °-180 °Zone	2.27%

Table 3: Test data per Goniophotometer Method

Spectral Power Distribution - Sphere Spectroradiometer Method

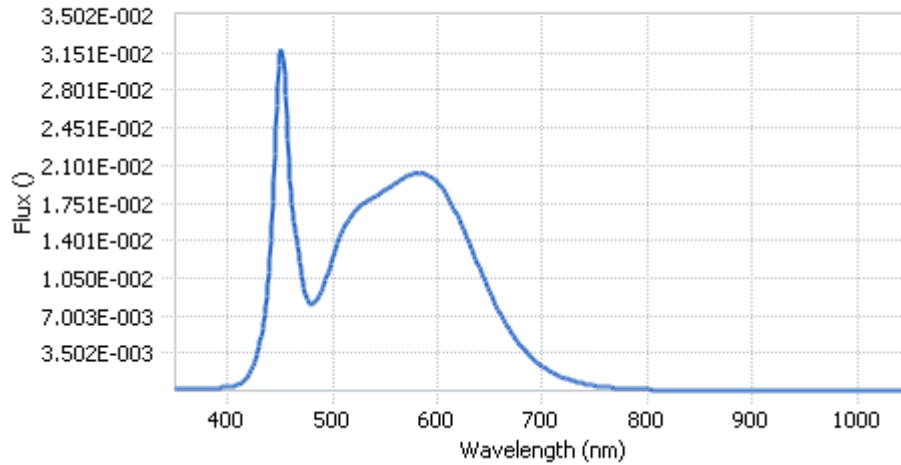
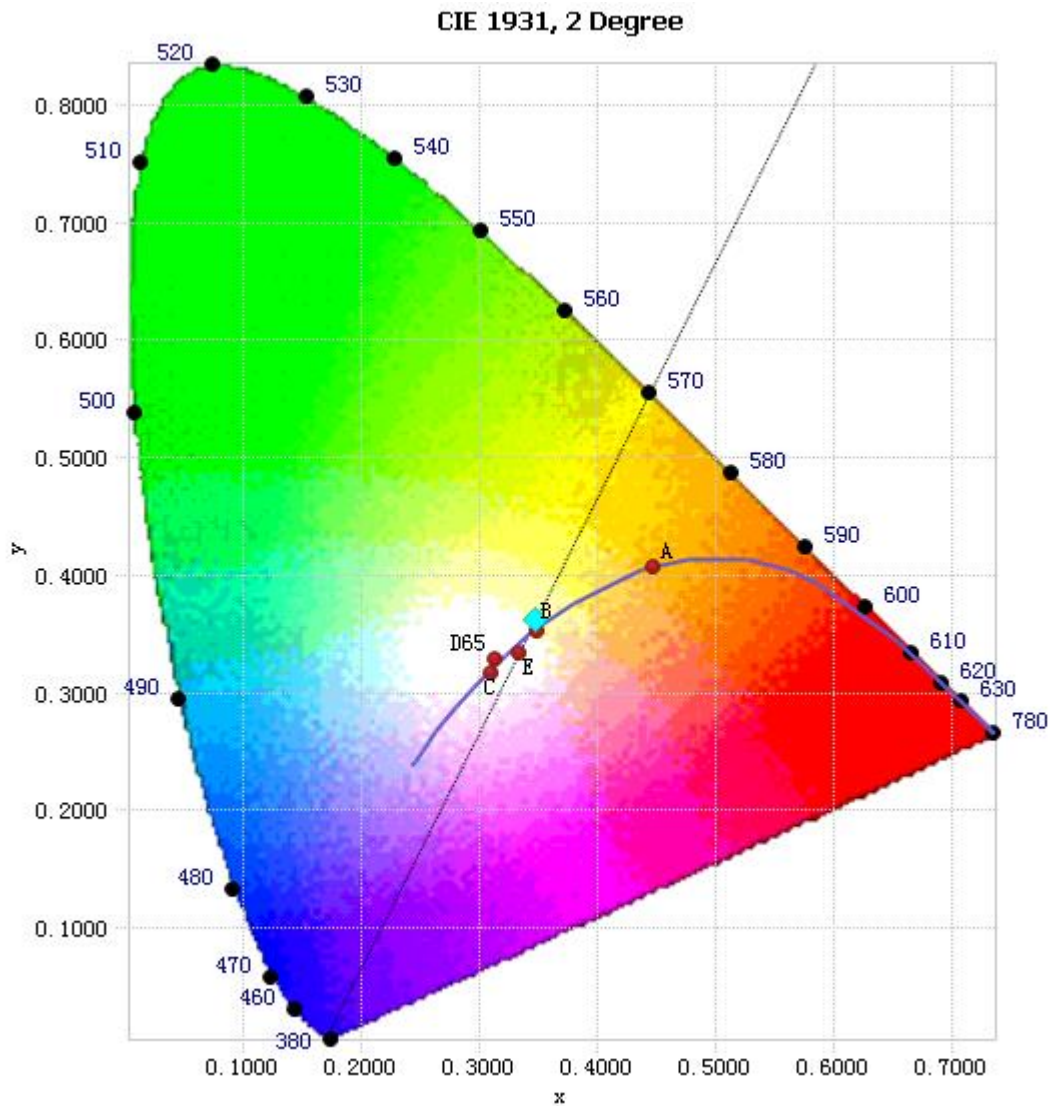


Chart 1: Spectral Power Distribution

Spectral Distribution over Visible Wavelength							
WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)	WL(nm)	Radiant(Watts)
380	2.55E-04	485	8.51E-03	590	2.01E-02	695	2.64E-03
385	2.56E-04	490	9.38E-03	595	1.99E-02	700	2.27E-03
390	2.74E-04	495	1.09E-02	600	1.94E-02	705	1.94E-03
395	3.09E-04	500	1.25E-02	605	1.88E-02	710	1.66E-03
400	3.43E-04	505	1.38E-02	610	1.81E-02	715	1.42E-03
405	4.29E-04	510	1.51E-02	615	1.71E-02	720	1.22E-03
410	5.92E-04	515	1.60E-02	620	1.61E-02	725	1.05E-03
415	9.06E-04	520	1.66E-02	625	1.50E-02	730	8.95E-04
420	1.45E-03	525	1.71E-02	630	1.38E-02	735	7.62E-04
425	2.45E-03	530	1.75E-02	635	1.26E-02	740	6.51E-04
430	4.14E-03	535	1.78E-02	640	1.14E-02	745	5.64E-04
435	7.11E-03	540	1.81E-02	645	1.03E-02	750	4.81E-04
440	1.24E-02	545	1.84E-02	650	9.16E-03	755	4.15E-04
445	2.20E-02	550	1.87E-02	655	8.14E-03	760	3.58E-04
450	3.15E-02	555	1.90E-02	660	7.16E-03	765	3.09E-04
455	2.75E-02	560	1.93E-02	665	6.28E-03	770	2.64E-04
460	1.85E-02	565	1.96E-02	670	5.47E-03	775	2.29E-04
465	1.47E-02	570	2.00E-02	675	4.77E-03	780	1.99E-04
470	1.14E-02	575	2.01E-02	680	4.13E-03		
475	8.66E-03	580	2.03E-02	685	3.57E-03		
480	8.07E-03	585	2.03E-02	690	3.07E-03		

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

Chromaticity Diagram - Sphere Spectroradiometer Method



Tristimulus values(x, y): (0.3481, 0.3629)

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

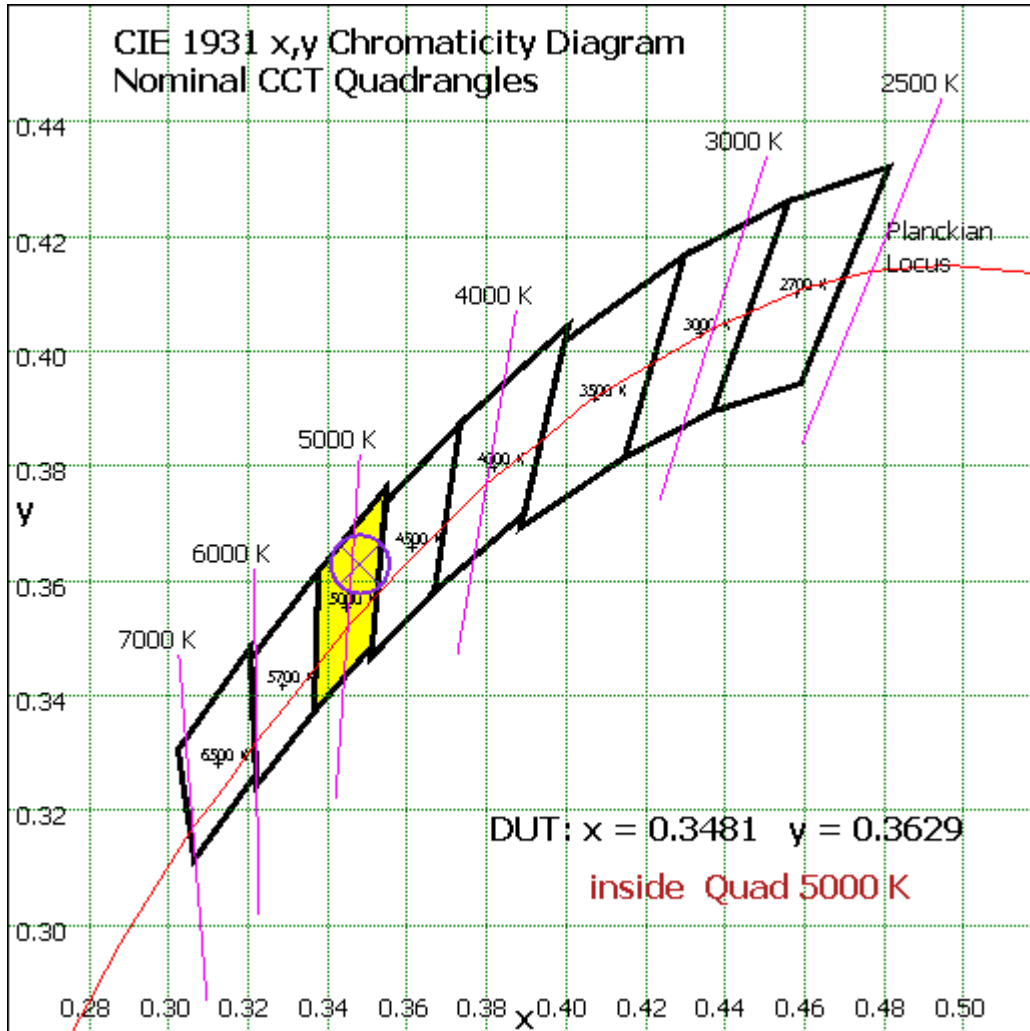


Chart 3: Plot of Lamp x/y coordinates on CIE 1931 Chromaticity Diagram

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

Zonal Lumen Tabulation- Goniophotometer Method

$\gamma(^{\circ})$	Lumens	% Total
0- 10	33.955	2.69%
10- 20	97.193	7.71%
20- 30	147.224	11.68%
30- 40	177.735	14.10%
40- 50	185.82	14.74%
50- 60	172.722	13.70%
60- 70	143.688	11.40%
70- 80	106.727	8.47%
80- 90	71.567	5.68%
90-100	46.621	3.70%
100-110	30.13	2.39%
110-120	18.546	1.47%
120-130	11.691	0.93%
130-140	7.508	0.60%
140-150	4.729	0.38%
150-160	2.846	0.23%
160-170	1.473	0.12%
170-180	0.347	0.03%
Total	1260.5	100%

$\gamma(^{\circ})$	Lumens	% Total
0- 60	814.649	64.63%
60- 90	321.982	25.54%
0-90	1136.631	90.17%
90- 180	123.891	9.83%
0- 180	1260.5	100%

Table 5: Zonal Lumen Data

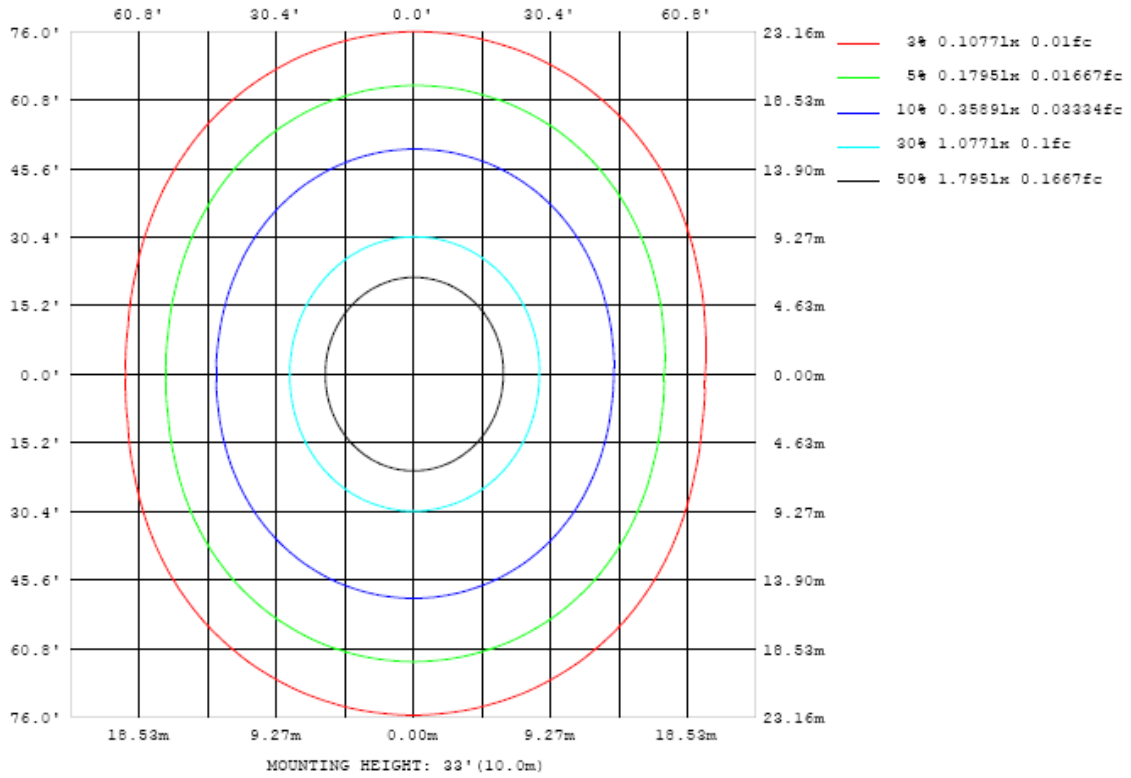


Chart 4: Beam Angle

Luminous Intensity Distribution Plots- Goniophotometer Method

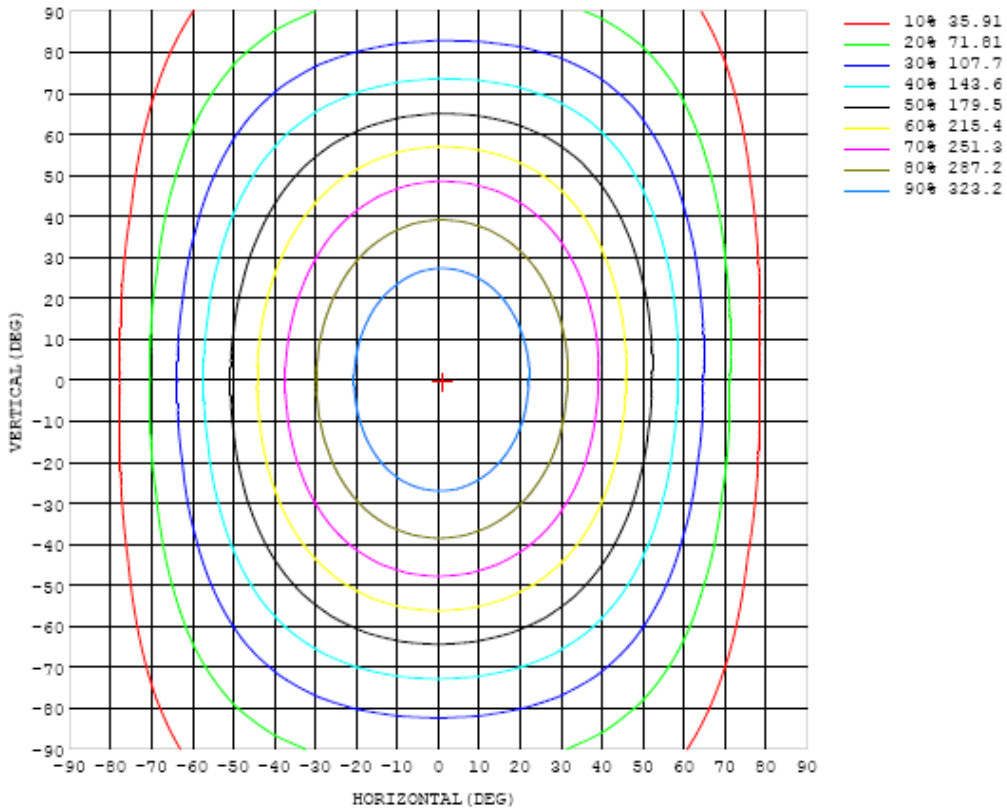


Chart 5: Illuminance Plot (Footcandles)

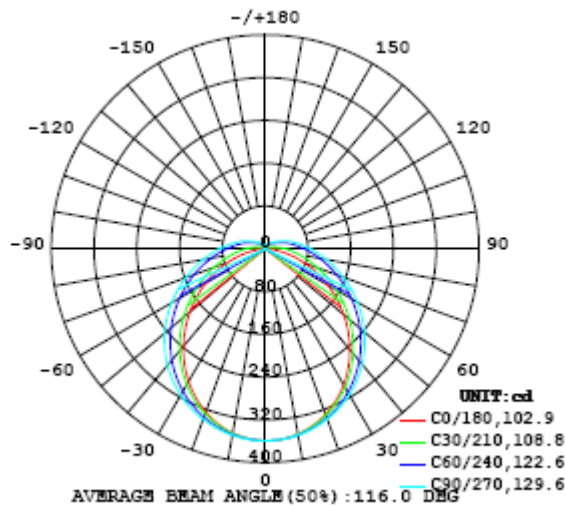


Chart 6: Polar Candela Distribution

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	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359
5	358	357	357	358	358	358	358	358	358	358	358	358	357	357	357	357	357	356	356
10	352	352	352	352	353	353	354	354	354	354	354	353	353	352	351	351	350	350	350
15	342	342	343	344	345	346	347	347	348	348	348	347	345	344	343	341	340	340	340
20	330	329	331	332	333	335	337	338	339	339	339	337	336	333	331	328	327	325	325
25	313	313	315	317	319	322	325	327	328	328	327	326	323	320	316	312	310	308	307
30	294	294	296	299	302	306	310	313	314	315	314	312	308	304	299	294	290	287	287
35	271	272	275	278	283	288	293	296	299	299	298	295	291	285	279	273	268	264	263
40	246	247	251	256	262	268	274	278	281	282	281	277	272	265	257	250	244	239	238
45	220	221	225	231	239	247	253	258	262	263	262	258	251	243	234	226	218	213	211
50	192	193	198	206	215	224	231	237	241	242	241	237	230	221	211	201	192	186	184
55	163	164	171	180	190	200	209	215	220	221	219	215	207	198	187	176	165	158	156
60	134	136	143	154	166	177	186	193	197	199	197	193	185	175	163	151	139	131	129
65	106	108	117	129	142	154	164	171	175	177	176	171	163	153	140	127	114	104	101
70	78.2	81.0	91.4	105	119	132	142	150	154	156	154	149	142	132	119	105	90.6	78.6	74.1
75	52.3	56.4	68.3	83.7	98.7	112	122	129	134	135	134	129	122	112	99.2	84.6	69.2	55.6	48.5
80	28.4	33.7	48.8	65.1	80.3	93.5	104	111	115	116	115	111	104	94.2	81.8	67.1	51.2	35.3	25.8
85	9.77	16.4	32.6	49.6	64.7	77.4	87.3	94.0	97.8	99.2	98.0	94.4	87.7	78.7	66.7	52.6	36.3	19.8	8.18
90	0.86	6.50	21.0	37.1	51.7	63.7	73.1	79.5	83.1	84.4	83.3	79.9	73.9	65.3	54.3	40.5	25.2	10.2	0.60
95	0.33	2.53	13.4	27.6	41.0	52.5	61.5	67.0	70.5	71.8	70.7	67.6	62.4	54.5	43.8	31.1	17.4	4.69	0.38
100	0.45	1.58	8.20	19.8	32.2	42.9	51.2	56.9	60.2	61.4	60.6	57.6	52.4	44.9	35.2	23.4	11.3	3.29	0.48
105	0.59	1.52	5.95	14.2	24.2	34.2	42.1	47.7	50.9	52.1	51.4	48.6	43.6	36.5	27.2	17.2	8.49	2.59	0.72
110	0.84	1.68	4.63	10.9	18.6	26.3	33.4	38.7	42.0	43.3	42.7	39.9	35.2	28.4	21.2	13.5	6.93	2.65	1.01
115	1.11	1.93	4.14	8.98	14.9	21.1	26.5	30.6	33.4	34.7	34.0	31.6	28.0	23.0	17.2	11.2	5.75	2.74	1.33
120	1.41	2.15	3.89	7.34	12.4	17.3	21.8	25.2	27.3	28.2	27.9	26.1	23.1	19.1	14.3	9.56	5.21	2.85	1.66
125	1.73	2.38	3.77	6.29	10.5	14.5	18.1	20.9	22.8	23.5	23.1	21.7	19.3	16.1	12.2	7.99	4.93	3.07	2.00
130	2.07	2.70	3.87	5.80	8.48	12.3	15.3	17.6	19.1	19.7	19.4	18.2	16.1	13.5	10.5	7.13	4.58	3.15	2.26
135	2.44	3.03	3.95	5.37	7.63	9.96	12.9	14.8	16.0	16.6	16.3	15.4	13.7	11.6	9.21	6.55	4.36	3.27	2.52
140	2.76	3.24	4.06	5.17	6.88	8.77	10.4	12.1	13.4	13.9	13.7	13.0	11.7	10.1	8.23	6.09	4.37	3.48	2.85
145	3.05	3.52	4.17	4.95	6.15	7.75	9.05	10.1	10.8	11.1	11.3	11.0	10.1	8.81	7.35	5.69	4.42	3.77	3.09
150	3.18	3.44	4.36	4.99	5.84	6.83	7.84	8.64	9.21	9.65	9.78	9.39	8.69	7.67	6.47	5.45	4.52	3.94	3.19
155	3.33	3.56	4.67	5.11	5.63	6.25	6.89	7.56	8.05	8.37	8.35	8.06	7.55	6.66	5.90	5.25	4.67	4.14	3.23
160	3.39	3.77	4.71	5.10	5.47	5.92	6.35	6.74	7.10	7.24	7.19	6.97	6.54	5.99	5.53	5.08	4.79	4.32	3.26
165	3.14	3.54	4.61	5.12	5.36	5.61	5.84	6.04	6.21	6.29	6.25	6.07	5.80	5.48	5.23	5.05	4.73	4.24	3.22
170	2.81	2.82	3.31	4.16	5.00	5.32	5.42	5.52	5.57	5.61	5.57	5.45	5.33	5.18	4.75	4.18	3.80	3.44	3.09
175	2.63	2.65	2.67	2.68	2.73	3.18	3.99	4.70	5.04	5.07	5.00	3.99	3.20	2.97	2.92	2.90	2.88	2.89	2.87
180	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

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	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359		
5	357	357	357	357	357	357	357	358	358	358	358	358	358	358	358	358	358		
10	350	350	351	351	352	353	353	354	354	354	354	354	353	353	353	352	352		
15	340	340	341	343	344	345	346	348	348	348	348	347	346	345	344	343	343		
20	325	327	328	330	333	335	337	339	340	340	339	338	336	334	333	331	330		
25	308	310	312	315	319	323	325	328	329	329	328	326	324	321	318	316	315		
30	287	290	293	298	303	308	311	315	316	316	314	312	308	305	301	298	295		
35	264	267	272	278	284	291	296	299	301	301	299	296	291	286	281	277	274		
40	239	243	249	256	264	272	278	282	284	284	282	277	272	266	259	253	249		
45	213	217	224	233	243	251	258	263	266	265	263	258	251	243	235	228	223		
50	185	191	199	209	220	230	237	243	246	245	242	237	229	220	210	202	195		
55	158	164	174	185	197	207	216	222	224	224	220	215	206	196	185	175	167		
60	131	138	149	161	174	185	193	200	202	202	198	192	183	172	160	148	140		
65	103	112	125	138	151	162	171	177	180	179	176	170	160	149	136	122	112		
70	77.3	87.9	102	117	130	142	150	156	158	158	154	148	139	127	112	97.7	85.6		
75	52.9	65.6	81.1	96.4	110	121	130	135	138	137	134	128	118	106	90.6	74.9	60.7		
80	31.5	46.5	62.9	78.4	91.8	103	111	116	118	118	115	109	99.3	86.7	71.7	55.1	38.9		
85	15.5	31.1	47.8	63.0	76.0	86.3	93.7	98.5	101	100	97.2	91.4	82.5	70.4	55.6	38.9	21.9		
90	6.07	20.2	35.8	50.1	62.4	72.0	79.0	83.3	85.2	84.7	82.1	76.6	68.2	56.7	42.5	26.6	10.8		
95	2.55	12.9	26.6	39.9	51.2	60.1	66.5	70.5	72.2	71.7	69.1	64.0	56.1	45.4	32.4	18.1	5.23		
100	1.63	8.11	19.6	31.5	41.8	50.0	55.9	59.6	61.2	60.7	58.2	53.4	46.0	36.2	24.4	11.9	3.04		
105	1.54	6.03	14.1	24.1	33.8	41.4	46.9	50.3	51.7	51.3	48.9	44.4	37.5	28.3	17.8	8.34	2.26		
110	1.81	5.05	11.0	18.5	26.1	33.3	38.6	41.9	43.2	42.8	40.5	36.0	29.3	21.4	13.2	6.42	2.15		
115	2.10	4.59	9.10	15.0	21.1	26.2	30.5	33.6	34.9	34.4	32.1	28.1	23.0	17.0	10.7	5.28	2.31		
120	2.39	4.38	7.86	12.4	17.3	21.7	25.1	27.3	28.1	27.7	26.0	23.0	18.8	13.8	8.92	4.77	2.41		
125	2.70	4.32	7.05	10.6	14.5	18.1	20.9	22.6	23.4	23.0	21.5	19.0	15.6	11.6	7.62	4.54	2.66		
130	3.00	4.37	6.51	9.29	12.3	15.2	17.4	18.9	19.5	19.2	18.0	15.9	13.1	9.93	6.85	4.47	3.02		
135	3.24	4.38	6.07	8.21	10.5	12.7	14.6	15.9	16.4	16.1	15.1	13.3	11.1	8.67	6.28	4.23	3.36		
140	3.53	4.42	5.75	7.40	9.18	10.9	12.3	13.3	13.6	13.4	12.6	11.3	9.65	7.72	5.94	4.40	3.67		
145	3.80	4.53	5.50	6.77	8.11	9.40	10.5	11.2	11.5	11.3	10.7	9.71	8.38	7.00	5.35	4.59	3.95		
150	4.00	4.64	5.33	6.16	7.21	8.18	8.95	9.45	9.65	9.50	9.06	8.36	7.41	6.00	5.30	4.75	4.17		
155	4.10	4.67	5.10	5.73	6.40	6.91	7.63	8.05	8.20	8.12	7.79	7.15	6.28	5.80	5.30	4.89	4.36		
160	3.72	4.56	4.94	5.26	5.62	6.13	6.52	6.68	6.71	6.67	6.54	6.29	5.99	5.66	5.29	5.01	4.53		
165	3.17	4.27	4.88	5.08	5.29	5.48	5.38	5.87	6.10	6.10	6.03	5.88	5.68	5.44	5.22	5.02	4.33		
170	2.97	3.15	3.49	3.80	4.10	4.50	5.01	5.15	4.57	5.30	5.45	5.38	5.31	5.10	4.44	3.54	3.03		
175	2.87	2.88	2.90	2.89	2.90	2.94	2.95	2.95	3.15	4.23	3.47	3.15	2.69	2.57	2.63	2.64	2.62		
180	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05		

Table 7: Luminous Intensity Data

EQUIPMENT LIST

Test Equipment	Model	Equipment No.	Calibration Date	Calibration Due date
Goniophotometer system	GO-R5000	HZTE011-01	Aug. 14, 2018	Aug. 13, 2019
Digital Power Meter	PF2010A	HZTE028-01	Sep. 12, 2018	Sep. 11, 2019
AC Power Supply	DPS1060	HZTE001-06	Aug. 09, 2018	Aug. 08, 2019
DC Power Supply	WY12010	HZTE004-03	Aug. 09, 2018	Aug. 08, 2019
Temperature recorder	JM624U	HZTE018-08	Aug. 09, 2018	Aug. 08, 2019
Temperature and humidity recorder	JR900	HZTE018-01	Aug. 09, 2018	Aug. 08, 2019
Standard source	D908	HZTE012-01	Aug. 14, 2018	Aug. 13, 2019
Integrate Sphere system	2M	HZTE015-01	Aug. 16, 2018	Aug. 15, 2019
Digital Power Meter	WT210	HZTE008-01	Aug. 02, 2018	Aug. 01, 2019
AC Power Supply	PCR 500L	HZTE001-07	Aug. 09, 2018	Aug. 08, 2019
DC Power Supply	IT6154	HZTE004-04	Aug. 09, 2018	Aug. 08, 2019
Standard source	SCL-1400	HZTE012-02	Aug. 16, 2018	Aug. 15, 2019
Temperature and humidity recorder	JR900	HZTE018-02	Aug. 09, 2018	Aug. 08, 2019
Temperature Meter	TES1310	HZTE017-01	Aug. 09, 2018	Aug. 08, 2019

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 4π . 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

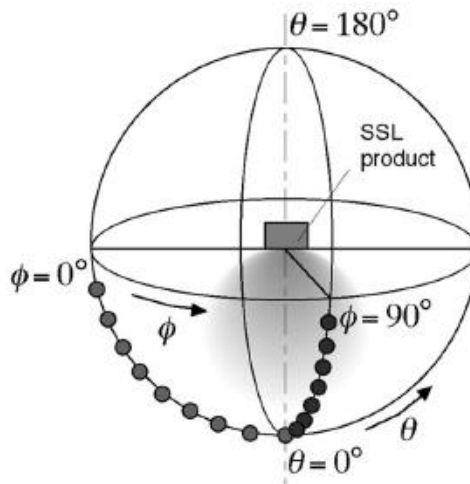
The color characteristics of SSL products include chromaticity coordinates, correlated color temperature, and color rendering index. These characteristics of SSL products may be spatially non-uniform, and thus, in order that they can be specified accurately, the color quantities shall be measured as 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° 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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