INTEGRATING SPHERE PHOTOMETRY

Integrating Sphere Photometer Light Measurement Guides

LM-9: IESNA Approved Method for the Electrical and Photometric Measurements of Fluorescent Lamps

LM-20: IESNA Approved Method for Photometric Testing of Reflector-Type Lamps

LM-45: IESNA Approved Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps

LM-51: IESNA Electrical and Photometric Measurements of High Intensity Discharge Lamps

LM-54: IESNA Lamp Seasoning

LM-58: IESNA Guide to Spectroradiometric Measurements

LM-59: IESNA Approved Method for the Electrical and Photometric Measurements of Low Pressure Sodium Lamps

LM-66: IESNA Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps

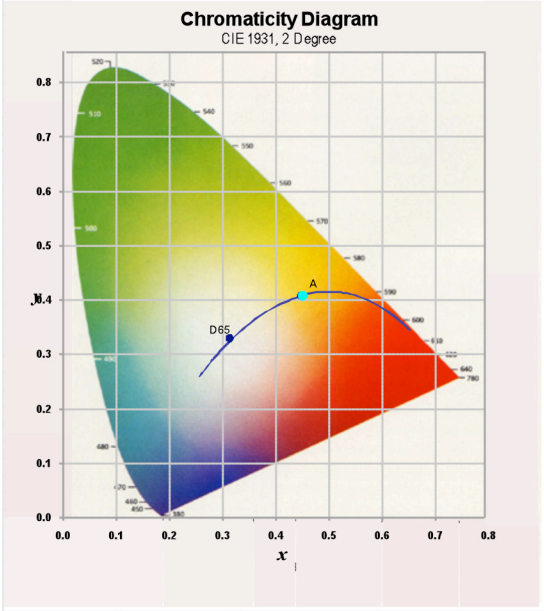
LM-78: IESNA Approved Method for Total Luminous Flux Measurement of Lamps Using an Integrating Sphere Photometer

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

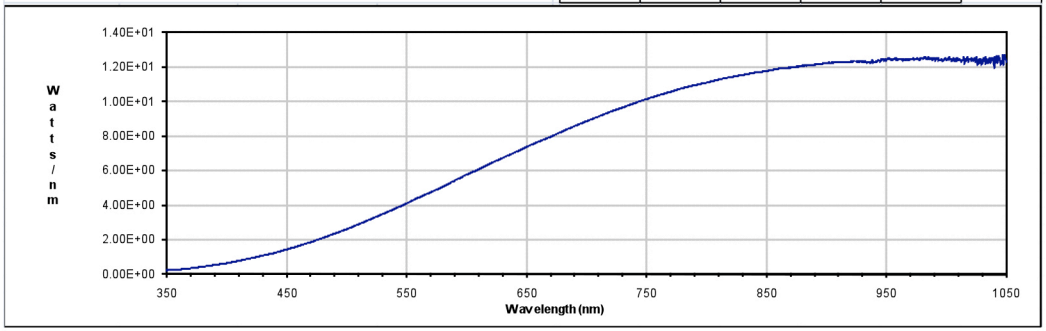
LM-80: IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources

Example of Reference Lamps Calibration Certificate

Radiant Flux (mW)	Luminous Flux (lumens)	Correlated Color Temp. (deg. K)	Color Rendering Index Avg. RA
5354	326	2825	99
Chromaticity coord x	Chromaticity coord y	Chromaticity coord u	Chromaticity coord v
0.4498	0.4079	0.2572	0.3499



Wavelength (nm)	Spectral Flux (mW/nm)	TSRF Uncertainty, k=2 (%)	Wavelength (nm)	Spectral Flux (mW/nm)	TSRF Uncertainty, k=2 (%)
350	2.28E-01	2.33	710	9.12E+00	1.64
360	2.61E-01	2.22	720	9.41E+00	1.64
370	3.46E-01	2.14	730	9.65E+00	1.64
380	4.30E-01	1.98	740	9.90E+00	1.64
390	5.40E-01	1.98	750	1.01E+01	1.64
400	6.34E-01	1.90	760	1.04E+01	1.64
410	7.72E-01	1.90	770	1.06E+01	1.64
420	9.21E-01	1.83	780	1.08E+01	1.64
430	1.08E+00	1.83	790	1.09E+01	1.64
440	1.23E+00	1.83	800	1.11E+01	1.64
450	1.43E+00	1.77	810	1.13E+01	1.64
460	1.63E+00	1.77	820	1.14E+01	1.64
470	1.85E+00	1.77	830	1.16E+01	1.64
480	2.09E+00	1.77	840	1.17E+01	1.71
490	2.35E+00	1.77	850	1.18E+01	1.71
500	2.59E+00	1.77	860	1.19E+01	1.71
510	2.89E+00	1.70	870	1.20E+01	1.71
520	3.18E+00	1.70	880	1.21E+01	1.71
530	3.48E+00	1.70	890	1.21E+01	1.71
540	3.78E+00	1.70	900	1.22E+01	1.71
550	4.09E+00	1.70	910	1.23E+01	1.71
560	4.44E+00	1.70	920	1.23E+01	1.71
570	4.73E+00	1.70	930	1.23E+01	1.71
580	5.05E+00	1.70	940	1.23E+01	1.71
590	5.41E+00	1.70	950	1.24E+01	1.71
600	5.76E+00	1.64	960	1.25E+01	1.71
610	6.07E+00	1.64	970	1.24E+01	1.71
620	6.41E+00	1.64	980	1.25E+01	1.71
630	6.72E+00	1.64	990	1.25E+01	1.71
640	7.04E+00	1.64	1000	1.24E+01	1.71
650	7.38E+00	1.64	1010	1.24E+01	1.71
660	7.67E+00	1.64	1020	1.24E+01	1.71
670	7.94E+00	1.64	1030	1.23E+01	1.71
680	8.26E+00	1.64	1040	1.19E+01	1.71
690	8.57E+00	1.64	1050	1.23E+01	1.71
700	8.85E+00	1.64			



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Lamp Measurement Theory

$$\Phi_{TEST}(\lambda) = \Phi_{REF}(\lambda) \cdot \frac{y_{TEST}(\lambda)}{y_{REF}(\lambda)} \cdot \frac{1}{\alpha(\lambda)}$$

$\Phi_{TEST}(\lambda)$ of a lamp under test is obtained by comparison to that of a reference standard $\Phi_{REF}(\lambda)$

y_{TEST} and y_{REF} are the spectroradiometer readings for lamp under test and for reference standard, respectively,

$\alpha(\lambda)$ is the self-absorption factor

$$\alpha(\lambda) = \frac{y_{aux,TEST}(\lambda)}{y_{aux,REF}(\lambda)}$$

$y_{aux,TEST}(\lambda)$ and $y_{aux,REF}(\lambda)$ are the spectroradiometer readings for the auxiliary lamp when the lamp under test or the reference total spectral radiant standard, respectively, are mounted in or on the sphere

From the measured total spectral radiant flux $\Phi_{TEST}(\lambda)$ [W/nm], the total luminous flux Φ_{TEST} [lm] is obtained by

$$\Phi_{TEST} = K_m \int_\lambda \Phi_{TEST}(\lambda) V(\lambda)\, d\lambda$$

$$(K_m = 683 \text{ lm/W})$$

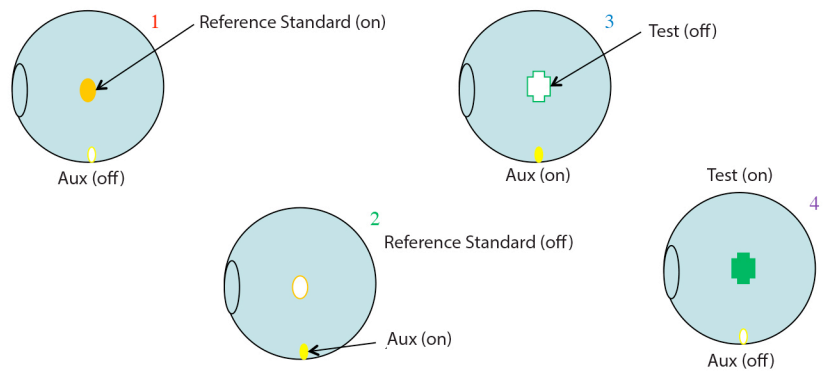
Practical Principles

- Recalibration frequency depends on usage and keeping the sphere in good shape.
- Have at least three master standards and transfer to at least 3 working standards for daily use.
- The DC voltage or current shall be regulated to within ±" 0.02 percent.
- The instrument (integrating sphere plus spectroradiometer) shall be calibrated against total spectral radiant flux standards traceable to a National Measurement Institute (NMI).

In the 4π geometry, as a guideline, the total surface area of the lamp should be less than 2% of the total area of the sphere wall. The longest physical dimension of a linear product should be less than 2/3 of the diameter of the sphere.

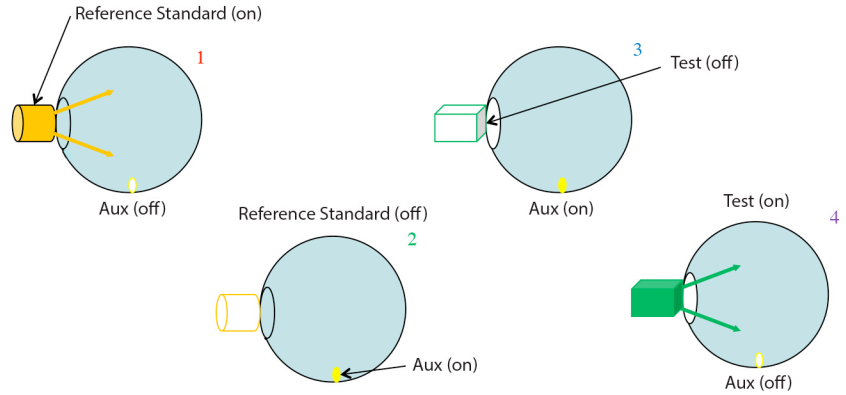
In the 2π geometry, the opening diameter to mount a lamp should be less than 1/3 of the diameter of the sphere.

4π Measurement Geometry



$$\Phi_{TEST}(\lambda) = \Phi_{REF}(\lambda) \cdot \frac{y_{TEST}(\lambda)}{y_{REF}(\lambda)} \cdot \frac{1}{\alpha(\lambda)}$$

2π Measurement Geometry



$$\Phi_{TEST}(\lambda) = \Phi_{REF}(\lambda) \cdot \frac{y_{TEST}(\lambda)}{y_{REF}(\lambda)} \cdot \frac{1}{\alpha(\lambda)}$$

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