ENERGY STAR® Program Requirements for Solid State Lighting Luminaires

Eligibility Criteria – Version 1.0

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Below are the product criteria for ENERGY STAR® qualified luminaires using solid-state lighting (SSL). A product must meet all the criteria in order to be qualified as ENERGY STAR.

Scope

The ENERGY STAR criteria cover the requirements for SSL products used for general illumination, including those with significant decorative function. If a decorative SSL product serves a significant general illumination function, it falls within the scope of these criteria. The criteria apply to both residential and commercial products. The criteria apply only to products designed to be connected to the electric power grid. In addition, they do not apply to SSL products made for indication (such as traffic lights and exit signs); to products exclusively intended for decoration (such as holiday lights); nor to SSL products intended for retrofit into existing fixtures.

General Requirements

The criteria are based upon compliance with existing lighting industry reference standards and test procedures, as well as new or revised standards and test procedures currently being developed by lighting industry organizations. These reference standards and test procedures are listed in the appendix.

The following general requirements apply to both Categories A and B. Additional requirements for correlated color temperature (CCT), luminaire efficacy, zonal lumen density, and minimum light output are listed under Categories A and B below.

All Luminaires

<table>
<tr><th colspan="3">Luminaire Requirements:</th></tr>
<tr><td>Correlated Color Temperature (CCT)</td><td colspan="2">The luminaire must have one of the following designated CCTs and fall within the 7-step chromaticity quadrangles as defined in the Appendix.</td></tr>
<tr><td></td><td>Nominal CCT[1]</td><td>CCT (K)</td></tr>
<tr><td></td><td>2700 K</td><td>2725 ± 145</td></tr>
<tr><td></td><td>3000 K</td><td>3045 ± 175</td></tr>
<tr><td></td><td>3500 K</td><td>3465 ± 245</td></tr>
<tr><td></td><td>4000 K</td><td>3985 ± 275</td></tr>
<tr><td></td><td>4500 K</td><td>4503 ± 243</td></tr>
<tr><td></td><td>5000 K</td><td>5028 ± 283</td></tr>
<tr><td></td><td>5700 K</td><td>5665 ± 355</td></tr>
<tr><td></td><td>6500 K</td><td>6530 ± 510</td></tr>
<tr><td>Color Spatial Uniformity</td><td colspan="2">The variation of chromaticity in different directions (i.e., with a change in viewing angle) shall be within 0.004 from the weighted average point on the CIE 1976 (u',v') diagram.</td></tr>
<tr><td>Color Maintenance</td><td colspan="2">The change of chromaticity over the lifetime of the product shall be within 0.007 on the CIE 1976 (u',v') diagram.</td></tr>
<tr><td>Color Rendering Index (CRI)</td><td colspan="2">Indoor luminaires shall have a minimum CRI of 75.</td></tr>
<tr><td>Off-state Power</td><td colspan="2">Luminaires shall not draw power in the off state.

Exception: Luminaires with integral occupancy, motion, photo-controls or individually addressable fixtures with external control and intelligence are exempt from this requirement. The power draw for such luminaires shall not exceed 0.5 watts when in the off state.</td></tr>
<tr><td>Warranty</td><td colspan="2">A warranty must be provided for luminaires, covering repair or replacement of defective electrical parts (including light source and power supplies) for a minimum of three (3) years from the date of purchase. For residential products, the written warranty must be included with the luminaire packaging at the time of shipment.</td></tr>
<tr><td>Thermal Management</td><td colspan="2">Luminaire manufacturers shall adhere to device manufacturer guidelines, certification programs, and test procedures for thermal management.</td></tr>
</table>

[1] Six of the eight allowed nominal CCTs correspond to those in the fluorescent lamp specification: 2700 K, 3000 K, 3500 K, 4100 K, 5000 K, and 6500 K.

Modules/Arrays

Comment on residential indoor lumen depreciation: The requirement for residential indoor lumen depreciation has been lowered to recognize the shorter operating cycles experienced in residential indoor applications. This reduction will allow more products into the market at lower cost while still yielding very long useful life. With 3-hour per day operation, residential indoor luminaires can be expected to maintain 70% of their initial light output for ~23 years. DOE believes maintaining 35,000 hours is appropriate for outdoor and commercial applications.

Module/Array Requirements	
Lumen Depreciation of LED Light Sources (L_{70})	LED module(s)/array(s) shall deliver at least 70% of initial lumens, when installed in-situ, for the minimum number of hours specified below: Residential Indoor: 25,000 hours Residential Outdoor: 35,000 hours All Commercial: 35,000 hours

Outdoor Luminaires

Outdoor Luminaire Requirements	
Residential Automatic Daylight Control	Residential luminaires designed for attaching to buildings and whose power consumption is greater than 13 watts must contain an integral photo-sensor that automatically prevents operation during daylight hours. In addition, the control must automatically reactivate within 24 hours of a manual override or test operation.

Power Supplies

Power Supply Requirements	
Power Factor	Residential ≥ 0.70 Commercial ≥ 0.90
Minimum Operating Temperature	Power Supply shall have a minimum operating temperature of -20°C or below when used in luminaires intended for outdoor applications.
Maximum Measured Power Supply Case or Manufacturer Designated Temperature Measurement Point (TMP)Temperature	Not to exceed the power supply manufacturer maximum recommended case temperature or TMP when measured during in-situ operation. **Note:** This performance characteristic is separate and distinct from thermal requirements established by UL which governs safety rather than longevity of the power supply. All qualified luminaires are expected to meet this requirement, including linear, suspended, close-to-ceiling, IC, ICAT and Non-IC recessed canisters, etc. as well as those luminaires that may be exempt from UL1598.

Output Operating Frequency	≥ 120 Hz **Note:** This performance characteristic addresses problems with visible flicker due to low frequency operation and applies to steady-state as well as dimmed operation. Dimming operation shall meet the requirement at all light output levels.
Electromagnetic and Radio Frequency Interference	• Power supplies designated by the manufacturer for residential applications must meet FCC requirements for consumer use (FCC 47 CFR Part 15/18 Consumer Emission Limits). • Power supplies designated by the manufacturer for commercial applications must meet FCC requirements for non-consumer use (FCC 47 CFR Part 15/18 Non- consumer Emission Limits).
Noise	Power supply shall have a Class A sound rating.
Transient Protection	Power supply shall comply with IEEE C.62.41-1991, Class A operation. The line transient shall consist of seven strikes of a 100 kHz ring wave, 2.5 kV level, for both common mode and differential mode.

Packaging Requirements

Packaging Requirements	
Incompatibility with Controls and Application Exceptions	Included documentation must clearly state any known incompatibility with photo-controls, dimmers or timing devices.

Category A: Near-term Applications

Comment on luminaire efficacy: The ENERGY STAR criteria for SSL Luminaires use Luminaire Efficacy to establish performance as defined below:

$$\text{Luminaire Efficacy} = \frac{\text{Luminaire Light Output (includes fixture efficiency and thermal effects)}}{\text{Luminaire Input Power}}$$

The ENERGY STAR criteria for non-SSL residential light fixtures (commonly referred to as RLF) use system efficacy defined as the light output of the lamp-ballast system divided by the input power measured in a 25°C environment. Established test procedures for fluorescent sources support this approach. However, the program requirements in this document are based upon luminaire efficacy, instead of system efficacy for the following reasons:

- Accurate measurement of the LED light source separate from the fixture is often not possible. LEDs typically are integrated into the fixture and not readily removable without altering the performance of the light source.
- LED performance is significantly affected by elevated temperature. LED devices generate heat that is typically removed by an external heat sink, which may be designed into the luminaire itself. Separating the light source from its heat sink will significantly impact test results. There are no standards or test procedures to measure system efficacy of LEDs. However, standards organizations are developing a test procedure for photometric measurement of LED luminaires. This test procedure is currently in draft form and scheduled to be final by the 4th quarter of 2007.
- Luminaire efficacy provides more realistic energy efficiency information because it accounts for power supply, thermal, and fixture losses, thus better meeting the needs of buyers who seek the most light output for the least energy input.

Under-cabinet kitchen lighting

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 125 lumens (initial) per lineal foot. The light output requirement is calculated by the following equation: $\frac{\text{Measured Fixture Length (inches)}}{12} \times 125 = \text{Minimum Required Light Output (lumens)}$ **Note:** The equation applies to all luminaire configurations. For rectangular geometries the "measured fixture length" is the longest dimension of the fixture. For circular geometries the "measured fixture length" is the diameter. For linear track luminaires the "measured fixture length" is the track length.
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 60% of total lumens (initial) within the 0-60° zone and a minimum of 25% of total lumens (initial) within the 60-90° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	24 lm/W
Allowable CCTs	2700 K, 3000 K and 3500 K

Under-cabinet shelf-mounted task lighting

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 125 lumens (initial) per lineal foot. The light output requirement is calculated by the following equation: $\frac{\text{Measured Fixture Length (inches)}}{12} \times 125 = \text{Minimum Required Light Output (lumens)}$ **Note:** The equation applies to all luminaire configurations. For rectangular geometries the "measured fixture length" is the longest dimension of the fixture. For circular geometries the "measured fixture length" is the diameter. For linear track luminaires the "measured fixture length" is the track length.
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 60% of total lumens (initial) within the 0-60° zone and a minimum of 25% of total lumens (initial) within the 60-90° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	29 lm/W
Allowable CCTs	2700 K, 3000 K, 3500 K, 4000 K, 4500 K and 5000 K

Portable desk task lights

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 200 lumens (initial).
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 85% of total lumens (initial) within the 0-60° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	29 lm/W
Allowable CCTs	2700 K, 3000 K, 3500 K, 4000 K, 4500 K and 5000 K

Comment on increased minimum light output for recessed downlights: The minimum light output for recessed downlights has been increased by 15% (from 300 to 345 and from 500 to 575 lumens, respectively) to account for the reduction in light output due to steady-state LED module/array operation in recessed IC and non-IC environments. DOE believes factoring for the reduction is simpler than adding an additional in-situ or thermal factor test procedure to determine the reduction in light output.

Recessed downlights

Application Requirements	
Minimum Light Output	≤ 4.5" Aperture: 345 lumens (initial) > 4.5" Aperture: 575 lumens (initial)
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 75% of total lumens (initial) within the 0-60° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	35 lm/W
Allowable CCTs	• 2700 K, 3000 K and 3500 K for Residential products • No restrictions for Commercial
Reduced Air Leakage	Recessed downlights intended for installation in insulated ceilings shall be IC rated and be leak tested per ASTM E-283 to demonstrate no more than 2.0 cubic feet per minute (cfm) at 75 Pascals (1.57 lbs/ft2) pressure difference. The luminaire must include a label certifying "airtight" or similar designation to show air leakage less than 2.0 CFM at 75 Pascals when tested in accordance with ASTM E283.

Outdoor wall-mounted porch lights

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 150 lumens (initial).
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 85% of total lumens (initial) within the 0-90° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	24 lm/W

Outdoor step lights

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 50 lumens (initial).
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 85% of total lumens (initial) within the 0-90° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	20 lm/W

Outdoor pathway lights

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 100 lumens (initial).
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 85% of total lumens (initial) within the 0-90° zone (bilaterally symmetrical).
Minimum Luminaire Efficacy	25 lm/W

Category B: Future Performance Targets

Clarification of changes in Category B: The intent of Category B is to announce DOE's intent, well in advance, of substantially increasing future performance requirements, and to encourage continued improvement in technology selection and design of luminaires using SSL sources. Category B is not restricted to the applications in Category A. Products for a wide range of general illumination applications will be eligible.

The minimum luminaire efficacy target given for Category B is intended to rival today's most efficient lighting systems using traditional light sources. For example, the best commonly available high-performance T8 fluorescent lamp and electronic ballast systems are rated around 100 lm/W. High-quality fixtures for these lamp-ballast systems are about 70% efficient, yielding 70 lm/W luminaire efficacy.

Based on current commercially available technology, the Category B level of minimum luminaire efficacy is not achievable for LED luminaires. However, DOE anticipates performance will rise rapidly over the coming years due to on-going progress in LED efficacy, LED high temperature tolerance, power supply efficiency improvements, and luminaire design.

DOE believes a significant number of general illumination products will be able to achieve 70 lm/W luminaire efficacy within three years after the effective date of these criteria. DOE will monitor the technical progress of the technology, steadily adding additional Category A products in future versions. If technology improves faster than expected, and opening category B prior to completion of a three-year waiting period would be in the public interest, DOE will advance the date for allowing products to qualify under Category B.

Category B is established as a future target for performance of SSL-based luminaires. Products cannot qualify under Category B until three years after the effective date of these criteria. If technology improves faster than expected, and opening category B prior to completion of a three-year waiting period would be in the public interest, DOE will advance the date for allowing products to qualify under Category B.

Future Luminaire Efficacy Target:	
Luminaire Efficacy	≥ 70 lm/W
All Other Requirements:	
Glare requirements	To be developed
All other requirements will be the same as those in effect for Category A at the time Category B becomes effective, except for minimum light output and zonal lumen density requirements, which will not be used in Category B.	

Standards and Documentation

Comment on NVLAP accreditation: DOE expects the key standards and test procedures to be completed by their respective organizations by the end of 2007. The process to accredit laboratories for the new test procedures can only be conducted once they have been formally approved. In addition, the time necessary to accredit laboratories may limit the available number of third-party laboratories to conduct testing in the near-term. DOE is funding NIST to address this potential shortcoming. In recognition of this delay, DOE will suspend the NVLAP accreditation requirement for a period of one year from the effective date. DOE believes this is necessary due to the increasing number of LED luminaires appearing on the market, wide variability in the performance of those products, unsubstantiated product performance claims, and the urgent need for buyer guidance. During the period of the NVLAP suspension, DOE will accept test results only from those laboratories on a pre-approved list compiled by DOE. The list of pre-approved laboratories, and the criteria used to select them, will be posted on the ENERGY STAR website.

In addition, DOE acknowledges lumen maintenance tests according to LM-80 will take more than eight months to complete, and can only be initiated after the final lumen maintenance test procedure is made public. DOE plans to make the pre-approved list of laboratories available to potential applicants before the test procedure is made public, thus allowing LM-80 testing to begin as soon as possible for those companies seeking to qualify products.

The NVLAP accreditation requirement will be suspended for a period of one year from the effective date of the criteria. All applicants seeking product qualification on the basis of tests conducted by non-NVLAP laboratories during the suspension period may only submit test results from laboratories pre-approved by DOE. The list of pre-approved laboratories will be posted on the ENERGY STAR website.

Performance Characteristic	Methods of Measurement Reference Standards	Required Documentation
Luminaire Efficacy: Light Output Input Power	IESNA LM-79-XX† ANSI C82.2	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production. Provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories. **Note:** If the laboratory used for this test is accredited by NVLAP or one of its MRA signatories it must also have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.

† Currently being developed by IESNA/ANSI Task Groups in coordination with DOE ENERGY STAR SSL program

Power Factor	ANSI C82.77	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production. Provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories. **Note:** If the laboratory used for this test is accredited by NVLAP or one of its MRA signatories it must also have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.
Lumen Depreciation (L_{70})	IESNA LM-80-XX†	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production. See the Qualification Process section for additional information on Lumen Depreciation testing. Provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories. **Note:** If the laboratory used for this test is accredited by NVLAP or one of its MRA signatories it must also have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.
Color Rendering Index	ANSI C78.377A† IESNA LM-79-XX CIE 13.3-1995 IESNA LM-58	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production. Provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories. **Note:** If the laboratory used for this test is accredited by NVLAP or one of its MRA signatories it must also have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.

† Currently being developed by IESNA/ANSI Task Groups in coordination with DOE ENERGY STAR SSL program

Chromaticity and Correlated Color Temperature	IESNA LM-79-XX CIE 15: 2004 IESNA LM-58 IESNA LM-16	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production. Provide a test report from a laboratory accredited by NVLAP or one of its MRA signatories. **Note:** If the laboratory used for this test is accredited by NVLAP or one of its MRA signatories it must also have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.
Color Spatial Uniformity and Color Maintenance	IESNA LM-79-XX CIE 15: 2004 IESNA LM-58 IESNA LM-16	Self Certification **Note:** A laboratory test report must be submitted upon DOE request.
Maximum Measured Power Supply Case or Manufacturer Designated Temperature Measurement Point (TMP) Temperature	UL 1598	Laboratory test results must be produced using the specific module(s)/array(s) and power supply combination that will be used in production.
Noise	Class A sound rating: Power supply not to exceed 24 dB	Self Certification **Note:** A laboratory test report must be submitted upon DOE request.
Luminaire Warranty		Provide copy of the actual three-year manufacturer luminaire warranty that is included in the packaging.
Safety Portable Fixtures Hardwired Fixtures	 ANSI/UL 153 UL 1598	Provide the cover page of a safety test report or a general coverage statement from an OSHA NRTL laboratory.

Qualification Process

Comment on allowing product variations: DOE received a number of comments concerning the requirement that all luminaires and all versions of those luminaires be tested as a condition of qualifying for ENERGY STAR. DOE understands the time and costs associated with testing all versions of a product. Accordingly, DOE has developed a product group qualification process that allows for limited variations between products tested for qualification and those to which the qualification applies.

In this approach, an applicant may group similar products. The applicant self-defines the product grouping and product variations to which the application applies. DOE will require and verify all units in this family are essentially identical except for minor variations. Applicants will provide a single luminaire from this family for testing. So long as the product passed ENERGY STAR testing, the entire proposed product grouping would be qualified to carry the ENERGY STAR label.

However, this seemingly lenient approach to product qualification would be backed by an aggressive quality assurance (QA) program. DOE will aggressively test qualified products included in product groupings after their appearance in the market, focusing on models that exhibited characteristics making them likely to perform less well than the tested product. If a QA test found a non-complying product, the entire product grouping would be disqualified. If a QA test found a second test failure in another product grouping from the same applicant, that applicant's rights to use product grouping would be suspended for a year.

The approach combines up-front trust of applicants' product groupings with an uncompromising back-end QA program. DOE believes the price for failing QA testing is high enough to induce applicants into being conservative with their product grouping designations. DOE will encourage them to select for qualification testing the product in a proposed grouping least likely to meet program requirements. If applicants don't follow that advice, they are likely to be subject to product de-listings (which their retailers and distributors will learn about), and they will have to incur significant testing expense for individual product variation testing.

DOE believes this approach to be a reasonable compromise between the competing needs for robust qualification testing and acceptable applicant testing costs.

Comment on alternate testing procedures: Several stakeholders also expressed concerns about the requirements for luminaire testing, citing the additional time and expense this would add to the qualification process. The current status of LED technology and available test procedures preclude qualification of LED fixtures on the basis of platform (i.e., lamp-ballast or LED-power supply) testing. There is too much variability in the way LEDs are integrated into fixtures and this integration materially impacts LED performance. At this early stage of LED development, DOE believes quality and end user satisfaction will be best served by qualifying luminaires, rather than platforms. DOE welcomes engagement and industry dialogue on streamlining and simplifying the testing procedures, while still capturing the necessary photometric, electrical, and colorimetric information necessary to ensure product quality and efficiency. Following adoption of these criteria, DOE will convene a process to develop alternative testing approaches, inviting participation by lighting manufacturers, lighting testing laboratories, and research institutions.

Product Variations

In recognition of the significant component substitution that occurs on a manufacturing production line, and in recognition of a range of product variations that may or may not have a material effect on product performance, these criteria allow for limited variation between products tested for qualification purposes, and products qualified as a result of those tests.

Applicants may choose to qualify product groups as a single SKU (one SKU, some variations) or a SKU family (multiple SKUs, some variations). Applicants self define product groupings. Under either option, qualified products must be essentially identical to the tested product. Only limited variation is allowed. The table below summarizes allowable variations.

Variations Within Product Groupings	
Housing/Chassis	not allowed
Heat Sink/Heat Management	not allowed
Finish	allowed
Reflector/Trim	allowed
Shade/Diffuser	allowed
Mounting	allowed
Light Source	allowed, w/ conditions
Power Supply	allowed, w/ conditions

As seen in the table, housing/chassis variations and heat sink/heat management component variations are not allowed, whether applying for a single SKU or SKU family, because they may materially impact LED performance. Finish, reflector/trim, and shade/diffuser variations are allowed. Light source and power supply variations are allowed, subject to conditions described below.

Products qualified under a single application may include LED module(s)/array(s) and power supplies from more than one manufacturer, but the LED module(s)/array(s) and power supplies must be substitutable components used to manufacture essentially identical luminaires and must be intended to produce the same quantity and quality of light. LED module(s)/array(s) and power supply substitutions intended to produce different CCT, CRI, total flux, and other quantitative and qualitative differences in light may not be included in a single product grouping. Further, all LED module(s)/array(s) substitution components must separately comply with the Option 1 (Component Performance) requirements in the Lumen Depreciation section below.

Lumen Depreciation Qualification

The LM-80 test procedure prescribes lumen depreciation testing for the module(s)/array(s) and/or the luminaire. The applicant may demonstrate compliance with either Option 1 (Component Performance) or Option 2 (Luminaire Performance).

OPTION 1: Component Performance

The Component Performance option allows the applicant to demonstrate compliance with the lumen depreciation requirement by demonstrating an LM-80 tested light source (module(s)/array(s)) operates at or below specified temperatures when operated in situ. To be eligible for the component performance option, **ALL** three of the conditions below must be met. If **ANY** of the conditions are not met, the component performance option may not be used and the applicant must use the luminaire performance option for compliance.

1. The LED module(s)/array(s) used in the fixture has/have been tested according to LM-80, and the module(s)/array(s) demonstrated 70% lumen maintenance at 25,000 hours (residential indoor) and 35,000 (residential outdoor and all commercial) hours or greater.
2. The module(s)/array(s) manufacturer prescribes/indicates a temperature measurement point (TMP)

on the module(s)/array(s).
3. The module(s)/array(s) TMP is accessible to allow temporary attachment of a thermocouple for measurement of in situ temperature. Access via a temporary hole in the housing, tightly resealed during testing with putty or other flexible sealant is allowable.

The luminaire **PASSES** the Lumen Depreciation requirements if:

1. The module/array(s) temperature measured in situ, at the TMP is less than or equal to the temperature(s) specified in the LM-80 test report for the corresponding drive current or higher, within the manufacturer's specified operating current range.
2. The drive current measured in the fixture is less than or equal to the drive current specified in the LM-80 test report at the corresponding temperature or higher.

OPTION 2: Luminaire Performance

The applicant demonstrates compliance with the lumen depreciation requirement by submitting an LM-80 test report for the entire luminaire. The test report must demonstrate an L_{70} lumen maintenance of 35,000 hours or greater when operated in-situ.

Power Supply Qualification

Power supplies integral with the module(s)/array(s) or enclosed within the fixture shall undergo in-situ operation. The power supply case temperature or TMP shall be measured under steady-state conditions. The luminaire passes power supply requirements if the case temperature or TMP is less than or equal to the warranted temperature specified by the power supply manufacturer.

Qualification Procedures

DOE will separately develop a document describing the specifics of qualification procedures, including application forms.

Quality Assurance (QA) Testing

Manufacturer partners selling approved ENERGY STAR SSL luminaires will be required to participate in a quality assurance testing program, which will use independent, third-party, qualified testing facilities. This third-party testing program is necessary to provide an active system to verify quality of ENERGY STAR qualified SSL Luminaire products in the marketplace. The information provided below is a general description and summary of the QA testing program. Detailed policies and procedures will be available in the ENERGY STAR SSL Quality Assurance Testing Program Manual.

A. **Overview:** Qualified luminaires will be selected for QA testing both on a random basis and through a product nomination process. The manufacturer of each selected luminaire will be required to commission third-party testing of the specified luminaire by a manufacturer-independent qualified testing lab. The testing lab will procure three (3) samples of each luminaire through normal market channels. Each luminaire will be tested for:

   - Total Luminous Flux
   - Luminaire Efficacy
   - Correlated Color Temperature
   - Color Rendering Index
   - Steady State Module/Array Temperature
   - Maximum Power Supply Case/TMP Temperature

B. **Results of Non-Compliance.** If a product qualified under a Single SKU product grouping or SKU Family product grouping fails QA testing, the entire product grouping is de-listed. If two or more variations of a product qualified under a product grouping fail QA testing, the applicant is placed on a probationary list. Applicants on the probationary list temporarily have their rights to use of product groupings suspended. They must individually qualify each unique product, including light source and power supply variations within a single SKU. An applicant is removed from the probationary list after one year, making it once again eligible to qualify for product groupings. Applicants will be returned to the probationary list if two or more of their product groupings subsequently fail QA tests.

   To limit the probability of test failure during QA testing and subsequent suspension of product grouping qualification rights, applicants are advised to test and qualify the least efficient version of luminaires covered by a single application, and to use only those substitute components that perform at least as well as components used in products tested for qualification.

   DOE reserves the right to terminate any partnership agreements with a manufacturer whose products repeatedly violate the specification.

A separate document will be developed by DOE to define the specifics of the quality assurance testing (QA) intended to accompany these criteria.

Effective Date

Comment on effective date: Under normal circumstances, DOE would establish an effective date 270 days after public release of the final criteria. However, additional time is required for these criteria because the LM-80 Lumen Depreciation test procedure has not yet been finally adopted by ANSI and IESNA. The test procedure will require tests that will take approximately nine months to complete. Therefore, products included in applications for qualification under these criteria will need to have initiated testing in early January, 2008 in order for those products to have completed testing prior to the effective date of September 30, 2008. Accordingly, should the LM-80 test procedure not be complete by January 1, 2008, DOE may be forced to delay the effective date.

The effective date for the ENERGY STAR Program Requirements and Criteria for SSL – Version 1.0 will be September 30, 2008. However, DOE will not make the criteria effective until all referenced standards and test procedures are in effect. Therefore DOE may find it necessary to delay the effective date in the event the relevant standards are not in place by January 1, 2008.

Future Specification Revisions

Due to the rapid pace of LED technology development, DOE anticipates regular revisions to these criteria. DOE anticipates that new applications will be added to the criteria as LED performance and efficacy improve. Revisions will be announced to all partners with time for input and review.

Appendix

Comment on changes to definitions: Definitions have been made consistent with recently completed additions to IESNA RP-16 *Nomenclature and Definitions for Illuminating Engineering*.

Definitions

A. **A2LA**: American Association for Laboratory Accreditation.
B. **ALA**: American Lighting Association.
C. **ANSI**: American National Standards Institute.
D. **ASSIST**: Alliance for Solid State Illumination Systems and Technologies.
E. **ASTM**: American Society for Testing of Materials.
F. **Automatic daylight shutoff**: A photocell device that automatically prevents operation of a luminaire during daylight hours.
G. **CIE**: Commission Internationale de l'Eclairage (translated International Commission on Illumination).
H. **Color rendition**: The effect the spectral characteristic of the light emitted by the LED has on the color appearance of the objects illuminated by it is called color rendition. The color rendering index (CRI) is defined in terms of a comparison of the spectral tri-stimulus values of the objects under test illumination and standard illumination according to the recommendations of CIE Publication No.13.3-1995.
I. **Commercial luminaire**: A luminaire using a Class A power supply.
J. **Correlated Color Temperature (CCT)**: The actual color of the LED is called the color temperature and is defined in terms of the spectral tri-stimulus values (color coordinates) according to the recommendations of IESNA LM-16. For color coordinates near the blackbody loci, the correlated color temperature, measured in Kelvin (K), is used.
K. **CSA**: Canadian Standards Association.
L. **IEC**: International Electrotechnical Commission.
M. **IESNA**: Illuminating Engineering Society of North America.
N. **Initial performance values**: The photometric and electrical characteristics at the end of the 100-hour aging period in a 25°C test environment.
O. **LED array**: An assembly of LED packages on a printed circuit board or substrate, possibly with optical elements and additional thermal, mechanical, and electrical interfaces. The device does not contain a power source and is not connected directly to the branch circuit.
P. **LED driver**: A power source with integral LED control circuitry designed to meet the specific requirements of a LED lamp or a LED array.
Q. **LED lumen depreciation (L_{70})**: The length of time declared by the manufacturer at which 70% lumen maintenance of any large sample of LEDs is reached.
R. **LED luminaire**: A complete LED lighting unit consisting of a light source and driver together with parts to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED array, an LED module, or an LED lamp. The LED luminaire is intended to connect directly to a branch circuit.
S. **LED module**: A component part of an LED light source that includes one or more LEDs that are connected to the load side of LED power source or LED driver. Electrical, electronic, optical, and mechanical components may also be part of an LED module. The LED module does not contain a power source.
T. **LED package**: An assembly of one or more LED die that contains wire bond connections, possibly with an optical element and thermal, mechanical, and electrical interfaces. The device does not include a power source and is not connected directly to the branch circuit.
U. **Luminaire efficacy**: The luminous flux of the luminaire divided by the input power.
V. **Lumen maintenance**: The luminous flux at a given time in the life of the LED and expressed as a percentage of the initial luminous flux.
W. **MacAdam color ellipse**: An elliptical region of chromaticity coordinates that is defined using a centroid, a tilt angle relative to a horizontal axis, and a defined level of variance. Such a region defines what chromaticity coordinates can be acceptably associated with a target Correlated Color Temperature. For these criteria, standardized color ellipses are defined using centroids based upon objective chromaticities (x,y) and tilt angles (è) specified in Table 1 and 2 of ANSI C78.376-2004, and a defined variance of four steps.

X. **Manufacturer designated Temperature Measurement Point (TMP)**: The temperature measurement point designated by the manufacturer correlating to photometric, life or warranty values.
Y. **Minimum operating temperature**: The minimum temperature at which the power supply will reliably operate.
Z. **MRA**: Mutual Recognition Arrangement.
AA. **NVLAP**: National Voluntary Laboratory Accreditation Program.
BB. **Portable luminaire**: A luminaire whose power supply connection is made by means of a cord with or without a plug.
CC. **Power factor**: The active power divided by the apparent power (i.e., product of the rms input voltage and rms input current of a driver).
DD. **Recessed downlight**: General purpose luminaire designed to provide general or ambient lighting in a space. They are recessed into the ceiling and are designed to produce illuminance on a floor or workplane. The luminaire encompasses the fixture housing, reflector, trim ring, and light source. For purposes of the ENERGY STAR SSL Luminaire criteria, two categories of recessed downlights are referenced:
    1. Recessed downlight aperture – the diameter (round configuration) or shortest width (rectangular configuration), measured across the inside of the housing with no trim or reflector installed.
    2. Recessed downlight fixture housing – the enclosure supporting the fixture to framing elements and to which lamps, trims and reflectors are attached.
    3. Recessed downlight trim – refers to the portion of the recessed downlight luminaire visible from below the ceiling, including the reflector, trim ring, light source, and parts necessary to connect the trim to the fixture housing. The trim kit can often be used to retrofit an existing recessed downlight fixture housing.
EE. **Residential luminaire**: A luminaire using a Class B power supply.
FF. **UL:** Underwriters Laboratories

Reference Standards and Test Procedures

Standards and Test Procedures in *ITALICS* are currently under development.

Reference Standards and Test Procedures		
Organization	Identifier	Description
ANSI	*ANSI C82.XXX*	*Electronic Drivers for LED Devices, arrays, or systems (In development).*
ANSI	*ANSI C78.377A*	*Specifications for the Chromaticity of Solid State Lighting Products (In development).*
ANSI	ANSI C82.77 - 2002	Harmonic Emission Limits – Related Power Quality Requirements for Lighting
ANSI	ANSI/IEEE C62.41 - 1991	Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
ANSI/UL	ANSI/UL 153 - 2005	Portable Electric Luminaires
ASTM	ASTM E 283 - 2004	Restricted air movement
CIE	CIE Pub. No. 13.3 - 1995	Method of Measuring and Specifying Color Rendering of Light Sources
FCC	FCC 47 CFR	Electromagnetic interference
IESNA	IESNA LM-16	Correlated Color Temperature
IESNA	IESNA LM-58	Color Rendering Index and Correlated Color Temperature
IESNA	*IESNA LM-79*	*Approved Method for the Electrical and Photometric Testing of Solid-State Lighting Devices (In Development)*
IESNA	*IESNA LM-80*	*Lumen Depreciation of LED Light Sources (In Development)*
NFPA	NFPA 70 - 2005	National Electric Code
UL	UL 1012 - 2005	Power Units Other Than Class 2
UL	UL 1310 - 2005	Class 2 Power Units
UL	UL 1598 - 2004	Luminaires
UL	UL 1838 - 2002	Low Voltage Landscape Lighting Systems
UL	UL 1994 - 2005	Luminous Egress Path Marking Systems

Chromaticity Specification and Tolerance Quadrangles

This chromaticity specification below was developed by ANSI to be as consistent as possible with existing fluorescent lamp standards, and to reflect the current (and near future) state of SSL technology and color binning capabilities. Each of the eight quadrangles as defined below overlap the six current the ANSI 7-step MacAdam ellipses (consistent with the current ENERGY STAR lighting criteria), and thus have the same nominal CCT as ENERGY STAR fluorescent lamps. Two additional CCTs (4500 and 5700K) are included to encompass the additional CCTs available in SSL. Each quadrangle is defined by the range of CCT and the distance from the Planckian locus on the chromaticity diagram. Refer to ANSI C78.377A for the details of these definitions. Figure 1 shows the plot of these chromaticity quadrangles and the table below shows (x,y) coordinates of the center points and the corners of each quadrangle.

	2700 K		3000 K		3500 K		4000 K		4500 K		5000 K		5700 K		6500 K	
	x	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**x**	**y**
Center point	0.4578	0.4101	0.4338	0.4030	0.4073	0.3917	0.3818	0.3797	0.3611	0.3658	0.3447	0.3553	0.3287	0.3417	0.3123	0.3282
Tolerance quadrangle	0.4813	0.4319	0.4562	0.4260	0.4299	0.4165	0.4006	0.4044	0.3736	0.3874	0.3551	0.3760	0.3376	0.3616	0.3205	0.3481
	0.4562	0.4260	0.4299	0.4165	0.3996	0.4015	0.3736	0.3874	0.3548	0.3736	0.3376	0.3616	0.3207	0.3462	0.3028	0.3304
	0.4373	0.3893	0.4147	0.3814	0.3889	0.3690	0.3670	0.3578	0.3512	0.3465	0.3366	0.3369	0.3222	0.3243	0.3068	0.3113
	0.4593	0.3944	0.4373	0.3893	0.4147	0.3814	0.3898	0.3716	0.3670	0.3578	0.3515	0.3487	0.3366	0.3369	0.3221	0.3261

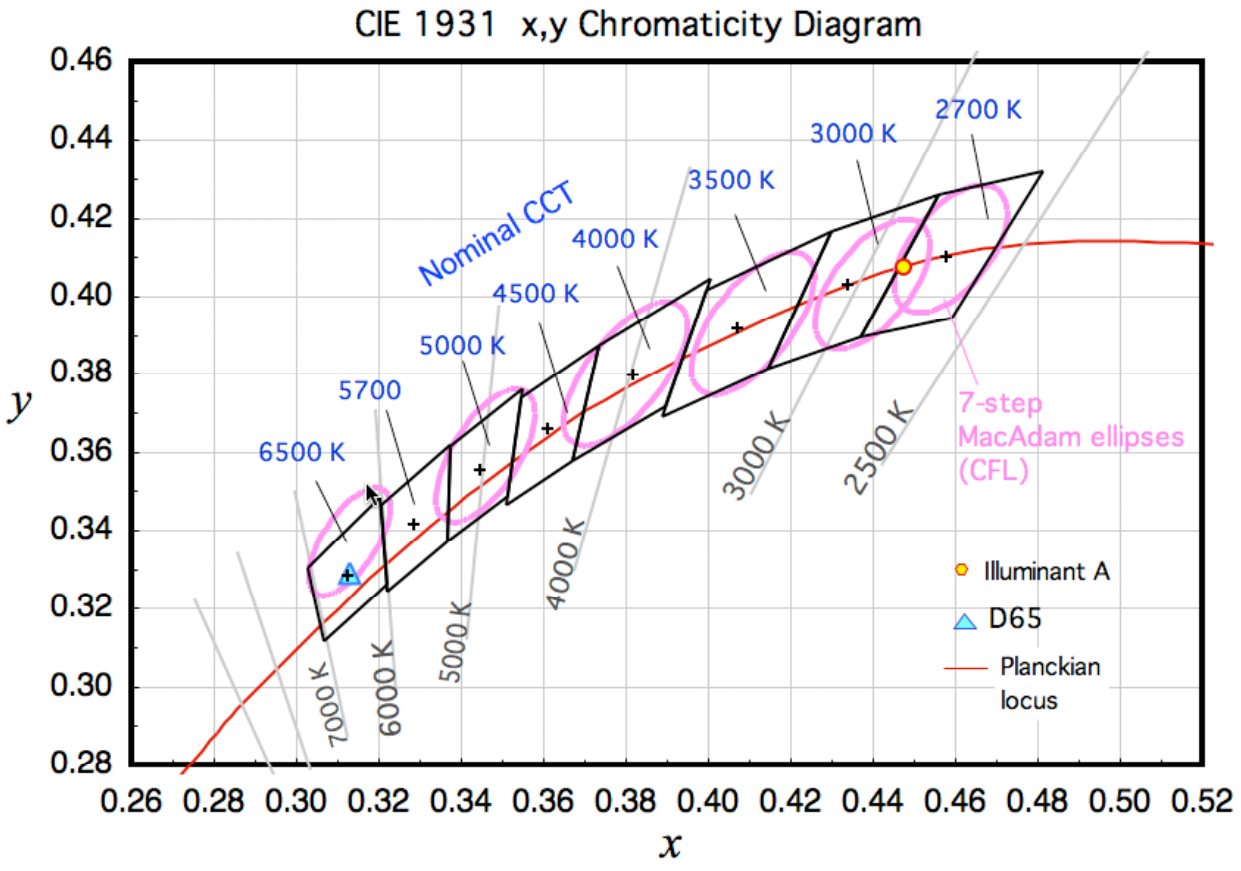

Figure 1. CIE 1931 Chromaticity Diagram Showing the Eight Nominal CCT Quadrangles