Measurement of SSL products and NVLAP accreditation

Cameron Miller
Optical Technology Division
NIST

Outline

What is laboratory accreditation? What is NVLAP?

Energy Efficient Lighting Program

LM-79 and LM-80 specifics

NVLAP SSL Proficiency Testing

Summary

Accreditation versus Certification

Accreditation: procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks.

Accreditation is used to verify that laboratories have an appropriate quality management system and can properly perform certain test methods and calibration parameters according to their scopes of accreditation.

Certification: procedure by which a third party gives written assurance (certificate of conformity) that a product, process or service conforms to specified requirements.

Certification is used for verifying that personnel have adequate credentials to practice certain disciplines, as well as for verifying that products meet certain requirements.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*.

National Voluntary Laboratory Accreditation Program

- A process for accreditation of testing and calibration laboratories
- Established in 1976
- Procedures set out in the U.S.Code of Federal Regulations (Part 285, Title 15)
- Linked to NIST measurement research
- Based on ISO/IEC standards
- Fee based system, available to any qualifying laboratory

NVLAP®

Sally S. Bruce, Chief

www.nist.gov/nvlap

ISO/IEC 17011, *Conformity assessment — General requirements for accreditation bodies accrediting conformity assessment bodies, 2004.*

ILAC Mutual Recognition Arrangement

International Laboratory Accreditation Cooperation

Signatories to the ILAC Arrangement for testing and/or calibration recognize with mutual confidence one another's accreditations within each signatory's scope of recognition under this Arrangement.

http://www.ilac.org/documents/pub_Ilac-p5.pdf

"The purpose of the ILAC Arrangement is to develop a global network of accredited testing and calibration laboratories that can be relied on to provide accurate results."

Why participate in accreditation?

Recognition of Testing Competence

means for customers to identify and select reliable testing, measurement and calibration services

Benchmark for Performance

laboratories operate in isolation to their peers, and rarely receive any independent evaluation

Marketing Advantage

accreditation bodies also publish a directory of their accredited laboratories

International Recognition for your Laboratory

Do my customers require an accredited laboratory?

Regulation of products – EPAct and EnergyStar

Outline

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Summary

History

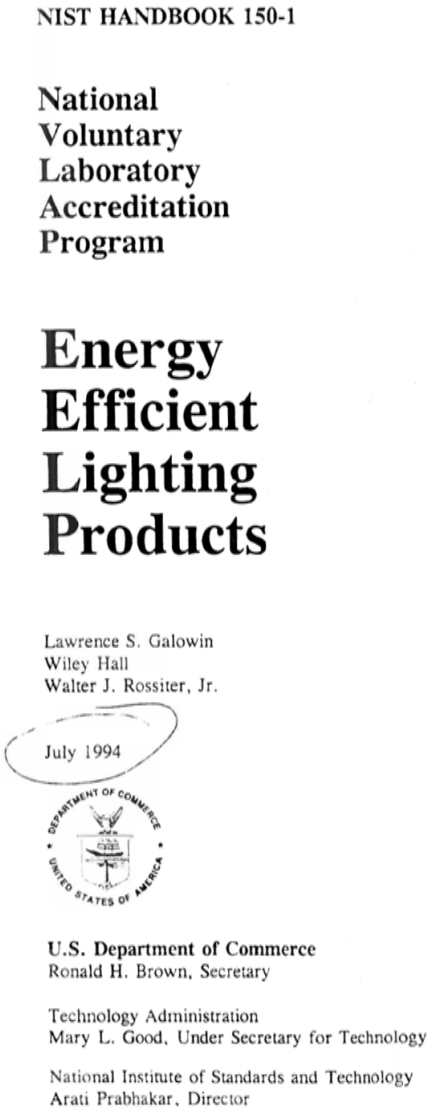
Handbook 150-1 “Energy Efficient Lighting Products”

July 1994

Public Law 102-486, “Energy Policy Act of 1992” (October 24, 1992) Required DOE to specify energy efficient standards for certain types of fluorescent and incandescent reflector lamps.

Test procedures for determining energy efficiency are to be prescribed by DOE, and are to be conducted by accredited laboratories using applicable IES or ANSI standards.

The Lighting Equipment Division of NEMA requested that NVLAP establish an accreditation program for laboratories that test certain types of lamps and luminaires.


NIST HANDBOOK 150-1

National
Voluntary
Laboratory
Accreditation
Program

Energy
Efficient
Lighting
Products

Lawrence S. Galowin
Wiley Hall
Walter J. Rossiter, Jr.

July 1994

U.S. Department of Commerce
Ronald H. Brown, Secretary

Technology Administration
Mary L. Good, Under Secretary for Technology

National Institute of Standards and Technology
Arati Prabhakar, Director

EEL Products LAP - Update

NVLAP®	**DEPARTMENT OF COMMERCE** National Institute of Standards and Technology National Voluntary Laboratory Accreditation Program	**ISSUE DATE:** March 5, 2009
	LAB BULLETIN	**NUMBER:** LB-38-2009 **LAP:** Energy Efficient Lighting Products
SUBJECT: Changes to Energy Efficient Lighting Products LAP		

This bulletin announces four changes in the NVLAP Energy Efficient Lighting Products (EEL) Program:

1) the EEL Test Method Selection List has been revised and expanded;
2) several changes to NIST Handbook 150-1 have been made and are published in this bulletin;
3) the Program-Specific Checklist for NIST Handbook 150-1 has been revised;
4) Solid State Lighting (SSL) test methods have been added to the EEL Program.

EEL Products Test Method Selection List

ENERGY EFFICIENT LIGHTING PRODUCTS
TEST METHOD SELECTION LIST

Instruction: Check each test method for which you are requesting accreditation. Laboratories should consider selecting those test methods for which they are seeking regulatory acceptance of their test reports.

An asterisk beside the NVLAP Test Method Code indicates that proficiency testing is required. Notification will be given for the required proficiency testing by NVLAP and/or a NVLAP contractor.

NVLAP Test Method Code	*Test Method Designation*	*Short Title*
Lamps (NIST Handbook 150-1 Test Methods)		
Color Measurements		
_____ 22/C02*	IES LM-58:1994	Spectroradiometric Measurements
_____ 22/C03	CIE Pub. 13.3:1995	Method of Measuring and Specifying Color Rendering of Light Sources
_____ 22/C04	CIE Pub. 13.2:1974	Method of Measuring and Specifying Color Rendering of Light Sources
Electrical Measurements		
_____ 22/E10*	IES LM-9:1988	Fluorescent Lamps - Electrical Measurements
_____ 22/E11*	IES LM-9:1999	Fluorescent Lamps - Electrical Measurements
_____ 22/E12*	IES LM-45:1991	Incandescent Lamps - Electrical Measurements
_____ 22/E13*	IES LM-45:2000	Incandescent Lamps - Electrical Measurements

EEL Products Test Method Selection List

Photometric Measurements

_____	22/P06a*	IES LM-9:1988	Fluorescent Lamps - Total Flux Measurements
_____	22/P06b*	IES LM-9:1988	Fluorescent Lamps - Intensity Measurements
_____	22/P07a*	IES LM-9:1999	Fluorescent Lamps - Total Flux Measurements
_____	22/P07b*	IES LM-9:1999	Fluorescent Lamps - Intensity Measurements
_____	22/P08a*	IES LM-20:1994	Reflector Type Lamps -Total Flux Measurements
_____	22/P08b*	IES LM-20:1994	Reflector Type Lamps - Intensity Measurements
_____	22/P09a*	IES LM-45:1991	Incandescent Lamps - Total Flux Measurements
_____	22/P09b*	IES LM-45:1991	Incandescent Lamps - Intensity Measurements
_____	22/P10a*	IES LM-45:2000	Incandescent Lamps - Total Flux Measurements
_____	22/P10b*	IES LM-45:2000	Incandescent Lamps - Intensity Measurements
_____	22/P11a	IES LM-51:2000	High-Intensity Discharge Lamps -Total Flux Measurements

Old Test Selection List – 29 tests

New Test Selection List – 59 tests

Code of Federal Regulations

Electronic Code of Federal Regulations
e-CFR™

e-CFR Data is current as of April 28, 2009

Title 10: Energy

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS
Subpart A—General Provisions

§ 430.3 Materials incorporated by reference.

(a) *General.* We incorporate by reference the following standards into Part 430. The material listed has been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Any subsequent amendment to a standard by the standard-setting organization will not affect the DOE regulations unless and until amended by DOE. Material is incorporated as it exists on the date of the approval and a notice of any change in the material will be published in theFederal Register.All approved material is available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.* Also, this material is available for inspection at U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586–2945, or go to: *http://www1.eere.energy.gov/buildings/appliance_standards/.* Standards can be obtained from the sources below.

Code of Federal Regulations

(1) CIE Publication No. 13.2–1974, corrected reprint 1993, Method of Measuring and Specifying Color Rendering Properties of Light Sources, approved March 27, 1975, ISBN 3 900 734 39 9, IBR approved for §430.2 and Appendix R to Subpart B.

(2) CIE 13.3–1995 ("CIE 13.3"), Commission Internationale de l'Eclairage International Commission on Illumination Internationale Beleuchtungskommission Technical Report: Method of Measuring and Specifying Colour Rendering Properties of Light Sources, 1995, ISBN 3 900 734 57 7, IBR approved for §430.2.

(2) IES LM–9–88, IES Approved Method for the Electrical and Photometric Measurements of Fluorescent Lamps, approved December 7, 1988, IBR approved for Appendix R to Subpart B.

(3) IESNA LM–16–1993 ("IESNA LM–16"), IESNA Practical Guide to Colorimetry of Light Sources, December 1993, IBR approved for §430.2 and Appendix R to Subpart B.

(4) IES LM–20–1994, IESNA Approved Method for Photometric Testing of Reflector-Type Lamps, approved December 3, 1994, IBR approved for Appendix R to Subpart B.

(5) IES LM–45–91, IES Approved Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps, approved December 8, 1990, IBR approved for Appendix R to Subpart B.

(6) IES LM–58–1994, IESNA Guide to Spectroradiometric Measurements, approved December 3, 1994, IBR approved for Appendix R to Subpart B.

(7) IES LM–66–1991, IES Approved Method for the Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, approved June 1991, IBR approved for Appendix R to Subpart B.

Code of Federal Regulations

(1) ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs, Version 3.0, approved October 30, 2003, IBR approved for Appendix V to Subpart B.

(2) ENERGY STAR Program Requirements for [Compact Fluorescent Lamps] CFLs, approved August 9, 2001, IBR approved for Appendix W to Subpart B.

(2) ENERGY STAR Program Requirements for Residential Light Fixtures, Version 4.0, approved January 10, 2005, IBR approved for Appendix V to Subpart B.

ENERGY STAR® program (CFL 2.0)

EPAct 2005 formally recognizes the federal ENERGY STAR® program (section 131 of the Energy Policy Act, Public Law 109-58) to identify and promote energy-efficient products and buildings through labeling.

FINAL VERSION: 8/9/01

ENERGY STAR PARTNER

ENERGY STAR® Program Requirements for CFLs
Partner Commitments

Eligible Organizations:
Manufacturers of Compact Fluorescent Light Bulbs

ANSI C78.375 – 1997 *Guide for Electrical Measurements of Fluorescent Lamps*

CIE Publication No. 13.3 – 1995 *Method of Measuring and Specifying Color Rendering of Light Sources*

IESNA LM-9 – 1998 *Electric & Photometric Measurement of Fluorescent Lamps*

IESNA LM-40 – 1987 *Approved Method for Life Performance Testing of Fluorescent Lamps*

IESNA LM-65 – 1991 *Life Testing of Single-ended Compact Fluorescent Lamps*

IESNA LM-66 – 1991 *Electrical and Photometric Measurements of Single-Compact Fluorescent Lamps*

ENERGY STAR® program (CFL 3.0)

FINAL VERSION: 10/30/03

ENERGY STAR® Program Requirements for CFLs
Partner Commitments

Eligible Organizations:
Manufacturers and Distributors of Compact Fluorescent Lamps (CFLs)

ANSI C78.375 – 1997 Guide for Electrical Measurements of Fluorescent Lamps

CIE Publication No. 13.3 – 1995 Method of Measuring and Specifying Color Rendering of Light Sources

IESNA LM-9 – 1999 Electric & Photometric Measurement of Fluorescent Lamps

IESNA LM-40 – 2001 Approved Method for Life Performance Testing of Fluorescent Lamps

IESNA LM-65 – 2001 Life Testing of Single-ended Compact Fluorescent Lamps

IESNA LM-66 – 2000 Electrical and Photometric Measurements of Single Ended Compact Fluorescent Lamps

ENERGY STAR® program (CFL 4.0)

CIE Publication No. 13.3 – 1995 *Method of Measuring and Specifying Color Rendering of Light Sources*

IESNA LM-9 – 1999 *Electric & Photometric Measurement of Fluorescent Lamps*

IESNA LM-16 *Practical Guide to Colorimetry of Light Sources*

IESNA LM-40 – 2001 *Approved Method for Life Performance Testing of Fluorescent Lamps*

IESNA LM-41 – 1998 *Approved Method for Photometric Testing of Indoor Fluorescent Luminaires*

IESNA LM-54 – 1999 *IESNA Guide to Lamp Seasoning*

IESNA LM-65 – 2001 *Approved Method for Life Testing of Single-ended Compact Fluorescent Lamps*

IESNA LM-66 – 2000 *Electrical and Photometric Measurements of Single Ended Compact Fluorescent Lamps*

EEL Products Test Method Selection List

Solid State Lighting (NIST Handbook 150-1A Test Methods)

Color Measurements

_____	22/S01*	IES LM-58:1994	Spectroradiometric Measurements
_____	22/S02*	CIE Pub. 13.3:1995	Method of Measuring and Specifying Color Rendering of Light Sources
_____	22/S03*	IES LM-79:2008 (Sec. 12)	Solid State Lighting Luminaires - Color Characteristic Measurements
_____	22/S04*	IES LM-16:1995	Practical Guide to Colorimetry of Light Sources
_____	22/S05*	CIE Pub. 15:2004	Method of Measuring and Specifying Color Rendering of Light Sources

Electrical Measurements

_____	22/S06*	ANSI C82.2:2002	Ballast for Fluorescent Lamps - Methods of Measurement
_____	22/S07*	ANSI C82.77:2002	Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment

Life Tests

_____	22/S08*	IES LM-80:2008	Solid State Lighting Luminaires - Lumen Maintenance

Photometric Measurements

_____	22/S09*	IES LM-79:2008 (Sec. 9)	Solid State Lighting Luminaires - Total Flux Measurements (Luminous Efficacy)
_____	22/S10*	IES LM-79:2008 (Sec. 10)	Solid State Lighting Luminaires - Luminous Intensity Measurements

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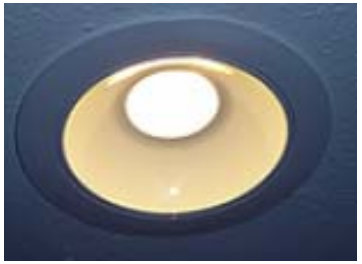
NVLAP SSL Proficiency Testing

Summary

Commercial SSL Products

Niche applications

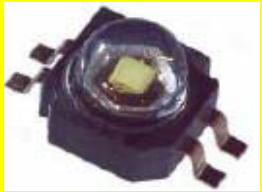


General lighting applications

Measurement of LED/SSL Products

LED chips/packages





LED modules/clusters


SSL products



Measurement quantities

- Total luminous flux (lm)
- Luminous efficacy (lm/W)
- Correlated Color Temperature (K)
- Color Rendering Index
- Color Spatial Uniformity
- Zonal Lumen Density

IES LM-79-2008

_____ 22/S09* IES LM-79:2008 (Sec. 9)
Solid State Lighting Luminaires - Total Flux Measurements (Luminous Efficacy)

_____ 22/S10* IES LM-79:2008 (Sec. 10)
Solid State Lighting Luminaires - Luminous Intensity Measurements

_____ 22/S03* IES LM-79:2008 (Sec. 12)
Solid State Lighting Luminaires - Color Characteristic Measurements

Management System Procedures

AMBIENT CONDITIONS
POWER SUPPLY CHARACTERISTICS
STABLIZATION OF SSL PRODUCT
OPERATING ORIENTATION
ELECTRICAL SETTINGS
ELECTRICAL INSTRUMENTATION

IES LM-79-2008 (Sec. 9)

Test Methods for Total Luminous Flux Measurements

- Integrating sphere with a spectroradiometer
  - Integrating sphere shall have a broadband auxiliary lamp for self-absorption measurement
  - 4π geometry mounted in center of sphere
    - total spectral radiant flux standard lamp
  - 2π geometry mounted on flush on the sphere wall
    - total spectral radiant flux standard lamp with only forward distribution (required)
  - ambient temperature in sphere 25° C ± 1° C
  - input optic flat diffuser or a satellite sphere

IES LM-79-2008 (Sec. 9)

Test Methods for Total Luminous Flux Measurements

- Integrating sphere with a photometer
  - Integrating sphere shall have an auxiliary lamp for self-absorption measurement (similar spectrum)
  - 4π geometry mounted in center of sphere
  - 2π geometry mounted on flush on the sphere wall
  - total luminous flux standard lamp (spatial corrections)
  - ambient temperature in sphere 25° C ± 1° C
  - detector cosine response with well matched to $V(\lambda)$ function including sphere spectral throughput

IES LM-79-2008 (Sec. 9)

Test Methods for Total Luminous Flux Measurements

- Goniophotometer
  - Type C only
  - Spatial ‘scanning resolution fine enough to accurately define the test sample shall be used.’
  - The range of the angular scan shall cover the entire solid angle to which the SSL product emits light.
  - The f'_1 of the detector shall be less than 3 %.
  - Detector shall be calibrated against an illuminance or luminous intensity standard traceable to national standards.

IES LM-79-2008 (Sec. 10)

Test Methods for Luminous Intensity Distributions

"The absolute intensity distribution of measured SSL products shall be reported."

Zonal flux calculation guidance is available in IES LM-35-02, Approved Method for Photometric Testing of Floodlights Using High Intensity Discharge or Incandescent Filament Lamps

Electronic data of measured luminous intensity distributions, if necessary, shall be prepared in the "IES file" format for absolute photometry specified in LM-63-02.

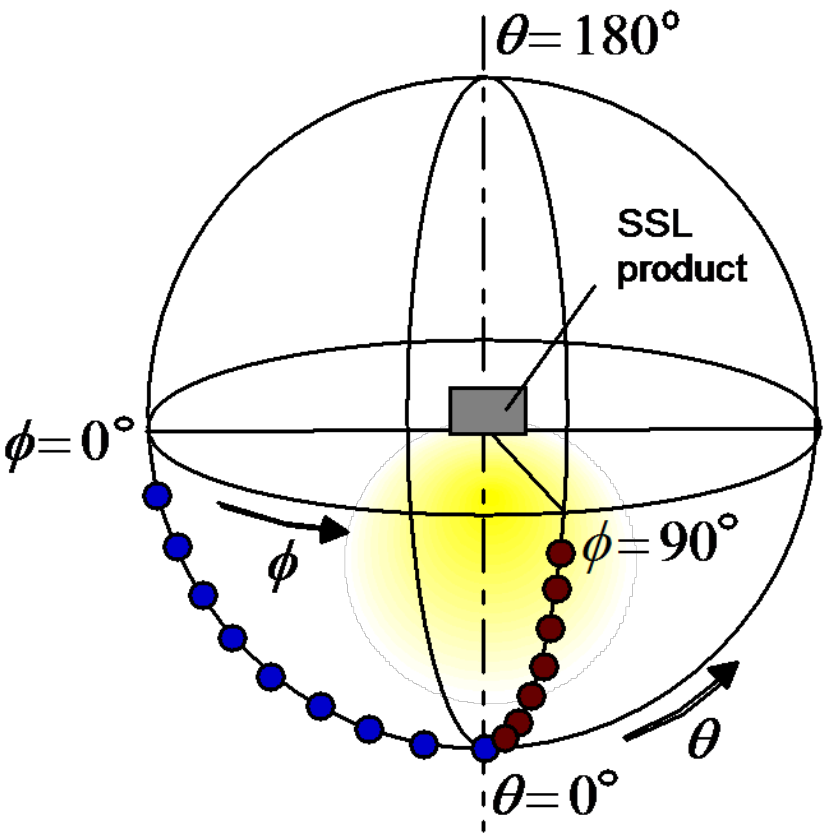
IES LM-79-2008 (Sec. 12)

Test Methods for Color Characteristics of SSL Products

Sphere-spectroradiometer system
- Chromaticity coordinates
- Correlated color temperature
- Color rendering index

Gonio-spectroradiometer system
- Chormaticity coordinates
- Correlated color temperature
- Color rendering index
- Color spatial uniformity

Manual positioning system



IES LM-79-2008 (Sec. 12)

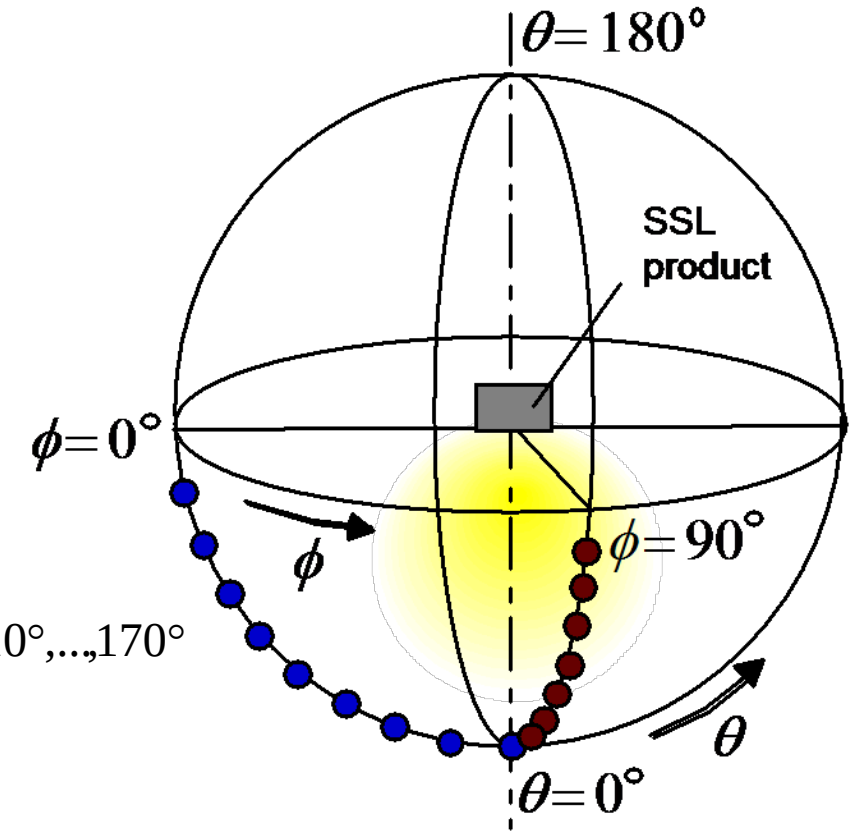
Test Methods for Color Characteristics of SSL Products

Manual positioning system

$$x_a = \sum_{i=1}^{19} x(\theta_i) \cdot w_i \qquad \text{with} \qquad w_i = \frac{I(\theta_i) \cdot \Omega(\theta_i)}{\sum_{i=1}^{19} I(\theta_i) \cdot \Omega(\theta_i)}$$

$$\Omega(\theta_i) = \begin{cases} 2\pi\left[\cos(\theta_i) - \cos(\theta_i + \frac{\Delta\theta}{2})\right]; \text{for } \theta_i = 0° \\ 2\pi\left[\cos(\theta_i - \frac{\Delta\theta}{2}) - \cos(\theta_i + \frac{\Delta\theta}{2})\right]; \text{for } \theta_i = 10°,\ldots,170° \\ 2\pi\left[\cos(\theta_i - \frac{\Delta\theta}{2}) - \cos(\theta_i)\right]; \text{for } \theta_i = 180° \end{cases}$$

$$\Delta\theta = 10°$$



IES LM-80-2008

Management System Procedures

AMBIENT AND PHYSICAL CONDITIONS
ELECTRICAL AND THERMAL CONDITIONS
TEST AND MEASUREMENT PROCEDURES
LUMEN MAINTENANCE TESTING METHOD FOR LED LIGHT SOURCES
TEST REPORT

On-SITE Proficiency Test

Prior to operation, sources shall be cleaned to eliminate handling marks and the manufacturer's handling instructions must be observed.

Individual LED light sources shall be tracked during life testing.

The identification method selected shall take into account the effect of exposure to light, and heat.

CIE Publications

_____ 22/S02* CIE Pub. 13.3:1995
Method of Measuring and Specifying Color Rendering of Light Sources

_____ 22/S05* CIE Pub. 15:2004 Colorimetry

Management System Procedures

Proficiency Test

Several sample spectra provided to validate calculation

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NVLAP SSL Proficiency Testing

Summary

NVLAP SSL Proficiency Testing

3.4.2 Laboratories applying for initial accreditation shall participate satisfactorily in a bi-lateral proficiency testing with NIST before accreditation will be granted. Solid state lighting luminaires along with instructions for specimen handling, preparation (including seasoning and pre-burning), conditioning, mounting, and testing, and data forms are provided to the participating laboratory. The completed test data forms are sent by the participating laboratory to NIST. The results are summarized in a report, which is edited and sent by NVLAP to the participant.

3.4.3 As NVLAP prescribes, NVLAP or a proficiency testing contractor conducts rounds at regular intervals. Solid state lighting luminaires along with instructions for specimen handling, preparation (including seasoning and pre-burning), conditioning, mounting, and testing, and data forms are provided to the participating laboratories. The completed test data forms are sent by the participating laboratories to NVLAP or, as directed, to the proficiency testing contractor. The results of all participants are summarized in a Tech Brief, which is edited and sent by NVLAP to the participants. The identity and performance of individual laboratories are kept confidential.

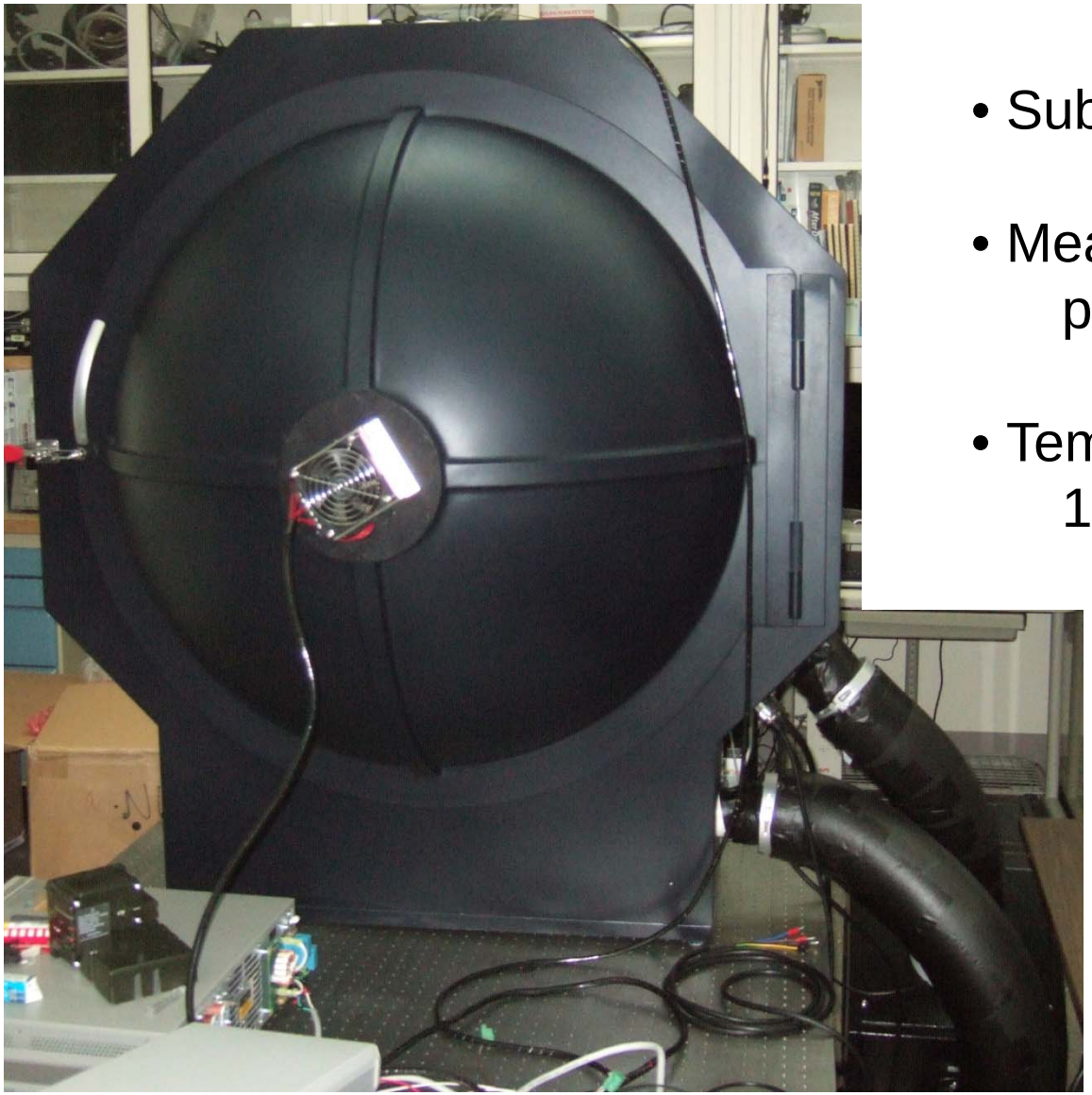
Bi-lateral Proficiency Testing with NIST

Time line

- NIST prepares 2 – 3 sets of bi-lateral artifacts
- NIST distributes a set to a lab 1 month before on-site
- On-site assessment occurs
- Lab may measure bi-lateral artifacts, again
- NIST analyzes data and prepares a report

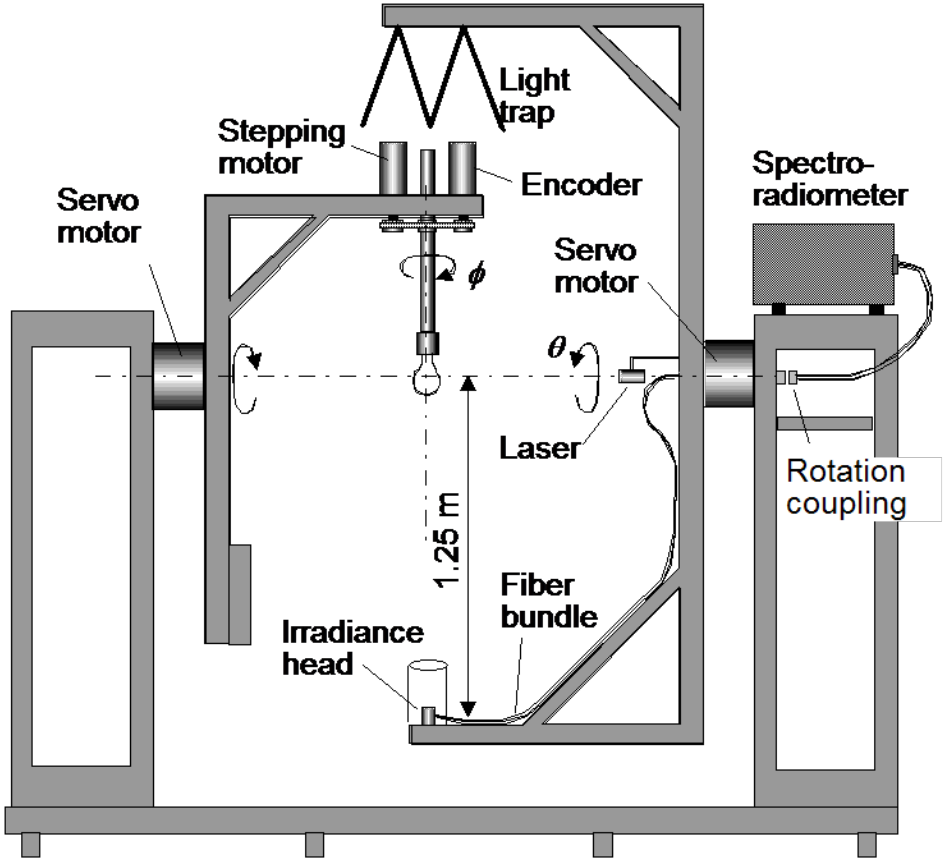
What goes into a set of bi-lateral artifacts?

Temperature Dependence

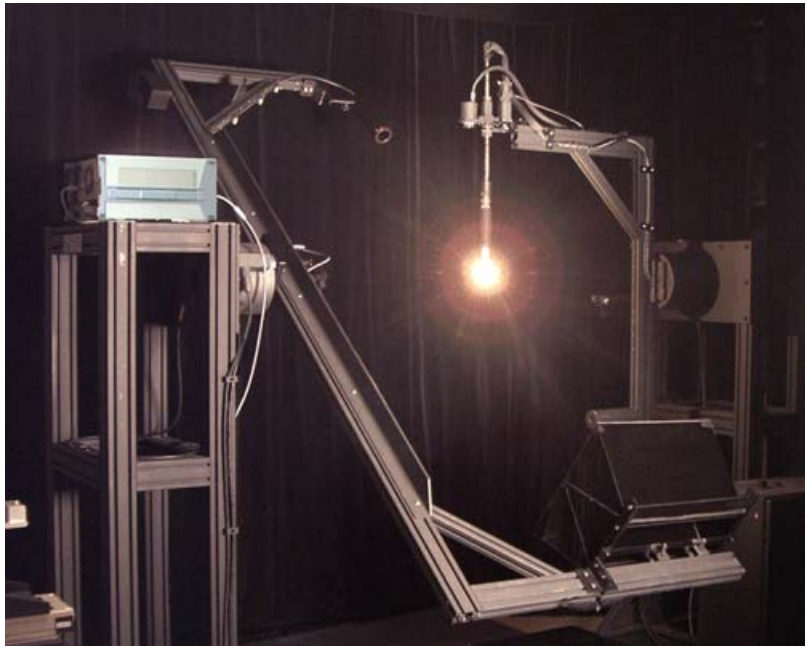


- Substitution photometry
- Measurement of small SSL products
- Temperature range 15° C to 55° C

Zonal Flux Measurements



- Total spectral radiant flux scale
- Measurement of small SSL products
  - Angular luminous intensity distribution
  - Color uniformity



Bi-lateral Proficiency Testing with NIST

Aspects tested with colored luminaires

- Laboratory temperature
- Spectral mismatch correction – wavelength calibration
- Spatial non-uniformity
- Stray light concerns
- Sphere fluorescence

Aspects tested with white luminaires

- Spectral mismatch correction – wavelength calibration
- Spatial non-uniformity (directional – isotropic – highly directional)

Aspects tested with large luminaire

- Self-absorption correction

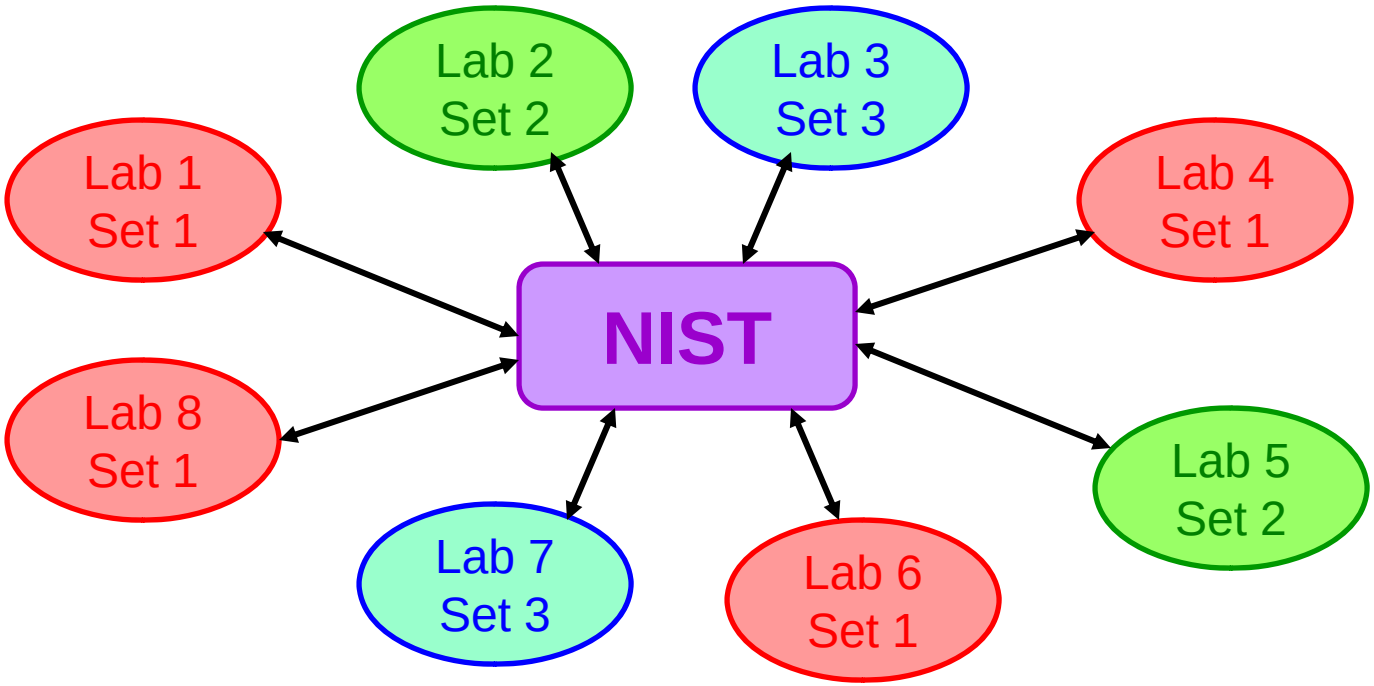
Calculations

Round Robin Testing

NIST prepares 3 – 4 sets of round robin artifacts

Consists of 4 – 5 different artifact models (Energy Star niche applications)
Each artifact model will have 3 items (12 – 15 total items)

NIST distributes sets in a star pattern



NIST analyzes data and prepares a Tech Brief

Artifact Characterization

Based on CALiPER results pick specific products

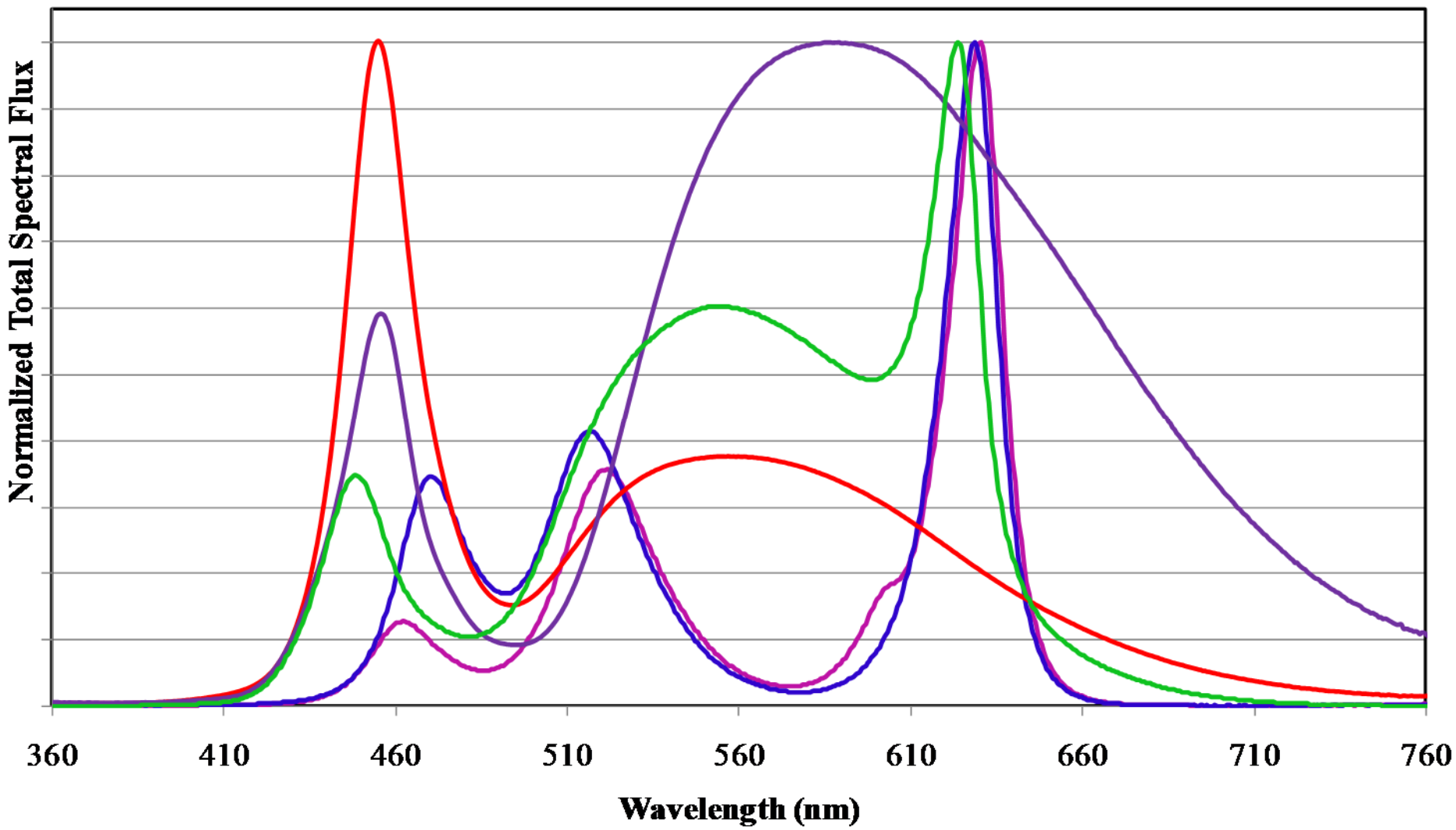
Measure, age 24 h, measure, age 24 h, measure, 120 h measure – seasoning

Measure luminaires 3 times – repeatability, stability time

	Current	Voltage	Power	Flux	Efficacy
Model 1	0.024 %	0.005 %	0.035 %	0.024 %	0.012 %
Model 2	0.139 %	0.005 %	0.101 %	0.015 %	0.086 %
Model 3	0.031 %	0.002 %	0.042 %	0.082 %	0.071 %
Model 4	0.014 %	0.002 %	0.016 %	0.054 %	0.038 %

Age 500 h, measure, age 1000 h, measure, age 1000 h, measure

Color Characterization



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Summary

DOE Supported Accreditation Work

- Expand the number of bi-lateral artifacts and round robin artifacts for Energy Efficient Lighting – Solid State Program
- Expand the number of EEL-SSL assessors by offering training specific to solid state lighting testing
- Expand the number of possible EEL-SSL testing laboratories by offering a seminar on the requirements for NVLAP accreditation
- Expand the number of possible EEL-SSL testing laboratories by having the Department of Energy pay for the first year of fees and onsite assessment for domestic United States laboratories that qualify.

NVLAP Fee Policy – Product Testing

SSL Energy Efficient Lighting Program Example

ADMINISTRATIVE / TECHNICAL SUPPORT FEE assessed annually on a laboratory's anniversary	~~$4,930~~
INITIAL APPLICATION FEE paid one time by laboratory	$750
ON-SITE ASSESSMENT FEE before initial accreditation during the first renewal year every two years thereafter	~~$3,120~~ $500
BI-LATERAL PROFICIENCY TESTING FEE (Round Robin) invoiced at the time the test is conducted	~~$3,000~~

Initial Amount: $750

NVLAP Fee Policy – Projected Yearly Cost

2009 – Initial Accreditation

Initial, Administrative, On-site, Bi-lateral

~~$8,800~~

$750

2010 – First Year of Accreditation

Administrative, On-site

$8,050

2011 – Second Year of Accreditation

Administrative, Proficiency

$5,430

2012 – Third Year of Accreditation

Administrative, On-site

$8,050

2013 – Fourth Year of Accreditation

Administrative, Proficiency

$5,430

Questions?