USC-SR
CALIBRATION CERTIFICATE

RENDERED TO: University of Pennsylvania

AUTHORIZATION: Purchase Order : 3374508

CALIBRATION LAB: Labsphere, Inc., Optical Calibration Laboratory
231 Shaker Street
North Sutton, N.H. 03260
Tel 603-927-4266 Fax 603-927-4694

CALIBRATED SYSTEM OR STANDARD
Unisource 600, SN# 001399

CALIBRATION REQUESTED
USC-SR, Spectral Radiance from 0.300µm to 2.400µm

APPLICABLE DOCUMENTS
QP-13001-000 Product Appearance and Mechanical-fit Requirements.
DM-02025-000 Spectral Radiance Calibration of a Uniform Source System

TEST AND TEST METHOD
The spectral radiance of the sphere is calibrated with equipment and methods traceable to the U.S. National Institute of Standards and Technology (NIST).

The calibration is accomplished by referencing FEL type tungsten halogen lamp standard of irradiance which irradiates a diffusely reflecting Spectralon standard. The standard becomes the reference source of radiance. The measuring instrument used to perform the calibration is a scanning, dispersive spectroradiometer. The radiance of the Spectralon standard is transferred to the diffraction grating monochromator with a four mirror input optics system. Long pass order sorting filters are used at the entrance slit to reduce stray light. A mechanical chopper provides a modulated reference signal. The complete spectral measurement range requires two photodetectors and three diffraction gratings. In the spectral region from 0.300µm to 0.375µm, a 1200 grooves/mm holographic grating is used with a silicon detector. From 0.375µm to 1.100µm, a 1200 grooves/mm, 500nm blaze grating is used with a silicon detector. In the spectral region from 1.100µm to 2.400µm, a 600 grooves/mm, 1.6µm grating is used with a thermoelectrically cooled InAs detector. Signal conditioning electronics include low noise, high impedance preamplifiers and a single-phase lock-in amplifier. Instrument calibration is performed by viewing the diffuse standard illuminated by the calibrated lamp of known spectral irradiance. After scanning the diffuse standard, it is replaced with the integrating sphere and the measurement process is repeated. The measured field-of-view is 10mm x 4mm with an aperture ratio of f/4. Spectral measurements are performed for this field of view positioned at the center of the plane of the diffuse standard.

The calibration was performed with the Unisource 600 operating as follows:

External fiber light source coupled at 6 o'clock port

Photopic silicon detector mounted at detector wedge

Nothing installed at exit port

NATIONAL LABORATORY TRACEABLE STANDARD(S): note only 1 Working Lamp Standard and 1 Working Reflectance Standard are used in a calibration

Generation	Standard	Report/File number	Calibration Date	
1a	REFL-01	685/281167-11	August 18, 2011	Labsphere primary standard of absolute spectral reflectance
1b	F-652	685/280517-11	April 14,2011	Labsphere primary standard of spectral irradiance
2a	REFL-27	99AA05-0314-8957	April 24, 2014	Labsphere working standard or absolute spectral reflectance
2b	F-1285 through F-1290	F-1285-1 through F-1290-1	May 1, 2014	Labsphere working standard of spectral irradiance

LABORATORY ENVIRONMENT
Temperature: 22 ±2°C

CALIBRATION RESULTS
See Table I, Spectral Radiance

CALIBRATION UNCERTAINTY
See Table II "Estimated Spectroradiometer Uncertainty"

CALIBRATION INTERVAL
If the system is handled with care, recalibration is recommended one year after the date of this certificate, at the discretion of the user

ISO 9001 REGISTERED

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Table I
Spectral Radiance
***Signal beyond 1300nm is too low for measurement**
**** "Foot-Lambert Reading" is only a reference. It does not equate to a true fL value**

	Unisource-600
Wavelength	Spectral Radiance
(um)	(mW/cm2-sr-um)
0.300	7.70E-04
0.310	8.92E-04
0.320	9.39E-04
0.330	8.68E-04
0.340	1.11E-03
0.350	1.37E-03
0.400	6.13E-01
0.450	2.17E+00
0.500	4.57E+00
0.555	7.49E+00
0.600	9.30E+00
0.655	1.15E+01
0.700	9.49E+00
0.800	4.96E-01
0.900	2.09E-01
1.050	1.31E+00
1.150	9.42E-01
1.200	1.90E+00
1.300	1.23E+00
1.540	*
1.600	*
1.700	*
2.000	*
2.100	*
2.300	*
2.400	*
Foot-Lambert Reading	9.10E+02

Calibrated by: Luke Labranche
Date: 06/10/15

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Table II
Estimated Spectroradiometer Uncertainty

Transfer uncertainty of our secondary standards relative to the National Institute of Standards and Technology (NIST) scale is estimated as follows:

Wavelength (nm)	NIST Spectral Irradiance Standard k=2 (%)	Transfer Uncertainty to Sphere k=2 (%)	Total Rel. Uncertainty k=2 (%)
250	1.74	4.94	5.24
350	1.27	3.42	3.65
450	0.91	0.57	1.07
555	0.77	0.28	0.82
654.6	0.69	0.40	0.80
900	0.57	0.67	0.88
1600	0.47	0.58	0.75
2000	0.50	0.72	0.88
2300	0.49	0.72	0.87
2400	1.11	0.57	1.25

This accuracy statement assumes similar geometric use of the standards by the customer and does not account for drift with time and use for the individual items issued.