NVLAP LAB CODE 200960-0

# LM-79-08 Test Report

for

## Ilsung Ltd.

NO. 501, DAEJI BLDG, 1125-15, HWAGOK-DONG, KANGSEO-GU, SEOUL, KOREA

## LED RETROFIT

## Model: AF6AD-DOB-827

### Laboratory: Leading Testing Laboratories

**NVLAP CODE: 200960-0**

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Report No.: HZ16030052a

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

**Review by:** April Zou

Engineer: April Zou

Jun 21, 2016

**Approved by:** Zhang

Manager: Jim Zhang

Jun 21, 2016

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

## Test Summary

Sample Tested: **AF6AD-DOB-827**

| Luminous Efficacy (Lumens /Watt) | Total Luminous Flux (Lumens) | Power (Watts) | Power Factor |
|---|---|---|---|
| 70.2 | 872.2 | 12.43 | 0.9887 |

| CCT (K) | CRI | Stabilization Time (Light & Power) |
|---|---|---|
| 2671 | 82.2 | 60 |

Table 1: Executive Data Summary

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

**Test specifications:**

**Date of Receipt** : May 10, 2016

**Date of Test** : May 24, 2016

**Test item** : Total Luminous Flux, Luminous Distribution Intensity, Luminous Efficacy, Correlated Color Temperature, Color Rendering Index, Chromaticity Coordinate, Electrical parameters

**Reference Standard** : IESNA LM-79-2008 Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products

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## Sample Photos

Figure 1- Overview of the sample

| Equipment Under Test (EUT) | |
|---|---|
| **Name** | : LED RETROFIT |
| **Model** | : AF6AD-DOB-827 |
| **Electrical Ratings** | : 120V, 60Hz |
| **Product Description** | : LED Luminaire, Dimmable |
| **Manufacturer** | : Ilsung Ltd. |
| **Address** | : NO. 501, DAEJI BLDG, 1125-15, HWAGOK-DONG, KANGSEO-GU, SEOUL, KOREA |

## TEST RESULTS

Test ambient temperature was 25.2℃.

Base orientation was light down. 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 |
| Test Current (A) | 0.1047 |
| Power Factor | 0.9887 |
| Test Power (W) | 12.43 |
| THD A% | 14.93 |
| Luminous Efficacy (lm/W) | 70.2 |
| Total Luminous Flux (lm) | 872.2 |
| Color Rendering Index (CRI) | 82.2 |
| R9 | 8.1 |
| Correlated Color Temperature (CCT) (K) | 2671 |
| Chromaticity Chroma x | 0.4634 |
| Chromaticity Chroma y | 0.4134 |
| Chromaticity Chroma u | 0.2635 |
| Chromaticity Chroma v | 0.3526 |
| Duv | 0.0003 |
| Chromaticity Chroma u ’ | 0.2635 |
| Chromaticity Chroma v’ | 0.5289 |

| Special Color Rendering Indices | |
|---|---|
| R1 | 80.2 |
| R2 | 90.4 |
| R3 | 97 |
| R4 | 80 |
| R5 | 80.2 |
| R6 | 89 |
| R7 | 82.4 |
| R8 | 57.9 |
| R9 | 8.1 |
| R10 | 78.5 |
| R11 | 79.2 |
| R12 | 75.2 |
| R13 | 82.4 |
| R14 | 98.9 |

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 24.2℃.

The photometric distance is 2.47m.

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) | 0.1048 |
| Power Factor | 0.9884 |
| Test Power (W) | 12.44 |
| Luminous Efficacy (lm/W) | 69.4 |
| Total Luminous Flux (lm) | 863.5 |
| Beam Angle (°) | 85.5 |
| Center Beam Candle Power (cd) | 424 |
| Spacing Criteria | 1.20 (0°-180°)/ 1.29 (90°-270°) |
| Zonal Lumens in the 0°-60°Zone | 96.39% |
| Zonal Lumens in the 60°-90°Zone | 3.30% |
| Zonal Lumens in the 90°-120°Zone | 0.17% |
| Zonal Lumens in the 120°-180°Zone | 0.14% |

Table 3: Test data per Goniophotometer Method

## Spectral Power Distribution - Sphere Spectroradiometer Method

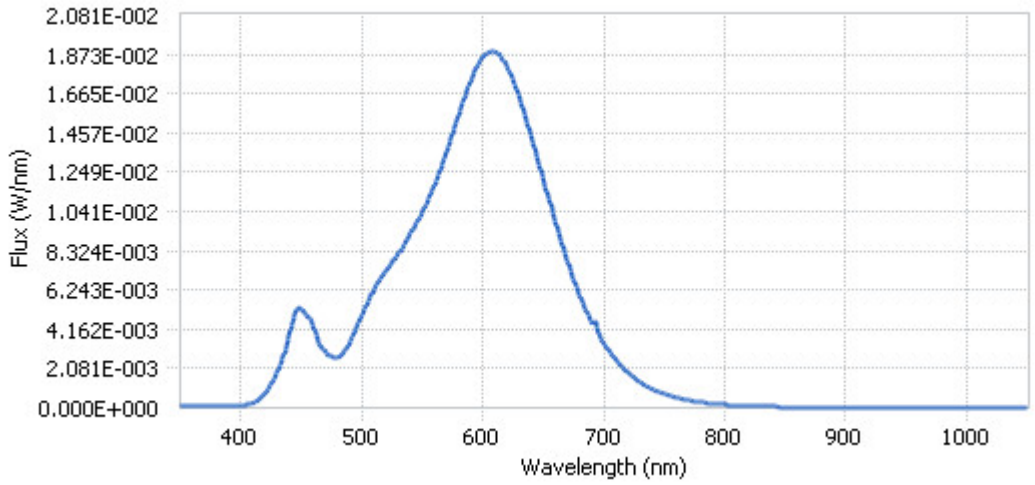
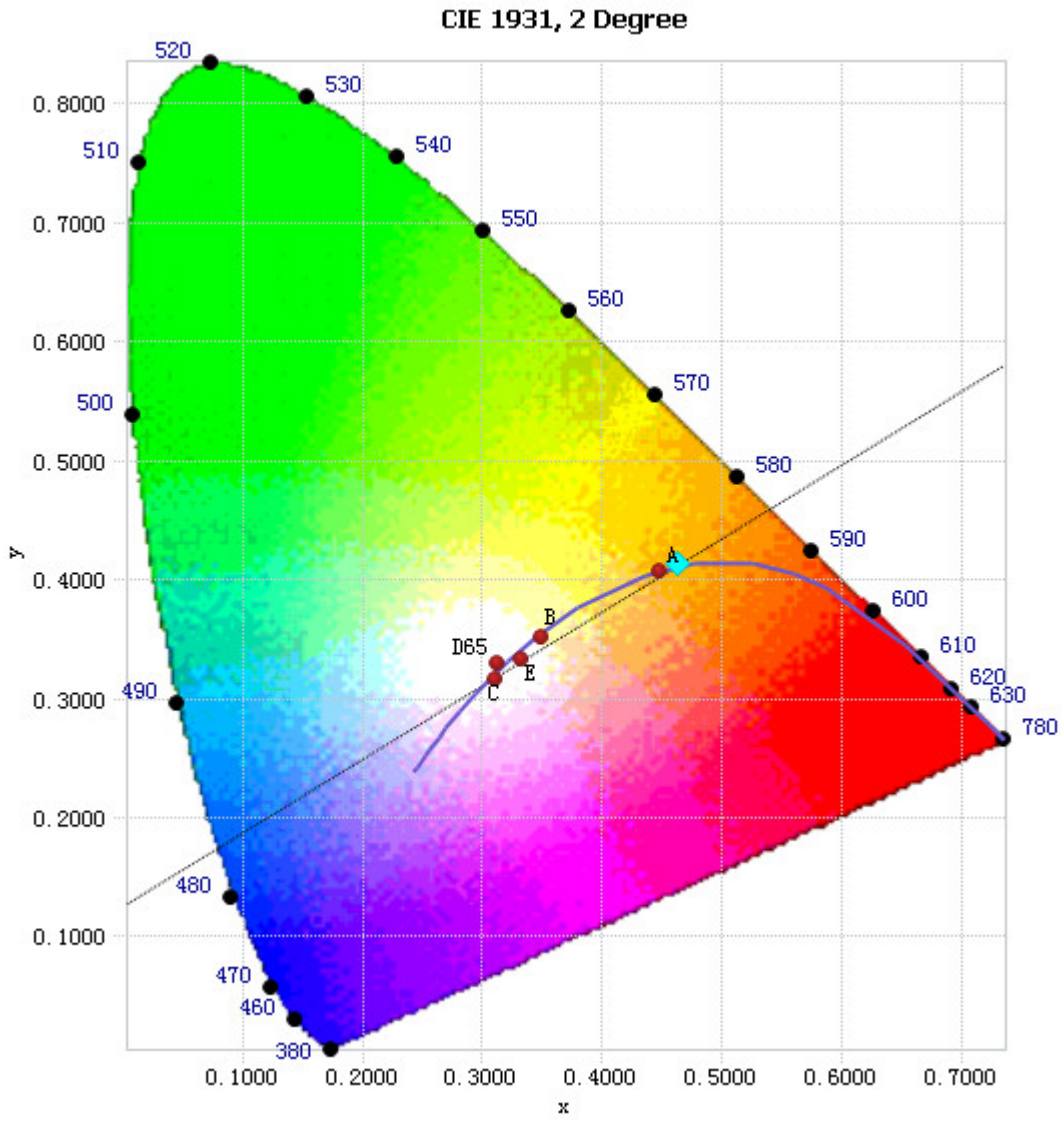



Chart 1: Spectral Power Distribution

| Spectral Distribution over Visible Wavelength | | | | | | | |
|---|---|---|---|---|---|---|---|
| WL(nm) | Radiant(Watts) | WL(nm) | Radiant(Watts) | WL(nm) | Radiant(Watts) | WL(nm) | Radiant(Watts) |
| 380 | 1.02E-04 | 485 | 2.93E-03 | 590 | 1.74E-02 | 695 | 4.23E-03 |
| 385 | 8.87E-05 | 490 | 3.48E-03 | 595 | 1.81E-02 | 700 | 3.43E-03 |
| 390 | 9.94E-05 | 495 | 4.12E-03 | 600 | 1.86E-02 | 705 | 2.96E-03 |
| 395 | 1.12E-04 | 500 | 4.87E-03 | 605 | 1.88E-02 | 710 | 2.55E-03 |
| 400 | 1.30E-04 | 505 | 5.62E-03 | 610 | 1.89E-02 | 715 | 2.21E-03 |
| 405 | 1.69E-04 | 510 | 6.23E-03 | 615 | 1.86E-02 | 720 | 1.90E-03 |
| 410 | 2.58E-04 | 515 | 6.82E-03 | 620 | 1.81E-02 | 725 | 1.61E-03 |
| 415 | 4.51E-04 | 520 | 7.23E-03 | 625 | 1.74E-02 | 730 | 1.38E-03 |
| 420 | 7.64E-04 | 525 | 7.67E-03 | 630 | 1.66E-02 | 735 | 1.18E-03 |
| 425 | 1.25E-03 | 530 | 8.17E-03 | 635 | 1.55E-02 | 740 | 1.01E-03 |
| 430 | 1.89E-03 | 535 | 8.61E-03 | 640 | 1.44E-02 | 745 | 8.57E-04 |
| 435 | 2.73E-03 | 540 | 9.18E-03 | 645 | 1.33E-02 | 750 | 7.43E-04 |
| 440 | 3.86E-03 | 545 | 9.72E-03 | 650 | 1.22E-02 | 755 | 6.37E-04 |
| 445 | 4.98E-03 | 550 | 1.03E-02 | 655 | 1.10E-02 | 760 | 5.48E-04 |
| 450 | 5.24E-03 | 555 | 1.10E-02 | 660 | 9.88E-03 | 765 | 4.68E-04 |
| 455 | 4.87E-03 | 560 | 1.18E-02 | 665 | 8.78E-03 | 770 | 4.01E-04 |
| 460 | 4.34E-03 | 565 | 1.27E-02 | 670 | 7.78E-03 | 775 | 3.46E-04 |
| 465 | 3.44E-03 | 570 | 1.35E-02 | 675 | 6.83E-03 | 780 | 2.97E-04 |
| 470 | 2.92E-03 | 575 | 1.45E-02 | 680 | 5.99E-03 | | |
| 475 | 2.73E-03 | 580 | 1.55E-02 | 685 | 5.25E-03 | | |
| 480 | 2.69E-03 | 585 | 1.64E-02 | 690 | 4.59E-03 | | |

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

## Chromaticity Diagram - Sphere Spectroradiometer Method




Tristimulus values(x, y): (0.4634, 0.4134)

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**

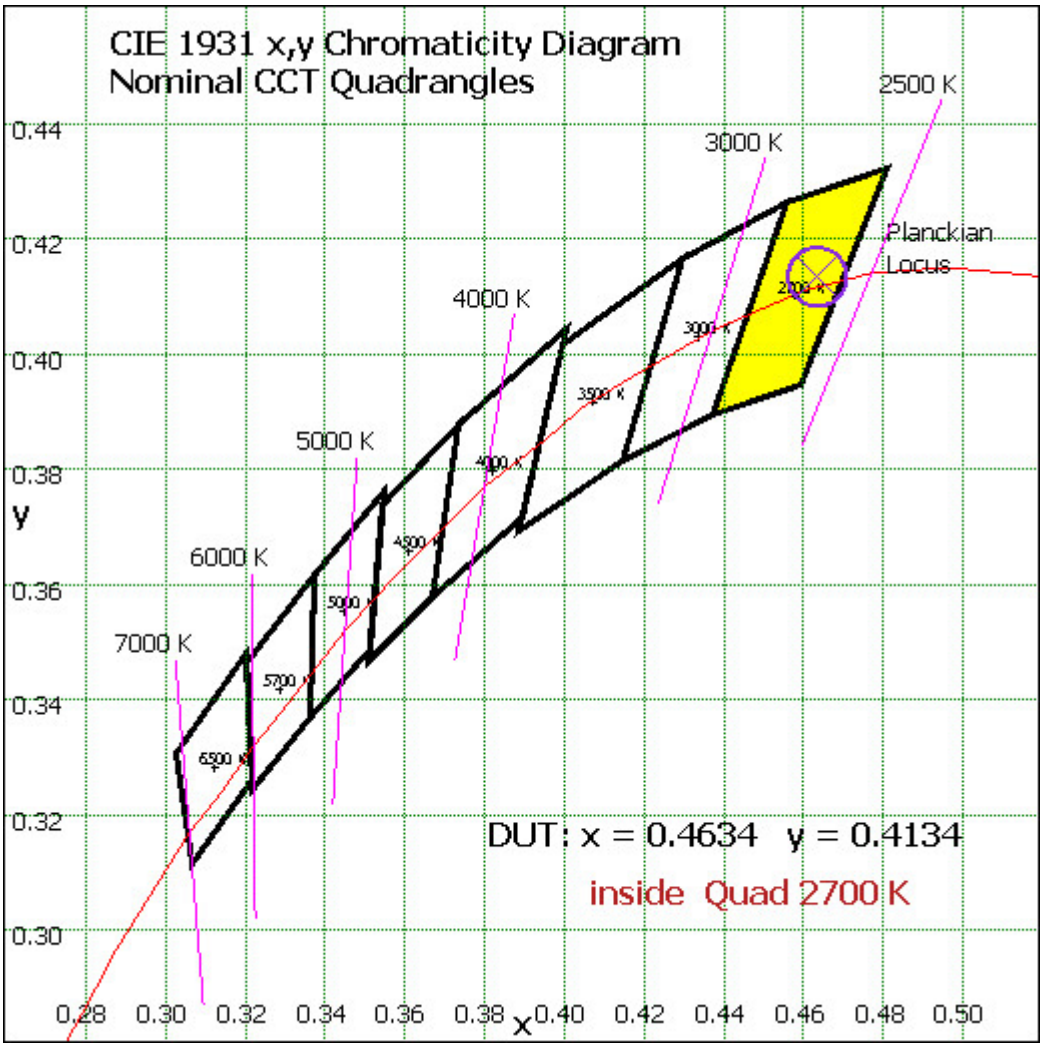



Chart 3: Plot of Lamp x/y coordinates on CIE 1931 Chromaticity Diagram

## Zonal Lumen Tabulation- Goniophotometer Method

| γ(°) | Lumens | % Total |
|---|---|---|
| 0- 10 | 41.483 | 4.80% |
| 10- 20 | 136.561 | 15.82% |
| 20- 30 | 239.887 | 27.78% |
| 30- 40 | 261.864 | 30.33% |
| 40- 50 | 116.648 | 13.51% |
| 50- 60 | 35.873 | 4.15% |
| 60- 70 | 18.803 | 2.18% |
| 70- 80 | 7.262 | 0.84% |
| 80- 90 | 2.396 | 0.28% |
| 90-100 | 0.454 | 0.05% |
| 100-110 | 0.576 | 0.07% |
| 110-120 | 0.479 | 0.06% |
| 120-130 | 0.375 | 0.04% |
| 130-140 | 0.303 | 0.04% |
| 140-150 | 0.229 | 0.03% |
| 150-160 | 0.149 | 0.02% |
| 160-170 | 0.093 | 0.01% |
| 170-180 | 0.033 | 0.00% |
| Total | 863.5 | 100% |

| γ(°) | Lumens | % Total |
|---|---|---|
| 0- 60 | 832.316 | 96.39% |
| 60- 90 | 28.461 | 3.30% |
| 0-90 | 860.777 | 99.69% |
| 90- 180 | 2.691 | 0.31% |
| 0- 180 | 863.5 | 100% |

Table 5: Zonal Lumen Data

## Illuminance Plots- Goniophotometer Method

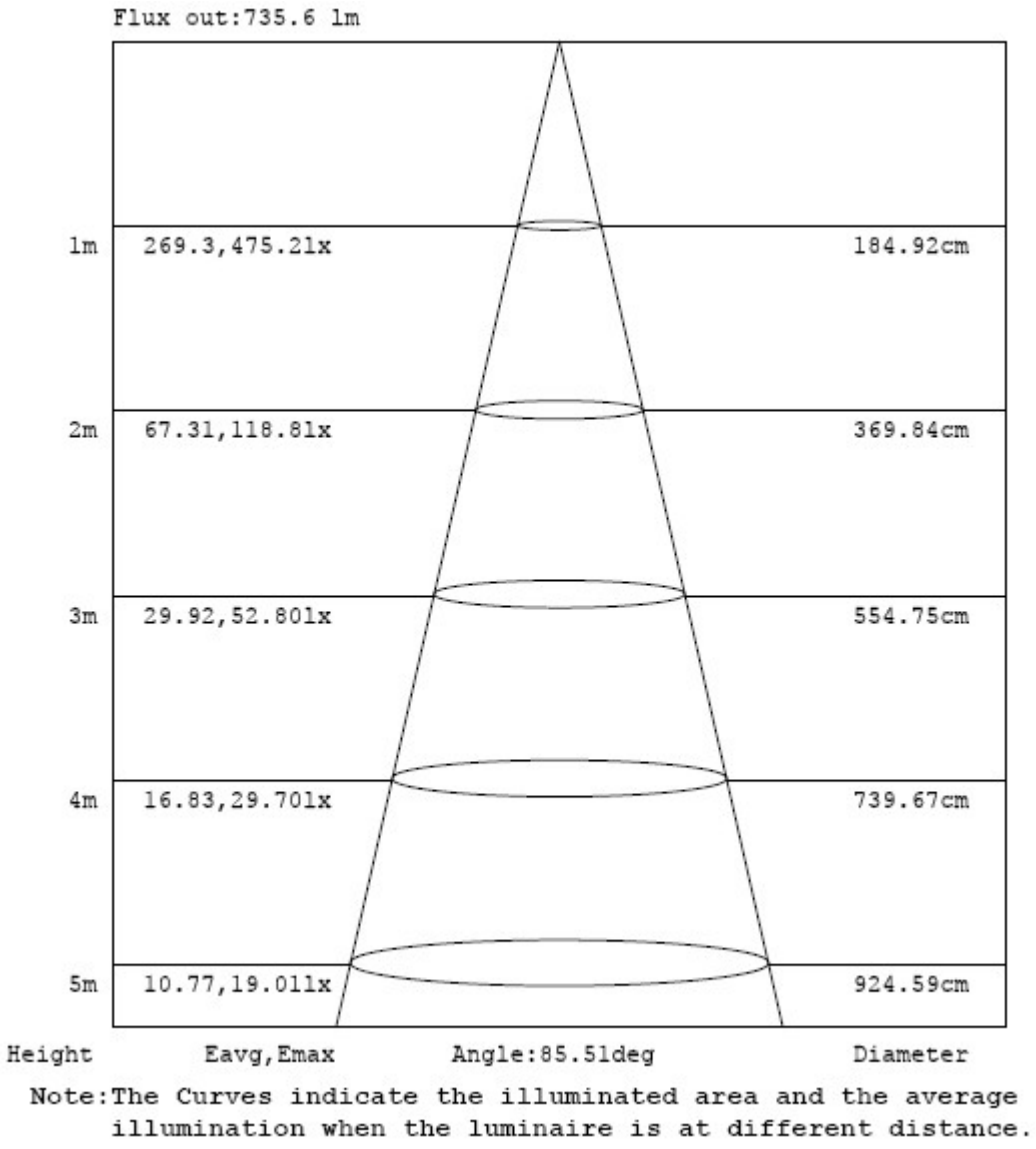



Chart 4: Beam Angle

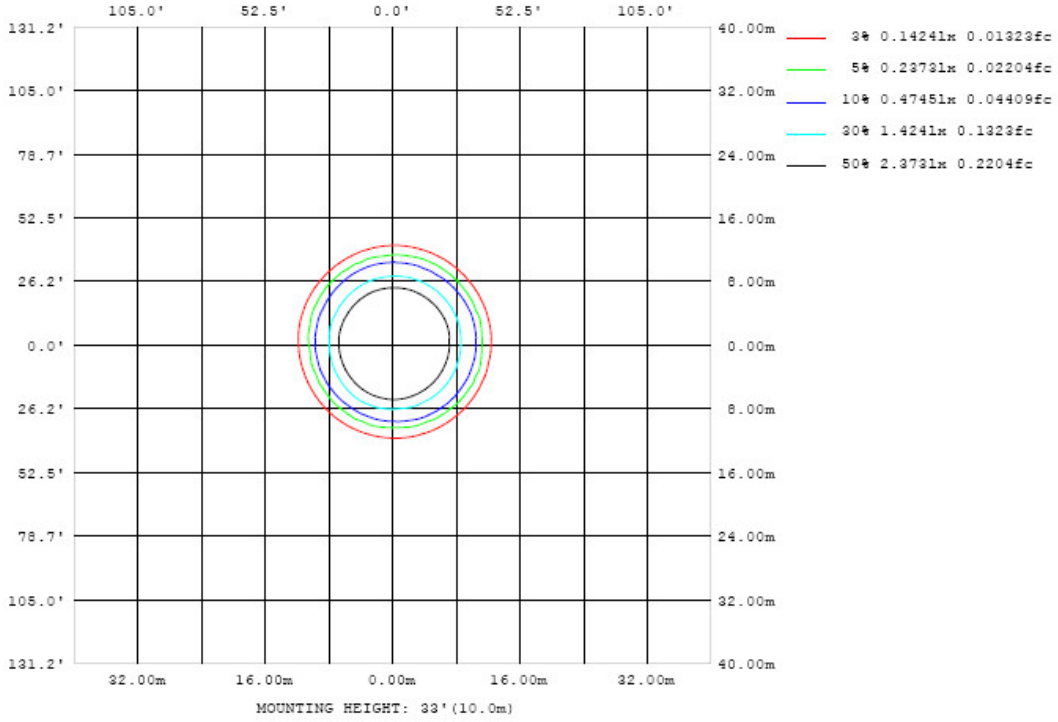



Chart 5: Illuminance Plot (Footcandles)

## Luminous Intensity Distribution Plots- Goniophotometer Method

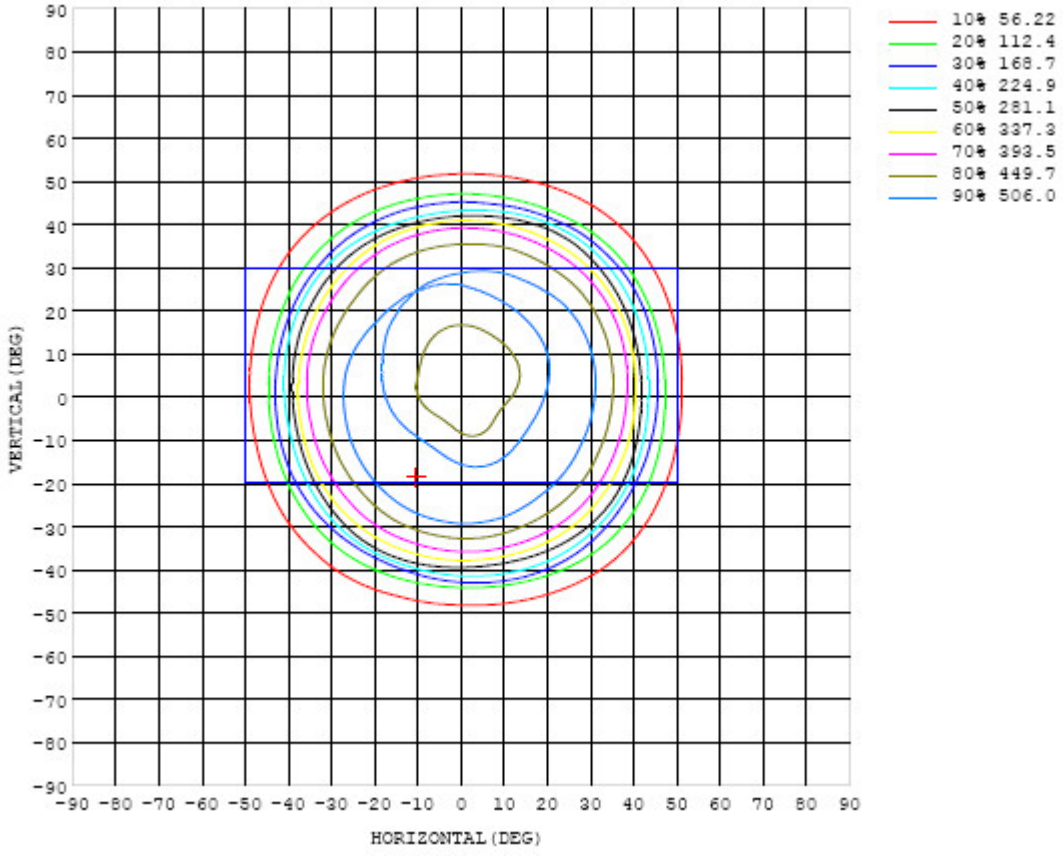



Chart 6: Isocandela Plot

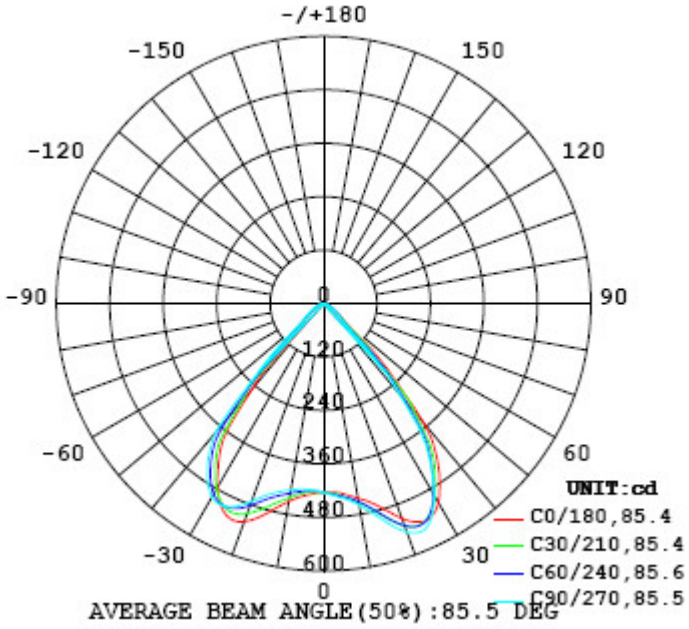



Chart 7: Polar Candela Distribution

## Luminous Intensity Data- Goniophotometer Method

Table--1 UNIT: cd

| γ (DEG) \ C (DEG) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| 5 | 427 | 429 | 431 | 432 | 433 | 433 | 434 | 434 | 436 | 437 | 439 | 440 | 441 | 441 | 440 | 438 | 436 | 434 | 431 |
| 10 | 444 | 449 | 453 | 453 | 453 | 452 | 451 | 452 | 455 | 460 | 465 | 470 | 473 | 474 | 471 | 466 | 460 | 455 | 451 |
| 15 | 470 | 479 | 486 | 489 | 489 | 488 | 487 | 488 | 493 | 500 | 510 | 519 | 524 | 524 | 519 | 511 | 501 | 493 | 486 |
| 20 | 513 | 521 | 527 | 531 | 530 | 529 | 530 | 533 | 538 | 545 | 553 | 558 | 561 | 559 | 552 | 545 | 537 | 528 | 520 |
| 25 | 538 | 539 | 539 | 539 | 538 | 537 | 540 | 545 | 549 | 552 | 551 | 549 | 544 | 540 | 536 | 532 | 528 | 525 | 522 |
| 30 | 515 | 509 | 502 | 499 | 496 | 492 | 493 | 496 | 496 | 495 | 491 | 487 | 482 | 476 | 472 | 470 | 471 | 472 | 476 |
| 35 | 450 | 443 | 435 | 431 | 426 | 421 | 416 | 413 | 412 | 409 | 405 | 401 | 398 | 396 | 392 | 391 | 394 | 398 | 406 |
| 40 | 349 | 337 | 324 | 315 | 307 | 296 | 282 | 271 | 265 | 265 | 266 | 267 | 261 | 253 | 240 | 232 | 230 | 233 | 248 |
| 45 | 182 | 166 | 155 | 149 | 146 | 135 | 117 | 97.7 | 85.7 | 82.9 | 83.6 | 84.7 | 85.4 | 86.2 | 84.0 | 82.5 | 82.1 | 86.4 | 101 |
| 50 | 62.3 | 60.9 | 58.7 | 56.6 | 55.5 | 54.0 | 52.5 | 51.2 | 50.2 | 49.6 | 48.4 | 48.0 | 47.9 | 48.0 | 48.1 | 48.4 | 49.3 | 50.4 | 52.2 |
| 55 | 41.9 | 41.0 | 40.0 | 39.1 | 38.1 | 37.3 | 36.6 | 35.8 | 35.1 | 34.5 | 34.1 | 33.8 | 33.8 | 33.8 | 33.9 | 34.2 | 34.9 | 35.8 | 37.2 |
| 60 | 29.2 | 28.6 | 27.8 | 27.1 | 26.5 | 25.9 | 25.4 | 24.9 | 24.4 | 23.9 | 23.5 | 23.3 | 23.2 | 23.1 | 23.2 | 23.5 | 24.1 | 24.9 | 26.1 |
| 65 | 19.9 | 19.5 | 19.0 | 18.5 | 18.1 | 17.7 | 17.3 | 17.0 | 16.5 | 16.0 | 15.7 | 15.4 | 15.3 | 15.2 | 15.1 | 15.4 | 15.9 | 16.5 | 17.5 |
| 70 | 13.4 | 13.0 | 12.7 | 12.4 | 12.1 | 11.6 | 11.2 | 10.7 | 9.96 | 8.77 | 7.92 | 7.76 | 7.56 | 7.38 | 7.67 | 7.81 | 8.70 | 9.72 | 10.8 |
| 75 | 6.69 | 6.54 | 6.36 | 6.22 | 6.03 | 5.83 | 5.63 | 5.48 | 5.37 | 5.29 | 5.25 | 5.23 | 5.19 | 5.11 | 5.14 | 5.21 | 5.30 | 5.42 | 5.64 |
| 80 | 4.54 | 4.32 | 4.13 | 4.01 | 3.85 | 3.71 | 3.60 | 3.53 | 3.50 | 3.51 | 3.54 | 3.55 | 3.52 | 3.43 | 3.49 | 3.58 | 3.64 | 3.68 | 3.79 |
| 85 | 3.10 | 2.89 | 2.70 | 2.55 | 2.23 | 1.90 | 1.65 | 1.12 | 0.85 | 0.72 | 0.64 | 0.61 | 0.54 | 0.43 | 0.56 | 0.73 | 0.96 | 1.23 | 1.73 |
| 90 | 0.40 | 0.25 | 0.18 | 0.19 | 0.19 | 0.24 | 0.32 | 0.35 | 0.37 | 0.40 | 0.44 | 0.44 | 0.38 | 0.26 | 0.35 | 0.46 | 0.49 | 0.49 | 0.47 |
| 95 | 0.43 | 0.29 | 0.19 | 0.25 | 0.25 | 0.27 | 0.33 | 0.40 | 0.44 | 0.48 | 0.50 | 0.49 | 0.45 | 0.33 | 0.42 | 0.52 | 0.57 | 0.56 | 0.52 |
| 100 | 0.52 | 0.36 | 0.25 | 0.36 | 0.38 | 0.39 | 0.43 | 0.50 | 0.56 | 0.59 | 0.59 | 0.58 | 0.56 | 0.43 | 0.53 | 0.61 | 0.66 | 0.64 | 0.58 |
| 105 | 0.58 | 0.44 | 0.33 | 0.44 | 0.45 | 0.46 | 0.49 | 0.55 | 0.59 | 0.61 | 0.61 | 0.60 | 0.56 | 0.45 | 0.57 | 0.63 | 0.67 | 0.67 | 0.63 |
| 110 | 0.54 | 0.43 | 0.33 | 0.41 | 0.42 | 0.43 | 0.45 | 0.49 | 0.52 | 0.53 | 0.54 | 0.54 | 0.50 | 0.43 | 0.53 | 0.56 | 0.59 | 0.59 | 0.58 |
| 115 | 0.46 | 0.39 | 0.32 | 0.37 | 0.39 | 0.39 | 0.41 | 0.44 | 0.45 | 0.46 | 0.48 | 0.49 | 0.45 | 0.40 | 0.49 | 0.51 | 0.52 | 0.51 | 0.53 |
| 120 | 0.40 | 0.35 | 0.29 | 0.34 | 0.35 | 0.36 | 0.38 | 0.40 | 0.40 | 0.41 | 0.43 | 0.44 | 0.41 | 0.38 | 0.46 | 0.46 | 0.47 | 0.45 | 0.50 |
| 125 | 0.36 | 0.33 | 0.27 | 0.31 | 0.32 | 0.33 | 0.34 | 0.36 | 0.36 | 0.37 | 0.39 | 0.40 | 0.38 | 0.35 | 0.43 | 0.42 | 0.43 | 0.42 | 0.48 |
| 130 | 0.34 | 0.30 | 0.26 | 0.29 | 0.30 | 0.30 | 0.30 | 0.33 | 0.34 | 0.33 | 0.35 | 0.37 | 0.36 | 0.33 | 0.40 | 0.39 | 0.39 | 0.40 | 0.49 |
| 135 | 0.33 | 0.29 | 0.25 | 0.27 | 0.28 | 0.27 | 0.29 | 0.28 | 0.30 | 0.31 | 0.31 | 0.34 | 0.33 | 0.31 | 0.38 | 0.37 | 0.37 | 0.40 | 0.50 |
| 140 | 0.32 | 0.26 | 0.23 | 0.25 | 0.26 | 0.25 | 0.26 | 0.24 | 0.26 | 0.27 | 0.29 | 0.31 | 0.30 | 0.30 | 0.35 | 0.35 | 0.36 | 0.39 | 0.49 |
| 145 | 0.32 | 0.25 | 0.22 | 0.23 | 0.24 | 0.23 | 0.23 | 0.23 | 0.24 | 0.25 | 0.27 | 0.28 | 0.28 | 0.28 | 0.32 | 0.32 | 0.34 | 0.39 | 0.48 |
| 150 | 0.31 | 0.24 | 0.21 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.23 | 0.24 | 0.26 | 0.26 | 0.25 | 0.27 | 0.29 | 0.29 | 0.31 | 0.36 | 0.44 |
| 155 | 0.30 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 | 0.24 | 0.25 | 0.25 | 0.25 | 0.26 | 0.26 | 0.26 | 0.26 | 0.32 | 0.39 |
| 160 | 0.31 | 0.23 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.25 | 0.25 | 0.26 | 0.26 | 0.25 | 0.26 | 0.26 | 0.26 | 0.32 | 0.37 |
| 165 | 0.34 | 0.25 | 0.26 | 0.26 | 0.27 | 0.27 | 0.27 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.34 | 0.37 |
| 170 | 0.36 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.28 | 0.30 | 0.30 | 0.30 | 0.31 | 0.37 | 0.38 |
| 175 | 0.36 | 0.36 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.35 | 0.37 | 0.38 | 0.39 |
| 180 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 |

Table 6: Luminous Intensity Data

Table--2 UNIT: cd

| γ (DEG) \ C (DEG) | 190 | 200 | 210 | 220 | 230 | 240 | 250 | 260 | 270 | 280 | 290 | 300 | 310 | 320 | 330 | 340 | 350 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | | |
| 5 | 429 | 427 | 426 | 424 | 423 | 421 | 420 | 420 | 419 | 418 | 418 | 419 | 420 | 420 | 421 | 423 | 425 | | |
| 10 | 447 | 445 | 443 | 440 | 436 | 432 | 428 | 426 | 425 | 425 | 425 | 426 | 426 | 427 | 429 | 432 | 438 | | |
| 15 | 479 | 475 | 470 | 464 | 457 | 450 | 445 | 442 | 441 | 441 | 443 | 445 | 446 | 447 | 448 | 452 | 460 | | |
| 20 | 514 | 508 | 502 | 495 | 488 | 482 | 476 | 473 | 472 | 474 | 476 | 478 | 480 | 482 | 485 | 490 | 501 | | |
| 25 | 519 | 515 | 511 | 508 | 507 | 505 | 503 | 502 | 503 | 506 | 510 | 513 | 516 | 518 | 521 | 525 | 532 | | |
| 30 | 480 | 481 | 481 | 483 | 488 | 494 | 498 | 500 | 501 | 505 | 507 | 509 | 512 | 517 | 520 | 521 | 521 | | |
| 35 | 413 | 418 | 421 | 426 | 434 | 442 | 449 | 453 | 456 | 460 | 463 | 462 | 463 | 468 | 468 | 465 | 459 | | |
| 40 | 265 | 278 | 286 | 297 | 314 | 335 | 356 | 371 | 376 | 374 | 373 | 371 | 373 | 377 | 379 | 378 | 369 | | |
| 45 | 112 | 118 | 121 | 129 | 145 | 156 | 166 | 172 | 176 | 175 | 185 | 189 | 201 | 200 | 206 | 205 | 197 | | |
| 50 | 53.9 | 55.4 | 56.8 | 58.2 | 59.8 | 61.6 | 63.1 | 64.5 | 65.7 | 66.6 | 67.1 | 67.6 | 67.2 | 66.7 | 66.2 | 65.7 | 64.7 | | |
| 55 | 38.4 | 39.3 | 40.0 | 40.5 | 41.1 | 42.0 | 42.8 | 43.6 | 44.2 | 44.4 | 44.5 | 44.6 | 44.5 | 44.3 | 44.0 | 43.6 | 43.1 | | |
| 60 | 27.1 | 27.8 | 28.3 | 28.7 | 29.1 | 29.7 | 30.3 | 30.8 | 31.1 | 31.2 | 31.3 | 31.3 | 31.2 | 31.0 | 30.7 | 30.5 | 30.1 | | |
| 65 | 18.3 | 18.9 | 19.4 | 19.8 | 20.1 | 20.6 | 21.0 | 21.4 | 21.6 | 21.6 | 21.6 | 21.5 | 21.4 | 21.2 | 21.0 | 20.8 | 20.6 | | |
| 70 | 11.5 | 12.1 | 12.7 | 13.0 | 13.3 | 13.5 | 13.9 | 14.3 | 14.5 | 14.5 | 14.4 | 14.4 | 14.3 | 14.1 | 14.0 | 13.9 | 13.8 | | |
| 75 | 5.83 | 6.03 | 6.24 | 6.42 | 6.59 | 6.74 | 6.87 | 7.00 | 7.10 | 7.14 | 7.15 | 7.17 | 7.17 | 7.08 | 7.06 | 6.97 | 6.87 | | |
| 80 | 3.85 | 3.93 | 4.06 | 4.23 | 4.42 | 4.62 | 4.69 | 4.83 | 4.95 | 5.00 | 5.03 | 5.04 | 5.02 | 5.00 | 4.96 | 4.88 | 4.77 | | |
| 85 | 1.86 | 2.19 | 2.50 | 2.69 | 2.91 | 3.08 | 3.07 | 3.17 | 3.30 | 3.34 | 3.35 | 3.32 | 3.31 | 3.30 | 3.32 | 3.30 | 3.24 | | |
| 90 | 0.37 | 0.27 | 0.24 | 0.27 | 0.38 | 0.47 | 0.35 | 0.40 | 0.50 | 0.51 | 0.49 | 0.41 | 0.40 | 0.39 | 0.45 | 0.46 | 0.44 | | |
| 95 | 0.42 | 0.35 | 0.33 | 0.32 | 0.38 | 0.46 | 0.34 | 0.38 | 0.50 | 0.49 | 0.47 | 0.41 | 0.40 | 0.39 | 0.43 | 0.46 | 0.46 | | |
| 100 | 0.51 | 0.46 | 0.44 | 0.43 | 0.46 | 0.51 | 0.42 | 0.47 | 0.60 | 0.58 | 0.56 | 0.52 | 0.51 | 0.50 | 0.52 | 0.54 | 0.54 | | |
| 105 | 0.58 | 0.54 | 0.53 | 0.52 | 0.54 | 0.57 | 0.48 | 0.54 | 0.69 | 0.67 | 0.63 | 0.61 | 0.61 | 0.60 | 0.60 | 0.61 | 0.61 | | |
| 110 | 0.56 | 0.53 | 0.51 | 0.51 | 0.53 | 0.54 | 0.47 | 0.52 | 0.66 | 0.65 | 0.62 | 0.61 | 0.59 | 0.59 | 0.59 | 0.59 | 0.58 | | |
| 115 | 0.52 | 0.50 | 0.49 | 0.49 | 0.50 | 0.49 | 0.43 | 0.46 | 0.59 | 0.58 | 0.56 | 0.55 | 0.54 | 0.54 | 0.54 | 0.53 | 0.51 | | |
| 120 | 0.49 | 0.48 | 0.47 | 0.47 | 0.48 | 0.46 | 0.41 | 0.42 | 0.53 | 0.53 | 0.52 | 0.51 | 0.50 | 0.50 | 0.50 | 0.49 | 0.46 | | |
| 125 | 0.49 | 0.48 | 0.47 | 0.46 | 0.47 | 0.44 | 0.40 | 0.41 | 0.50 | 0.50 | 0.49 | 0.49 | 0.48 | 0.48 | 0.48 | 0.46 | 0.43 | | |
| 130 | 0.49 | 0.48 | 0.47 | 0.47 | 0.47 | 0.44 | 0.40 | 0.41 | 0.49 | 0.49 | 0.48 | 0.47 | 0.47 | 0.47 | 0.47 | 0.45 | 0.43 | | |
| 135 | 0.50 | 0.49 | 0.48 | 0.48 | 0.47 | 0.46 | 0.42 | 0.43 | 0.49 | 0.49 | 0.48 | 0.47 | 0.47 | 0.47 | 0.46 | 0.45 | 0.44 | | |
| 140 | 0.49 | 0.48 | 0.48 | 0.48 | 0.48 | 0.47 | 0.44 | 0.44 | 0.49 | 0.49 | 0.47 | 0.46 | 0.46 | 0.46 | 0.46 | 0.45 | 0.44 | | |
| 145 | 0.47 | 0.46 | 0.46 | 0.46 | 0.47 | 0.47 | 0.44 | 0.44 | 0.48 | 0.47 | 0.46 | 0.45 | 0.44 | 0.44 | 0.44 | 0.43 | 0.43 | | |
| 150 | 0.43 | 0.42 | 0.43 | 0.43 | 0.44 | 0.45 | 0.43 | 0.42 | 0.45 | 0.45 | 0.43 | 0.42 | 0.42 | 0.41 | 0.41 | 0.41 | 0.41 | | |
| 155 | 0.38 | 0.38 | 0.38 | 0.39 | 0.41 | 0.41 | 0.40 | 0.39 | 0.41 | 0.41 | 0.40 | 0.39 | 0.39 | 0.38 | 0.38 | 0.37 | 0.37 | | |
| 160 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.38 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.37 | 0.36 | 0.36 | | |
| 165 | 0.37 | 0.37 | 0.38 | 0.38 | 0.39 | 0.39 | 0.37 | 0.35 | 0.37 | 0.38 | 0.38 | 0.39 | 0.39 | 0.38 | 0.37 | 0.36 | 0.36 | | |
| 170 | 0.38 | 0.38 | 0.38 | 0.39 | 0.39 | 0.39 | 0.38 | 0.36 | 0.36 | 0.37 | 0.39 | 0.39 | 0.39 | 0.38 | 0.38 | 0.37 | 0.36 | | |
| 175 | 0.40 | 0.40 | 0.40 | 0.40 | 0.39 | 0.38 | 0.38 | 0.37 | 0.36 | 0.36 | 0.37 | 0.38 | 0.38 | 0.38 | 0.37 | 0.36 | 0.36 | | |
| 180 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | | |

Table 7: Luminous Intensity Data

## Color Spatial Uniformity- Goniophotometer Method

Color uniformity was measured at two horizontal angles, 0°and 90°, the vertical intervals was 1°.

| | C Angle = 0° | | C Angle = 90° | |
|---|---|---|---|---|
| γ Angle (°) | Chromaticity Coordinate u' | Chromaticity Coordinate v' | Chromaticity Coordinate u' | Chromaticity Coordinate v' |
| 0 | 0.2635 | 0.529 | 0.2635 | 0.529 |
| 1 | 0.2636 | 0.529 | 0.2636 | 0.529 |
| 2 | 0.2635 | 0.5289 | 0.2635 | 0.529 |
| 3 | 0.2635 | 0.5289 | 0.2635 | 0.529 |
| 4 | 0.2636 | 0.5289 | 0.2635 | 0.529 |
| 5 | 0.2636 | 0.529 | 0.2635 | 0.529 |
| 6 | 0.2636 | 0.5289 | 0.2635 | 0.529 |
| 7 | 0.2636 | 0.5289 | 0.2635 | 0.5291 |
| 8 | 0.2635 | 0.5289 | 0.2636 | 0.5291 |
| 9 | 0.2636 | 0.5289 | 0.2636 | 0.5291 |
| 10 | 0.2636 | 0.5289 | 0.2636 | 0.5291 |
| 11 | 0.2636 | 0.5289 | 0.2635 | 0.5292 |
| 12 | 0.2637 | 0.529 | 0.2635 | 0.5292 |
| 13 | 0.2637 | 0.529 | 0.2636 | 0.5292 |
| 14 | 0.2637 | 0.529 | 0.2636 | 0.5292 |
| 15 | 0.2638 | 0.5291 | 0.2636 | 0.5293 |
| 16 | 0.2639 | 0.5291 | 0.2637 | 0.5294 |
| 17 | 0.2639 | 0.5291 | 0.2637 | 0.5295 |
| 18 | 0.2639 | 0.5291 | 0.2638 | 0.5296 |
| 19 | 0.2641 | 0.5292 | 0.2639 | 0.5296 |
| 20 | 0.2641 | 0.5292 | 0.2639 | 0.5296 |
| 21 | 0.2641 | 0.5293 | 0.2639 | 0.5297 |
| 22 | 0.2642 | 0.5294 | 0.264 | 0.5298 |
| 23 | 0.2642 | 0.5294 | 0.2641 | 0.5298 |
| 24 | 0.2642 | 0.5294 | 0.2641 | 0.5298 |
| 25 | 0.2643 | 0.5295 | 0.2641 | 0.5298 |

| | | | | |
|---|---|---|---|---|
| 26 | 0.2643 | 0.5295 | 0.2641 | 0.5298 |
| 27 | 0.2643 | 0.5295 | 0.2641 | 0.5298 |
| 28 | 0.2643 | 0.5296 | 0.2641 | 0.5298 |
| 29 | 0.2643 | 0.5296 | 0.2642 | 0.5298 |
| 30 | 0.2643 | 0.5296 | 0.2642 | 0.5299 |
| 31 | 0.2643 | 0.5296 | 0.2642 | 0.5299 |
| 32 | 0.2643 | 0.5297 | 0.2642 | 0.5298 |
| 33 | 0.2643 | 0.5297 | 0.2642 | 0.5298 |
| 34 | 0.2642 | 0.5297 | 0.2643 | 0.5298 |
| 35 | 0.2642 | 0.5296 | 0.2642 | 0.5297 |
| 36 | 0.2642 | 0.5297 | 0.2643 | 0.5297 |
| 37 | 0.2644 | 0.5298 | 0.2643 | 0.5297 |
| 38 | 0.2644 | 0.5297 | 0.2642 | 0.5297 |
| 39 | 0.2644 | 0.5295 | 0.2643 | 0.5299 |
| 40 | 0.2643 | 0.5295 | 0.2643 | 0.5301 |
| 41 | 0.2643 | 0.5296 | 0.2642 | 0.5304 |
| 42 | 0.2642 | 0.5295 | 0.2641 | 0.5306 |
| 43 | 0.2646 | 0.5296 | 0.2643 | 0.5308 |
| 44 | 0.2651 | 0.5298 | 0.2643 | 0.5309 |
| 45 | 0.2652 | 0.5301 | 0.2646 | 0.5311 |
| 46 | 0.2648 | 0.5302 | 0.2651 | 0.5315 |
| 47 | 0.2643 | 0.5301 | 0.2646 | 0.5308 |
| 48 | 0.2643 | 0.5301 | 0.2643 | 0.5303 |
| 49 | 0.2643 | 0.5301 | 0.2643 | 0.5302 |
| 50 | 0.2642 | 0.5301 | 0.2643 | 0.5302 |
| 51 | 0.2642 | 0.5301 | 0.2641 | 0.5301 |
| 52 | 0.2641 | 0.53 | 0.2641 | 0.5301 |
| 53 | 0.2642 | 0.5301 | 0.2641 | 0.5301 |
| 54 | 0.2642 | 0.5301 | 0.2641 | 0.5301 |
| 55 | 0.2642 | 0.5301 | 0.2641 | 0.5301 |
| 56 | 0.2642 | 0.5301 | 0.2641 | 0.5302 |
| 57 | 0.2642 | 0.5301 | 0.2641 | 0.5302 |

| | | | | |
|---|---|---|---|---|
| 58 | 0.2642 | 0.5301 | 0.2641 | 0.5302 |
| 59 | 0.2641 | 0.5301 | 0.2641 | 0.5302 |
| 60 | 0.2641 | 0.5301 | 0.264 | 0.5302 |

Table 8: Chromaticity per Measurement Angle

| **Weighted Average** | |
|---|---|
| **u'** | **v'** |
| 0.2597 | 0.5251 |

The chromaticity measurements need to be made only for the γ angles where the average luminous intensity is more than 10 % of the peak intensity.

| **γ Angle (°)** | **C Angle = 0°/180°** | | **C Angle = 90°/270°** | |
|---|---|---|---|---|
| | **Δu'** | **Δv'** | **Δu'** | **Δv'** |
| 0 | 0.0004 | 0.0000 | 0.0004 | 0.0000 |
| 1 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 2 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 3 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 4 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 5 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 6 | 0.0003 | 0.0000 | 0.0003 | 0.0001 |
| 7 | 0.0004 | 0.0000 | 0.0001 | 0.0001 |
| 8 | 0.0004 | 0.0000 | 0.0001 | 0.0001 |
| 9 | 0.0004 | 0.0000 | 0.0002 | 0.0001 |
| 10 | 0.0004 | 0.0001 | 0.0002 | 0.0001 |
| 11 | 0.0004 | 0.0001 | 0.0002 | 0.0001 |
| 12 | 0.0004 | 0.0001 | 0.0002 | 0.0001 |
| 13 | 0.0004 | 0.0001 | 0.0002 | 0.0001 |
| 14 | 0.0004 | 0.0001 | 0.0002 | 0.0001 |
| 15 | 0.0005 | 0.0001 | 0.0002 | 0.0001 |
| 16 | 0.0005 | 0.0001 | 0.0002 | 0.0000 |
| 17 | 0.0005 | 0.0001 | 0.0002 | 0.0000 |
| 18 | 0.0005 | 0.0002 | 0.0003 | 0.0000 |
| 19 | 0.0005 | 0.0002 | 0.0003 | 0.0001 |
| 20 | 0.0006 | 0.0002 | 0.0003 | 0.0000 |
| 21 | 0.0005 | 0.0002 | 0.0002 | 0.0001 |
| 22 | 0.0006 | 0.0002 | 0.0002 | 0.0000 |
| 23 | 0.0006 | 0.0002 | 0.0002 | 0.0000 |
| 24 | 0.0005 | 0.0002 | 0.0002 | 0.0000 |
| 25 | 0.0005 | 0.0003 | 0.0003 | 0.0000 |
| 26 | 0.0005 | 0.0003 | 0.0003 | 0.0000 |
| 27 | 0.0006 | 0.0003 | 0.0003 | 0.0000 |

| | | | | |
|---|---|---|---|---|
| 28 | 0.0006 | 0.0003 | 0.0004 | 0.0001 |
| 29 | 0.0007 | 0.0003 | 0.0003 | 0.0001 |
| 30 | 0.0006 | 0.0004 | 0.0004 | 0.0001 |
| 31 | 0.0005 | 0.0003 | 0.0003 | 0.0001 |
| 32 | 0.0003 | 0.0002 | 0.0003 | 0.0000 |
| 33 | 0.0002 | 0.0002 | 0.0000 | 0.0001 |
| 34 | 0.0000 | 0.0001 | 0.0001 | 0.0001 |
| 35 | 0.0002 | 0.0000 | 0.0005 | 0.0003 |
| 36 | 0.0004 | 0.0001 | 0.0005 | 0.0003 |
| 37 | 0.0003 | 0.0001 | 0.0008 | 0.0004 |
| 38 | 0.0003 | 0.0000 | 0.0007 | 0.0004 |
| 39 | 0.0004 | 0.0001 | 0.0008 | 0.0004 |
| 40 | 0.0004 | 0.0000 | 0.0007 | 0.0004 |
| 41 | 0.0003 | 0.0000 | 0.0007 | 0.0004 |
| 42 | 0.0003 | 0.0000 | 0.0007 | 0.0004 |
| 43 | 0.0004 | 0.0000 | 0.0006 | 0.0004 |
| 44 | 0.0004 | 0.0000 | 0.0006 | 0.0004 |
| 45 | 0.0004 | 0.0000 | 0.0006 | 0.0004 |
| 46 | 0.0004 | 0.0000 | 0.0009 | 0.0004 |
| 47 | 0.0004 | 0.0000 | 0.0008 | 0.0004 |
| 48 | 0.0006 | 0.0000 | 0.0008 | 0.0004 |
| 49 | 0.0005 | 0.0000 | 0.0009 | 0.0004 |
| 50 | 0.0005 | 0.0000 | 0.0009 | 0.0004 |
| 51 | 0.0006 | 0.0000 | 0.0010 | 0.0004 |
| 52 | 0.0007 | 0.0000 | 0.0010 | 0.0004 |
| 53 | 0.0007 | 0.0000 | 0.0011 | 0.0004 |
| 54 | 0.0007 | 0.0000 | 0.0010 | 0.0003 |
| 55 | 0.0009 | 0.0000 | 0.0011 | 0.0003 |
| 56 | 0.0009 | 0.0000 | 0.0011 | 0.0003 |
| 57 | 0.0009 | 0.0000 | 0.0012 | 0.0003 |
| 58 | 0.0010 | 0.0000 | 0.0012 | 0.0003 |
| 59 | 0.0012 | 0.0001 | 0.0013 | 0.0003 |
| 60 | 0.0012 | 0.0001 | 0.0013 | 0.0003 |

Table 9: Chromatic Spatial Uniformity

**Spatial non-uniformity of chromaticity Δu'v': 0.0013**

## EQUIPMENT LIST

| Test Equipment | Model | Equipment No. | Calibration Date | Calibration Due date |
|---|---|---|---|---|
| Goniophotometer system | GO-R5000 | HZTE011-01 | Jul. 17, 2015 | Jul. 16, 2016 |
| Digital Power Meter | PF2010A | HZTE028-01 | Jul. 17, 2015 | Jul. 16, 2016 |
| AC Power Supply | PCR 500L | HZTE001-08 | Jul. 17, 2015 | Jul. 16, 2016 |
| DC Power Supply | WY12010 | HZTE004-03 | Jul. 17, 2015 | Jul. 16, 2016 |
| Temperature Meter | TES1310 | HZTE017-01 | Jul. 17, 2015 | Jul. 16, 2016 |
| Standard source | D908 | HZTE012-01 | Jul. 23, 2015 | Jul. 22, 2016 |
| Integrate Sphere system | 2M | HZTE015-01 | Jul. 16, 2015 | Jul. 15, 2016 |
| Digital Power Meter | WT210 | HZTE008-01 | Jul. 17, 2015 | Jul. 16, 2016 |
| AC Power Supply | PCR 500L | HZTE001-07 | Jul. 17, 2015 | Jul. 16, 2016 |
| DC Power Supply | 6154 | HZTE004-04 | Jul. 17, 2015 | Jul. 16, 2016 |
| Temperature and humidity recorder | JR900 | HZTE018-01 | Jul. 21, 2015 | Jul. 20, 2016 |
| Standard source | SCL-1400 | HZTE012-02 | Oct. 21, 2015 | Oct. 20, 2016 |

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 expended uncertainty is 1.06% 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 expended uncertainty is 1.94% with a coverage factor k=2.

**Color Characteristics Measurements**

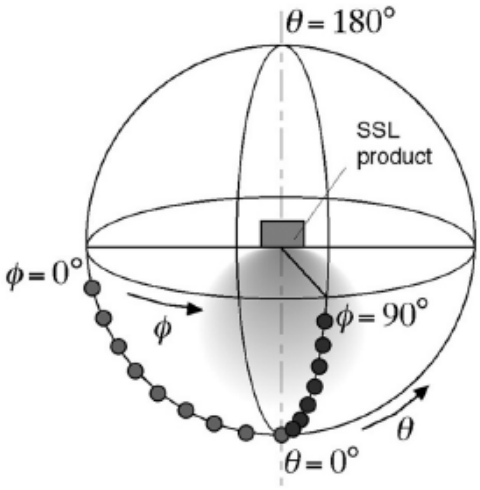
The color characteristics of SSL products include chromaticity coordinates, correlated color temperature, and color rendering index. These characteristics of SSL products may be spatially non-uniform, and thus, in order that they can be specified accurately, the color quantities shall be measured as 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°/180° and C=90°/270°) 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, Δu'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 ***