



**PHOTOMETRIC TESTING & EVALUATION TO IES LM-79-08**

Sample Tested  
**iMR1630230N-UUT3**

Prepared for:

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## Program Description

Photometric and electrical testing of an “iMR1630230N-UUT3” replacement lamp to IES LM-79-08.

## Executive Summary

Sample Tested = iMR1630230N-UUT3

| <b>Luminous Efficacy*</b><br><b>(Lumens/Watt)</b> | <b>Luminous Flux*</b><br><b>(Lumens)</b> | <b>Input Power*</b><br><b>(Watts)</b> | <b>Power Factor*</b> |
|---|--|---------------------------------------|----------------------|
| <b>79.79</b>                                      | <b>354.3</b>                             | <b>4.440</b>                          | <b>0.563</b>         |

| <b>CCT (K)*</b> | <b>CRI*</b> | <b>Stabilization Time</b><br><b>(Light &amp; Power)</b> |
|-----------------|-------------|---|
| <b>3016.7</b>   | <b>81</b>   | <b>36 minutes</b>                                       |

\* The above results are recorded / derived from measurements made using an Integrating Sphere



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**Sample**

The following sample was submitted for evaluation:

**MSI SSL – iMR1630230N-UUT3**



**iMR1630230N-UUT3**

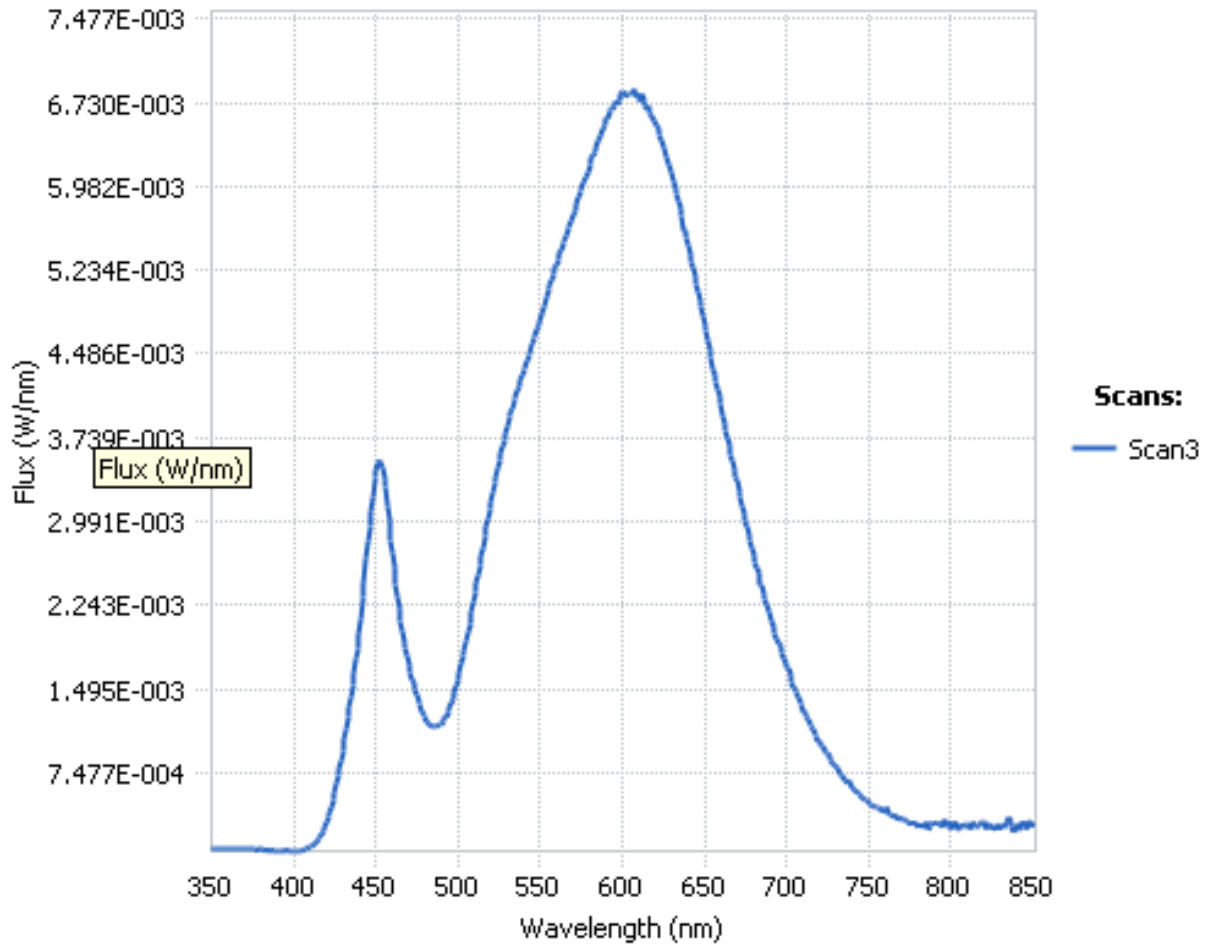


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| <b>Test Results –</b>   |   |                        |
|---|---|------------------------|
| The following results were measured after stabilization of the sample in the <b>Integrating Sphere</b> (unless otherwise stated). Stability is reached when the variation of 3 readings of light output and electrical power, taken 15 minutes apart, is less than 0.50% (in accordance with IES LM-79-08). |   |                        |
| <b>Key Photometric Results</b>  | <b>Sample Reference</b>                     |                        |
|   | <b>iMR1630230N-UUT3</b>                     |                        |
|   | <b>Integrating Sphere</b>                   | <b>Goniophotometer</b> |
| Luminous Efficacy (Lumens/Watt)   | <b>79.79</b>                                | <b>77.69</b>           |
| Total Luminous Flux (Lumens)  | <b>354.3</b>                                | <b>341.85</b>          |
| Total Radiant Flux (Watts)  | <b>4.440</b>                                |                        |
| Correlated Color Temperature (CCT)  | <b>3016.7</b>                               |                        |
| Color Rendering Index (CRI)   | <b>81</b>                                   |                        |
| R9 Value  | <b>14.7</b>                                 |                        |
| Chromaticity (Chroma x / Chroma y)  | <b>0.4352 / 0.4027</b>                      |                        |
| Chromaticity (Chroma u / Chroma v)  | <b>0.2500 / 0.3471</b>                      |                        |
| Chromaticity (Chroma u' / Chroma v')  | <b>0.2500/ 0.5206</b>                       |                        |
| D <sub>uv</sub> Value   | <b>-0.00028</b>                             |                        |
| Stabilization Time (Light and Power)  | <b>Approx. 47 minutes</b>                   |                        |
| Total Run Time – Integrating Sphere   | <b>51 minutes</b>                           |                        |
| Total Run Time – Goniophotometer  | <b>112 minutes</b>                          |                        |
| Spacing Criteria  | <b>0.38 (0° – 180°) / 0.40 (90° – 270°)</b> |                        |
| <b>Electrical Input Results:</b>  | <b>Sample Reference</b>                     |                        |
|   | <b>iMR1630230N-UUT3</b>                     |                        |
|   | <b>Integrating Sphere</b>                   | <b>Goniophotometer</b> |
| Input Power (Watts)   | <b>4.440</b>                                | <b>4.4</b>             |
| Input Voltage (Volts AC)  | <b>12.0</b>                                 | <b>12.0</b>            |
| Input Current (Amps)  | <b>0.656</b>                                | <b>0.665</b>           |
| Input Frequency (Hertz)   | <b>60.0</b>                                 | <b>60.0</b>            |
| Power Factor  | <b>0.563</b>                                | <b>0.551</b>           |
| <b>Additional Information</b>   | <b>Sample Reference</b>                     |                        |
|   | <b>iMR1630230N-UUT3</b>                     |                        |
| Ambient Temperature   | <b>25.3°C</b>                               |                        |
| Integrating Sphere Detector   | <b>CDS 600 Spectroradiometer</b>            |                        |
| Absorption Correction used?   | <b>Yes</b>                                  |                        |

**Spectral Flux**

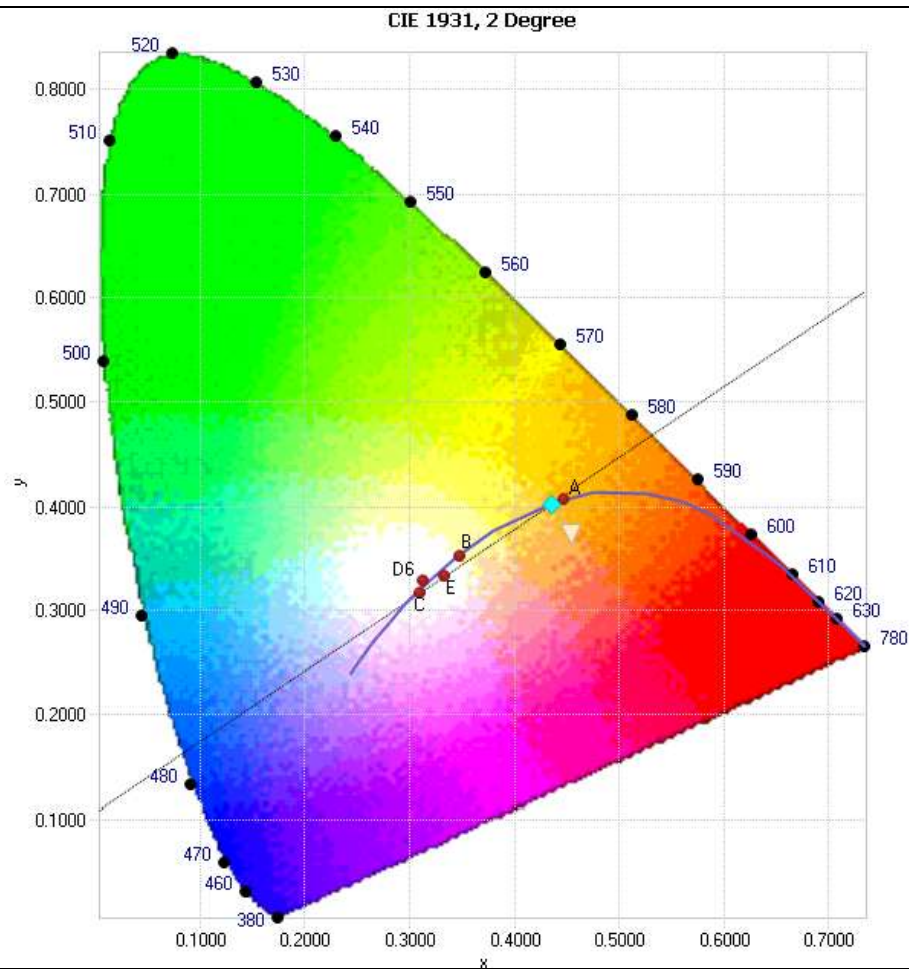
The following graph shows the spectral response curve of the radiant flux for the sample:



**Spectral response of the Radiant Flux**  
 (350nm to 850nm – calibrated range of the Spectroradiometer).

### Chromaticity Diagram

The following image shows the chromaticity diagram for the sample:



**Tristimulus values (from page 6):**  
 $x / y = 0.4352 / 0.4027$

The locations on the diagram of the tristimulus coordinates are indicated by the blue diamond.



**Test Results – Flux Distribution – Zonal Lumen Summary**

The following table depicts the zonal lumen distribution for the sample:

| <b>Zone</b>  | <b>Lumens</b>        | <b>% Total</b> |
|--------------|----------------------|----------------|
| 0 - 10       | 102.9                | 30.10%         |
| 10 - 20      | 110.9                | 32.40%         |
| 20 - 30      | 51.1                 | 14.90%         |
| 30 - 40      | 28.9                 | 8.40%          |
| 40 - 50      | 17.7                 | 5.20%          |
| 50 - 60      | 11.8                 | 3.50%          |
| 60 - 70      | 8                    | 2.30%          |
| 70 - 80      | 4.4                  | 1.30%          |
| 80 - 90      | 1.6                  | 0.50%          |
| 90 - 100     | 0.7                  | 0.20%          |
| 100 - 110    | 0.6                  | 0.20%          |
| 110 - 120    | 0.7                  | 0.20%          |
| 120 - 130    | 0.6                  | 0.20%          |
| 130 - 140    | 0.4                  | 0.10%          |
| 140 - 150    | 0.4                  | 0.10%          |
| 160 - 170    | 0.5                  | 0.10%          |
| 170 - 180    | 0.5                  | 0.10%          |
| <b>Total</b> | <b>341.85 Lumens</b> | <b>100%</b>    |

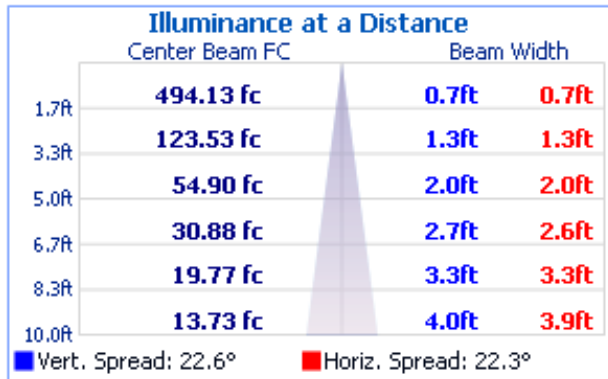
**Zonal Lumen Summary**

| <b>Zone</b> | <b>Lumens</b> | <b>% Lamp / Luminaire</b> |
|-------------|---------------|---------------------------|
| 0 - 60      | 323.3         | 94.6 %                    |
| 60 - 90     | 14.1          | 4.1 %                     |
| 0 - 90      | 337.4         | 98.7 %                    |
| 90 - 180    | 4.4           | 1.3 %                     |
| 0 - 180     | 341.9         | 100 %                     |

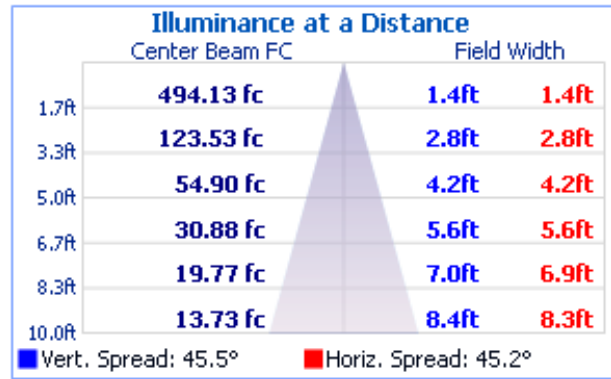


**Test Results – Illuminance Plots**

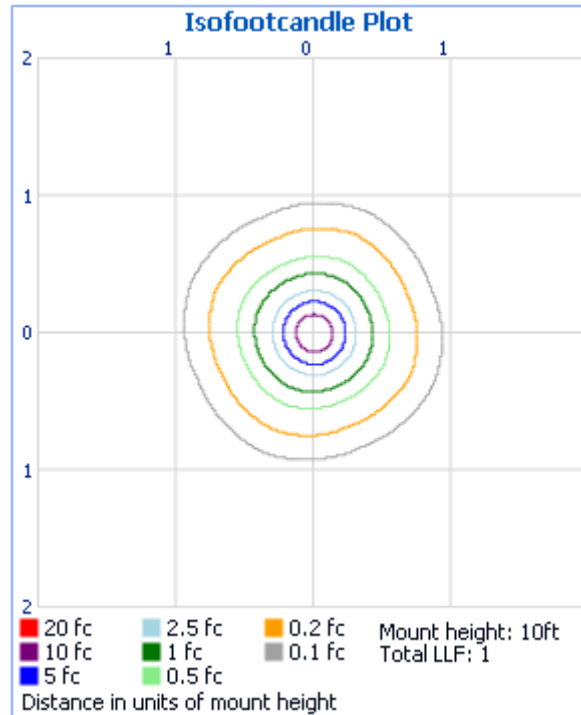
The following images depict the illuminance characteristics of the luminaire.



Beam Angle



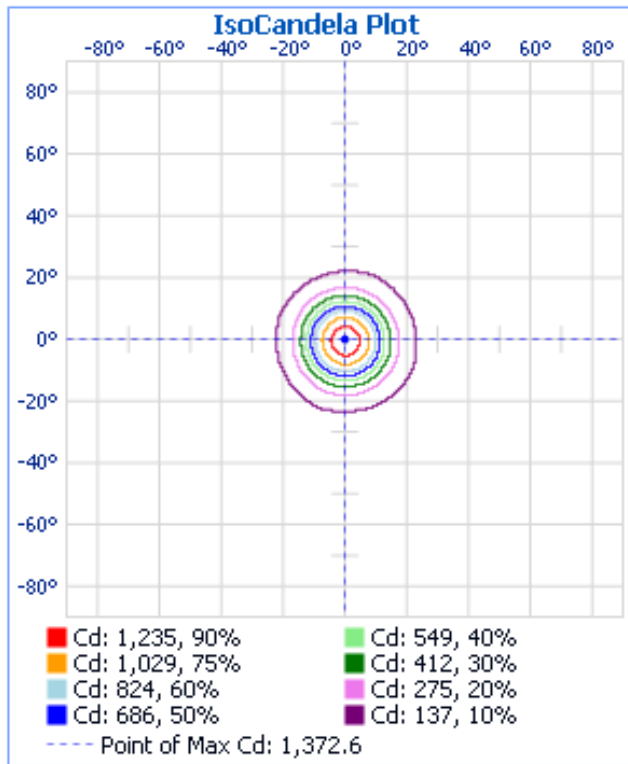
Field Angle



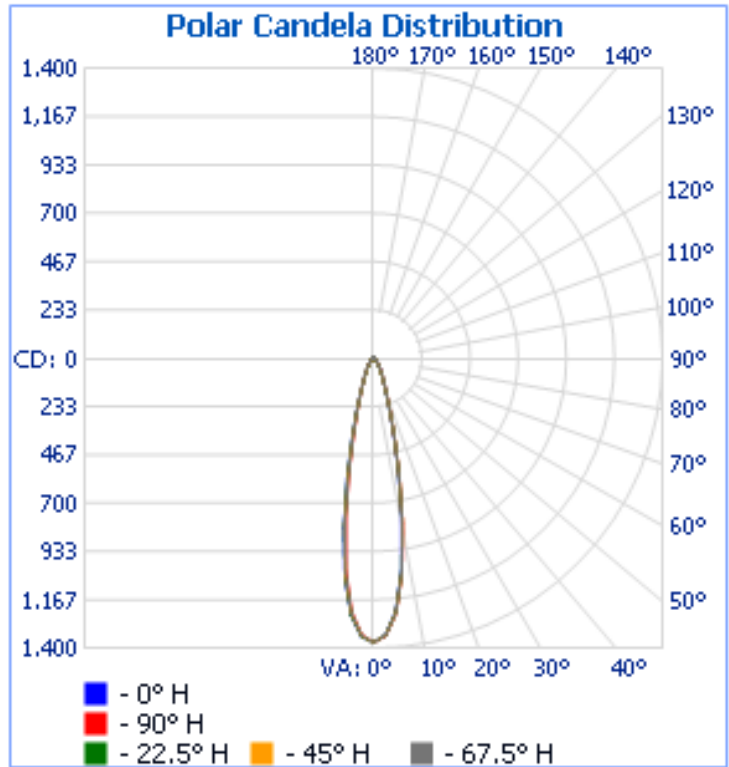
Illuminance Plot (Footcandles)

**Test Results – Candela Plots**

The following images depict the luminous intensity distribution characteristics of the luminaire.



Isocandela Plot



Polar Candela Distribution



**Test Results – Candela Tabulation**

The following table provides the tabulated Candela measurements:

|      | 0.0  | 22.5 | 45.0 | 67.5 | 90.0 | 112.5 | 135.0 | 157.5 | 180.0 | 202.5 | 225.0 | 247.5 | 270.0 | 292.5 | 315.0 | 337.5 | 360.0 |
|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.0  | 1373 | 1373 | 1373 | 1373 | 1373 | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  | 1373  |
| 2.5  | 1336 | 1338 | 1340 | 1341 | 1342 | 1344  | 1345  | 1345  | 1345  | 1344  | 1342  | 1340  | 1337  | 1336  | 1334  | 1334  | 1335  |
| 5.0  | 1227 | 1231 | 1233 | 1236 | 1237 | 1240  | 1242  | 1246  | 1247  | 1245  | 1239  | 1234  | 1228  | 1223  | 1221  | 1223  | 1226  |
| 7.5  | 1034 | 1040 | 1046 | 1047 | 1050 | 1055  | 1062  | 1067  | 1069  | 1063  | 1056  | 1045  | 1033  | 1022  | 1024  | 1027  | 1033  |
| 10.0 | 786  | 794  | 801  | 804  | 806  | 814   | 822   | 830   | 832   | 823   | 810   | 798   | 780   | 769   | 770   | 777   | 785   |
| 12.5 | 551  | 559  | 565  | 567  | 569  | 577   | 585   | 593   | 593   | 585   | 571   | 558   | 542   | 534   | 535   | 541   | 550   |
| 15.0 | 373  | 378  | 382  | 383  | 382  | 389   | 397   | 404   | 405   | 399   | 390   | 381   | 371   | 362   | 360   | 362   | 367   |
| 17.5 | 251  | 252  | 255  | 257  | 258  | 261   | 270   | 279   | 281   | 277   | 271   | 267   | 259   | 250   | 248   | 250   | 251   |
| 20.0 | 179  | 177  | 180  | 184  | 183  | 182   | 191   | 199   | 199   | 195   | 194   | 194   | 188   | 179   | 179   | 181   | 179   |
| 22.5 | 133  | 130  | 134  | 137  | 136  | 134   | 141   | 148   | 147   | 143   | 144   | 147   | 141   | 134   | 134   | 137   | 133   |
| 25.0 | 103  | 98   | 102  | 107  | 105  | 103   | 108   | 115   | 113   | 108   | 110   | 115   | 109   | 102   | 103   | 108   | 103   |
| 27.5 | 81   | 76   | 80   | 85   | 83   | 80    | 85    | 92    | 89    | 84    | 87    | 91    | 86    | 80    | 82    | 86    | 81    |
| 30.0 | 65   | 60   | 63   | 69   | 67   | 64    | 68    | 74    | 71    | 67    | 70    | 74    | 69    | 63    | 65    | 69    | 65    |
| 32.5 | 53   | 48   | 51   | 57   | 54   | 51    | 55    | 61    | 58    | 54    | 57    | 61    | 56    | 51    | 53    | 56    | 52    |
| 35.0 | 43   | 39   | 42   | 47   | 45   | 42    | 45    | 51    | 48    | 44    | 47    | 51    | 46    | 42    | 44    | 46    | 43    |
| 37.5 | 36   | 33   | 35   | 39   | 37   | 35    | 38    | 42    | 40    | 37    | 39    | 42    | 39    | 35    | 36    | 39    | 36    |
| 40.0 | 30   | 27   | 29   | 33   | 31   | 29    | 32    | 36    | 33    | 31    | 33    | 36    | 32    | 29    | 30    | 32    | 30    |
| 42.5 | 25   | 23   | 25   | 28   | 26   | 24    | 27    | 30    | 28    | 26    | 28    | 30    | 27    | 24    | 25    | 27    | 25    |
| 45.0 | 21   | 20   | 21   | 23   | 22   | 21    | 23    | 25    | 24    | 22    | 24    | 25    | 23    | 21    | 22    | 23    | 21    |
| 47.5 | 18   | 17   | 18   | 20   | 19   | 18    | 20    | 22    | 20    | 19    | 20    | 22    | 20    | 18    | 19    | 19    | 18    |
| 50.0 | 16   | 15   | 16   | 17   | 16   | 16    | 17    | 18    | 18    | 17    | 18    | 18    | 17    | 16    | 16    | 17    | 16    |
| 52.5 | 14   | 14   | 14   | 15   | 14   | 14    | 15    | 16    | 15    | 15    | 15    | 16    | 15    | 14    | 14    | 15    | 14    |
| 55.0 | 12   | 12   | 12   | 13   | 13   | 13    | 13    | 14    | 14    | 13    | 14    | 14    | 13    | 13    | 13    | 13    | 12    |
| 57.5 | 11   | 11   | 11   | 12   | 11   | 11    | 12    | 12    | 12    | 12    | 12    | 13    | 12    | 12    | 11    | 12    | 11    |
| 60.0 | 10   | 10   | 10   | 10   | 10   | 10    | 10    | 11    | 11    | 11    | 11    | 11    | 11    | 10    | 10    | 10    | 10    |
| 62.5 | 9    | 9    | 9    | 9    | 9    | 9     | 9     | 10    | 10    | 9     | 10    | 10    | 9     | 9     | 9     | 9     | 9     |
| 65.0 | 8    | 8    | 8    | 8    | 8    | 8     | 8     | 8     | 8     | 8     | 8     | 9     | 8     | 8     | 8     | 8     | 8     |
| 67.5 | 7    | 7    | 7    | 7    | 7    | 7     | 7     | 7     | 7     | 7     | 7     | 8     | 7     | 7     | 7     | 7     | 7     |
| 70.0 | 6    | 6    | 6    | 6    | 6    | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     | 6     |
| 72.5 | 5    | 5    | 5    | 5    | 5    | 5     | 5     | 5     | 5     | 5     | 5     | 5     | 5     | 5     | 5     | 5     | 5     |
| 75.0 | 4    | 4    | 4    | 4    | 4    | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     | 4     |
| 77.5 | 3    | 3    | 3    | 3    | 3    | 3     | 3     | 3     | 4     | 3     | 3     | 3     | 3     | 3     | 3     | 3     | 3     |
| 80.0 | 2    | 3    | 3    | 3    | 3    | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 3     | 3     | 3     | 2     | 2     |
| 82.5 | 2    | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 85.0 | 1    | 2    | 2    | 2    | 2    | 2     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 87.5 | 1    | 1    | 1    | 1    | 1    | 1     | 1     | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 90.0 | 1    | 1    | 1    | 1    | 1    | 1     | 1     | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |

Continued.....



**Test Results – Candela Tabulation Cont.**

|       | 0.0 | 22.5 | 45.0 | 67.5 | 90.0 | 112.5 | 135.0 | 157.5 | 180.0 | 202.5 | 225.0 | 247.5 | 270.0 | 292.5 | 315.0 | 337.5 | 360.0 |
|-------|-----|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 92.5  | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 95.0  | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 97.5  | 0   | 1    | 1    | 1    | 1    | 1     | 1     | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 0     |
| 100.0 | 0   | 1    | 1    | 1    | 0    | 1     | 1     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 0     |
| 102.5 | 0   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 0     |
| 105.0 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 107.5 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 110.0 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 112.5 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 115.0 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 117.5 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 120.0 | 1   | 1    | 1    | 1    | 1    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 122.5 | 1   | 1    | 1    | 1    | 0    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 125.0 | 1   | 1    | 1    | 1    | 0    | 1     | 1     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 127.5 | 1   | 1    | 1    | 1    | 0    | 1     | 1     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 1     | 1     | 1     |
| 130.0 | 1   | 1    | 1    | 0    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 1     | 1     | 1     |
| 132.5 | 1   | 1    | 1    | 0    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0     | 1     | 1     | 1     | 1     |
| 135.0 | 1   | 1    | 1    | 0    | 0    | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 137.5 | 1   | 1    | 1    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 140.0 | 1   | 1    | 1    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 142.5 | 1   | 1    | 1    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 145.0 | 1   | 1    | 1    | 0    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 147.5 | 1   | 1    | 1    | 1    | 0    | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     |
| 150.0 | 1   | 1    | 1    | 1    | 0    | 0     | 0     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 152.5 | 2   | 1    | 1    | 1    | 1    | 1     | 0     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 2     |
| 155.0 | 2   | 2    | 1    | 1    | 1    | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 2     |
| 157.5 | 2   | 2    | 1    | 1    | 1    | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 2     | 2     |
| 160.0 | 2   | 2    | 2    | 1    | 1    | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 2     | 2     |
| 162.5 | 2   | 2    | 2    | 2    | 1    | 1     | 1     | 1     | 1     | 1     | 1     | 2     | 2     | 2     | 2     | 2     | 2     |
| 165.0 | 2   | 2    | 2    | 2    | 2    | 2     | 1     | 1     | 1     | 1     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 167.5 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 1     | 1     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 170.0 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 172.5 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 175.0 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 177.5 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     |
| 180.0 | 2   | 2    | 2    | 2    | 2    | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 0     |

### Photometric Testing Information

The sample was evaluated for photometric and electrical characteristics using an integrating sphere and a goniophotometer, each located in purpose-built, temperature and humidity-controlled, draft free environments.

The integrating sphere is a 76-inch diameter sphere manufactured by Labsphere (Model# LMS760) which exhibits a “ $4\pi$  geometry” configuration according to IES LM-79-08 and is applicable for all types of LED products (directional and non-directional light projections). Its spectroradiometer is an array-type detector manufactured and calibrated by Labsphere (Model# CDS600).

The integrating sphere uses self-absorption correction to eliminate errors due to mismatches between the standard reference lamp and the test samples being measured. The auxiliary lamp used to perform this task is a halogen type lamp powered by a calibrated *Lamp Power Supply* manufactured and calibrated by Labsphere (model LPS 200). Ambient temperature (for photometric analysis) is measured using a “J-Type” thermocouple located inside the integrating sphere at the same height as the sample under test and not more than 1 meter in horizontal distance away from the sample. The thermocouple is located behind the baffle of the photo detector in order to eliminate any direct optical radiation from the sample under test.

#### Luminaire Stabilization.

The sample was placed inside the integrating sphere and powered by a regulated and conditioned 12.0 Volt, alternating current supply. The correlated color temperature, color rendering index, chromaticity coordinates and electrical power measurements contained in this report are the numeric **averages** of the three readings upon which stabilization is verified. The stabilization times shown on the results pages of this report denote the time of the 1<sup>st</sup> measurement (of the 3 consecutive readings) since this is the minimum time that the sample is assumed to have taken to reach stabilization.

The integrating sphere is calibrated using a quartzline halogen lamp with the following specifications:

Manufacturer: Sylvania

Model# 75Q/CL-28V

Voltage = 28.0 Volt

Wattage = 75.0 Watts

Calibration Current = 2.679 Amperes

Luminous Flux = 1538.8 Lumens

Calibration Date = 8-18-2005 (calibrated by Labsphere – NIST traceable).

Continued.....

**Photometric Testing Information (continued)**

The goniophotometer is calibrated using a frosted tungsten filament FDS/DZE lamp with the following specifications:

Manufacturer: General Electric  
 Part Number: CSB-110  
 Bulb Number: 108-A  
 Voltage: 24.0 Volts  
 Wattage: 150.0 Watts  
 Calibration Current: 4.799 Amperes  
 Luminous Intensity: 150.3 Candelas  
 Calibration Date: 4-14-2009 (NIST traceable)

A *Power Analyzer* was used to measure all electrical characteristics of the sample.

CSA is an accredited Test Laboratory (TL-430)  
 to IESNA LM79-08 by IAS  
 (International Accreditation Service)



**Equipment List:**

| Description                | Manufacturer and Model Number | CSA Instrument Reference Number | Calibration Due Date |
|----------------------------|-------------------------------|---------------------------------|----------------------|
| Integrating Sphere 76"     | Labsphere LMS760              | SPH200                          | N/A                  |
| Spectroradiometer          | Labsphere CDS600              | CDS600                          | 5/2012               |
| Auxiliary Lamp PSU         | Labsphere LPS200              | LPS200                          | 2/2012               |
| Power Analyzer             | Yokogawa WT210                | PA111                           | 1/2012               |
| Power Analyzer             | Yokogawa WT210                | PA108                           | 5/2012               |
| Regulated Power Supply     | Chroma Instruments 61603      | AC303                           | N/A                  |
| Regulated Power Supply     | Chroma Instruments 61602      | AC301                           | N/A                  |
| Thermometer (Thermocouple) | Fluke 52                      | TH100                           | 8/2011               |

All equipment is calibrated by TMI (Technical Maintenance, Inc.) ISO / IEC 17025-2005 Accredited (Cert. 1378.01) except: Labsphere CDS600 which is calibrated by Labsphere, USA.