



# ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs)

## Eligibility Criteria Version 1.0, DRAFT 2

Following is the Version 1.0 ENERGY STAR Product Specification for Lamps. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

To qualify a lamp for ENERGY STAR, first determine which requirements in this document are applicable to the specific lamp.

**Note:** Partners are strongly encouraged to read the cover letter distributed with this draft, and all note boxes located throughout this draft.

For purposes of this specification development process, EPA invites stakeholders to send comments to [lamps@energystar.gov](mailto:lamps@energystar.gov), with “ENERGY STAR Lamps V1.0 Draft 2 Comments” in the subject line.

### Specification Scope & Lamp Classification

The ENERGY STAR Lamps specification (“this specification”) scope includes the lamp types outlined in table 1. The scope is limited to lamps intended to be connected to the electric power grid.

Standard Compliance	Lamp Type	Lamp Shapes or Description	Lamp Bases
ANSI Standard	Directional	Lamps meeting applicable directional performance requirements in this specification in ANSI standard lamp shapes R, BR, ER, MR and PAR.	Screw bases: E26, E26d, E17, E12  Multiple pin bases: GU24, GU10, GU5.3, GX5.3
Non-Standard	Directional	Lamps meeting applicable directional performance requirements in this specification but not Lamp Shape Dimensional Requirements (p. 29).  Self-ballasted compact fluorescent reflector lamps are included.	
ANSI Standard	Omnidirectional	Lamps meeting applicable omnidirectional performance requirements in this specification in ANSI standard lamp shapes A, BT, G, P, PS, S and T.	
Non-Standard	Omnidirectional	Lamps meeting applicable omnidirectional performance requirements in this specification but not Lamp Shape Dimensional Requirements (p. 29).  The following self-ballasted compact fluorescent lamps are included: <ul style="list-style-type: none"> <li>• Bare spiral</li> <li>• Bare mini-spiral</li> <li>• Bare twin tube</li> <li>• Bare triple tube</li> <li>• Bare quadruple tube</li> <li>• Covered lamps</li> <li>• T/C (circline)</li> <li>• 2D</li> </ul>	
Non-Standard	Semidirectional	Lamps which do not meet omnidirectional or directional luminous intensity distribution requirements in this specification, and may or may not meet Lamp Shape and Dimensional Requirements (p. 29).	
ANSI Standard	Decorative	B, BA, C, CA, DC, F	

**Table 1:** Specification scope and classification.

Excluded products:

- Lamps that operate on an external (i.e. not integral to the lamp) ballast, driver or transformer, e.g. pin-based fluorescent lamps (linear and compact).
- Solid state lamps intended to replace linear fluorescent or high intensity discharge lamps.
- Lamps powered by an internal power source, e.g. solar.
- Lamps incorporating power-consuming features which do not provide illumination (e.g. audio functions, air fresheners).
- Lamp technologies lacking applicable industry standardized methods of measurement.
- Lamps with bases not detailed in ANSI standards.
- Zhaga compliant LED light engines.

**Note:** Comments received regarding Draft 1 indicated strong support for maintaining MR-16 lamps within the scope of this specification. Citing strong demand for these lamps in the commercial segment of the market, partners and stakeholders also expressed concern that without the ENERGY STAR, energy efficiency program partners would have difficulty ensuring that incentives are directed to high efficacy, high quality lamps. EPA notes that the 2011 DOE report “Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications” affirms that in the U.S., the predominant savings opportunity for MR-16 lamps are for those used in commercial applications.

To address these concerns EPA has added low voltage MR-16 lamps to the scope of the specification. These lamps must meet new commercial grade requirements detailed in the specification, including longer rated life, higher power factor, and longer warranty requirements. Commercial grade labeling provisions extend to all other types of lamps as well.

The line voltage MR-16 lamp with a GU10 base is a lamp configuration which in recent years has become much more prevalent in the residential segment of the market. Pending resolution of dimensional standards, this lamp type has also been added to the scope of the specification.

The Agency also received recommendations to include an allowance for additional power consumed by connectivity features, for example, utility demand response systems. EPA will continue to follow such developments and may evaluate inclusion of such provisions during a future specification revision.

Semidirectional lamps have been added to the specification scope, intended to include non-standard lamps which are neither omnidirectional nor directional per this specification.

### **Effective Date**

The ENERGY STAR Lamps Version 1.0 specification shall take effect on *TBD*. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on its date of manufacture. The date of manufacture is specific to each unit and is the exact date on which a unit is considered to be completely assembled.

### **Future Specification Revisions**

EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through industry discussions. In the event of a specification revision, please note that ENERGY STAR qualification is not automatically granted for the life of a product model.

While this document currently refers to industry standards and test procedures for fluorescent and solid state lighting sources, as new technologies emerge that have equal or better performance to the levels proposed here, consistent with a technology neutral approach, EPA may amend the program requirements by adding additional requirements, methods of measurement and reference documents.

## Definitions

**ANSI:** American National Standards Institute.

**ASTM:** American Society for Testing of Materials.

**Beam Angle:** The angle, in degrees, between the two opposite directions in which the average intensity is 50% of the center beam intensity as measured in at least two rotational planes, 90° from each other, around and through the beam axis (ANSI C78.379-2006).

**CFL:** See Compact Fluorescent Lamp.

**CIE:** Commission Internationale de l'Eclairage (International Commission on Illumination).

**Color Rendering:** Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant (CIE 17.4, ANSI/IES RP-16-10).

**Color Rendering Index of a Light Source (CRI):** A measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source of comparable color temperature (CIE 13.3, ANSI/IES RP-16-10).

**Compact Fluorescent Lamp (CFL):** A fluorescent lamp with a small diameter glass tube (T5 or less) that is folded, bent, or bridged to create a long discharge path in a small volume. The lamp design generally includes an amalgam and a cold chamber, or a cold spot to control the mercury vapor pressure and light output (ANSI/IES RP-16-10).

**Correlated Color Temperature of a Light Source (CCT):** The absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source (ANSI/IES RP-16-10).

**Covered Lamp:** A lamp with an integral ballast or driver and a translucent envelope over the light source(s). See Envelope.

**Decorative Lamp:** Lamps with a lamp shape B, BA, C, CA, DC, and F as defined in ANSI C79.1-2002.

**Directional Lamp:** A lamp having at least 80% light output with a solid angle of  $\pi$  sr, corresponding to a cone with an angle of 120°. (Commission of the European Communities (EC) No 244/2009). For purposes of this specification, ANSI standard R, BR and ER shapes are considered to be directional regardless of compliance with this definition.

**Envelope:** A transparent or translucent enclosure over a light source. An envelope can also consist of a reflector with integral front cover (adapted from ANSI C78.357-2010).

**FTC:** United States Federal Trade Commission.

**Field Angle:** The angle between the two directions for which the intensity is 10% of the maximum intensity as measured in a plane through the nominal beam centerline (ANSI/IES RP-16-10).

**GU24 Based Integrated Lamp:** A lamp unit that integrates the lamp and its ballast. It does not include any replaceable or interchangeable parts, and utilizes the ANSI standardized GU24 base type.

**IEC:** International Electrotechnical Commission.

**IES:** Illuminating Engineering Society.

**Input Power:** The power consumption in watts of a ballast or driver and a light source system operating in a normal mode, as determined in accordance with ANSI Standard 82.2-2002.

**Integrated LED Lamp:** An integrated assembly comprised of LED packages (components) or LED arrays (modules), LED driver, ANSI standard base and other optical, thermal, mechanical and electrical components. The device is intended to connect directly to the branch circuit through a corresponding ANSI standard lamp-holder (socket). (ANSI/IES RP-16-10)

**Lamp:** A generic term for a man-made source created to produce optical radiation. By extension, the term is also used to denote sources that radiate in regions of the spectrum adjacent to the visible (ANSI/IES RP-16-10).

**LED:** See Light Emitting Diode.

**LED Array or Module:** An assembly of LED packages (components) or dies on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces that are intended to connect to the load side of a LED driver. Power source and ANSI standard base are not incorporated into the device. The device cannot be connected directly to the branch circuit (ANSI/IES RP-16-10).

**LED Driver Case Temperature Measurement Point (TMP<sub>C</sub>):** A location on an LED driver case, designated by its manufacturer, which will have the highest temperature of any point on the driver case during normal operation.

**LED Package:** An assembly of one or more LED dies that includes wire bond or other type of electrical connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. Power source and ANSI standardized base are not incorporated into the device. The device cannot be connected directly to the branch circuit (ANSI/IES RP-16-10).

**LED Temperature Measurement Point (TMP<sub>LED</sub>):** A location on an LED package/module/array, designated by its manufacturer, which provides a surrogate temperature measurement location for the actual LED junction. The TMP<sub>LED</sub> may be a solder joint at the board attachment site, a point on the LED package case, or a location on the board of an LED module or array.

**Light Emitting Diode (LED):** A pn junction semiconductor device that emits incoherent optical radiation when forward biased. The optical emission may be in the ultraviolet, visible, or infrared wavelength regions (ANSI/IES RP-16-10).

**Lumen Maintenance:** The luminous flux output remaining (typically expressed as a percentage of the initial output) at any selected operating time. Lumen maintenance is the converse of lumen depreciation (adapted from IES LM-80-08).

**Lumens per Watt (lm/W):** The quotient of the total luminous flux emitted by the total light source power input. It is expressed in lm/W. (Adapted from ANSI/IES RP-16-10: "Luminous Efficacy of a Source of Light")

**MacAdam Color Ellipse:** A space around a chromaticity coordinate that sets the boundary at which a given percentage of people are able to determine that two colors, one with chromaticity coordinates at the center of the ellipse, and one with chromaticity coordinates on the ellipse, are just noticeably different (adapted from IES Handbook 10<sup>th</sup> Edition).

**NEMA:** National Electrical Manufacturers Association.

**NRTL**: Nationally Recognized Testing Laboratory as recognized by OSHA's NRTL Program, which is a part of OSHA's Directorate of Technical Support.

**OSHA**: Occupational Safety & Health Administration.

**Power Factor**: The input power in watts divided by the product of RMS input voltage and RMS input current of a ballast or driver.

**Rated Lumen Maintenance Life (L<sub>p</sub>)**: The elapsed operating time over which the LED light source will maintain the percentage, p, of its initial light output, e.g., L<sub>70</sub> (hours): time to 70% lumen maintenance (IES LM-80-08).

**Referenced Incandescent Lamp**: An incandescent lamp available in the market meeting federal requirements in effect on the date of qualification.

**Run-up Time**: The time needed after switching on the supply for the lamp to reach 80.0% of its stabilized luminous flux (ANSI C78.5-2003).

**Secondary Optics**: Materials modifying the distribution of light from, but not integral to a light source, including but not limited to lamp envelopes, reflectors, and total internal reflection optics.

**Solid State Lighting (SSL)**: The term "solid state" refers to the fact that the light is emitted from a solid object – a block of semiconductor – rather than from a vacuum or gas tube, as in the case of an incandescent and fluorescent lighting. There are two types of solid-state light emitters: inorganic light-emitting diodes (LEDs) or organic light-emitting diodes (OLEDs). (Sandia National Laboratories)

**Standardized Color Ellipse**: A MacAdam color ellipse defined by center chromaticity coordinates (CIE x, y) and a measure of certainty for detecting a color difference specified in standard deviation units called steps (ANSI C78.376-2001).

**TMP<sub>C</sub>**: See LED Driver Case Temperature Measurement Point.

**TMP<sub>LED</sub>**: See LED Temperature Measurement Point.

**UL**: Underwriters Laboratories.

**Note**: The definition of covered lamp has been generalized to cover both CFLs and LED lamps. The definition of MacAdam Color Ellipse has been updated.

New definitions have been added for beam angle, envelope, field angle, LED driver case temperature measurement point, referenced incandescent lamp, and secondary optics.

## Test Criteria

Performance requirements in this specification are determined in part by referencing the performance data of an incandescent lamp available in the market meeting federal requirements in effect on the date of qualification (the “referenced incandescent lamp”). Referenced incandescent lamp performance data shall include shape designations appearing in ANSI C79.1-2002 (e.g. A, C, G, MR, PAR etc.), lamp diameter in eighths of an inch (e.g. MR-16 dia. = 16 eighths), nominal wattage, and beam angle for directional types.

Performance requirements in this specification are also determined by the replacement lamps’ type and standard compliance per table 1. Lamps claiming equivalency with an ANSI lamp shape on the lamp, its base or packaging, product literature or point-of-purchase materials, either printed or electronic, shall meet all requirements detailed in this specification for ANSI standard lamps.

Lamps to be marketed as “commercial grade” or the like shall meet all commercial grade requirements detailed in the specification (see Lumen Maintenance and Rated Life Requirements, Power Factor Requirements, and Warranty Requirements). Low voltage MR-16 lamps shall meet requirements for commercial grade lamps.

When testing lamps, the methods of measurement identified for each performance characteristic in the “Methods of Measurement and/or Reference Documents” column of the performance requirements tables presented within this specification shall be used to determine ENERGY STAR qualification.

IES LM-9, LM-65 and LM-66 are applied to both hot and cold cathode lamps.

**Note:** This section has been expanded from Draft 1 to explain the specification’s structure relative to standard lamps, non-standard lamps, and commercial grade lamps.

EPA has added low voltage MR-16 lamps to the scope of the specification. Language included above articulates the requirement that these lamps meet more stringent requirements typical of commercial grade products.

For cold cathode lamps, language has been added indicating applicability of existing methods of measurement to the technology.

## Product Qualification

### A. Product Variations

Any variation in lamp design or composition that significantly impacts the performance of the lamp is considered a new, unique product which shall be tested in accordance with all requirements detailed in this specification. Allowances are detailed below for variations in lamp composition or construction that do not significantly impact lamp performance.

The model which the laboratory expects to have the greatest difficulty meeting the performance requirements outlined in this specification shall be tested (“tested representative model”). Variants shall be identical to the tested representative model with the exception of allowed variations listed in table 2, below.

Except as noted in table 2, variants are permitted to reference the test reports of the tested representative model to satisfy lumen maintenance and rated life requirements, including rapid cycle stress testing, and transient protection requirements.

The following shall be satisfied for all product variations:

1. The tested representative model and the variant(s) shall have the same rated input voltage.
2. Across a sample of five units of a variant, the average of *in situ* temperatures of critical components shall be no greater than 2.5°C above the same average of *in situ* temperatures in a sample of five units of the tested representative model. Critical components include (as applicable) the highest temperature LED package/array/module measured at  $TMP_{LED}$ , LED driver measured at  $TMP_C$ , capacitors and fuses.
3. OSHA NRTL safety listing or certification report shall be available that covers and includes descriptions of both the tested representative model and variant(s) demonstrating their identical construction except for the allowable variations detailed in table 2.

4. Test report(s) shall be available from EPA-recognized laboratory(ies) for the tested representative model and the variant(s) demonstrating that variant performance for the following parameters varies by no more than  $\pm 5\%$  while meeting this specification's requirements:
  - a. Input current
  - b. Input wattage
  - c. Power factor
  - d. Maximum overall length, except as affected only by variations in lamp base or envelope shape.
  - e. Maximum overall diameter

Lamp Attribute	Allowable Variation
Paint Color	Variations in lamp body color/pigment only, not the type of paint or plastic.
Beam Angle (solid state only)	Variations in the dimensions of lamp secondary optics only (e.g. lens thickness, refractor patterns). Variation in secondary optical material not allowed.  Variation not allowed where, in a sample of five units of the representative lamp model, the average of <i>in situ</i> temperatures measured at each unit's highest temperature $TMP_{LED}$ is within $5^{\circ}C$ of the maximum case temperature tested in the corresponding IES LM-80 report.
Lamp Base (solid state)	Variations in the lamp base so long as base material is unchanged.  Variation not allowed where, in a sample of five units of the representative lamp model, the average of <i>in situ</i> temperatures measured at each unit's highest temperature $TMP_{LED}$ is within $5^{\circ}C$ of the maximum case temperature tested in the corresponding IES LM-80 report.
Base Type (compact fluorescent)	Variations in the lamp base so long as base material is unchanged.
Envelope Shape (decorative shapes only)	Variations in lamp envelope shape so long as the envelope material and thickness are unchanged. The surface area and volume of the tested representative model's envelope shall be less than or equal to that of the variant.
Envelope Finish (decorative shapes only)	Variations in lamp envelope finish so long as the envelope material and thickness are unchanged. The surface area and volume of the tested representative model's envelope shall be less than or equal to that of the variant.

**Table 2:** Allowable variations.

#### B. Solid State Lumen Maintenance Performance Data

Content and application of IES LM-80-08 reports for LED lamps shall comply with [ENERGY STAR Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products](#).

#### C. Temperature Measurements

All temperature measurements including *in situ* measurements (i.e.  $TMP_{LED}$ , ballast case, driver case) shall be made in accordance with temperature test methods and apparatus outlined in ANSI/UL 1993-2009. For purposes of thermocouple access, minimally sized holes may be drilled into lamps under test and tightly sealed with flexible sealant. All access holes shall be photographed for repeatability.

#### D. Photographs

Photographs shall be taken of lamp optics, lamp profile and lamp labeling, and shall be maintained in records.

#### E. Significant Digits and Rounding

- a. All calculations shall be carried out with directly measured (unrounded) values.
- b. Unless otherwise specified, compliance with specification limits shall be evaluated using directly measured or calculated values without any benefit from rounding.
- c. Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the nearest significant digit as expressed in the corresponding specification limit.

**Note:** To minimize testing burden, EPA has developed the allowable product variations above to enable manufacturing partners to certify multiple products when test results are applicable to a variety of models. EPA is open to exploring additional variations and requests data sufficient to expand this section.

## Methods of Measurement and Reference Documents

Organization	Identifier	Description
ANSI/IEEE	<a href="#">C62.41.2-2002</a>	IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits
ANSI	<a href="#">C78.20-2003</a>	Electric Lamps—A, G, PS and Similar Shapes with E26 Medium Screw Bases
ANSI	<a href="#">C78.21-2011</a>	Electric Lamps—PAR and R Shapes
ANSI	<a href="#">C78.23-1995 (R2003)</a>	Incandescent Lamps—Miscellaneous Types
ANSI/ANSLG	<a href="#">C78.357-2010</a>	For Incandescent Lamps: Tungsten Halogen Lamps (non-vehicle)
ANSI	<a href="#">C78.376-2001</a>	Specifications for the Chromaticity of Fluorescent Lamps
ANSI/ANSLG	<a href="#">C78.377-2011</a>	Specifications for the Chromaticity of Solid State Lighting Products
ANSI	<a href="#">C78.389-2004 (R2009)</a>	Electric Lamps - High-Intensity Discharge (HID) - Methods of Measuring Characteristics
ANSI	<a href="#">C78.5-2003</a>	Specifications for Performance of Self-ballasted Compact Fluorescent Lamps
ANSI	<a href="#">C79.1-2002</a>	Nomenclature for Glass Bulbs Intended for Use with Electric Lamps
ANSI/ANSLG	<a href="#">C81.61-2009</a>	Specifications for Bases (Caps) for Electric Lamps
ANSI/NEMA	<a href="#">C82.2-2002</a>	Fluorescent Lamp Ballasts, Methods of Measurement of (includes supplements)
ANSI	<a href="#">C82.77-2002</a>	Harmonic Emission Limits—Related Power Quality Requirements for Lighting Equipment
ANSI/IEEE	<a href="#">C62.41.2-2002</a>	IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits
ANSI/IES	<a href="#">RP-16-10</a>	Nomenclature and Definitions for Illuminating Engineering
ANSI/UL	<a href="#">1993-2009</a>	Standard for Safety of Self-Ballasted Lamps and Lamp Adapters
ANSI/UL	<a href="#">8750-2009</a>	Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products
CIE	<a href="#">Pub. No. 13.3-1995</a>	Method of Measuring and Specifying Color Rendering of Light Sources
CIE	<a href="#">Pub. No. 15:2004</a>	Colorimetry
Commission of the European Communities	<a href="#">(EC) No 244/2009</a>	Commission Regulation (EC) No 244/2009 of 18 March 2009 Implementing Directive 2005/32/EC of the European Parliament and of the Council
FCC	<a href="#">CFR Title 47 Part 2</a>	Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
FCC	<a href="#">CFR Title 47 Part 15</a>	Radio Frequency Devices
FCC	<a href="#">CFR Title 47 Part 18</a>	Industrial, Scientific, and Medical Equipment
IEC	<a href="#">62321:2008 (Ed. 1)</a>	Electrotechnical Products - Determination Of Levels Of Six Regulated Substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers)
IES	<a href="#">LM-9-09</a>	Electrical and Photometric Measurements of Fluorescent Lamps
IES	LM-20-12	Photometric Testing of Reflector-Type Lamps (renewal anticipated in 2012)
IES	<a href="#">LM-40-10</a>	Life Testing of Fluorescent Lamps
IES	<a href="#">LM-47-12</a>	Life Testing of High Intensity Discharge (HID) Lamps
IES	<a href="#">LM-51-00</a>	Electrical and Photometric Measurements of High Intensity Discharge Lamps
IES	LM-54-12	Guide to Lamp Seasoning (renewal anticipated in 2012)
IES	LM-58-12	Guide to Spectroradiometric Measurements of Light Sources (renewal anticipated in 2012)
IES	<a href="#">LM-65-10</a>	Life Testing of Compact Fluorescent Lamps
IES	<a href="#">LM-66-11</a>	Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps
IES	<a href="#">LM-79-08</a>	Electrical and Photometric Measurements of Solid-State Lighting Products
IES	<a href="#">LM-80-08</a>	Measuring Lumen Maintenance of LED Light Sources
IES	<a href="#">TM-21-11</a>	Projecting Long Term Lumen Maintenance of LED Light Sources

## Photometric Performance Requirements

### Luminous Efficacy Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements		Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
	Lamp shall meet the applicable requirement in the table below.		<b>Measurement (fluorescent):</b> IES LM-9-09  IES LM-66-11  <b>Measurement (solid state):</b> IES LM-79-08  <b>Reference Documents:</b> IES LM-54-12 (renewal anticipated in 2012)	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> Average of unit values shall meet the applicable requirement, and $\geq 9$ units individually shall meet the requirement.  <hr/> For fluorescent lamps, measurements shall be taken at the end of 100 hours of seasoning according to IES LM-54-12.  For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  Average of the unit values shall be reported.
	<b>Lamp Input Power (watts)</b>	<b>Minimum Lamp Efficacy (initial lm/W)</b>		
<b>Omnidirectional and Semidirectional</b>	$<10$	55		
	$\geq 10$	60		
<b>Directional</b>	$<10$	40		
	$\geq 10$	45		
<b>Decorative</b>	$<10$	45		
	$\geq 10$	50		

**Note:** Efficacy requirements have been clarified as measured initial values. Clarifications have also been made to passing test requirements and reporting details.

Methods of measurement for high intensity discharge in this table and all subsequent references have been removed.

EPA has maintained references to IES LM-9-09 for partners certifying self-ballasted circline lamps. All guidance regarding fluorescent lamp seasoning now references IES LM-54-12 (renewal anticipated in 2012).



**Light Output Requirements  
(Exemption: ANSI Standard MR and PAR Shapes)**

Note: Wattage equivalency claims on the lamp, its base or packaging, product literature or point-of-purchase materials, either printed or electronic may not exceed values certified according to the tables below.

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance																								
<b>Omnidirectional Except ANSI Globe (G) Shape</b> (see below)	Lamp minimum initial light output (total luminous flux) shall be greater than or equal to that of the referenced incandescent lamp per the table below.	<b>Measurement (fluorescent):</b> IES LM-9-09 IES LM-66-11  <b>Measurement (solid state):</b> IES LM-79-08  <b>Reference Documents:</b> IES LM-54-12 (renewal anticipated in 2012)	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> Average of unit values shall meet the requirement, and $\geq 9$ units individually shall meet the requirement.																								
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<b>Omnidirectional ANSI Globe (G) Shape</b>	Lamp minimum initial light output (total luminous flux) shall be greater than or equal to that of the referenced incandescent lamp per the table below.		For fluorescent lamps, measurements shall be taken at the end of 100 hours of seasoning according to IES LM-54-12.  For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  Average of the unit values shall be reported.																								
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100		650-1099																									
150		1100-1300																									

<b>Directional (R, BR and ER)</b>	<p>Lamp initial light output (in lumens) shall be greater than or equal to ten times the incandescent lamp's rated wattage (e.g. a lamp replacing a 25W incandescent shall produce <math>\geq 250</math> lumens, or a lamp replacing a 45R20 shall produce <math>\geq 450</math> lumens), for the following referenced incandescent lamps:</p> <ul style="list-style-type: none"> <li>• 65 watt BR30, BR40 and ER40 lamps</li> <li>• BR30, ER30, BR40 and ER40 lamps <math>\leq 50</math> watts</li> <li>• R20 lamps <math>\leq 45</math> watts</li> <li>• Lamps <math>\leq 40</math> watts</li> <li>• Lamps smaller than 2.25" diameter</li> </ul> <p>For all other directional lamps not included above, light output (in lumens) shall be greater than or equal to that of the referenced incandescent lamp per the table below.</p> <table border="1" data-bbox="383 579 894 909"> <thead> <tr> <th>Rated Wattage of the Referenced Incandescent Lamp (watts)</th> <th>Light Output for R20 (Lumens)</th> <th>Light Output for Lamps Larger Than R20 (Lumens)</th> </tr> </thead> <tbody> <tr><td>45</td><td>630</td><td>750</td></tr> <tr><td>50</td><td>720</td><td>850</td></tr> <tr><td>65</td><td>1,010</td><td>1,190</td></tr> <tr><td>75</td><td>1,210</td><td>1,420</td></tr> <tr><td>90</td><td>1,520</td><td>1,790</td></tr> <tr><td>100</td><td>1,740</td><td>2,050</td></tr> <tr><td>120</td><td>2,190</td><td>2,580</td></tr> <tr><td>150</td><td>2,910</td><td>3,430</td></tr> </tbody> </table>	Rated Wattage of the Referenced Incandescent Lamp (watts)	Light Output for R20 (Lumens)	Light Output for Lamps Larger Than R20 (Lumens)	45	630	750	50	720	850	65	1,010	1,190	75	1,210	1,420	90	1,520	1,790	100	1,740	2,050	120	2,190	2,580	150	2,910	3,430		
Rated Wattage of the Referenced Incandescent Lamp (watts)	Light Output for R20 (Lumens)	Light Output for Lamps Larger Than R20 (Lumens)																												
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150	2,910	3,430																												
<b>Decorative</b>	<p>Lamp minimum initial light output (total luminous flux) shall be greater than or equal to that of the referenced incandescent lamp per the table below.</p> <table border="1" data-bbox="383 1020 894 1220"> <thead> <tr> <th>Rated Wattage of the Referenced Incandescent Lamp (watts)</th> <th>Light Output (Lumens)</th> </tr> </thead> <tbody> <tr><td>10</td><td>70-89</td></tr> <tr><td>15</td><td>90-149</td></tr> <tr><td>25</td><td>150-299</td></tr> <tr><td>40</td><td>300-499</td></tr> <tr><td>60</td><td>500-699</td></tr> </tbody> </table>	Rated Wattage of the Referenced Incandescent Lamp (watts)	Light Output (Lumens)	10	70-89	15	90-149	25	150-299	40	300-499	60	500-699																	
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10	70-89																													
15	90-149																													
25	150-299																													
40	300-499																													
60	500-699																													
<b>Semidirectional</b>	<p>Lamp minimum initial light output (total luminous flux) shall be no less than 400 lumens.</p>																													

**Note:** Some requirements and supplemental testing guidance language has been revised for clarity.

As first mentioned in Draft 1, the light output requirements for R, BR and ER shaped lamps newly proposed in this draft were developed in consideration of final rules issued by the Department of Energy on June 26, 2009, pursuant to Energy Policy Act of 1992 amendments to the Energy Policy and Conservation Act of 1975. The proposed values are intended to ensure that light output from certified reflector lamps is consistent with expectations set by incandescent lamps meeting these rules which become effective July 12, 2012. For lamps replacing types exempted from this rule, the proposed requirements are carried forward from the Integral LED Lamps specification.

A minimum light output requirement for semidirectional lamps has been proposed.

**Elevated Temperature Light Output Ratio:  
All Directional Lamps, and Semidirectional Lamps Marketed for Recessed Applications  
(Exemption: Omnidirectional and Decorative Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Directional and Semidirectional Marketed for Recessed	Lamp shall maintain $\geq 90\%$ of initial rated light output (total luminous flux) when tested in the elevated temperature condition.	<b>Measurement:</b> ENERGY STAR Elevated Temperature Initial Light Output Ratio Test (Annex C)	<b>Sample Size:</b> One unit tested base-up.  <b>Passing Test:</b> The unit shall meet the requirement.

**Note:** Originally included in the Compact Fluorescent Lamps (CFL) specification, the above requirement was inadvertently left out of Draft 1. The requirement has been generalized to include solid state lamps, to ensure that heat buildup in recessed applications does not have a severe negative impact on lamp light output.

The Elevated Temperature Initial Light Output Ratio test is attached as Annex C for stakeholder review and comment.

**Center Beam Intensity Requirement: ANSI Standard PAR and MR Shapes  
(Exemption: All Other Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance															
ANSI Standard PAR Shapes and Low-Voltage MR-16 Lamps	Lamp center beam intensity shall be greater than or equal to the minimum center beam intensity value calculated by the <a href="http://www.energystar.gov/ia/products/lighting/iledl/IntLampCenterBeamTool.zip">ENERGY STAR Center Beam Intensity Benchmark Tool</a> for the referenced incandescent lamp. ( <a href="http://www.energystar.gov/ia/products/lighting/iledl/IntLampCenterBeamTool.zip">http://www.energystar.gov/ia/products/lighting/iledl/IntLampCenterBeamTool.zip</a> )	<b>Measurement (fluorescent):</b> IES LM-66-11	<b>Sample Size:</b> One new unit. The sample shall be the same unit for testing color angular uniformity.  <b>Passing Test:</b> The unit shall meet the requirement.															
Line-Voltage MR-16 Lamps	Lamp minimum initial center beam intensity shall be greater than or equal to that of the referenced incandescent lamp per the table below.  <table border="1" data-bbox="370 1255 883 1537"> <thead> <tr> <th>Rated Wattage of the Referenced Incandescent Lamp (watts)</th> <th>Minimum Center Beam Intensity (candelas)</th> </tr> </thead> <tbody> <tr><td>20</td><td>150</td></tr> <tr><td>25</td><td>300</td></tr> <tr><td>35</td><td>400</td></tr> <tr><td>45</td><td>600</td></tr> <tr><td>50</td><td>600</td></tr> <tr><td>75</td><td>1,200</td></tr> <tr><td>100</td><td>2,500</td></tr> </tbody> </table>	Rated Wattage of the Referenced Incandescent Lamp (watts)		Minimum Center Beam Intensity (candelas)	20	150	25	300	35	400	45	600	50	600	75	1,200	100	2,500
Rated Wattage of the Referenced Incandescent Lamp (watts)	Minimum Center Beam Intensity (candelas)																	
20	150																	
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100	2,500																	

**Luminous Intensity Distribution Requirements:  
ANSI Standard Omnidirectional and PAR Shapes, and Low Voltage MR Lamps  
(Exemption: All Other Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>ANSI Standard Omnidirectional Shapes</b>	<p>Lamp luminous intensity distribution shall emulate that of the referenced incandescent lamp as follows.</p> <p>Each luminous intensity measured value (candelas) shall vary by no more than 20% from the average of all measured values.</p> <p>No less than 5% of total flux (lumens) shall be emitted in the 135° to 180° zone.</p> <p>See Appendix A for illustration.</p>	<p><b>Measurement (fluorescent):</b> IES LM-66-11</p> <p><b>Measurement (solid state):</b> IES LM-79-08</p>	<p><b>Sample Size:</b> One new unit.</p> <p><b>Passing Test:</b> The unit shall meet the requirement.</p> <hr/> <p>Lamp luminous intensity shall be measured in vertical planes 0°, 45°, and 90° about the lamp axis, at 5° increments (max) within each plane's 0° to 135° zone.</p>
<b>ANSI Standard PAR Shapes and Low Voltage MR Lamps</b>	<p>Lamp luminous intensity distribution shall emulate that of the referenced incandescent lamp, including its nominal beam angle ("reference angle" or <math>\angle_{ref}</math>), as follows.</p> <p>Measured on two rotational planes 90° from each other around and through the beam axis, lamp luminous intensity within each plane shall measure no less than 45% and no greater than 55% of the center beam intensity (<math>I_c</math>) on each edge of the beam (<math>0.5 \cdot \angle_{ref}</math>).</p> <p>For reference angles less than 13°, on each side of the beam axis at (<math>0.25 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 73% of <math>I_c</math>.</p> <p>For reference angles of 13° to 50°, on each side of the beam axis:</p> <ul style="list-style-type: none"> <li>• at (<math>0.125 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 87% of <math>I_c</math>; and,</li> <li>• at (<math>0.25 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 74% of <math>I_c</math>; and,</li> <li>• at (<math>0.375 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 62% of <math>I_c</math>.</li> </ul> <p>For reference angles 51° or greater, on each side of the beam axis:</p> <ul style="list-style-type: none"> <li>• at (<math>0.125 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 91% of <math>I_c</math>; and,</li> <li>• at (<math>0.25 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 76% of <math>I_c</math>; and,</li> <li>• at (<math>0.375 \cdot \angle_{ref}</math>), lamp luminous intensity within each plane shall measure no less than 61% of <math>I_c</math>.</li> </ul> <p>Comparing the two rotational planes, each of the corresponding aforementioned values shall not vary by more than 20%.</p> <p>See Appendix B for illustration.</p>	<p><b>Measurement (fluorescent):</b> IES LM-20-12 (renewal anticipated in 2012)</p> <p><b>Measurement (solid state):</b> IES LM-79-08</p> <p>IES LM-20-12 (renewal anticipated in 2012)</p> <p><b>Reference Document (directional):</b> ANSI C78.379-2006 sections 3 and 4.1.</p>	<p><b>Sample Size:</b> One new unit. The sample shall be the same unit for testing color angular uniformity.</p> <p><b>Passing Test:</b> The unit shall meet the requirement.</p> <hr/> <p>A tolerance of <math>\pm 0.5^\circ</math> may be applied to all measurement angles.</p> <p>The reported beam angle shall be <math>\angle_{ref}</math>.</p>

**Note:** The Center Beam Intensity Benchmark Tool has been carried forward from the Integral LED Lamps specification for PAR shape lamps and low-voltage MR-16 lamps. For line-voltage MR-16 lamps, EPA has developed the proposed minimum center beam intensity values based on analyses of GU10-based line-voltage halogen MR-16 lamps available in the market.

The omnidirectional luminous intensity distribution requirement language has been carried forward from the Integral LED Lamps specification with some adjustments for clarity on evaluating symmetry.

As indicated in Draft 1, EPA has in Draft 2 proposed intensity distribution requirements for directional lamps intended to ensure that certified lamps provide consumers and end users beam performance akin to that provided by the standard and halogen lamps being replaced. To characterize the performance that LED lamps should emulate, the Agency analyzed IES data files with luminous intensity distribution patterns for 193 incandescent reflector lamps, including PAR (120 volt, up to 150 watts) and MR shapes. With this information EPA developed basic beam quality requirements to ensure that certified lamps closely match the incandescent lamps they are designed to replace.

The Agency acknowledges that the scope of ANSI C78.379 refers to reflector lamps with a reflective coating intended to provide control of the light output, i.e. incandescent and high intensity discharge sources. However, as ENERGY STAR certified lamps are intended to replace standard and halogen incandescent light sources while providing performance akin to those lamps, EPA believes referencing this standard is an appropriate means to ensure that certified lamps are classified in a consistent manner as the lamps being replaced.

The Agency seeks comment on this approach to improving the performance of directional lamps.

### Correlated Color Temperature (CCT) Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Compact Fluorescent</b>	Lamp light output shall correlate to one of the following nominal CCTs: <ul style="list-style-type: none"> <li>• 2700K</li> <li>• 3000K</li> <li>• 3500K</li> <li>• 4000/4100K</li> <li>• 5000K</li> <li>• 6500K</li> </ul>	<b>Measurement:</b> IES LM-9-09  IES LM-66-11  ANSI C78.5-2003  <b>Calculation:</b> CIE 15.2004  <b>Reference Documents:</b> ANSI C78.376-2001 sections 2 and 4, and table 2  IES LM-54-12 (renewal anticipated in 2012)	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> All units shall fall within a 7-step MacAdam ellipse for the designated CCT, with ellipses constructed per ANSI C78.376-2001 sections 2 and 4, and table 2. <hr/> For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  Measurements shall be taken at the end of 100 hours of seasoning according to IES LM-54-12.  Reported CCT shall be the average of the unit measured values.
<b>Solid State</b>		<b>Measurement:</b> IES LM-79-08  <b>Calculation:</b> CIE 15.2004  <b>Reference Document:</b> ANSI C78.377-2011	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> All units shall fall within the defined 7-step ANSI quadrangle for the target correlated color temperature. <hr/> For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  Reported CCT shall be the average of the passing unit measured values.

**Note:** In Draft 1, EPA proposed tightening color consistency requirements from 7-step MacAdam ellipses / ANSI quadrangles to 4-step while maintaining the passing requirement of 9 out of 10 units. Comments received reflected concern about the manufacturing cost impacts of the proposal. Given the current state of manufacturing, EPA agrees that implementing this change could be detrimental to the development of the market, and therefore will delay this change until a future specification revision. The above proposal reverts correlated color temperature requirements to the 7-step ellipses/quadrangles found in the existing specifications, but increases the passing requirement to 10 out of 10 units, with the understanding that the majority of qualified lamps have been able to meet this requirement.

EPA has referenced ANSI C78.376-2001 as detailed in the fluorescent references and passing test language above, for the sake of brevity, rather than printing the 7-step ellipses as an appendix to this specification

Having also received partner feedback indicating strong consumer interest in 6500 Kelvin lamps, the Agency has added this CCT value in this draft.

In addition, some supplemental testing guidance language has been clarified.

### Color Rendering Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Compact Fluorescent</b>	Lamp shall have a color rendering index ( $R_a$ ) $\geq$ 80, and an $R_9 > 0$ .	<b>Measurement:</b> IES LM-9-09  IES LM-66-11  <b>Calculation:</b> CIE 13.3-1995	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> Average of units tested shall meet the requirements and no more than 3 units shall have $R_a < 77$ . No unit shall have $R_a < 75$ .
<b>Solid State</b>		<b>Measurement:</b> IES LM-79-08  <b>Calculation:</b> CIE 13.3-1995	<hr/> For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  Reported $R_a$ and $R_9$ shall be the averages of the unit measured values.

**Note:** In Draft 1, EPA proposed that all lamps including compact fluorescent would be required to meet the positive  $R_9$  requirement included in the Integral LED Lamps specification. CFL manufacturing partners expressed concerns about their ability to meet this requirement while maintaining existing pricing levels. The Agency however understands that CFL color quality continues to be a detractor to some consumers, particularly where accurate color rendering of foods, clothing and interior décor (e.g. wood surfaces) is of concern. This concern for consumer satisfaction related to color was shared by some stakeholders commenting on the  $R_9$  proposal. Draft 2 therefore maintains the proposal to add the positive  $R_9$  requirement to compact fluorescent lamps. EPA seeks detailed responses characterizing the potential cost increase associated with this change.

**Color Maintenance Requirements: All Solid State Lamps  
(Exemption: Compact Fluorescent Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<p><b>Solid State</b></p>	<p>Lamp change in chromaticity from 0-hour measurement, at any measurement point during the first 6,000 hours of lamp operation, shall be within a total distance of 0.007 on the CIE 1976 u'v' diagram.</p>	<p><b>Measurement:</b> IES LM-79-08</p> <p><b>Reference Document:</b> ANSI C78.377-2011</p>	<p><b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.</p> <p><b>Passing Test:</b> ≥ 9 units shall meet the requirement.</p> <hr/> <p>For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.</p> <p>Reported maintenance shall be the average of the unit measured values.</p>

**Note:** In Draft 1, EPA proposed tightening of the color maintenance requirement from the 0.007 value appearing in the Integral LED Lamps specification. Some partner comments expressed concerns about cost implications, citing decreased LED manufacturing yield available to support ENERGY STAR qualification. Others expressed concern about meeting this increased requirement while also meeting other proposed changes to the specification. Recognizing the need to maintain the cost effectiveness of certified replacement lamps, the Agency has adjusted the proposed requirement to carry forward the requirement detailed in the existing specification.

Clarifications have been made to performance requirements, and reporting details.



**Color Angular Uniformity Requirements: Solid State Directional Lamps  
(Exemption: All Other Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Solid State Directional</b>	Variation of chromaticity across the field angle of the lamp shall be within a total distance of 0.004 from the weighted average point on the CIE 1976 (u'v') diagram.	<p><b>Measurement:</b> IES LM-79-08</p> <p><b>Reference Document:</b> ANSI C78.377-2011</p>	<p><b>Sample Size:</b> One new unit. The sample shall be a unique sample for this test.</p> <p><b>Passing Test:</b> The unit shall meet the requirement.</p> <hr/> <p>For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.</p> <p>Lamp shall be scanned on two vertical axes separated by 90 degrees. Vertical scanning resolution shall be....</p> <p><i>Scanning angles and resolution TBD.</i></p>

**Note:** EPA has received input from testing laboratories that measurements taken between a lamp's beam and field angles – where luminous intensity values are considerably lower than the beam itself - may suffer from excessive noise, calling into question the reliability of the measurements. This is a known issue being explored by the IES LM-79 working group developing a revision to the method of measurement. The issue is also being explored through round-robin testing by the Lamp Testing Engineers Conference (LTEC). The Agency will continue to follow the work of these groups and will in a subsequent draft issue further supplemental testing guidance intended to mitigate these issues.

## Lumen Maintenance and Rated Life Requirements

Note: Required durations of lumen maintenance and rapid cycle stress testing corresponding to lamp's rated life claim shall be completed. Rated life claims on the lamp, its base or packaging, product literature or point-of-purchase materials, either printed or electronic may not exceed values certified according to this specification. Rated life claims may be upgraded as ongoing testing satisfies all requirements associated with longer life claims.

### Lumen Maintenance Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Compact Fluorescent</b>	<p>Lamp shall maintain 80% of initial lumen output at 40% of rated life*.</p> <p>* designates total on time, not including off time</p>	<p><b>Measurement:</b> ENERGY STAR Elevated Temperature Life Test (Annex A)</p> <p>ENERGY STAR Ambient Temperature Life Test (Annex B)</p> <p><b>Reference Documents:</b> IES LM-54-12 (renewal anticipated in 2012)</p>	<p><b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.</p> <p><b>Passing Test:</b> Average lumen maintenance of the samples shall meet the requirement. No more than 3 units may have lumen maintenance &lt; 75%. For lamps with a rated life of &lt; 15,000 hours, no units may have lumen maintenance &lt; 70%.</p> <hr/> <p>All directional and semidirectional lamps, and all omnidirectional lamps ≥ 10 watts, shall be tested in accordance with the Elevated Temperature Life Test. Directional lamps to be marketed as commercial grade shall be tested per Annex A, option A.</p> <p>All decorative lamps, and omnidirectional lamps &lt; 10 watts, shall be tested in accordance with the Ambient Temperature Life Test.</p> <p>Initial lumen output measurements shall be taken at the end of 100 hours of seasoning according to IES LM-54-12.</p> <p>For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.</p> <p>A tolerance of -3% may be applied to lumen maintenance averages.</p> <p>Average of the surviving unit values shall be reported.</p>

**Solid State**

Lamp shall maintain minimum percentage of 0-hour light output after completion of the test duration corresponding to lamp's life claim (hours to 70% lumen maintenance or L<sub>70</sub>) per the table(s) below. Lamp may earn optional early interim qualification after 3,000 hours, with a rated life claim ≤ 35,000 hours, per the provisions below. Lamps to be marketed as commercial grade shall satisfy requirements for no less than 35,000 hour rated life claims.

Maximum Life Claim (hours to L <sub>70</sub> )	Test Duration (hours) *	Minimum Lumen Maintenance After Test Duration	Status After Completion of Test Duration
15,000	6,000	86.7%	Final qualification testing completed.
20,000	6,000	89.9%	
25,000	6,000	91.8%	
30,000	6,000	93.1%	Interim qualification ; continue testing per below.
35,000	6,000	94.1%	
40,000	6,000	94.8%	
45,000	6,000	95.4%	
50,000	6,000	95.8%	

**For Extended Lifetime Claims:**

For lamp life claims > 25,000 hours, lamp shall maintain ≥ 91.5% of 0-hour light output after completion of the test duration corresponding to lamp's life claim per the table below.

Maximum Life Claim (hours to L <sub>70</sub> )	Test Duration (hours) *
30,000	7,500
35,000	8,750
40,000	10,000
45,000	11,250
50,000	12,500

**To Qualify For Early Interim Qualification After 3,000 Hours:**

Lamp shall maintain minimum percentages of 0-hour light output corresponding to the lamp's life claim per the table below, and shall meet all other requirements in this specification. A lumen maintenance projection calculation using the applicable LM-80-08 test report for the employed LED package/module/ array model ("device"), the *in situ* temperature of highest temperature TMP<sub>LED</sub>, and the forward drive current applied to each device shall support a rated lumen maintenance life greater than or equal to the lamp rated life value to be claimed on product packaging.

Maximum Life Claim (hours to L <sub>70</sub> )	Minimum Lumen Maintenance After 3,000 Hours
15,000	93.1%
20,000	94.8%
25,000	95.8%
35,000	97.0%

\* designates total on time, not including off time

**Measurement (lamps):**  
ENERGY STAR Elevated Temperature Life Test (Annex A)

ENERGY STAR Ambient Temperature Life Test (Annex B)

**Measurement (devices):**  
IES LM-80-08

**Lumen Maintenance Projection:**  
IES TM-21-11

**Lamp Sample Size:** 10 lamps per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.

**Lamp Sample Size for Early Interim Qualification Temperature Test:** One lamp per model for *in situ* measurement of highest temperature TMP<sub>LED</sub>. The *in situ* temperature test report shall be submitted by an OSHA NRTL laboratory.

**Device Sample Size for Early Interim Qualification:** Minimum sample size of 20 units for LED packages, or 10 units for LED arrays or LED modules, for each T<sub>s</sub> and drive current combination (refer to IES TM-21-11, section 4.2).

**Final Qualification Passing Test:** The average lumen maintenance of the ≥ 9 surviving units shall meet the minimum requirement for the designated life claim.

**Early Interim Qualification Passing Test:** The average lumen maintenance of the 10 units shall meet the 3,000 hour requirement for the lamp's life claim. The 3,000 hour testing for the rated life requirement (next section), and the lumen maintenance projection requirement shall be met.

All directional and semidirectional lamps, and all omnidirectional lamps ≥ 10 watts, shall be tested in accordance with the Elevated Temperature Test. Directional lamps to be marketed as commercial grade shall be tested per Annex A, option A. All decorative lamps, and omnidirectional lamps < 10 watts, shall be tested in accordance with the Ambient Temperature Test. Testing for early interim and final qualification shall be conducted on the same samples, which shall also satisfy the 6,000 hour testing for the rated life requirements (next section).

For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.

A tolerance of -3% may be applied to lumen maintenance averages.

If units are tested both base-up and base-down, the average of surviving unit measured values shall be calculated for each orientation, and the reported lumen maintenance shall be the lesser of the two averages. If units are tested in restricted position, the average of surviving unit measured values shall be reported.

**Note:** These notes pertain to the lumen maintenance section (preceding pages) and rated life requirements (following pages), which refer to the test results for the same sample of lamps.

In Draft 1, EPA proposed a technology-neutral minimum life requirement of 10,000 hours, a change from the 8,000 hour requirement in the current CFL spec, and the 15,000 and 25,000 hour requirements detailed in the current Integral LED Lamps specification.

For LED lamps, stakeholder comments regarding the proposal reflected that many partners were interested in the opportunities such a change could present. Some partners commented that changing the minimum from 25,000 hours to 10,000 hours would present cost reduction opportunities which could encourage more rapid adoption of this relatively new, promising technology by providing consumers a greater range of options from which to choose. Others commented that reducing the requirement could be perceived by some consumers as reducing the quality of ENERGY STAR certified LED lamps.

After further industry discussions and data analyses, EPA concluded that while reducing the minimum life requirement for LED lamps to 10,000 hours could present new opportunities for less expensive products brought more quickly to market, among other benefits, the associated cost reductions are largely unknown and may not be compelling. In addition, as noted by utility partners, ENERGY STAR minimum performance requirement values often serve as the basis for public service commission evaluations of program cost effectiveness. Therefore, a dramatic reduction in the minimum life requirement would significantly undercut utilities' ability to claim savings from programs providing incentives for certified LED lamps. For these reasons the Agency has reverted to the 15,000 and 25,000 hour minimum life requirements in the existing specification (see next page). The proposed increase for CFL minimum life requirements, from 8,000 hours to 10,000 hours, remains unchanged from Draft 1.

Commercial applications and incentive programs were cited as requiring products with longer rated life values. In support of these applications and programs, EPA has in Draft 2 included new provisions for commercial grade lamp labeling. To carry the ENERGY STAR, a commercial grade lamp must satisfy requirements for a minimum rated life claim of 35,000 hours (see also increased requirements in the Power Factor and Warranty Requirements). The Agency seeks stakeholder feedback on this approach.

In Draft 1 EPA proposed applying the Elevated Temperature Life Test, currently required for reflector CFLs and most LED lamps, to all lamps greater than or equal to 5 watts. This was proposed out of concern that despite consumer education efforts and information on product packaging, consumers often install efficient lighting into applications for which the lamps were not designed, resulting in early failures which leave consumers questioning the value proposition of efficient lighting technologies generally. Some comments were entered indicating that this issue is better addressed through consumer education rather than increased testing. Strong support was entered by energy efficiency programs, citing concerns about product quality and consumer dissatisfaction due to early product failures. Comments were also entered questioning laboratory capacity to accommodate such a change.

In response to these concerns, seeking a balance between increasing product reliability and consumer satisfaction with efficient lighting, and practical matters related to such testing, EPA has adjusted the requirement. The Elevated Temperature Life Test is now proposed for all directional and semidirectional lamps and all omnidirectional lamps of 10 watts or greater. Directional lamps to be marketed as commercial grade are to be tested using option A, the recessed can method of the Elevated Temperature Life Test, which generally produces higher ambient temperatures around the lamp. For all other lamps including decorative, the proposal is to test at room temperature with the Ambient Temperature Life Test.

The Elevated Temperature Life Test has been clarified from its original form as an annex to the CFL specification, and is attached to Draft 2 as Annex A, for stakeholder review and comment. This test formerly applied elevated ambient temperatures of 45°C and 55°C to LED and CFL lamps, respectively. EPA proposes to align the requirement to 55°C for all lamps for which the test is applicable. The Ambient Temperature Life Test is also attached, as Annex B, nearly identical to Annex A except for ambient testing temperatures of 25°C.

The reference to IES LM-9 was corrected to LM-40, applicable to lumen maintenance testing of self-ballasted circline lamps. A tolerance of -3% may be applied to lumen maintenance averages.

Notes pertaining to minimum testing periods and rated life claims have been added at the top of this section.

**Rated Life Requirements: All Lamps**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Compact Fluorescent</b>	<p>Lamp shall have a rated life <math>\geq</math> 10,000 hours.</p> <p>At 40% of rated life or 6,000 hours, whichever point occurs first, all tested units shall be operational (<math>\geq</math> 90% of the tested units if coincident). At the second point, <math>\geq</math> 90% of the tested units shall be operational</p> <p><math>\geq</math> 50% of the tested units shall be operational at rated life.</p>	See Lumen Maintenance Requirements Section.	<p><b>Sample:</b> The same sample used for lumen maintenance testing.</p> <p><b>Passing Test:</b> All of the requirements shall be met.</p>
<b>Solid State</b>	<p>Decorative lamps shall have a rated life <math>\geq</math> 15,000 hours. All other lamps shall have a rated life of <math>\geq</math> 25,000 hours. Lamps to be marketed as commercial grade shall have a rated life <math>\geq</math> 35,000 hours.</p> <p>All tested units shall be operational at 3,000 hours.</p> <p><math>\geq</math> 90% of the tested units shall be operational at 6,000 hours.</p>		

**Note:** In response to Draft 1, comments were received stating support for increased stringency in ENERGY STAR requirements for lamp life. Other comments reflected concerns that product failures do occur on occasion; therefore this specification should include allowances for such failures during the first few thousand hours of testing. With the understanding that the majority of qualified lamps have been able to meet these proposed requirements, EPA has maintained language requiring all tested units to be operational at the first rated life testing milestone. Compact fluorescent language has been rephrased for clarity.

As noted in the previous note box, solid state requirements above have been adjusted to continue the life requirements appearing in the existing Integral LED Lamps specification.

**Rapid Cycle Stress Test: All Lamps**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	Lamp shall survive cycling once per hour of rated life, at 5 minutes on, 5 minutes off, for no more than 15,000 cycles.	<b>Measurement:</b> IES LM-65-10 (clauses 2,3,5,6)  ANSI C78.5-2003	<b>Sample Size:</b> 10 lamps per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position. The sample shall be a unique sample for this test.  <b>Passing Test:</b> ≥ 9 units shall survive the minimum number of cycles.  <hr/> For dimmable/2-way/3-way products, testing shall be conducted at the highest wattage setting listed for the model.

**Note:** In Draft 1, EPA proposed changing the present rapid cycle stress test requirements to require one cycle per hour of rated life, with cycle timing of 5 minutes on, 5 minutes off. The proposed change is intended to address common concerns about consumer dissatisfaction resulting from early failures due to frequent switching, and early failures frequently found in the Program’s verification testing program.

Comments supporting the proposal were received from utilities and energy efficiency programs concerned about reliability and consumer satisfaction. Other comments reflected concerns about increased costs, particularly testing costs. Further, some manufacturers noted that lamps with very long life claims (e.g. 50,000 hours) would be testing for most of a year, which may be longer than a given product’s life cycle.

In Draft 2, EPA has proposed to cap rapid cycle stress testing at a maximum of 15,000 cycles. This cap reduces test time and testing burden for lamps with rated life >15,000 hours, including commercial grade lamps which are typically switched less frequently, while maintaining increased stringency for residential applications where consumer satisfaction is a key concern. This cap also ensures that rapid cycle stress testing does not impede early interim certification. EPA seeks stakeholder input on these proposals.

## Electrical Performance Requirements

### Electrical Safety Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	Lamp shall comply with ANSI/UL 1993-2009, and ANSI/UL 8750-2009 as applicable.	<b>Measurement:</b> ANSI/UL 1993-2009  ANSI/UL 8750-2009	<b>Sample Size:</b> As required to satisfy safety testing requirements.  <b>Passing Test:</b> Units shall meet the requirement.

**Note:** ANSI/UL 8750-2009 has been added for solid state lamps. Sample size language has been adjusted.

### Power Factor Requirements: All Lamps > 5 Watts (Exemption: Lamps ≤ 5 Watts)

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
Compact Fluorescent	Lamp shall have a power factor $\geq 0.5$ for residential applications, or $\geq 0.9$ if marketed as commercial grade.	<b>Measurement:</b> ANSI C82.2-2002	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  <b>Passing Test:</b> Average of units tested shall meet the requirement.
Solid State	Lamp shall have a power factor $\geq 0.7$ for residential applications, or $\geq 0.9$ if marketed as commercial grade.	<b>Measurement:</b> ANSI C82.77-2002 sections 6 and 7	Tested units shall be operated at rated voltage.  For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.

**Note:** Partner and stakeholder feedback from the Draft 1 proposal to require  $\geq 0.7$  power factor for all lamps included extensive manufacturer concerns about the cost of redesigning to meet the requirement, the time involved to do so, and other issues including reliability, form factor, and the benefit to consumers. Absent an argument from utilities, EPA has adjusted the requirements in this section to align with requirements in the Luminaires specification, developed to ensure a balance between cost and performance.

### Operating Frequency Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
Compact Fluorescent	Lamp shall have an operating frequency within 20 to 33kHz, or $\geq$ 40kHz.	Measurement: TBD	Sample Size: One unit per model.  Passing Test: Unit shall meet the requirement.
Solid State	TBD		

**Note:** Operating frequency requirements and methods of measurement will be refined in a subsequent draft. EPA is working with the IEEE [PAR 1789](#) working group, IES, and the Alliance for Solid-State Illumination Systems and Technologies ([ASSIST](#)) to identify appropriate performance requirements and methods of measurement to ensure that qualified lamps do not produce perceptible flicker, stroboscopic effects, or adverse health effects. Since the issuance of Draft 1 each organization has made progress in their respective areas of focus. The Agency continues to follow progress and will synthesize the groups' recommendations into one unified proposal for stakeholder comment once their publications are made publicly available.

### Start Time Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	Lamp shall remain continuously illuminated within one second of application of electrical power.	Measurement: ENERGY STAR Start Time Test (Annex D)	Sample Size: 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.  Passing Test: Average of units tested shall meet the requirement.  For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.

**Note:** In Draft 1 EPA proposed reducing the start time requirement from one second to half a second. Manufacturer comments noted a conflict between increasing this requirement and the proposed increases in rapid cycle stress testing requirements. With this in mind, EPA has adjusted the requirement back to one second.

Chartered through the existing CFL specification, the CFL Technical and Research Working Group has collaborated on the development of a method of measurement for start time, absent from the existing specifications. Attached to this specification is a draft of the Start Time Test, in Annex D, for stakeholder review and comment.



**Run-Up Time Requirements: All Compact Fluorescent Lamps  
(Exemption: All Solid State Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>Covered Compact Fluorescent</b>	Lamp shall achieve 100% stabilized light output in $\leq 90$ seconds.  Secondary light sources employed during lamp run up shall operate for no more than 60 seconds.	<b>Measurement:</b> ENERGY STAR Run-Up Time Test (Annex E)	<b>Sample Size:</b> 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position.
<b>All Other Compact Fluorescent Lamps</b>	Lamp shall achieve:  $\geq 50\%$ of stabilized light output in $\leq 30$ seconds; and,  $\geq 80\%$ of stabilized light output in $\leq 45$ seconds; and,  100% stabilized light output in $\leq 60$ seconds.	<b>Reference Documents:</b> IES LM-54-12 (renewal anticipated in 2012)	<b>Passing Test:</b> Average of units tested shall meet the requirement.  For dimmable/2-way/3-way products, measurements shall be taken at the highest wattage setting listed for the model.  For fluorescent lamps, measurements shall be taken at the end of 100 hours of seasoning according to IES LM-54-12.

Note: As mentioned in Draft 1, a common consumer complaint about compact fluorescent lamps is that they are not bright enough. EPA believes this is not due to the light output of the lamps, but instead due to the slow warm up times relative to the incandescent lamps they replace (they are not bright enough when first energized). An analysis of currently qualified CFLs found that 70% of bare lamps were qualified with a run up time of 45 seconds, and 92% were qualified with a run up time of 60 seconds. For qualified covered CFLs, 63% were qualified with a run up time of 90 seconds.

Comments received on the Draft 1 proposal reflected a mix of views, with some expressing concern about the financial costs associated with increases to these requirements. Others expressed concern about the cost of consumer dissatisfaction with slow run-up times, and the resulting difficulty in further engaging consumers with efficient lighting products, citing consumer misunderstandings about full light output versus slow run-up times. EPA has elected to maintain the proposal from Draft 1 in the interest of addressing a well understood consumer dissatisfier.

The CFL Technical and Research Working Group has developed a draft of the Run-Up Time Test, developed in absence of an appropriate industry method of measurement to reference. The test is attached in Annex E for stakeholder review and comment.

**Dimming Requirements: All Lamps Marketed as Dimmable  
(Exemption: Lamps Marked Non-Dimmable per ANSI/UL 1993-2009)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>All Lamps Marketed As Dimmable</b>	Lamp shall meet each of the following requirements if noted as capable of dimming on the lamp, its base or packaging, product literature or point-of-purchase materials, either printed or electronic.  <i>Dimming level: TBD</i>  <i>Flicker: TBD</i>  <i>Audible noise: TBD</i>  <i>Compatibility: TBD</i>	<b>Measurement:</b> <i>TBD</i>	<b>Sample Size:</b> <i>TBD</i>  <b>Passing Test:</b> <i>TBD</i>

**Note:** Working with the Lighting Research Center, NEMA, NRDC and other stakeholders, EPA is developing a set of performance requirements for dimming range, flicker, audible noise and compatibility for inclusion in this specification. The group is also developing a method of measurement and compatibility metric for dimmable lamps carrying the ENERGY STAR. The Agency seeks a definition of dimming which emphasizes quality, ensuring that qualified dimmable lamps dim down to levels meeting consumer expectations, are compatible with the majority of the installed base of dimmers, and are free from audible noise and flicker, among other criteria. Important ongoing and completed work by ANSI, ASSIST, LRC, NEMA, PNNL, and others will be included in this effort, the results of which will be distributed under separate cover or in a subsequent draft for partner and stakeholder comment.

Among other topics, recent industry discussions have included the topic of dimming range. Manufacturers generally agree that 20% (measured) of maximum light output is a threshold for consumer satisfaction. Above 20%, manufacturers hear from consumers that the dimming range is not satisfactory. Incandescent lamps are capable of dimming to 0%, therefore the lower the specification requirement, the more comparable the performance of certified lamps to the incandescent lamps they replace. EPA seeks stakeholder input on what level of dimming range should be required for dimmable lamps to earn the ENERGY STAR.

**Transient Protection Requirements: All Line Voltage Lamps  
(Exemption: Low Voltage Lamps)**

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
<b>All Line Voltage Lamps</b>	Lamp shall survive 7 strikes of a 100 kHz ring wave, 2.5 kV level, for both common mode and differential mode.	<b>Measurement:</b> ANSI/IEEE C62.41.2-2002, Category A operation.	<b>Sample Size:</b> 5 units per model. The sample shall be a unique sample for this test.  <b>Passing Test:</b> All units shall be fully operational at the completion of testing.

**Note:** In Draft 2, supplemental testing guidance language regarding lamp base orientation has been removed. The test has been clarified to be applicable to line voltage lamps only.

## Electromagnetic and Radio Frequency Interference Requirements

Compliance with requirements of the United States Federal Communications Commission is required by law.

**Note:** This table has been removed.

### Noise Requirements: All Lamps Marketed as Dimmable (Exemption: Lamps Marked Non-Dimmable per ANSI/UL 1993-2009)

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	TBD	Measurement: TBD	TBD

**Note:** Related to dimming requirements, EPA has been exploring performance requirements and metrics for measuring audible noise from certified lamps. With the understanding that dimmable lamps present the greatest problems, in Draft 2 EPA has elected to narrow this requirement to cover only dimmable lamps. Under separate cover or in a subsequent draft, the Agency will distribute a proposal for stakeholder review and comment.

## Lamp Toxics Reduction Requirements

### Lamp Toxics Reduction Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements	Method of Compliance
<b>All Lamps</b>	<p>Lamps ≤ 23.0 rated watts shall contain ≤ 2.5 milligrams (mg) mercury per lamp</p> <p>Lamps &gt; 23.0 rated watts shall contain ≤ 3.0 milligrams (mg) mercury per lamp</p> <p>When present, lamp shall contain restricted levels of the following materials, where the maximum concentration values allowed by weight in homogeneous materials are:</p> <ul style="list-style-type: none"> <li>• Lead: 0.1%</li> <li>• Cadmium: 0.01%</li> <li>• Hexavalent chromium: 0.1%</li> <li>• Polybrominated biphenyls (PBB): 0.1%</li> <li>• Polybrominated diphenyl ethers (PBDE): 0.1%</li> </ul>	<p>For purposes of third-party certification, lamp toxics documentation shall not be reviewed when products are initially certified or during verification testing. Instead, consistent with EU RoHS requirements, manufacturer shall maintain documentation on file to demonstrate that certified products meet these requirements. EPA reserves the right to request this documentation at any time. For the purposes of documenting mercury content, the following test procedure shall be used: IEC 62554 ed 1.0 Sample Preparation for Measurement of Mercury Level in Fluorescent Lamps (2011-08-19).</p> <p>For materials other than mercury, manufacturer may rely on component suppliers to provide certification or declaration documents to show that homogenous materials used in lamps comply with the requirement. Alternatively, manufacturer may have lamp components tested in accordance with IEC 62321 or other appropriate analytical technique to verify that homogenous materials do not exceed the concentration limits of the six regulated substances. Handheld XRF analyzers/scanners may also be used to verify compliance.</p>

**Note:** The above requirements for mercury content are based upon analyses of what is technically feasible today for compact fluorescent lamps. A reference to an international test procedure for measuring mercury content has also been added to this draft. Beyond the mercury requirements, in the interest of transparency the relevant toxics reduction requirements have been printed in the specification draft, rather than a reference to EU RoHS resources.

Requirements related to lamp wattage have been clarified to reference rated wattage.

## Dimensional Requirements

### Lamp Shape Dimensional Requirements: All ANSI Standard Lamps (Exemption: Non-Standard Lamps)

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	Lamp shall comply with ANSI minimum overall length (min OAL), maximum overall length (MOL) and maximum lamp diameter values.	Reference Documents: ANSI C78.20-2003  ANSI C78.21-2011  ANSI C78.23-1995 (R2003)	None.

**Note:** In Draft 2, requirements for lamp base dimensions and tolerances have been removed, because these dimensions are verified in the process of electrical safety testing per ANSI/UL 1993-2009.

## Thermal Requirements

### Minimum Operating Temperature Requirement: All Lamps

Lamp Type	ENERGY STAR Requirements	Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
All Lamps	Lamp shall have a minimum ambient operating temperature of 0°F (-18°C) or below.	None.	TBD

**Note:** The Minimum Operating Temperature Requirement has been relocated from the Lamp Packaging Requirements, where it appeared in Draft 1.

## Lamp Labeling, Packaging & Warranty Requirements

### Lamp Labeling Requirements: All Lamps

Lamp Type	ENERGY STAR Requirement
<b>All Lamps</b>	Each of the following shall be printed on the lamp: <ul style="list-style-type: none"> <li>• lamp manufacturer or brand name</li> <li>• lamp model number as will appear on the ENERGY STAR qualifying product list</li> <li>• lamp nominal correlated color temperature including "Kelvin" or "K"</li> <li>• rated wattage in watts (lamps not covered by FTC requirements)</li> <li>• lamp rated lumen output in lumens (lamps not covered by FTC requirements)</li> </ul>

### Lamp Packaging Requirements: All Lamps Except as Noted

Note: these items are required to appear on the exterior of lamp packaging but shall not be placed on the bottom of lamp packaging. Products to be sold exclusively outside of the United States shall have packaging that complies with the legal requirements of the country(ies) into which they will be sold; such packaging need not comply with U.S. federal labeling requirements. The outermost package of bulk packaged (i.e. multi-pack) lamps facing the intended end user shall meet these requirements.

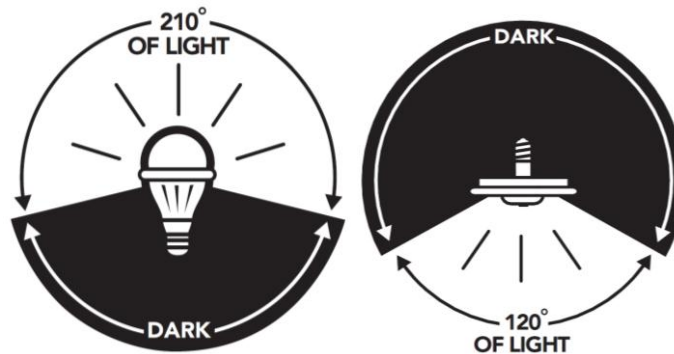
Criteria	ENERGY STAR Requirement
<b>Model Number</b>	Lamp packaging shall include model number and retail number (as applicable) as will appear on the ENERGY STAR qualifying product list.
<b>Controls Compatibility</b>	Lamp packaging exterior shall display on the front panel in $\geq 8$ point type an indication of the lamp's dimming capability: "dimmable", "for dimmers", "non-dimmable", "do not use with dimmers" or the like.  Dimmable lamp packaging shall indicate that the lamp may not be compatible with all dimmers, and shall reference a website providing regularly updated dimmer compatibility information for the lamp model.  Packaging for lamps not designed for operation with photosensors, motion sensors or timing devices shall indicate in $\geq 8$ point type "not compatible with photosensors", "not compatible with timers", "not compatible with motion sensors", "not compatible with photosensors, motion sensors, or timers", or the like.
<b>Application Exceptions</b>	Lamp packaging exterior shall state specific applications that would compromise the performance of the lamp. This includes installations which would result in a lamp's noncompliance with the ENERGY STAR specification performance requirements. Examples include totally enclosed fixtures, insulated ceiling air-tight (ICAT) recessed downlights, damp locations, and any other application restrictions.  A voltage waveform (AC or DC) for which a low voltage MR-16 lamp does not provide the certified performance shall be considered an application exception which shall be detailed on lamp packaging: "Not intended for AC operation." or "Not intended for operation on AC transformers." or "Not for use with AC transformers." or the like, where "DC" may be substituted for "AC", as applicable.
<b>Restricted Position (As Applicable)</b>	Lamp packaging shall indicated restricted operating position (e.g. base up only, base down only) as applicable.
<b>Maximum/Minimum Starting Temperature</b>	Lamp packaging shall state the minimum starting ambient temperature and shall state any other conditions required for reliable starting.
<b>Warranty</b>	Lamp packaging shall include warranty information detailed in the Warranty Requirements section of this specification.

**Non-Standard Light Output Diagram (Solid State Lamps Only)**

Lamps qualified to meet non-standard lamp requirements in this specification shall include a black and white light output diagram of the manufacturer's design, including all of the following elements:

- An iconic representation of the lamp itself at least one quarter inch along its longest dimension.
- Two arrowed arcs joining to create a circle around the icon, where one arc illustrates the angle of lamp light output and the other illustrates the remainder of the circumference around the lamp:
  - One arc shall be bisected by the term "xx° of Light" where "xx" is replaced by the angle in degrees between the two opposite directions in which the average intensity is 10% of the peak intensity, as measured in two rotational planes 90° from each other around and through the lamp axis. This portion of the diagram illustrating light output, from the center of the lamp icon to the aforementioned arc angles, shall be printed in black, on a white background.
  - The other arc shall be bisected by the term "Dark"; this portion of the diagram shall be printed in reverse, in white on a black background.
  - The diameter of the resulting circle shall be no greater than 4 times the longest dimension of the lamp icon.

Examples (enlarged) illustrating base-down and base-up non-standard light output diagrams:



**Warranty Requirements: All Lamps**

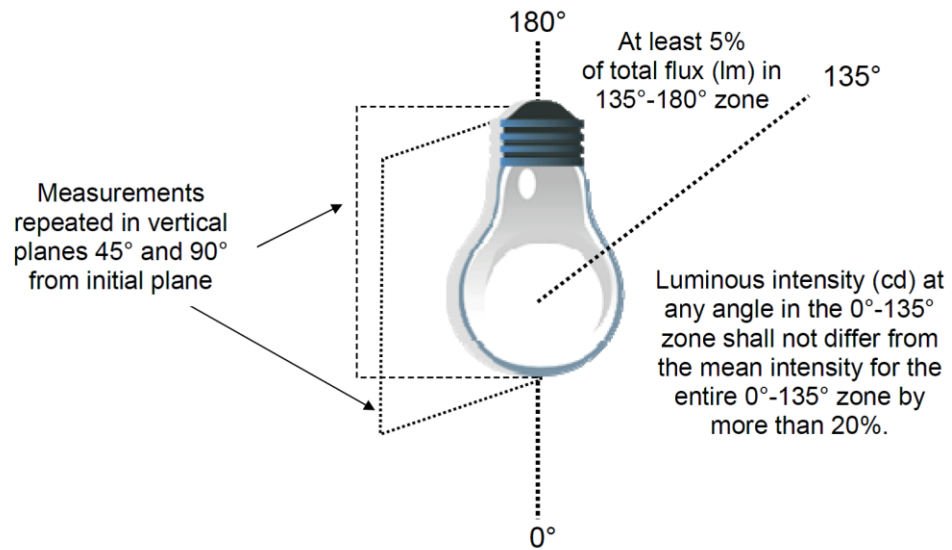
Criteria	ENERGY STAR Requirement											
<b>Warranty</b>	Per the table below lamps shall be backed by a minimum warranty corresponding to the lamp life rating and no less than the corresponding number of hours per day.											
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="background-color: #f2f2f2;">Lamp Life Rating (Hours)</th> <th style="background-color: #f2f2f2;">Minimum Warranty (Years From Date of Purchase)</th> <th style="background-color: #f2f2f2;">Hours of Use Per Day</th> </tr> </thead> <tbody> <tr> <td>&lt; 15,000</td> <td>2</td> <td>3</td> </tr> <tr> <td>≥ 15,000</td> <td>3</td> <td>3</td> </tr> <tr> <td>Lamps marketed as commercial grade</td> <td>5</td> <td>10</td> </tr> </tbody> </table> <p>Lamp packaging exterior shall state "Warranty" or "Limited Warranty", the warranty period (in years) per the above table, and a phone number or website address for consumer complaint resolution. The complete written warranty shall be printed on packaging exterior or included within lamp packaging. Partner is solely responsible for honoring warranty; intermediate parties (e.g. showrooms, electrical distributors, retailers) are not responsible for honoring warranty requirements.</p>	Lamp Life Rating (Hours)	Minimum Warranty (Years From Date of Purchase)	Hours of Use Per Day	< 15,000	2	3	≥ 15,000	3	3	Lamps marketed as commercial grade	5
Lamp Life Rating (Hours)	Minimum Warranty (Years From Date of Purchase)	Hours of Use Per Day										
< 15,000	2	3										
≥ 15,000	3	3										
Lamps marketed as commercial grade	5	10										

**Note:** As reflected in Draft 2, EPA will rely on the FTC Lighting Facts label and ANSI/UL safety requirements to provide the bulk of the information consumers need to select a lamp that meets their needs. There are a few additional lamp labeling and product packaging requirements important to the ENERGY STAR program which remain.

END OF SPECIFICATION

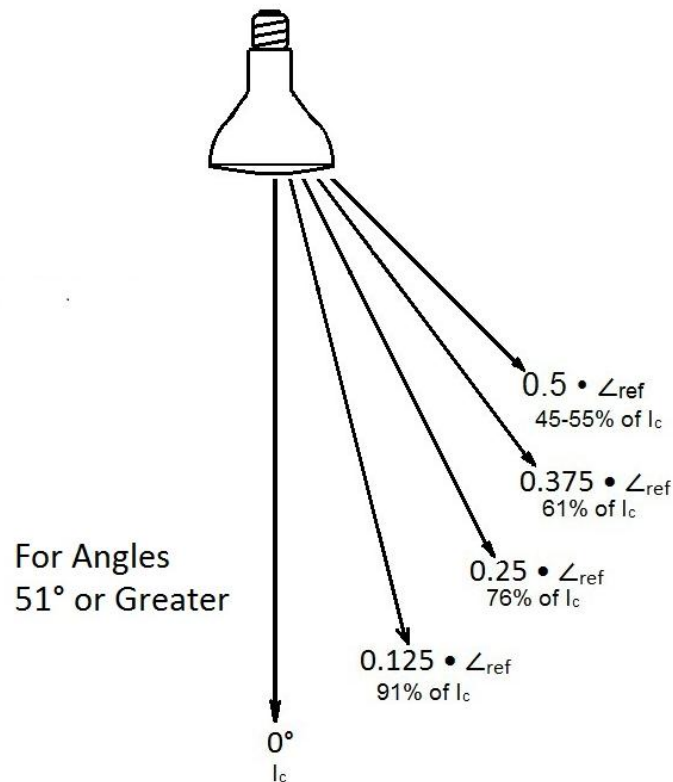
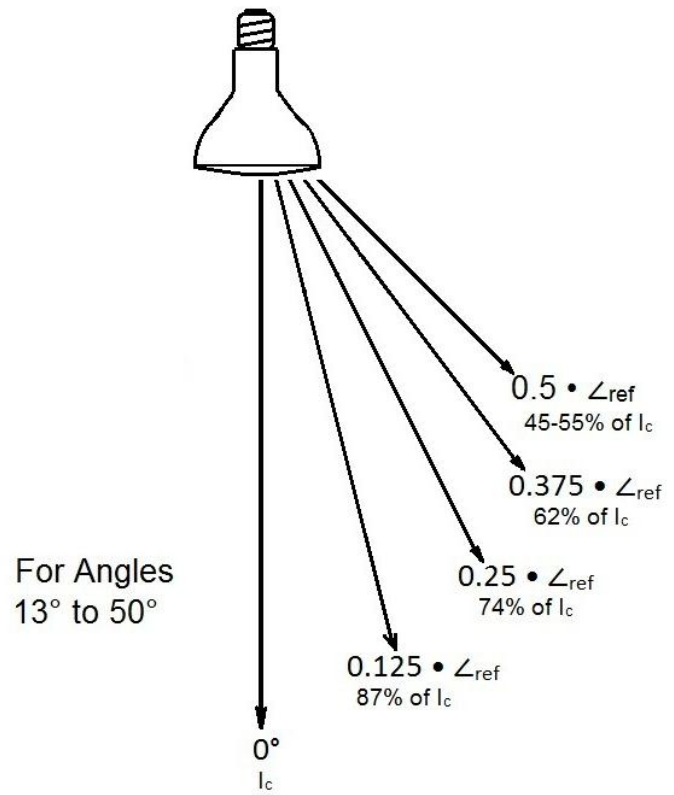
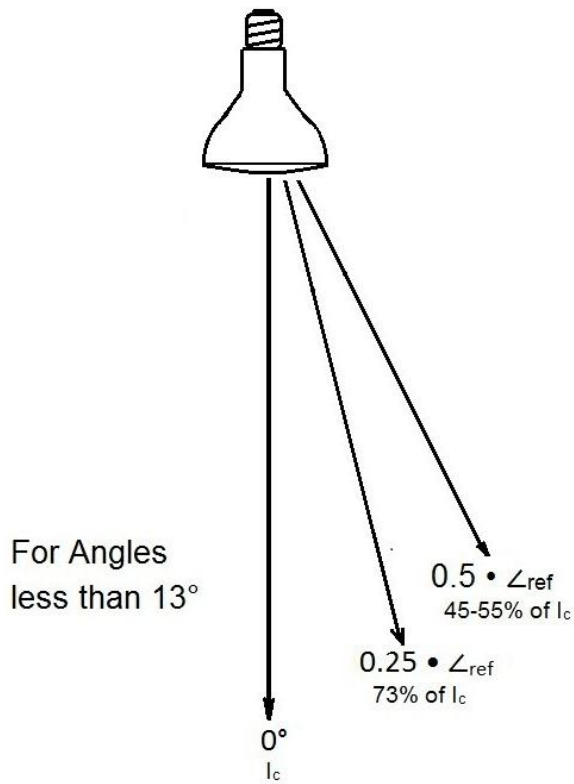
## Appendix A: Luminous Intensity Distribution Diagram for Omnidirectional Lamp

Omnidirectional lamp in base-up position





## Appendix B: Luminous Intensity Distribution Diagrams for Directional Lamps



# Annex A: ENERGY STAR<sup>®</sup> Elevated Temperature Life Test

## Introduction

This document provides a description of the test method for lumen maintenance and reliability testing of integrated compact fluorescent lamps (CFLs) and integrated LED lamps ("LED lamps") ("lamps") in an elevated temperature environment. Three options, "A", "B", and "C," are provided for performing Elevated Temperature Life Tests (ETLT). The test procedure simulates the environment of a lamp in restricted airflow luminaires and is intended to address a common cause of premature lamp failure.

## Testing Details For All Options

### Environmental Conditions

The test environment shall be clean and free from large amounts of dust and moisture. During the lamps' ON cycle, drafts shall be minimized.

### Power Requirements

The power requirements shall be per IES LM-66-11 or LM-79-08 as applicable.

Note: When selecting a power supply for use with integrated lamps, it is necessary to apply an appropriate power factor when specifying the Volt-Amp rating of the power supply. Many integrated lamps have a power factor in the range of 0.5 to 0.6.

### Operating Cycle

Operation of the lamps shall be three hours ON and 20 minutes OFF.

### Lamp Monitoring

The lamps shall be monitored for continuous operation in accordance with IES LM-65-10, section 6.5.

### Photometric Measurements

For non-integrating sphere measurements, the photodetector used for photometric measurements shall be a silicon detector corrected to closely fit the Commission Internationale de l'Eclairage (CIE) spectral luminous efficiency curve ( $V_{\lambda}$ ). For integrating sphere measurements, see IES LM-66-11 or IES-LM-79-08 as applicable.

### Lamp Seasoning

Prior to the first readings, CFL lamps shall be seasoned for 100 hours in accordance with IES-LM-54-99 and shall be seasoned in the position that the lamps will undergo the ETLT. This seasoning shall be accomplished outside of any elevated temperature testing apparatus.

LED lamps shall not be seasoned.

## **Lamp Transfer and Re-stabilization**

CFLs to be removed from the elevated temperature housing or elevated temperature area for photometric testing shall be allowed to cool down for at least 15 minutes before being transported to the photometric equipment. Care shall be exercised to maintain lamp orientation and avoid shaking or bumping the lamp during the transfer. All lamps shall be re-stabilized prior to taking photometric measurements.

## **Temperature Measurement**

Temperature measurements shall be taken using a temperature measurement device consisting of a thermocouple junction or resistance temperature detector (RTD) probe combined with an appropriate meter. Thermocouples or probes shall be chosen to ensure accuracy within the test temperature range.

## **Sample Selection**

Samples shall be representative of the manufacturer's typical product. The samples shall be clean and thoroughly inspected before testing. Any flaws or inconsistencies in the lamp samples shall be noted.

## **Elevated Temperature Life Testing General Procedure**

### **Elevated Temperature Life Test Procedure**

1. Conduct measurement of each lamp following the procedures set forth in IES LM-66-11 or IES LM-79-08, as applicable (hours = 0 for LED lamps, hours = 100 for CFL lamps). Record the results obtained at 25°C.
2. Install the lamps in the elevated temperature situation per the test option used.
3. Operate lamps according to Operating Cycle, modified by conditions described in the testing option selected (Option A, B or C, below).
4. Conduct measurements of test lamps at specified intervals.

### **Elevated Temperature Life Test Report**

ETLT report data shall include the following test information:

1. Manufacturer's name and product identification
2. Name and location of testing facility
3. Test date
4. ETLT Option used
5. Lamp base orientation
6. Photometric measurements at the specified intervals
7. As applicable, number of hours of operation before failure or indication that the lamp reached rated life
8. As applicable, description of failure (e.g. envelope failure, broken glass, cracking, failed LEDs or excessive discoloration) of any lamp that completes testing

## **Elevated Temperature Life Testing (Option A)**

### **Applicability**

Lamp Types: directional and semi-directional lamps

Lamp Orientation: vertical base-up only.

### **Ambient Conditions**

The ambient temperature around the housing shall be maintained at 30°C ±5°C.

### **Elevated Temperature Housing and Support**

Testing shall be conducted using the Halo® model H7UICAT incandescent downlight housing or EPA-approved substitute. No trim shall be used. Luminaires shall be oriented such that the lamp operates vertical base-up during the life test. The luminaires may be arranged in a horizontal plane or stacked vertically. If stacked vertically, a minimum spacing of 24 inches shall be maintained between the bottoms of each row.

## **Elevated Temperature Life Testing (Option B)**

### **Applicability**

Lamp types: all lamps

Lamp orientation: vertical base-up only.

### **Operating Cycle**

At the onset of the OFF cycle, the exhaust fan shall automatically operate to purge the apparatus with ambient air.

### **Ambient Conditions**

The ambient temperature external to the apparatus shall be maintained at 30°C ± 5°C. The perimeter of the apparatus shall be kept clear of obstacles so that airflow is not inhibited from entering the apparatus during the purge portion of the test cycle. The operating temperature within the apparatus shall be represented as the average of at least four measurement locations as specified in the "Temperature Measurement Locations" section (below) and shall be maintained at 55°C ± 5°C during the ON cycle. The operating temperature within the apparatus shall be achieved within 45 minutes upon ON cycle initiation.

### **Elevated Temperature Testing Apparatus (See Figure 1)**

The interior of the Elevated Temperature Testing Apparatus (ETTA) shall be a flat section of perforated substrate with ceramic lampholders arranged in a rectangular array. The perforated substrate shall have holes of a minimum diameter of ¼-in. spaced at a maximum spacing of 1-in. on center. The spacing between lampholders shall be no less than 8-in. on center and no greater than 12-in. on center. Radiant baffles shall be installed at the mid-point between all lampholders and along the perimeter of the lampholder array. The radiant baffles shall be constructed of an opaque, rigid material and shall be a minimum of 10-in. in height. The exterior of the ETTA shall be sealed and insulated to a minimum level of R-13 on all four sides and the hood. The sides of the apparatus shall extend a minimum of 12-in. below the bottom of the radiant baffles and shall have an intake section a minimum of 6-in. in height below the sides of the apparatus. The slope of the hood of the apparatus shall be at least 30° above the horizontal. The top of the hood shall be equipped with an exhaust fan and louver. The fan shall be sized to deliver a minimum of 4.0 cubic feet per minute (cfm) per square foot of apparatus area net of intake and exhaust restrictions. The exhaust fan shall be thermostatically controlled to maintain the appropriate ambient temperature within the apparatus. The louver shall automatically close when the fan is not operating.

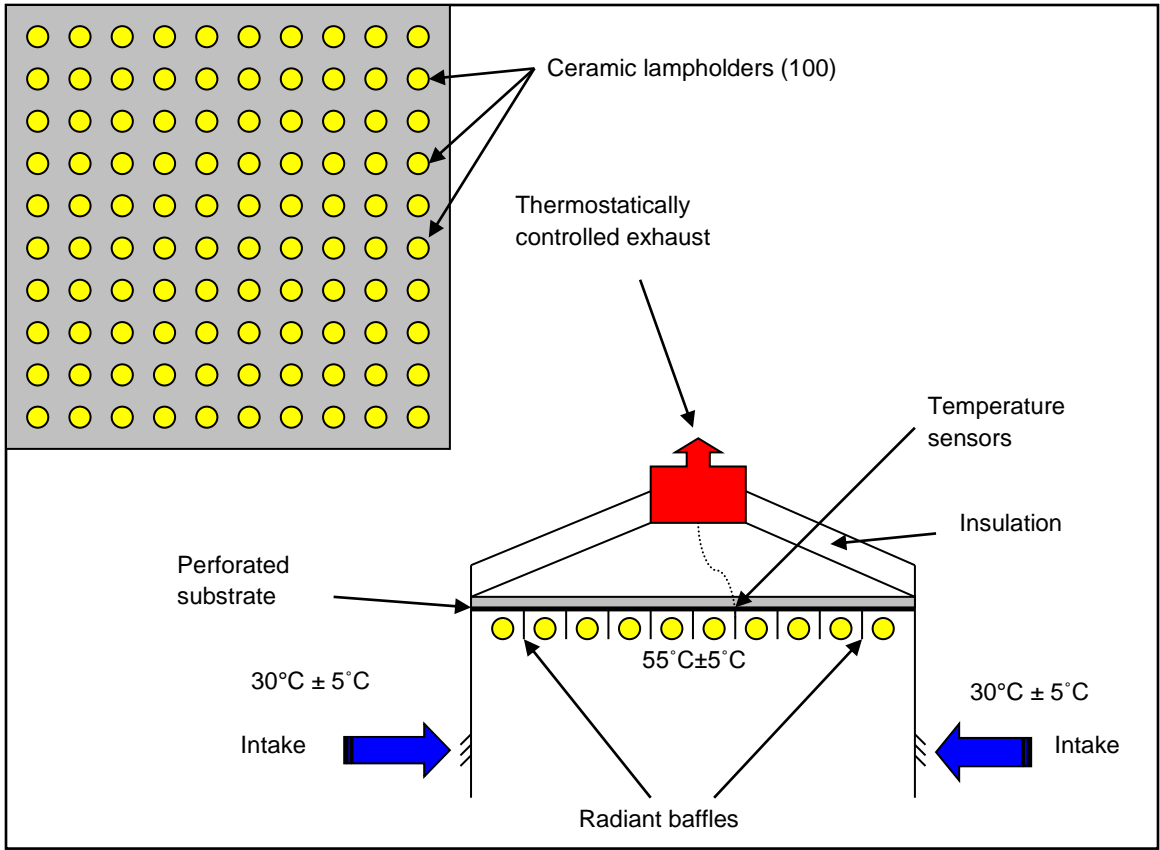


Figure 1: Option B Elevated Temperature Test Apparatus

**Temperature Measurement Locations**

The apparatus shall be equipped with at least four ambient temperature measurement devices. These devices shall be placed in at least two locations between 16 and 24 inches measured inwards from the perimeter of the apparatus and at least two locations between 16 and 24 inches measured outwards from the center of the apparatus. The operating temperature of the testing area is then defined as the average of at least four temperature readings within the testing area. The measurement points shall be located at the height of the lamps under test.

**Photometric Measurement**

There are two methods of photometric measurement, as applicable, for Elevated Temperature Testing Option B.

Option B Photometric Measurement Method 1: Applicable to CFL, semi-directional and omnidirectional LED lamps only

The photometric measurement device shall consist of a securely mounted photodetector positioned such that the plane of its detector is horizontal. Sufficient shielding shall be incorporated such that only the light from the lamp under test is measured. This shielding can be accomplished by the use of a flat-black-painted tube that extends from the photodetector to the bottom edge of the radiant baffles. Additionally, it is recommended that a piece of diffuse transmissive material be installed above the photodetector to diminish the sensitivity of the measurement from minor misalignments of the photodetector.

Photometric measurements shall be acquired at a point at least two hours after the beginning of an ON cycle, allowing the light output of the lamp to reach a steady state. In the situation where the specified measurement time occurs before the lamp has reached its steady state operating time, the lamp shall be measured at the closest steady state period.

Option B Photometric Measurement Method 2: Applicable to all lamps

The operating cycle shall be stopped at the appropriate measurement points during one of the OFF cycles, and lamps shall be measured in an integrating sphere according to IES LM-66-11 or LM-79-08, as applicable. In transferring to the integrating sphere and back to the test apparatus, compact fluorescent lamps shall be handled in accordance with section 10.3 of IES LM-66-11.

Any pre-burning and stabilization time while the lamps have been removed from the apparatus for photometric testing shall be recorded and incorporated into tested time. If applicable, when all lamps have completed photometric testing, the lamps can be returned to the same socket in the apparatus and the elevated temperature life testing can continue.

## **Elevated Temperature Life Testing (Option C)**

### **Applicability**

Lamp Types: all lamps

Lamp Orientation: all orientations

### **Ambient Conditions**

The ambient temperature shall be maintained at  $55^{\circ}\text{C} \pm 5^{\circ}\text{C}$ .

### **Elevated Temperature Housing and Support**

The lamps may be burned in open air in the required testing orientation so long as the required ambient temperature of  $55^{\circ}\text{C} \pm 5^{\circ}\text{C}$  is maintained. The spacing between lampholders shall be positioned between 8 and 12 inches on center, and there shall be a minimum of 2" space between lamps.

### **Temperature Measurement Locations**

If burned in open air, the testing area shall be equipped with at least four ambient temperature measurement devices. These devices shall be placed in at least two locations between 16 and 24 inches measured inwards from the perimeter of the testing area and at least two locations between 16 and 24 inches measured outwards from the center of the testing area. The operating temperature of the testing area is then defined as the average of at least four temperature readings within the testing area. The measurement point shall be located at the height of the lamps under test.

## **Methods of Measurement and Reference Documents**

1. IES LM-65-01. 2010. IES Approved Method for Life Testing of Compact Fluorescent Lamps, IES Testing Procedures Committee, Illuminating Engineering Society, New York.
2. IES LM-66-11. 2011. IES Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, Illuminating Engineering Society, New York.
3. IES LM-79-08. 2008. IES Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products, Illuminating Engineering Society, New York.
4. IES LM-54-99. 1999. IES Guide to Lamp Seasoning, Illuminating Engineering Society, New York.
5. CIE-18.2.1983. 1983. The Basis of Physical Photometry, Commission Internationale de l'Eclairage, Bureau Central de la CIE, Vienna.
6. IES LM-28-89. 1989. Guide for the Selection, Care, and Use of Electrical Instruments in the Photometric Laboratory, IES Testing Procedures Committee, Illuminating Engineering Society, New York.

# Annex B: ENERGY STAR<sup>®</sup> Ambient Temperature Life Test

## Introduction

This document provides a description of the test method for lumen maintenance and reliability testing of integrated compact fluorescent lamps (CFLs) and integrated LED lamps (“LED lamps”) (“lamps”) in an ambient temperature environment. Two options, “A” and “B” are provided for performing the Ambient Temperature Life Test (ATLT).

## Testing Details for All Options

### Ambient Conditions

The test environment shall be clean and free from large amounts of dust and moisture. During the lamps’ ON cycle, drafts shall be minimized.

### Power Requirements

The power supply utilized in the testing shall be capable of providing the nominal rated input voltage and frequency for the lamp(s) under test. The input voltage of the power supply shall be regulated to within  $\pm 2\%$  of the rated RMS value.

Note: When selecting a power supply for use with integrated lamps, it is necessary to apply an appropriate power factor when specifying the Volt-Amp rating of the power supply. Many integrated lamps have a power factor in the range of 0.5 to 0.6.

### Operating Cycle

Operation of the lamps shall be three hours ON and 20 minutes OFF.

### Lamp Monitoring

The lamps shall be monitored for continuous operation in accordance with IES LM-65-10, section 6.5.

### Photometric Measurements

For non-integrating sphere measurements, the photodetector used for photometric measurements shall be a silicon detector corrected to closely fit the Commission Internationale de l’Eclairage (CIE) spectral luminous efficiency curve ( $V(\lambda)$ ). For integrating sphere measurements see IES LM-66-11 or IES-LM-79-08 as applicable.

### Lamp Seasoning

Prior to the first readings, CFL lamps shall be seasoned for 100 hours in accordance with IES-LM-54-99 and shall be seasoned in the position that the lamps will undergo the ATLT.

LED lamps shall not be seasoned.

## **Lamp Transfer and Re-stabilization**

CFLs to be removed from the ambient temperature housing or ambient temperature area for photometric testing shall be allowed to cool down for at least 15 minutes before being transported to the photometric equipment. Care shall be exercised to maintain lamp orientation and avoid shaking or bumping the lamp during the transfer. All lamps shall be re-stabilized prior to taking photometric measurements.

## **Temperature Measurement**

Temperature measurements shall be taken using a temperature measurement device consisting of a thermocouple junction or resistance temperature detector (RTD) probe combined with an appropriate meter. Thermocouples or probes shall be chosen to ensure accuracy within the test temperature range.

## **Sample Selection**

Samples shall be representative of the manufacturer's typical product. The samples shall be clean and thoroughly inspected before testing. Any flaws or inconsistencies in the lamp samples shall be noted.

## **Ambient Temperature Life Testing General Procedure**

### **Test Procedure**

1. Conduct measurement of each lamp following the procedures set forth in IES LM-66-11 or IES LM-79-08 as applicable (hours = 0 for LED lamps, hours = 100 for CFL lamps). Record the results.
2. Install the lamps in the ambient temperature situation per the test option used.
3. Operate lamps according to Operating Cycle, modified by conditions described in the testing option selected (Option A or B, below).
4. Conduct measurements of test lamps at specified intervals.

### **Ambient Temperature Life Test Report**

ATLT report data shall include the following test information:

1. Manufacturer's name and product identification
2. Name and location of testing facility
3. Test date
4. ATLT Option used
5. Lamp base orientation
6. Photometric measurements at the specified intervals
7. As applicable, number of hours of operation before failure or note that the lamp reached rated life
8. As applicable, description of failure (e.g. envelope failure, broken glass, cracking, failed LEDs or excessive discoloration) of any lamp that completes testing.



## **Ambient Temperature Life Testing (Option A)**

### **Applicability**

Lamp types: all lamps

Lamp orientation: vertical base-up only

### **Operating Cycle**

At the onset of the OFF cycle, the exhaust fan shall automatically operate to purge the apparatus with ambient air.

### **Ambient Conditions**

The ambient temperature external to the apparatus shall be maintained within the specification designated temperature range. The perimeter of the apparatus shall be kept clear of obstacles so that airflow is not inhibited from entering the apparatus during the purge portion of the test cycle. The operating temperature within the apparatus shall be represented as the average of at least four measurement locations as specified in the "Temperature Measurement Locations" section (below) and shall be maintained within the specification designated temperature range during the ON-cycle. The operating temperature within the apparatus shall be achieved within 45 minutes upon ON-cycle initiation.

### **Elevated Temperature Testing Apparatus (See Figure 1)**

The Elevated Temperature Testing Apparatus (ETTA) that is used for testing lamps at elevated temperatures in Annex A may be used for the ATLT if the temperature can be regulated to the specification defined temperature for ATLT. Per Annex A, the interior of the ETTA shall be a flat section of perforated substrate with ceramic lampholders arranged in a rectangular array. The perforated substrate shall have holes of a minimum diameter of ¼-in. spaced at a maximum spacing of 1-in. on center. The spacing between lampholders shall be no less than 8-in. on center and no greater than 12-in. on center. Radiant baffles shall be installed at the mid-point between all lampholders and along the perimeter of the lampholder array. The radiant baffles shall be constructed of an opaque, rigid material and shall be a minimum of 10-in. in height. The exterior of the ETTA shall be sealed and insulated to a minimum level of R-13 on all four sides and the hood. The sides of the apparatus shall extend a minimum of 12-in. below the bottom of the radiant baffles and shall have an intake section a minimum of 6-in. in height below the sides of the apparatus. The slope of the hood of the apparatus shall be at least 30° above the horizontal. The top of the hood shall be equipped with an exhaust fan and louver. The fan shall be sized to deliver a minimum of 4.0 cubic feet per minute (cfm) per square foot of apparatus area net of intake and exhaust restrictions. The exhaust fan shall be thermostatically controlled to maintain the appropriate ambient temperature within the apparatus. The louver shall automatically close when the fan is not operating.

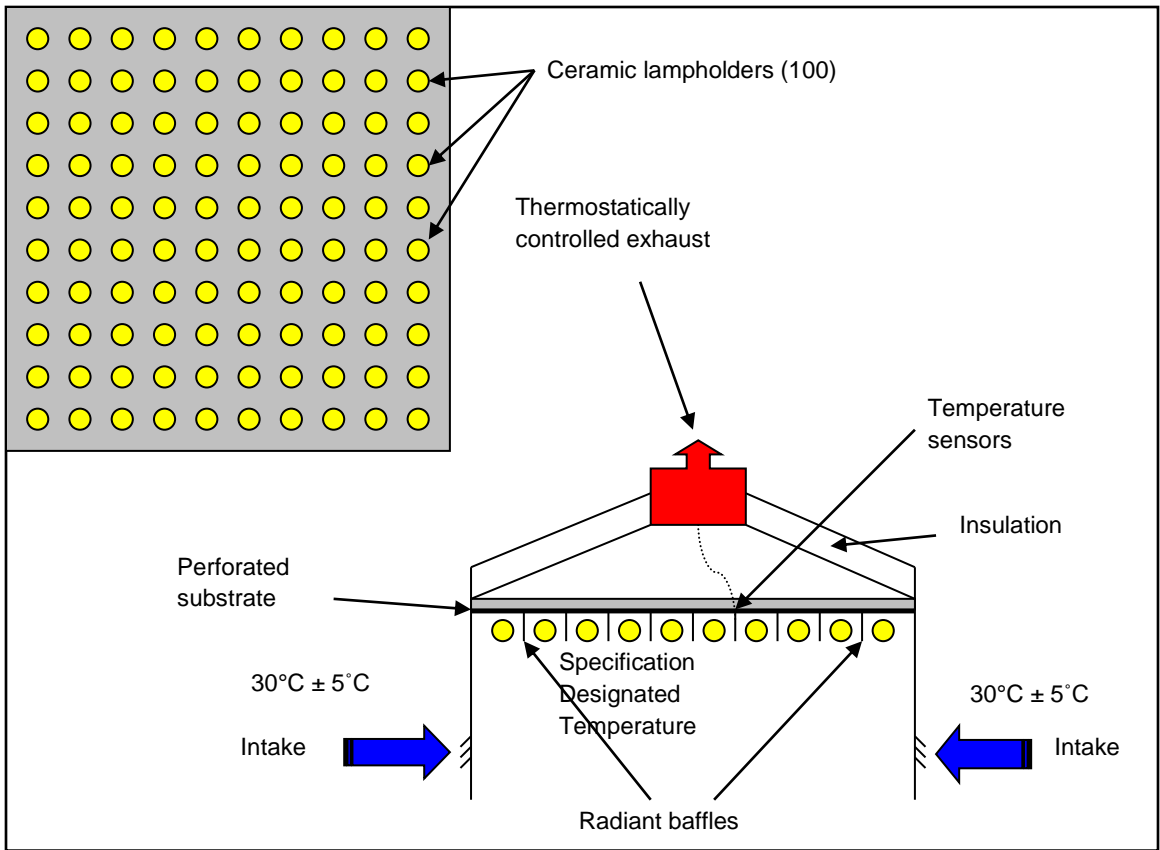


Figure1: Option A Elevated Temperature Test Apparatus

### Temperature Measurement Locations

The apparatus shall be equipped with at least four ambient temperature measurement devices. These devices shall be placed in at least two locations between 16 and 24 inches measured inwards from the perimeter of the apparatus and at least two locations between 16 and 24 inches measured outwards from the center of the apparatus. The operating temperature of the testing area is then defined as the average of at least four temperature readings within the testing area. The measurement points shall be located at the height of the lamps under test.

### Photometric Measurement

There are two methods of photometric measurement, as applicable, for Ambient Temperature Life Testing Option A.

Option A Photometric Measurement Method 1: applicable to CFL, semi-directional and omnidirectional LED lamps only

The photometric measurement device shall consist of a securely mounted photodetector positioned such that the plane of its detector is horizontal. Sufficient shielding shall be incorporated such that only the light from the lamp under test is measured. This shielding can be accomplished by the use of a flat-black-painted tube that extends from the photodetector to the bottom edge of the radiant baffles. Additionally, it is recommended that a piece of diffuse transmissive material be installed above the photodetector to diminish the sensitivity of the measurement from minor misalignments of the photodetector.

Photometric measurements shall be acquired at a point at least two hours after the beginning of an ON cycle, allowing the light output of the lamp to reach a steady state. In the situation where the specified measurement time occurs before the lamp has reached its steady state operating time, the lamp shall be measured at the closest steady state period.

### Option A Photometric Measurement Method 2: applicable to all lamps

The operating cycle shall be stopped at the appropriate measurement points during one of the OFF cycles, and lamps shall be measured in an integrating sphere according to IES LM-66-11 or LM-79-08 as applicable. In transferring to the integrating sphere and back to the test apparatus, compact fluorescent lamps shall be handled in accordance with section 10.3 of IES LM-66-11.

Any pre-burning and stabilization time while the lamps have been removed from the apparatus for photometric testing shall be recorded and incorporated into tested time. If applicable, when all lamps have completed photometric testing, the lamps can be returned to the same socket in the apparatus and the ATLT can continue.

## **Ambient Temperature Life Testing (Option B)**

### **Applicability**

Lamp Types: all lamps

Lamp Orientation: all orientations

### **Ambient Conditions**

The ambient temperature shall be maintained within the specification designated temperature range.

### **Ambient Temperature Housing and Support**

The lamps may be burned in open air in the required testing orientation so long as the required ambient temperature is within the specification designated temperature range. The spacing between lampholders shall be positioned between 8 and 12 inches on center, and there shall be a minimum of 2" space between lamps.

### **Temperature Measurement Locations**

If burned in open air, the testing area shall be equipped with at least four ambient temperature measurement devices. These devices shall be placed in at least two locations between 16 and 24 inches measured inwards from the perimeter of the testing area and at least two locations between 16 and 24 inches measured outwards from the center of the testing area. The operating temperature of the testing area is then defined as the average of at least four temperature readings within the testing area. The measurement point shall be located at the height of the lamps under test.

## **Methods of Measurement and Reference Documents**

1. IES LM-65-01. 2010. IES Approved Method for Life Testing of Compact Fluorescent Lamps, IES Testing Procedures Committee, Illuminating Engineering Society, New York.
2. IES LM-66-11. 2011. IES Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, Illuminating Engineering Society, New York.
3. IES LM-79-08. 2008. IES Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products, Illuminating Engineering Society, New York.
4. IES LM-54-99. 1999. IESNA Testing Procedures Committee, IES Guide to Lamp Seasoning, Illuminating Engineering Society, New York.
5. CIE-18.2.1983. 1983. The Basis of Physical Photometry, Commission Internationale de l'Eclairage, Bureau Central de la CIE, Vienna.
6. IES LM-28-89. 1989. Guide for the Selection, Care, and Use of Electrical Instruments in the Photometric Laboratory, IES Testing Procedures Committee, Illuminating Engineering Society, New York.

# Annex C: ENERGY STAR<sup>®</sup> Elevated Temperature Initial Light Output Ratio

## Introduction

This document provides a description of the test method for determining the light output ratio of integrated compact fluorescent lamps (CFLs) and integrated LED lamps ("LED lamps") ("lamps") tested in an elevated temperature environment compared to an ambient temperature environment. Two measurement methods are provided for performing Elevated Temperature Initial Light Output Ratio test (ETILOR). The test procedure contrasts the light output of lamps in restricted airflow luminaires to the light output of lamps in an ambient temperature environment.

## Testing Details for All Methods

### Environmental Conditions

The test environment shall be clean and free from large amounts of dust and moisture.

### Power Requirements

The power requirements shall be per IES LM-66-11 or LM-79-08 as applicable.

Note: When selecting a power supply for use with integrated lamps, it is necessary to apply an appropriate power factor when specifying the Volt-Amp rating of the power supply. Many integrated lamps have a power factor in the range of 0.5 to 0.6.

### Lamp Seasoning

Prior to the first readings, CFL lamps shall be seasoned for 100 hours in accordance with IES LM-54-12 and shall be seasoned in the position that the lamps will undergo the ETILOR test. This seasoning shall be accomplished outside of any elevated temperature testing environment.

LED lamps shall not be seasoned.

### Lamp Stabilization, Transfer and Re-stabilization

Stabilize lamps per IES LM-66-11 or LM-79-08 as applicable. CFLs to be removed from the controlled temperature housing or controlled temperature area for photometric testing shall be allowed to cool down for at least 15 minutes before being transported to the photometric equipment. Care shall be exercised to maintain lamp orientation and avoid shaking or bumping the lamp during the transfer. All lamps shall be re-stabilized prior to taking any photometric measurements.

### Sample Selection

Samples shall be representative of the manufacturer's typical product. The samples shall be clean and thoroughly inspected before testing. Any flaws or inconsistencies in the lamp samples shall be noted.

### Test Procedure

1. Situate the lamp in the thermally controlled environment or thermal chamber.
2. Apply the rated lamp voltage while operating the thermally controlled environment such that the temperature at the test point is stable as determined by three measurements 5 minutes apart at 25°C not varying by more than  $\pm 1^\circ\text{C}$ .
3. Achieve lamp stabilization per the "Lamp Stabilization, Transfer and Re-stabilization" section, described above.
4. Measure and record light output, input electrical values and test point temperature.

5. For the thermal chamber, in accordance with the *Elevated Temperature Housing and Support* section for Option A in Annex A, repeat steps 2 through 4 such that the temperature at the test point is stable as determined by three measurements 5 minutes apart and not varying by more than  $\pm 1^\circ\text{C}$ .

For the thermally controlled environment, in accordance with the *Elevated Temperature Testing Apparatus* section for Option B or the *Elevated Temperature Housing and Support* section for Option C in Annex A, repeat steps 2 through 4 such that the temperature at the test point is stable as determined by three measurements 5 minutes apart at  $50^\circ\text{C}$  not varying by more than  $\pm 5^\circ\text{C}$ .

## Test Report

ETILOR report data may be included in an overall performance report or a standalone report, and shall include the following test information:

1. Manufacturer's name and product identification
2. Name and location of the testing facility
3. Test date
4. Lamp base orientation
5. Electrical and photometric values at the  $25^\circ\text{C}$  ambient condition
6. Electrical and photometric values at the elevated temperature condition
7. Elevated Temperature Initial Light Output Ratio, calculated as the light output at the elevated temperature condition divided by the light output at the  $25^\circ\text{C}$  ambient condition, expressed as a percentage

## Method 1: Photometric Measurement in Thermal Chamber

### Applicability

Lamps: all CFL, semi-directional LED lamps and omnidirectional LED lamps

### Thermal Chamber/Thermally Controlled Environment

The thermal chamber shall be in accordance with the *Elevated Temperature Housing and Support* section for Option A or the *Elevated Temperature Testing Apparatus* section for Option B in Annex A - ENERGY STAR® Elevated Temperature Life Test.

### Controlled Draft Enclosure

A controlled draft enclosure shall be used to limit air movement across the lamp to a maximum of 0.08 m/s (15.7 ft/min) when placed in the thermal chamber.

### Temperature Measurement Location

Ambient air temperature measurements shall be taken at a location 1-in. below the base (defined as the lowest point on the metal Edison socket when installed in a base-up position) of the lamp and 2-in. from the base of the lamp toward the enclosure wall.

### Photometric Measurement Location

The photometric measurement device shall consist of a securely mounted photodetector positioned such that the plane of its detector is horizontal. Sufficient shielding shall be incorporated such that only the light from the lamp under test is measured. This shielding can be accomplished by the use of a flat-black-painted tube that extends from the photodetector to the base of the lamp. Additionally, it is recommended that a piece of diffuse transmissive material be installed above the photodetector to diminish the sensitivity of the measurement from minor misalignments of the photodetector.

## Method 2: Photometric Measurement in Integrating Sphere

### Applicability

Lamps: all lamps ( $4\pi$  sphere), directional lamps only ( $2\pi$  sphere)

### Integrating Sphere

The test environment shall be clean and free from large amounts of dust and moisture, see IES LM-78-07.

### Thermal Chamber

For  $2\pi$  geometry integrating sphere systems in which the lamp is external to the sphere, a thermal chamber around the lamp may be used to achieve the elevated ambient temperature without elevating the temperature of the sphere. The thermal chamber may be in accordance with the *Elevated Temperature Housing and Support* section for Option A in Annex A - ENERGY STAR® Elevated Temperature Life Test.

### Controlled Drafts

Integrating sphere or thermal chamber shall limit air movement across the lamp, using the method described in IES LM-66-11 section 5.3 to verify there is no discernible airflow.

## Methods of Measurement and Reference Documents

1. IES LM-66-11. 2011. IES Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, Illuminating Engineering Society, New York.
2. IES LM-79-08. 2008. IES Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products, Illuminating Engineering Society, New York.
3. IES LM-78-07. 2007 IES Approved Method for Total Luminous Flux Measurement of Lamps Using an Integrating Sphere Photometer, Illuminating Engineering Society, New York.
4. IES LM-54-12. 2012. IESNA Testing Procedures Committee, IES Guide to Lamp Seasoning, Illuminating Engineering Society, New York.
5. IES LM-28-89. 1989. Guide for the Selection, Care, and Use of Electrical Instruments in the Photometric Laboratory, IES Testing Procedures Committee, Illuminating Engineering Society, New York.

# Annex D: ENERGY STAR® Start Time Test

## Introduction

This document provides a description of the test method for determining start time of integrated compact fluorescent lamps (CFLs) and integrated LED lamps ("LED lamps") (lamps) in an ambient air temperature environment.

## Definition

Starting time is the time between application of power to the device and the point where the light output reaches 98% of its initial plateau.

## General Requirements

### Environmental Conditions

Lamps shall be stored at  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$  for a minimum of 24 hours prior to the test, and testing shall take place in an ambient temperature of  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . Drafts shall be minimized.

### Equipment Required

1. Regulated AC or DC power supply (as applicable)
2. Multichannel oscilloscope with data storage capability
3. 10X probe
4. Photodetector

### Power Requirements

The power requirements shall be per IES LM-66-11 or LM-79-08 as applicable.

Note: When selecting a power supply for use with integrated lamps, it is necessary to apply an appropriate power factor when specifying the Volt-Amp rating of the power supply. Many integrated lamps have a power factor in the range of 0.5 to 0.6.

### Photometric Measurements

The photodetector used for photometric measurements shall be a silicon detector corrected to closely fit the Commission Internationale de l'Eclairage (CIE) spectral luminous efficiency curve ( $V_{\lambda}$ ). For integrating sphere measurements, see IES LM-66-11 or IES-LM-79-08 as applicable.

### Lamp Seasoning

Prior to the first readings, CFL lamps shall be seasoned for 100 hours in accordance with IES LM-54-12 and shall be seasoned in the position(s) that the lamps will undergo lumen maintenance testing.

LED lamps shall not be seasoned.

### Lamp Transfer

CFLs shall be stored per requirements in the Environmental Conditions section before being transported to the start time testing equipment. Care shall be exercised to maintain lamp orientation and avoid shaking or bumping the lamp during the transfer.

## Sample Selection

Samples shall be representative of the manufacturer's typical product. The samples shall be clean and thoroughly inspected before testing. Any flaws or inconsistencies in the lamp samples shall be noted.

## Start Time Test Procedure

### Test Procedure

Test samples in orientation(s) as specified by the ENERGY STAR specification or manufacturer specified position if different.

1. Connect oscilloscope probe to measure the input voltage to the sample.
2. Set the scope to trigger off the input voltage signal. Set trigger level at 10V.
3. Position the photocell so it sees the main body of the discharge tube or array (as applicable). Shield from extraneous light as required. When testing a covered product, the photocell only needs to see the outer luminous face of the sample.
4. Set power supply to rated voltage and frequency of the device. If a range is specified, test sample at the midpoint of the range.
5. Use an exemplar sample to determine the proper voltage and time base settings. Suggested initial time base is 200 mS/div.
6. Apply rated voltage/frequency to the device.
7. Record waveform on which the starting time was based.
8. Record starting time. See Examples 1 and 2 below.

### Test Report

Start Time Test (STT) report data shall include the following test information:

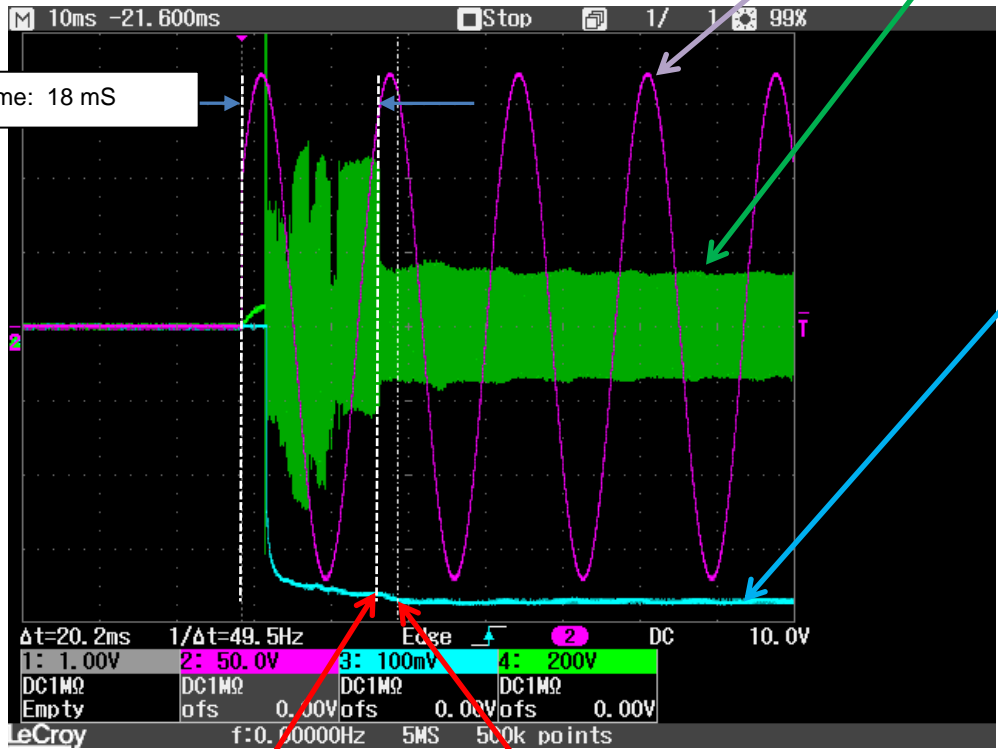
1. Manufacturer's name and product identification
2. Name and location of testing facility
3. Test date
4. Lamp base orientation
5. Test voltage (V)
6. Test frequency (Hz)
7. Time base setting (mS/div)
8. Waveform on which the starting time is based
9. Starting time (mS)

## Normative References

1. IES LM-66-11: 2011. IES Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, Illuminating Engineering Society, New York.
2. IES LM-79-08: 2008. IES Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products, Illuminating Engineering Society, New York.
3. IES LM-54-12: 2012. IES Guide to Lamp Seasoning, Illuminating Engineering Society, New York.



### Example 1 – Compact fluorescent lamp



Purple Trace – Input Voltage

Green Trace – Lamp Arc Voltage

Blue Trace – Light Output

Starting time: 18 mS

98% of Initial Plateau

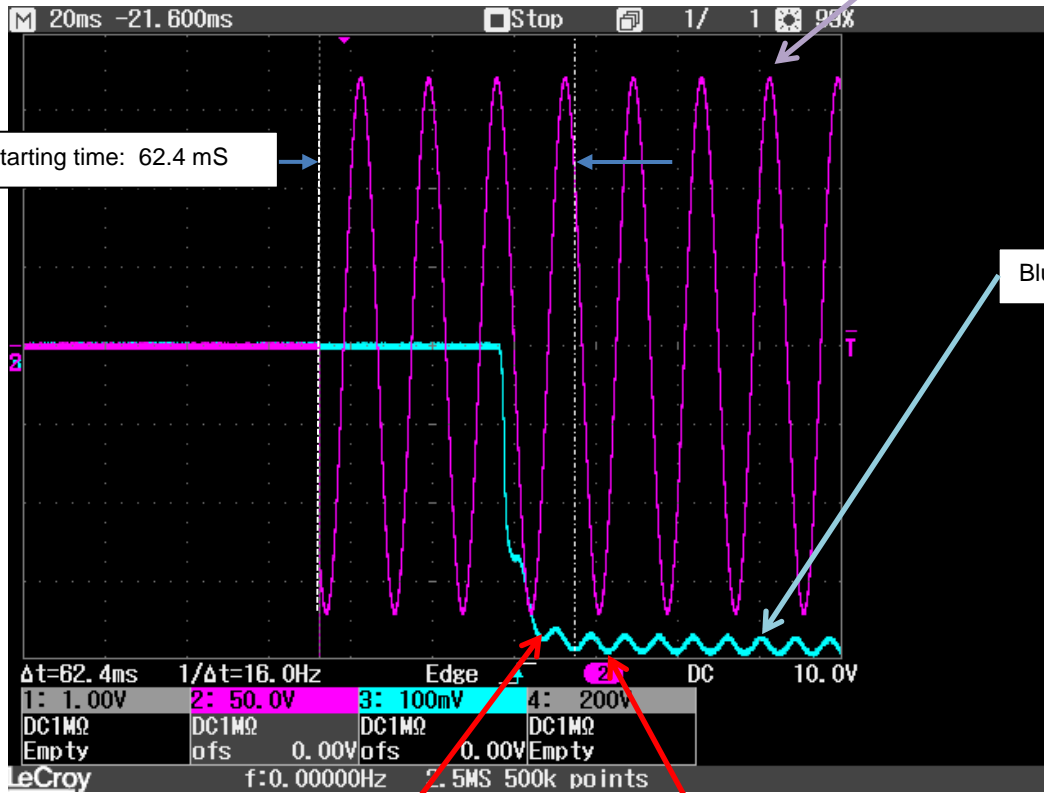
Initial Plateau

## Example 2 – LED lamp

Purple Trace – Input Voltage

Starting time: 62.4 ms

Blue Trace – Light Output



98% of Initial Plateau

Initial Plateau

# Annex E: ENERGY STAR<sup>®</sup> Run-Up Time Test

## Introduction

This document provides a description of the test method for determining run-up time of integrated compact fluorescent lamps (CFLs) (lamps) in an ambient air temperature environment.

## Definition

Run-up time is the time between the application of power to the device and the time when the light output first reaches a specified percentage of stable light output, i.e., t80%, t90%, etc.

## General Requirements

### Environmental Conditions

Lamps shall be stored at  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$  for a minimum of 24 hours prior to the test, and testing shall take place in an ambient temperature of  $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . Drafts shall be minimized.

### Equipment

1. Regulated AC or DC power supply (as applicable)
2. Integrating sphere, cube, or similar device and associated equipment
3. Means of recording light output vs. time (i.e., computer sampling or digital recorder) in one second intervals or less
4. Photodetector

### Power Requirements

The power requirements shall be per IES LM-66-11.

Note: When selecting a power supply for use with integrated lamps, it is necessary to apply an appropriate power factor when specifying the Volt-Amp rating of the power supply. Many integrated lamps have a power factor in the range of 0.5 to 0.6.

### Photometric Measurements

The photodetector used for photometric measurements shall be a silicon detector corrected to closely fit the Commission Internationale de l'Eclairage (CIE) spectral luminous efficiency curve ( $V_{\lambda}$ ). For integrating sphere measurements, see IES LM-66-11.

### Lamp Seasoning

Prior to the first readings, CFL lamps shall be seasoned for 100 hours in accordance with IES LM-54-12 and shall be seasoned in the position(s) that the lamps will undergo lumen maintenance testing.

### Lamp Transfer

CFLs shall be stored per requirements in the Environmental Conditions section before being transported to the start time testing equipment. Care shall be exercised to maintain lamp orientation and avoid shaking or bumping the lamp during the transfer.

## Sample Selection

Samples shall be representative of the manufacturer's typical product. The samples shall be clean and thoroughly inspected before testing. Any flaws or inconsistencies in the lamp samples shall be noted.

## Conditioning

CFL samples shall be off for 20 hours  $\pm$  4 hours prior to the test. If the sample has been off more than 24 hours, it shall be operated for 3 hours and then turned off for 20 hours  $\pm$  4 hours.

## Run-Up Time Test Procedure

### Test Procedure Method 1 – Relative Method

Method 1 requires the sample to be in the test chamber until it stabilizes. As method 1 is a relative measurement, the test chamber does not need to be an integrating sphere, and may be something less sophisticated such as a cube or other shaped chamber.

1. Test samples in orientation(s) as specified by the ENERGY STAR specification or manufacturer specified position if different or restricted.
2. Set power supply to rated voltage and frequency of the device. If a range is specified, test sample at the midpoint of the range.
3. Randomly select sample from available lamps and place in integrating sphere, cube, dodecahedron, or similar device that eliminates extraneous light.
4. Apply rated voltage/frequency to the device.
5. Record light output in no greater than one second intervals until the light output has stabilized.
6. Record stabilization time.
7. Determine desired run-up characteristic, i.e., t80%, t90%, etc. from the data.

### Test Procedure Method 2 – Absolute method

Method 2 requires a short test once the stable lumens are known, but an integrating sphere is required, as an absolute lumen comparison is being made.

1. Test samples in orientation(s) as specified by the ENERGY STAR specification or manufacturer if position restricted.
2. Set power supply to rated voltage and frequency of the device. If a range is specified, test sample at the midpoint of the range.
3. Randomly select sample from available lamps and place in an integrating sphere.
4. Apply rated voltage/frequency to the device.
5. Record light output in no greater than one second intervals for the time to reach the specified percentage of measured, stable light output, i.e., t80%, t90%, etc.
6. Determine desired run-up characteristic (i.e., t80%, t90%, etc.) by comparing the data with the measured, stable luminous flux.

## Test Report

Run-Up Time Test (RUTT) report data may be included in an overall performance report or a standalone report, and shall include the following test information:

1. Manufacturer's name and product identification
2. Name and location of testing facility
3. Test date
4. Lamp base orientation
5. Test voltage (V)
6. Test frequency (Hz)
7. Percentage of stable light output tested to
8. Waveform on which the run up time is based
9. Stabilized light output
10. Run-up light output
11. Run-up time (S)

## Normative References

1. IES LM-66-11: 2011. IES Approved Method for Electrical and Photometric Measurements of Single-Ended Compact Fluorescent Lamps, Illuminating Engineering Society, New York.
2. IES LM-54-12: 2012. IES Guide to Lamp Seasoning, Illuminating Engineering Society, New York.