DEPARTMENT OF ENERGY

10 CFR Parts 429 and 430

[Docket No. EERE–2011–BT–TP–0071]

RIN 1904–AC67

Energy Conservation Program: Test Procedures for Integrated Light-Emitting Diode Lamps

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Supplemental notice of proposed rulemaking.

SUMMARY: On April 9, 2012, the U.S. Department of Energy (DOE) published a notice of proposed rulemaking (NOPR) in which DOE proposed a test procedure for light-emitting diode (LED) lamps (hereafter referred to as LED lamps). This supplemental notice of proposed rulemaking (SNOPR), revises DOE's proposal for a new test procedure for LED lamps. This SNOPR supports implementation of labeling provisions by the Federal Trade Commission (FTC) and implementation of DOE's energy conservation standards for general service lamps that includes general service LED lamps. The SNOPR continues to define methods for measuring the lumen output, input power, and relative spectral distribution (to determine correlated color temperature, or CCT). Further, the SNOPR revises the method for calculating the lifetime of LED lamps, and defines the lifetime as the time required for the LED lamp to reach a lumen maintenance of 70 percent (that is, 70 percent of initial light output). Additionally, the SNOPR adds calculations for lamp efficacy as well as the color rendering index (CRI) of LED lamps, which were not proposed in the test procedure NOPR.

DATES: DOE will accept comments, data, and information regarding this SNOPR, but no later than August 4, 2014. See section V, ''Public Participation,'' for details.

ADDRESSES: Any comments submitted must identify the SNOPR for Test Procedures for LED lamps, and provide docket number EE–2011–BT–TP–0071 and/or regulatory information number (RIN) number 1904–AC67. Comments may be submitted using any of the following methods:

1. *Federal eRulemaking Portal: www.regulations.gov.* Follow the instructions for submitting comments.

2. *Email: LEDLamps-2011-TP-0071@ee.doe.gov.* Include the docket number and/or RIN in the subject line of the message.

3. *Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Office, Mailstop EE–5B, 1000 Independence Avenue SW., Washington, DC, 20585–0121. If possible, please submit all items on a CD. It is not necessary to include printed copies.

4. *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza SW., Suite 600, Washington, DC, 20024. Telephone: (202) 586–2945. If possible, please submit all items on a CD. It is not necessary to include printed copies.

For detailed instructions on submitting comments and additional information on the rulemaking process, see section V of this document (Public Participation).

Docket: The docket is available for review at regulations.gov, including **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials. All documents in the docket are listed in the regulations.gov index. However, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

A link to the docket Web page can be found at: *www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/18.* This Web page will contain a link to the docket for this notice on the regulations.gov site. The regulations.gov Web page contains simple instructions on how to access all documents, including public comments, in the docket. See section V for information on how to submit comments through regulations.gov.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact Ms. Brenda Edwards at (202) 586–2945 or by email: *Brenda.Edwards@ee.doe.gov.*

FOR FURTHER INFORMATION CONTACT: Ms. Lucy deButts, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE–5B, 1000 Independence Avenue SW., Washington, DC, 20585–0121. Telephone: (202) 287–1604. Email: *light_emitting_diodes@ee.doe.gov.*

Ms. Celia Sher, U.S. Department of Energy, Office of the General Counsel, GC–71, 1000 Independence Avenue SW., Washington, DC, 20585–0121. Telephone: (202) 287–6122. Email: *Celia.Sher@hq.doe.gov.*

SUPPLEMENTARY INFORMATION:

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I. Authority and Background

Title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291, et seq.; ''EPCA'') sets forth a variety of provisions designed to improve energy efficiency. (All

references to EPCA refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112–210 (Dec. 18, 2012)). Part B of title III, which for editorial reasons was redesignated as Part A upon incorporation into the U.S. Code (42 U.S.C. 6291–6309, as codified), establishes the ''Energy Conservation Program for Consumer Products Other Than Automobiles.''

Under EPCA, this program consists of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. This SNOPR proposes test procedures that manufacturers of integrated LED lamps (hereafter referred to as ''LED lamps'') would use to meet two requirements, namely, to: (1) satisfy any future energy conservation standards for general service LED lamps, and (2) meet obligations under labeling requirements for LED lamps promulgated by the Federal Trade Commission (FTC).

First, this SNOPR would be used to assess the performance of LED lamps relative to any potential energy conservation standards in a future rulemaking that includes general service LED lamps. DOE is currently developing energy conservation standards for general service lamps (GSLs), a category of lamps that includes general service LED lamps. *See* 78 FR 73737 (Dec. 9, 2013).

Second, the LED lamp SNOPR supports obligations under labeling requirements promulgated by FTC under section 324(a)(6) of EPCA (42 U.S.C. 6294(a)(6)). The Energy Independence and Security Act of 2007 (EISA 2007) section 321(b) amended EPCA (42 U.S.C. 6294(a)(2)(D)) to direct FTC to consider the effectiveness of lamp labeling for power levels or watts, light output or lumens, and lamp lifetime. This SNOPR supports FTC's determination that LED lamps, which had previously not been labeled, require labels under EISA section 321(b) and 42 U.S.C. 6294(a)(6) in order to assist consumers in making purchasing decisions. 75 FR 41696, 41698 (July 19, 2010).

FTC published a final rule for light bulb [1] labeling (Lighting Facts) that required compliance on January 1, 2012. 75 FR 41696 (July 19, 2010). The FTC Lighting Facts label covers three types of medium screw base lamps: general service incandescent lamps (GSIL), compact fluorescent lamps (CFL), and general service LED lamps.[2] The label requires manufacturers to disclose information about the lamp's brightness [3] (lumen output), estimated annual energy cost, life [4] (lifetime), light appearance (CCT), and energy use (input power). FTC requires manufacturers to calculate the estimated annual energy cost by multiplying together the energy used, annual operating hours, and an estimate for energy cost per kilowatt-hour. FTC references DOE test procedures, when available, for testing lamps for the FTC Lighting Facts label. *See* 42 U.S.C. 6294(c). This SNOPR would enable FTC to reference a DOE test procedure for LED lamps. DOE invites comments on all aspects of the SNOPR for LED lamps.

II. Summary of the Supplemental Notice of Proposed Rulemaking

In this SNOPR, DOE proposes test procedures for determining the lumen output, input power, lamp efficacy, CCT, CRI, lifetime, and standby mode power of an LED lamp. DOE proposes to define an LED lamp using the ANSI [5]/IESNA [6] RP–16–2010 [7] definition of an integrated LED lamp. DOE pursued an SNOPR for two main reasons: (1) to revise the method of measuring lifetime based on public comment and (2) to add directions for calculating the metrics lamp efficacy and CRI and standby mode power to support the ongoing general service lamp rulemaking. To determine lumen output, input power, CCT, and CRI, DOE proposes to incorporate by reference IES LM–79–2008.[8] DOE reviewed several potential approaches to testing lamp lumen output, input power, CCT, and CRI, and determined that this IES standard is the most appropriate based on discussions with industry experts. IES LM–79–2008 appears to yield reliable results, and industry generally uses it to measure photometric characteristics of LED lamps. To determine the standby mode power, DOE proposes to incorporate by reference International Electrotechnical Commission (IEC) 62301.[9] In addition, DOE proposes to calculate the efficacy of an LED lamp in units of lumens per watt by dividing the measured initial lamp lumen output in lumens by the measured lamp input power in watts. Lastly, no industry standards are available for determining the lifetime of LED lamps. Therefore, the SNOPR proposes a method for measuring and projecting LED lamp lifetime that uses a continuous equation based on the underlying exponential decay function in the ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0.[10]

III. Discussion

A. Scope of Applicability

EISA 2007 section 321(a)(1)(B) added the definition for LED as a p-n junction [11] solid state device, the radiated output of which, either in the infrared region, the visible region, or the ultraviolet region, is a function of the physical construction, material used, and exciting current [12] of the device. (42 U.S.C. 6291(30)(CC)) In the NOPR, published on April 9, 2012, DOE stated that this rulemaking applies to LED lamps that meet DOE's proposed definition of an LED lamp, which is based on the term as defined by ANSI/IESNA RP–16–2010, ''Nomenclature and Definitions for Illuminating Engineering.'' This standard defines integrated LED lamps as an integrated assembly that comprises LED packages (components) or LED arrays (modules) (collectively referred to as an LED source), LED driver, ANSI standard base, and other optical, thermal, mechanical and electrical components (such as phosphor layers, insulating materials, fasteners to hold components within the lamp together, and electrical wiring). The LED lamp is intended to connect directly to a branch circuit through a corresponding ANSI standard

[1] FTC uses the term 'bulb,' while DOE uses the term 'lamp.' Bulb and lamp refer to the same product.

[2] FTC defines general service LED lamps as a lamp that is a consumer product; has a medium screw base; has a lumen range not less than 310 lumens and not more than 2,600 lumens; and is capable of being operated at a voltage range at least partially within 110 and 130 volts. This proposed test procedure rulemaking could be applied to general service LED lamps as defined by FTC as well as all other integrated LED lamps as discussed in section 0 of this SNOPR.

[3] Although 'light output' is the technically correct term, FTC uses the term 'brightness' on the Lighting Facts label because FTC's research indicated that consumers prefer the term 'brightness' to 'light output.'

[4] FTC uses the term 'life' while DOE uses the term 'lifetime.' Life and lifetime have the same meaning.

[5] American National Standards Institute.

[6] Illuminating Engineering Society of North America (also abbreviated as IES).

[7] ''Nomenclature and Definitions for Illuminating Engineering.'' Approved by ANSI on October 16, 2009. Approved by IES on November 15, 2009.

[8] ''Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.'' Approved by IES on December 31, 2007.

[9] ''Household electrical appliances—Measurement of standby power.'' Edition 2.0 2011–01.

[10] ''ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0.'' U.S. Environmental Protection Agency, August 28, 2013.

[11] P-n junction is the boundary between p-type and n-type material in a semiconductor device, such as LEDs. P-n junctions are active sites where current can flow readily in one direction but not in the other direction—in other words, a diode.

[12] Exciting current is the current passing through an LED chip during steady state operation.

socket. 77 FR 21038, 21041 (April 9, 2012)

The National Electrical Manufacturers Association (hereafter referred to as NEMA) agreed with the proposed scope and incorporation of ANSI/IESNA RP–16–2010 for the definition of LED lamps. (NEMA, Public Meeting Transcript, No. 7 at p. 2 [13]) DOE received no adverse comment on this proposal. Thus, in this SNOPR, DOE proposes to maintain the scope and definition of LED lamps.

B. Standby and Off-Mode

EPCA directs DOE to amend test procedures ''to include standby mode and off mode energy consumption . . . with such energy consumption integrated into the overall energy efficiency, energy consumption, or other energy descriptor for each covered product, unless the Secretary determines that—(i) the current test procedures for a covered product already fully account for and incorporate the standby and off mode energy consumption of the covered product . . .'' 42 U.S.C. 6295(gg)(2)(A(i) Because LED lamps are placed in Part A of EPCA, they are covered consumer products, and thus the standby and off mode applicability of these products must be reviewed.

First, to provide context for standby and off-modes, active mode is defined as the condition in which an energy-using product—is connected to a main power source; has been activated; and provides one or more main functions.10 CFR 430.2 DOE's proposals for active mode test metrics include lumen output, input power, lamp efficacy, CCT, CRI, and lifetime.

Standby mode is defined as the condition in which energy-using product—is connected to a main power source; and offers one or more of the following user-oriented or protective functions: to facilitate the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor, or timer; or continuous functions, including information or status displays (including clocks) or sensor-based functions.10 CFR 430.2 Some LED lamps can be operated by a remote control to activate active mode or to change the appearance of the light (color or dimming). Therefore, standby mode applies to LED lamps.

Off mode is defined as the condition in which an energy using product—is connected to a main power source; and is not providing any standby or active mode function.10 CFR 430.2 LED lamps do not operate in off mode because when connected to a main power source, the LED lamp is either in active mode or standby mode. No other modes of operation exist for LED lamps beyond active and standby mode.

EPCA directs DOE to amend its test procedures for all covered products to integrate measures of standby mode and off mode energy consumption, if technically feasible. (42 U.S.C. 6295(gg)(2)(A)) Standby mode and off mode energy must be incorporated into the overall energy efficiency, energy consumption, or other energy descriptor for each covered product unless the current test procedures already account for and incorporate standby and off mode energy consumption or such integration is technically infeasible. If an integrated test procedure is technically infeasible, DOE must prescribe a separate standby mode and off mode energy use test procedure for the covered product, if technically feasible. *Id.* Any such amendment must consider the most current versions of IEC Standard 62301, ''Household electrical appliances—measurement of standby power,'' and IEC Standard 62087, ''Methods of measurements for the power consumption of audio, video, and related equipment,'' [14] as applicable.

DOE proposes separate test methods for standby and active mode metrics. This proposal is consistent with other lighting products (fluorescent lamp ballasts and metal halide ballasts) which use separate test methods for active and standby modes. Any future energy conservation standards that cover LED lamps will consider the most effective method of addressing both active and standby mode energy use. DOE proposes a method of measuring standby mode power in section III.E.

DOE requests comment on its characterization of the modes of operation that apply to LED lamps.

C. Proposed Approach for Determining Lumen Output, Input Power, Lamp Efficacy, Correlated Color Temperature, and Color Rendering Index

1. NOPR Proposals

The NOPR proposed to incorporate IES LM–79–2008 for determining lumen output, input power, and CCT, with some modifications. 77 FR at 21041 (April 9, 2012) IES LM–79–2008 specifies the test setup and conditions at which the measurements and calculations must be performed. These include ambient conditions, power supply characteristics, lamp orientation, and stabilization methods for LED lamps, and instrumentation and electrical settings. These requirements, and any related comments, are further discussed in the sections III.C.1 through III.C.4.

Kristopher Kritzer (hereafter referred to as Kritzer) expressed support for adopting the complete NOPR test method and backed DOE's efforts to adopt industry practices for testing LED lamps. (Kritzer, No. 3 at p. 1) Lutron Electronics Company, Inc. (hereafter referred to as Lutron) and NEMA did not support all test methods proposed in the NOPR, but did agree that IES LM–79–2008 should be used to determine lumen output, input power, and CCT. (Lutron, Public Meeting Transcript, No. 7 at p. 25; NEMA, Public Meeting Transcript, No. 7 at p. 2) However, several interested parties expressed concern with the overall proposal. Delft University of Technology (which refers to itself as TUD) and an anonymous commenter had reservations about adopting the test methods proposed in the NOPR. TUD indicated that the NOPR proposal will not guarantee tested LED products are well-qualified. (Anonymous, No. 8 at p. 1; TUD, No. 15 at p. 1) NEMA, the California Investor Owned Utilities (hereafter referred to as CA IOUs), and Philips Lighting Electronics N.A. (hereafter referred to as Philips) urged that DOE not modify or supplement any industry standard. (NEMA, No. 16 at p. 2, 7; CA IOUs, No. 19 at p. 5, 6; Philips, Public Meeting Transcript, No. 7 at p. 114) Finally, the Appliance Standards Awareness Project, the American Council for an Energy Efficient Economy, and the Natural Resources Defense Council (hereafter referred to as the Joint Comment) stated that test procedures need to mimic real world installations whenever possible and, when knowledge of real world installations is not available, the test method needs to approximate a worst-case installation scenario. (Joint Comment, No. 18 at p. 1)

IES is the recognized technical authority on illumination, and the IES LM–79–2008 standard was prepared by the IES subcommittee on Solid-State Lighting Sources of the IESNA Testing Procedure Committee. IES LM–79–2008 was also developed in collaboration with the ANSI Solid State Lighting Joint Working Group C78–09 and C82–09 comprising individuals from several

[13] A notation in the form ''NEMA, Public Meeting Transcript, No. 7 at p. 2'' identifies a statement made in a public meeting that DOE has received and has included in the docket of this rulemaking. This particular notation refers to a comment: (1) submitted during the public meeting on May 3, 2012; (2) in document number 7 in the docket of this rulemaking; and (3) appearing on page 2 of the transcript.

[14] IEC standards are available online at *www.iec.ch.*

organizations. DOE believes that the committee members who worked on developing the IES LM–79–2008 standard represent relevant industry groups and interested parties. Based on an independent review by DOE and general acceptance by industry, DOE proposes that IES LM–79–2008 specifies much of the information that is required for providing a complete test procedure for determining lumen output, input power, CCT, and CRI of LED lamps. DOE agrees that the LED lamp test procedure needs to mimic real world installations and believes that the procedures described in the IES LM–79–2008 standard are representative of such conditions. IES LM–79–2008 specifies the test conditions and setup at which the measurements and calculations must be performed. However, DOE proposes some clarifications to establish a repeatable procedure for all LED lamp testing. These clarifications to IES LM–79–2008 include mounting orientation and electrical setting requirements. These requirements, and any clarifications proposed by DOE, are further discussed in the sections III.C.2 through III.C.4.

2. Test Conditions

In the NOPR, DOE proposed that the ambient conditions for testing LED lamps be as specified in section 2.0 [15] of IES LM–79–2008. 77 FR at 21041. These conditions include setup and ambient temperature control, as well as air movement requirements. Both are discussed in further detail below.

Section 2.2 of IES LM–79–2008 specifies that photometric measurements shall be taken at an ambient temperature of 25 degrees Celsius (°C) ±1 °C. In the NOPR, DOE indicated that a tolerance of 1°C for the ambient temperature is practical, limits the impact of ambient temperature on measurements, and would not be burdensome because the instruments used to measure the temperature provide greater accuracy than required, allowing the test laboratories to maintain the temperature within the required tolerance for testing. *Id.* Section 2.2 of IES LM–79–2008 further specifies that the temperature shall be measured at a point not more than one meter from the LED lamp and at the same height as the lamp. The standard requires that the temperature sensor that is used for measurements be shielded from direct optical radiation from the lamp or any other source to reduce the impact of radiated heat on the ambient temperature measurement. The NOPR stated that this setup for measuring and controlling ambient temperature is appropriate for testing because it requires that the lamp be tested at room temperature and in an environment that is commonly used for testing other lighting technologies. *Id.* DOE did not receive adverse comments, and therefore maintains this proposal for ambient temperature conditions in the SNOPR.

In the NOPR, DOE proposed that the requirement for air movement around the LED lamp be as specified in section 2.4 of IES LM–79–2008, which requires that the air flow around the LED lamp be such that it does not affect the lumen output measurements of the tested lamp. *Id.* DOE also considered specifying a method for determination of a draft-free environment, such as that in section 4.3 of IES LM–9–2009,[16] which requires that a single ply tissue paper be held in place of the lamp to allow for visual observation of any drafts.

Philips, Osram Sylvania, Inc. (hereafter referred to as OSI), and NEMA all indicated that the surrounding air temperature and airflow for LED lamps does not have a noticeable impact on long-term lumen degradation. Based on this, DOE believes that the IES LM–79–2008 air movement requirements proposed in the NOPR are more than adequate to ensure the accuracy of test data. (Philips, Public Meeting Transcript, No. 7 at p. 27; OSI, Public Meeting Transcript, No. 7 at pp. 27–28; NEMA, Public Meeting Transcript, No. 7 at pp. 2–3; NEMA, No. 16 at p. 2–3) However, other stakeholders suggested adding quantitative requirements for air movement. The People's Republic of China (hereafter referred to as P.R. China) suggested that air movement in the vicinity of the luminaire not exceed 0.2 m/s. For lamps designed with a larger tolerance for ambient temperature changes, faster air movement may be acceptable. (P.R. China, No. 12 at p. 3) The Joint Comment noted that the air movement procedures in IES LM–79–2008 are informative, but not very specific. Therefore, they recommended that DOE investigate a quantitative approach so that air flow around the device is better understood. However, the Joint Comment expressed concern that direct measurement of the airflow (anemometry) would increase the testing burden to manufacturers substantially; instead, they recommended DOE investigate a suitable proxy measure to judge the stability of the airflow around the lamp. As an example, they suggested DOE may want to consider stability criteria on a measurement of the case temperature. The Joint Comment noted that it is likely that other parameters may also provide valuable information about the airflow while minimizing testing burden. (Joint Comment, No. 18 at p. 3)

Although DOE agrees that the air movement requirement in IES LM–79–2008 could be more precise, DOE is maintaining its proposal from the NOPR not to modify the surrounding air temperature and airflow specifications provided in IES LM–79–2008. DOE does not believe that additional requirements to establish a draft-free environment would improve measurement accuracy relative to current industry practice. Furthermore, specifying a quantitative procedure for measuring air movement would result in an unnecessary increase to testing burden. Therefore, in this SNOPR, DOE maintains its proposal to retain the requirements in IES LM–79–2008 to ensure that air movement is minimized to acceptable levels. These requirements would apply to lamps measured in both active mode and standby mode.

3. Test Setup

a. Power Supply

In the NOPR, DOE proposed that section 3.1 and 3.2 of IES LM–79–2008 be incorporated by reference to specify requirements for both alternating current (AC) and direct current (DC) power supplies. 77 FR at 21042. Section 3.1 specifies that an AC power supply shall have a sinusoidal voltage waveshape at the input frequency required by an LED lamp such that the root mean square (RMS) [17] summation of the harmonic components does not exceed three percent of the fundamental frequency [18] while operating the LED lamp. Section 3.2 of IES LM–79–2008 also requires that the voltage of an AC power supply (RMS voltage) or DC power supply (instantaneous voltage) applied to the LED lamp be within ±0.2 percent of the specified lamp input voltage (see section III.C.3.d for discussion of the proposed electrical settings, including input voltage). These requirements are achievable with

[15] IES standards use the reference 2.0, 3.0, etc. for each primary section heading. Sub-sections under each of these sections are referenced as 2.1, 2.2, 3.1, 3.2, etc. This SNOPR refers to each IES section exactly as it is referenced in the standard.

[16] ''IES Approved Method for the Electrical and Photometric Measurement of Fluorescent Lamps.'' Approved January 31, 2009.

[17] Root mean square (RMS) voltage/current is a statistical measure of the magnitude of a voltage/current signal. RMS voltage/current is equal to the square root of the mean of all squared instantaneous voltages/currents over one complete cycle of the voltage/current signal.

[18] Fundamental frequency, often referred to as fundamental, is defined as the lowest frequency of a periodic waveform.

minimal testing burden and provide reasonable stringency in terms of power quality based on their similarity to voltage tolerance requirements for testing of other lighting technologies. DOE did not receive adverse comment on this proposal and, therefore, this proposal remains unchanged for the SNOPR. These power supply requirements would apply to lamps measured in both active mode and standby mode.

b. Instrumentation

In the NOPR, DOE proposed that instrumentation requirements for the AC power meter and the AC and DC voltmeter and ammeter, as well as the acceptable tolerance for these instruments, be as specified in section 8.0 of IES LM–79–2008. *Id.* Section 8.1 of IES LM–79–2008 specifies that for DC-input LED lamps, a DC voltmeter and DC ammeter shall be connected between the DC power supply and the LED lamp under test. The DC voltmeter shall be connected across the electrical power input of the LED lamp, and the input electrical power shall be calculated as the product of the measured input voltage and current. Section 8.2 of IES LM–79–2008 specifies that the tolerance for the DC voltage and current measurement instruments shall be ±0.1 percent. For AC-input LED lamps, section 8.1 of IES LM–79–2008 further specifies that an AC power meter shall be connected between the AC power supply and the LED lamp under test. The AC power, input voltage, and current shall be measured. Section 8.2 of IES LM–79–2008 specifies that the tolerance of the AC voltage and current measurement instruments shall be ±0.2 percent and the tolerance of the AC power meter shall be ±0.5 percent. In the NOPR, DOE concluded that the electrical instrumentation requirements set forth in section 8.0 of IES LM–79–2008 are achievable and provide reasonable stringency in terms of measurement tolerance based on their similarity to instrument tolerance requirements for testing of other lighting technologies. *Id.* DOE did not receive adverse comment on these electrical instrumentation requirements and, therefore, this proposal remains unchanged for the SNOPR.

Regarding photometric instrumentation used for measuring lumen output, CCT, and CRI, DOE proposed in the NOPR that either a sphere-spectroradiometer, sphere-photometer, or goniophotometer system be used for lumen output measurement of the LED lamp as specified in IES LM–79–2008. DOE requested comment on the differences in values measured by an integrating sphere (via photometer or spectroradiometer) versus a goniophotometer. 77 FR at 21042 NEMA commented that both systems are appropriate for lumen determination, but acknowledged that a perfect correlation between the two techniques is not possible. (NEMA, No. 16 at p. 3)

While DOE recognizes that the integrating sphere and goniophotometer (a goniometer fitted with a photometer as the light detector) are both valid means of photometric measurement, DOE is concerned about the potential for a difference in the measured values. A test procedure that yields more than one possible value depending on instrumentation presents problems for certification and enforcement. If DOE and the manufacturer use different test methods, DOE could find that a lamp certified as compliant could be tested as non-compliant during a verification or enforcement proceeding. IES LM–79–2008 does not explicitly specify the scanning resolution (i.e., quantity and location of measurements around the lamp), and instead provides guidance that must be implemented differently for each lamp. DOE also determined that further specification of the goniophotometer method is unreasonable, because the scanning resolution specification would need to be adequate for the lamp that requires the finest resolution. This would likely present an overly burdensome test method for many other lamps that could be measured at a lower resolution. In contrast, use of an integrating sphere enables photometric characteristics of the LED lamp to be determined with a single measurement. Therefore, integrating spheres are the preferred method for photometric measurement due to the reduction in time required for testing.

In consideration of the lack of measurement correlation between integrating spheres and goniophotometers and the reduced burden and much higher incidence of use of integrating spheres, DOE proposes in the SNOPR to require all photometric measurements, including lumen output, CCT, and CRI to be carried out in an integrating sphere and that goniometer systems must not be used. Therefore, DOE proposes that the instrumentation used for lumen output measurements be as described in sections 9.1 and 9.2 of IES LM–79–2008, and CCT and CRI measurements be as described in section 12.0 of IES LM–79–2008 with the exclusion of section 12.2 of IES LM–79–2008, as goniometers must not be used. DOE invites interested parties to comment on the proposal to require all photometric values be measured by an integrating sphere (via photometer or spectroradiometer). These instrumentation requirements would apply to lamps measured in both active mode and standby mode.

c. Lamp Mounting and Orientation

In the NOPR, DOE considered testing LED lamps as specified in section 6.0 of IES LM–79–2008, which states that LED lamps shall be tested in the operating orientation recommended by the lamp manufacturer for the intended use of the LED lamp. *Id.* As discussed in the NOPR, DOE determined that manufacturers do not typically specify the operating orientation for an LED lamp in their product literature. Further, DOE indicated that it is possible manufacturers would recommend an orientation for testing that provides the highest lumen output rather than the orientation in which the lamp is most frequently operated in practice. Therefore, the NOPR proposed that an LED lamp be mounted as specified in section 2.3 of IES LM–79–2008 and be positioned in the base-up, base-down, and horizontal orientations for testing.

Numerous commenters raised concerns about DOE's proposal. General Electric Lighting (hereafter referred to as GE), Philips, NEMA, Samsung Electronics (hereafter referred to as Samsung), and P.R. China commented that the base-up and base-down orientations constitute the best and worst-case scenarios. (GE, Public Meeting Transcript, No. 7 at p. 29; Philips, Public Meeting Transcript, No. 7 at pp. 29–30; NEMA, No. 16 at p. 3; Samsung, No. 14 at p. 1; China, No. 12 at p. 3) Samsung stated that testing in the base up and base down positions is also consistent with ENERGY STAR test procedures. (Samsung, No. 14 at p. 1) In addition, GE and NEMA commented that testing in the horizontal position with either type of sphere will add uncertainty to the lumen output measurement, and that testing in the horizontal position with a goniophotometer is very difficult or even impossible. (GE, Public Meeting Transcript, No. 7 at pp. 42–43; NEMA, No. 16 at p. 3) Underwriter Laboratories (hereafter referred to as UL) indicated that shadowing is an issue with testing in the horizontal position. Lamps are usually supported from above or below, and if tested horizontally the support structure could interfere with the light measurement. (UL, Public Meeting Transcript, No. 7 at p. 54) NEMA commented that current FTC instruction for CFLs does not require testing in multiple orientations, only that the manufacturer specify if an orientation

change will result in a greater than five percent difference in measured performance. (NEMA, No. 16 at p. 6) The Republic of Korea (hereafter referred to as South Korea) suggested that DOE be consistent with both International Electrotechnical Commission (IEC) 62612 [19] and IES LM–79–2008, which require that the orientation of lamps during testing follow the manufacturer's recommendations. (South Korea, No. 17 at p. 2) Finally, P.R. China noted that testing in the horizontal position will increase the cost of the testing as well as the total time required for testing. (P.R. China, No. 12 at p. 3)

Other commenters supported DOE's proposals and suggested further research. The Joint Comment and the CA IOUs agreed with DOE's proposal to include the horizontal position for lumen output testing because it is likely a worst-case condition. This is because heat sink fins are most effective at dissipating heat when air flow is parallel to the direction of the fins, rather than when air flow is perpendicular to the fins. Because most heat sink fins are parallel to the body of the lamp, they are likely to dissipate heat differently when the lamp is oriented vertically than when oriented horizontally. When heat is not dissipated effectively in a lamp, lumen output generally decreases. (Joint Comment, No. 18 at p. 4; CA IOUs, No. 19 at p. 6) In addition, the CA IOUs indicated that they expect to have LED lamp performance data collected in all three orientations by the end of 2012 (subsequently published in February 2013).[20] The CA IOUs further commented that manufacturer concerns about testing in the horizontal position are not an issue for testing in a sphere-spectroradiometer or sphere-photometer. The CA IOUs stated that accurate horizontal measurements are regularly taken for other lamp technologies, and they do not believe any unique challenge exists for measuring LED lamps that do not exist for other lamps of similar shapes and base types. (CA IOUs, No. 19 at p. 6) The Joint Comment suggested that DOE investigate whether shadowing is a significant concern in a goniophotometer when the lamp is configured horizontally. (Joint Comment, No. 18 at p. 4) The Joint Comment also suggested that DOE consider the appropriateness of testing at intermediate angles for certain types of lamps that contain heat pipes, noting that heat pipes often have the best heat transfer performance at inclinations of 60–70 degrees. (Joint Comment, No. 18 at p. 4)

In light of commenters' varying opinions about the impact of lamp orientation on lamp performance, DOE collected test data for several LED lamps tested in each of the three orientations. DOE investigated two sets of photometric test data, the first provided by ENERGY STAR and the second (mentioned by the CA IOUs in the previous paragraph) from a collaborative testing effort between the Pacific Gas and Electric Company (hereafter referred to as PG&E), California Lighting Technology Center (hereafter referred to as CLTC), and the Collaborative Labeling and Appliance Standards Program (hereafter referred to as CLASP). *Id.* These test data represent 10 samples each of 47 different LED lamp products. Of the 47 lamp products tested, 36 were mounted in base-up, base-down, and horizontal configurations, and 11 were mounted in base-up and base-down configurations. DOE analyzed the data to determine the variation of input power, lumen output, CCT, and CRI in each of the three orientations. The analysis of the test data revealed that some lamp models exhibited variation between the three orientations. Of the three orientations, analysis indicated that the base-up and base-down orientations represent the best (highest lumen output) and worst (lowest lumen output) case scenarios. Therefore, DOE believes that there is no need to test horizontally.

The Joint Comment stated that other lamp orientations may represent the best-case scenario and suggested that DOE investigate testing at intermediate angles, such as 60 to 70 degrees. DOE notes that intermediate angles could represent a best-case scenario for some lamps; however, testing LED lamps at these angles is not common industry practice. Although there is no data available for testing LED lamps at intermediate angles, DOE consulted an LED lamp manufacturer as to whether intermediate angle testing could be a best-case scenario for some LED lamps. The manufacturer indicated that this could improve efficiency theoretically; however, this possible improvement would be negligible and likely within the measurement error of the lumen output measuring equipment. From this, DOE has determined that these performance gains would not be measureable. Therefore, DOE is not proposing testing of LED lamps at intermediate angles.

As mentioned above, DOE also received comments about whether it was possible to test LED lamps in all potential orientations. GE, NEMA, and UL indicated that testing in the horizontal position could interfere with the lumen output measurement. (GE, Public Meeting Transcript, No. 7 at pp. 42–43; NEMA, No. 16 at p. 3; UL, Public Meeting Transcript, No. 7 at p. 54) DOE researched this concern by consulting with the Lighting Research Center (LRC), which has extensive lamp testing experience, and believes that testing lumen output in the horizontal position does not lead to significant measurement error when using the majority of sphere-spectroradiometer, sphere-photometer, and goniophotometer systems. For either a sphere-spectroradiometer or sphere-photometer system, the bracket, which secures the lamp in place, can be designed and configured to eliminate any significant measurement error due to shadowing. For large goniophotometer systems, there would be sufficient space to make a bracket to hold the lamp in any orientation without risk of significant shadowing. It is possible that smaller goniophotometer systems could have mounting and bracket limitations that result in error when testing in the horizontal orientation due to shadowing. However, as discussed in section III.C.3.b, DOE proposes in the SNOPR to require all photometric measurements to be carried out in an integrating sphere and that goniometer systems must not be used.

In the SNOPR, DOE proposes that LED lamps be positioned such that an equal number of units are oriented in the base-up and base-down orientations. This proposal specifies two commonly used orientations for LED lamps that span the highest and lowest light-output scenarios, creating a dataset that represents average performance in practice. These lamp mounting and orientation requirements would apply to lamps measured in both active mode and standby mode. DOE requests comment on the proposal for an equal number of lamps to be operated in the base-up and base-down orientations during lumen output, input power, CCT, and CRI testing.

d. Electrical Settings

In the NOPR, DOE proposed requiring testing of LED lamps at the rated voltage as specified in IES LM–79–2008. For lamps with multiple operating voltages, DOE proposed that lamps be tested at

[19] IEC/PAS 62612: Self-ballasted LED-lamps for general lighting services—Performance requirements.

[20] CLTC, ''Omni-Directional Lamp Testing'' Prepared for PG&E and CLASP, February 25th, 2013. *http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Lighting_12-AAER-2B/California_IOUs_Response_to_the_Invitation_to_Participate_for_LED_Lamps_REFERENCE/PGandE_2013a_Omni-Directional_Lamp_Testing-Report_Draft.pdf.*

120 volts because 120 volts is the most common operating voltage of available lamps. However, if the lamp is not rated at 120 volts, DOE proposed that it be tested at the highest rated voltage. *Id.* NEMA disagreed with DOE's proposal to test at rated voltage only, arguing the proposal was in conflict with FTC regulations that require testing lamps at 120 volts and the rated voltage. (NEMA, No. 16 at p. 3)

In this SNOPR, DOE maintains the NOPR proposal but, in addition, indicates that manufacturers may also test at other operating voltages as long as the final DOE test procedure is used for making energy representations. These electrical settings would apply to lamps measured in both active mode and standby mode. To ensure the SNOPR proposal is not in conflict with the FTC Lighting Facts label requirements, as was suggested by NEMA, DOE reviewed the FTC regulations detailed in 16 CFR 305.15. The FTC regulation states that a general service lamp shall be measured at 120 volts, regardless of the lamp's design or rated voltage. If a lamp's design voltage is 125 volts or 130 volts, the disclosures of the wattage, light output, energy cost, and lifetime must disclose the voltage at which these metrics were measured. DOE's proposal is not in conflict with FTC's Lighting Facts requirements because manufacturers must test at 120 volts as required by FTC and, if the LED lamp is rated for additional voltages, the lamp may also be tested at the highest rated voltage. This supports FTC's program and does not provide conflicting instructions.

In the NOPR, DOE proposed incorporating section 7.0 of IES LM–79–2008, which specifies electrical settings for LED lamps with multiple modes of operation, such as variable CCT and dimmable lamps. 77 FR at 21043. Section 7.0 of IES LM–79–2008 indicates LED lamps with variable CCT shall be tested in each mode of operation, and for dimmable lamps, directs that they be tested at the maximum input power.

Philips commented that when specifying electrical settings for variable CCT lamps it is important that DOE consider the scenario that the testing is intended to reflect (i.e., worst-case versus most common operating conditions) because lumen output can change based on the CCT mode. (Philips, Public Meeting Transcript, No. 7 at p. 32) OSI agreed with this point and indicated that in the future it is foreseeable that LED lamps with variable CCT, CRI, and lumen output will be available. (OSI, Public Meeting Transcript, No. 7 at pp. 32–33) Both P.R. China and Samsung stated that LED lamps with multiple modes of operation are currently available. (P.R. China, No. 12 at p. 4; Samsung, No. 14 at p. 1) GE and Samsung indicated that multiple mode lamps in the future could operate at continuously variable CCT making testing at a distinct CCT impossible. (GE, Public Meeting Transcript, No. 7 at p. 32; Samsung, No. 14 at p. 1) OSI commented that testing at the worst-case scenario could be a possible option for LED lamps with variable CCT, while Samsung suggested requiring both a best- and worst-case scenario. (OSI, Public Meeting Transcript, No. 7 at pp. 33; Samsung, No. 14 at p. 1) P.R. China suggested DOE follow international standard IEC/PAS 62717–2011,[21] which states that LED modules with adjustable color point must be adjusted/set to one fixed value as indicated by the manufacturer or responsible vendor. (P.R. China, No. 12 at p. 3) At the May 3, 2012 NOPR public meeting (hereafter the May 2012 public meeting), NEMA argued against testing at a CCT, CRI, or lumen output setting that would rarely be used in the field. For lamps that can vary CCT over the power range, NEMA suggested testing the lamps only at the CCT that occurs at full power. (NEMA, Public Meeting Transcript, No. 7 at p. 33; NEMA, No. 16 at p. 3) Finally, regarding dimming, NEMA agreed with DOE's proposal to measure dimmable lamps at full power as this will reflect the rating on the packaging. (NEMA, No. 16 at p. 3)

DOE believes that LED lamps with multiple modes of operation, including variable CCT and CRI as well as dimmable lamps, should be tested at maximum input power because this is the highest energy consuming state. Therefore, DOE proposes to require testing for such lamps at the mode that occurs at maximum input power, since this is the highest energy consuming state. When multiple modes (such as multiple CCTs and CRIs) occur at the same maximum input power, the manufacturer can select any of these modes for testing. Manufacturers may also test at other modes as long as the final DOE test procedure is used for making representations about the energy consumption of an LED lamp. All measurements (lumen output, input power, efficacy, CCT, CRI, lifetime, and standby mode power) must be conducted at the same mode of operation. DOE invites comment on its proposals for testing lamps for which multiple modes (such as multiple CCTs and CRIs) can occur at the same maximum input power.

4. Test Method

a. Lamp Seasoning

In the NOPR, DOE proposed requiring energizing and operating LED lamps for 1,000 hours to season them before beginning photometric measurements. 77 FR at 21043. DOE proposed a 1,000 hour seasoning time because it has been indicated by industry [22] [23] that light output of an LED source (and therefore, potentially the lamp) can change during the first 1,000 hours of operation. DOE also noted that IES TM–21–2011 [24] specifies that the data obtained from the first 1,000 hours of operating an LED source shall not be used to project the lifetime of an LED source.

Cree, Philips, Feit Electric Company, NEMA, P.R. China, the Joint Comment, CA IOUs, Northwest Energy Efficiency Alliance (hereafter referred to as NEEA), and South Korea all commented that LED lamps not be seasoned for 1,000 hours prior to collecting lumen output data. They argued that due to the evolving nature of these products, there is no common seasoning time. (Cree, Public Meeting Transcript, No. 7 at pp. 34–35; Philips, Public Meeting Transcript, No. 7 at p. 35, 36; Feit, Public Meeting Transcript, No. 7 at p. 45; NEMA, Public Meeting Transcript, No. 7 at p. 36; P.R. China, No. 12 at p. 4; NEMA, No. 16 at p. 3; Joint Comment, No. 18 at pp. 5–6; CA IOUs, No. 19 at p. 5; NEEA, No. 20 at p. 2; South Korea, No. 17 at p. 2) Cree indicated that sudden increases or decreases in light output in the first 1,000 hours of operation depend on several factors in the construction of the LED lamp. (Cree, Public Meeting Transcript, No. 7 at pp. 36–37) P.R. China, NEEA, and the CA IOUs stated that DOE should remain consistent with the specifications of IES LM–79–2008, and require no seasoning prior to photometric measurements. (P.R. China, No. 12 at p. 4; NEEA, No. 20 at p. 2; CA IOUs, No. 19 at p. 5)

The Joint Comment indicated that when taking photometric measurements, it is not obvious if seasoning is necessary. They suggested that DOE investigate and report on the

[21] IEC/PAS 62717: LED modules for general lighting—Performance requirements.

[22] Cheong, Kuan Yew. ''LED Lighting Standards Update.'' CREE, August 5, 2011. Page 31. *www.nmc.a-star.edu.sg/LED_050811/Kuan_CREE.pdf*

[23] Richman, Eric. ''Understanding LED Tests: IES LM–79, LM–80, and TM–21.'' DOE SSL Workshop, July 2011. Page 13. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/richman_tests_sslmiw2011.pdf*

[24] ''Projecting Long Term Lumen Maintenance of LED Light Sources.'' Approved by IES on July 25, 2011.

necessity of seasoning lamps prior to photometric measurements, as this seasoning is in direct conflict with procedures established in IES LM–79–2008. Should DOE decide that there is sufficient variability in devices that can be mitigated by seasoning; they recommend that DOE collaborate with industry to minimize testing burden and potential re-testing of current LED sources/lamps. (Joint Comment, No. 18 at pp. 5–6) The National Institute of Standards and Technology (hereafter referred to as NIST) and Samsung, however, commented that seasoning LED lamps for 1,000 hours prior to collecting lumen output data is reasonable. (NIST, Public Meeting Transcript, No. 7 at p. 47; Samsung, No. 14 at p. 1) NIST argued that including a seasoning time of 1,000 hours would help identify faulty products. (NIST, Public Meeting Transcript, No. 7 at p. 47)

In the SNOPR, DOE proposes to eliminate the requirement to season lamps for 1,000 hours prior to taking photometric measurements. Although some LED lamps do experience changes in light output during the first 1,000 hours of operation, independent research and manufacturer comments indicate that this is not true for all LED lamps. Each LED lamp is unique, and as a result, initial trends in light output are not consistent from lamp to lamp. Therefore, seasoning all lamps for a predetermined duration does not provide a more accurate initial test measurement, though it does increase testing burden. The current industry-accepted test procedure, IES–79–2008, reflects this understanding by not allowing lamp seasoning. Therefore, the SNOPR proposes to remain consistent with section 4.0 of IES LM–79–2008, which indicates LED lamps shall not be seasoned before beginning photometric measurements. These seasoning requirements would apply to lamps measured in both active mode and standby mode. DOE requests comment on this proposal.

b. Lamp Stabilization

In the NOPR, DOE proposed stabilizing lamps for the time specified in section 5.0 of IES LM–79–2008. DOE further proposed that stability of the LED lamp is reached when the variation [(maximum—minimum)/minimum] of at least three readings of light output and electrical power over a period of 30 minutes, taken 15 minutes apart, is less than 0.5 percent. 77 FR at 21043. This calculation was included to add clarification to the method specified in section 5.0 of IES LM–79–2008. For stabilization of a number of products of the same model, section 5.0 of IES LM–79–2008 suggests that preburning [25] of the product may be used if it has been established that the method produces the same stabilized condition as when using the standard method described above.

NEMA agreed that the lamp stabilization method in IES LM–79–2008 be used for the LED lamp test procedure but argued that the standard did not need further clarification. (NEMA, Public Meeting Transcript, No. 7 at pp. 38–39; NEMA, No. 16 at p. 3) However, GE advocated for presenting the lamp stabilization equation as a percent. (GE, Public Meeting Transcript, No. 7 at p. 39)

DOE reconsidered its NOPR proposal, but came to the same conclusion for the SNOPR. IES LM–79–2008 does not clearly specify the calculation for determining the stabilization value, leaving this requirement open to interpretation. Therefore, DOE continues to propose in the SNOPR that variation of at least three readings of light output and electrical power over a period of 30 minutes, taken 15 minutes apart is calculated as [maximum—minimum]/minimum. DOE expects this proposal is the same or very similar to the stabilization calculation methods already used in practice. As in the NOPR, DOE continues to propose in this SNOPR that stabilization of multiple products of the same model can be carried out as specified in section 5.0 of IES LM–79–2008. These stabilization requirements would apply to lamps measured in both active mode and standby mode.

c. Lumen Output Metric

In the NOPR, DOE proposed that the test method for measuring the lumen output of an LED lamp be as specified in section 9.0 of IES LM–79–2008 and proposed the same lumen output measurement method for all LED lamps, including directional [26] LED lamps. *Id.* For directional LED lamps, DOE suggested measuring total lumen output from the lamp rather than beam lumens [27] because other directional lamp technologies currently measure and report total lumen output on the FTC Lighting Facts label.

As discussed in section III.C.3.b, DOE proposes in the SNOPR that goniometers may not be used for photometric measurements. As a result, DOE proposes that the method for measuring lumen output in the SNOPR be as specified in sections 9.1 and 9.2 of IES LM–79–2008. Section 9.3 of IES LM–79–2008 discusses usage of goniometers, and DOE is not including that method in the SNOPR proposal.

Regarding directional lamps, NEMA commented that industry has not yet reached consensus regarding a light output metric for directional lamps. (NEMA, Public Meeting Transcript, No. 7 at p. 43; NEMA, No. 16 at p. 4) Furthermore, NEMA highlighted that DOE has other rulemakings specifically for reflector lamps that specify the use of total lumens. Therefore, a deviation from measuring total lumens in the LED lamp test procedure would have a significant impact on all types of directional lamps. (NEMA, Public Meeting Transcript, No. 7 at p. 44) The CA IOUs commented that if measuring beam lumens is only required for the LED lamp test procedure and not all general service reflector lamps, this could hinder the industry's ability to compare lamps across technologies. (CA IOUs, No. 19 at p. 7) However, the CA IOUs supported DOE's efforts to develop a beam efficacy metric and recommended that this metric be applied to all directional lamp technologies. (CA IOUs, No. 19 at p. 7) In contrast, P.R. China argued that testing total lumen output instead of the beam lumen output and center-beam candle power might bring inconsistency and confusion to the industry. Therefore, they recommended that DOE reference the Energy Star Program Requirements for Integral LED Lamps: Eligibility Criteria—Version 1.4 [28] which specifies that the center-beam candle power and beam angle be tested for directional lamps. (P.R. China, No. 12 at p. 4)

Because total lumen output is the measurement reported on the FTC Lighting Facts label for other directional lamp technologies, DOE agrees with NEMA and the CA IOUs comments not to include measurements for beam lumens in this test procedure. Therefore, DOE maintains its proposal from the NOPR to measure the total lumen output for LED lamps. Measuring the total lumen output for LED lamps

[25] IES LM–79–2008 defines preburning as the operation of a light source prior to mounting on a measurement instrument, to shorten the required stabilization time on the instrument.

[26] Directional lamps are designed to provide more intense light to a particular region or solid angle. Light provided outside that region is less useful to the consumer, as directional lamps are typically used to provide contrasting illumination relative to the background or ambient light.

[27] Please refer to the NOPR Test Procedures for Light-Emitting Diode Lamps (Docket No. EERE–2011–BT–TP–0071) for a detailed explanation of why DOE is not proposing to measure beam lumens for directional LED lamps (77 FR at 21043; April 9, 2012).

[28] ''Energy Star Program Requirements for Integral LED Lamps: Eligibility Criteria—Version 1.4.'' U.S. Environmental Protection Agency, August 28, 2013.

will enable industry and consumers to compare general service lamp products across different technologies.

d. Input Power

Following seasoning and stabilization, input power to the LED lamp is measured using the instrumentation specified in section III.C.3.b. All test conditions and test setup requirements from sections III.C.2 and III.C.3 should also be followed.

e. Lamp Efficacy Metric

In the NOPR, DOE proposed test procedures for measuring lumen output and input power, and also specified testing dimmable lamps at full light output. 77 FR at 21041. However, commenters noted that efficacy may appear in future mandates, and therefore recommended it be included in DOE's test procedure for LED lamps. The CA IOUs commented that a test procedure with an efficacy metric would be needed in the future to comply with federal legislative mandates, and for this reason they urged DOE to include an efficacy metric in the test procedure. Both the CA IOUs and NEEA recommended that DOE adopt IES LM–79–2008, which defines luminous efficacy as the quotient of the measured total luminous flux (in lumens) and the measured electrical input power (in watts), or lumens per watt. (CA IOUs, No. 19 at p. 3; NEEA, No. 20 at p. 1)

As discussed in section I, this proposed test procedure will support any potential future energy conservation standards for general service LED lamps, which may include efficacy as a metric for setting standards. Accordingly, for the SNOPR, DOE proposes that the efficacy of an LED lamp be calculated by dividing measured initial lamp lumen output in lumens by the measured lamp input power in watts, in units of lumens per watt. DOE believes that providing a calculation for efficacy of an LED lamp does not increase testing burden because the test procedure already includes metrics for input power and lumen output. DOE requests comment on the proposal to add a calculation for efficacy of an LED lamp.

f. Measuring Correlated Color Temperature

In the NOPR, DOE proposed that the CCT of an LED lamp be calculated as specified in section 12.4 of IES LM–79–2008. 77 FR at 21044. The CCT is determined by measuring the relative spectral distribution, calculating the chromaticity coordinates, and then matching the chromaticity coordinates to a particular CCT of the Planckian radiator. The setup for measuring the relative spectral distribution, which is required to calculate the CCT of the LED lamp, shall be as specified in section 12.0 of IES LM–79–2008. That section describes the test method to calculate CCT using a sphere-spectroradiometer system and a spectroradiometer or colorimeter system. Section 12.0 of IES LM–79–2008 also specifies the spectroradiometer parameters that affect CCT and the method to evaluate spatial non-uniformity of chromaticity.

South Korea disagreed with the proposal in the NOPR and recommended that DOE follow industry standard IEC/PAS 62612 which states that nominal CCT values shall be reported (South Korea, No. 17 at pp. 3–4). Nominal CCT values are defined by a region of the chromaticity diagram and any lamp that falls in a certain region is assigned a single CCT value. However, nominal CCT values do not address all regions of the chromaticity diagram. Although manufacturers in the marketplace may choose to design lamps that fall within regions defined by nominal CCT, DOE's goal is to establish one test method that applies to all LED lamps. Therefore, DOE is not proposing to follow a nominal CCT methodology and maintains its proposal in the NOPR regarding the method to calculate the CCT of an LED lamp. Furthermore, as discussed in section III.C.3.b, DOE also proposes in the SNOPR to require all photometric measurements (including CCT) be carried out in an integrating sphere, and that goniometer systems must not be used. Therefore, DOE proposes that the instrumentation used for CCT measurements be as described in section 12.0 of IES LM–79–2008 with the exclusion of section 12.2 of IES LM–79–2008.

g. Measuring Color Rendering Index

In the SNOPR, DOE proposes to add a requirement that the CRI of an LED lamp be determined as specified in section 12.4 of IES LM–79–2008. As discussed in section III.C.3.b, DOE also proposes in the SNOPR to require all photometric measurements (including CRI) be carried out in an integrating sphere. Therefore, the setup for measuring the relative spectral distribution, which is required to calculate the CRI of the LED lamp, must be as specified in section 12.0 of IES LM–79–2008 with the exclusion of section 12.2 of IES LM–79–2008, as goniometer systems must not be used. Section 12.4 of IES LM–79–2008 also specifies that CRI be calculated according to the method defined in the International Commission on Illumination (CIE) 13.3–1995.[29] DOE proposes that the test procedure for LED lamps include measurement methods for CRI in order to support the upcoming general service lamps energy conservation standard rulemaking. DOE requests comment on the proposal to add CRI to the test procedure for LED lamps.

D. Proposed Approach for Lifetime Measurements

1. LED Lamp Lifetime Definition

There are currently no industry standards that define or provide instructions for measuring the lifetime[30] of LED lamps. Thus, for the NOPR, DOE conducted literature research and interviewed several subject matter experts to understand how industry characterized lifetime for these products. Based on the information gathered, DOE proposed to measure lumen maintenance to determine the lifetime of LED lamps. Although other lighting technologies define lamp lifetime as the time at which 50 percent of tested samples stop producing light, industry believes that an LED lamp has reached the end of its useful life when it achieves a lumen maintenance of 70 percent (i.e. 70 percent of initial lumen output, or L_{70}). 77 FR at 21046.

Philips, OSI, and Cree agreed that currently no industry accepted procedure exists for measuring the lifetime of LED-based lighting products. (Philips, Public Meeting Transcript, No. 7 at p. 64; OSI, Public Meeting Transcript, No. 7 at pp. 74–75; Cree, Public Meeting Transcript, No. 7 at p. 65) However, Litecontrol and NEMA disagreed with DOE's proposal, stating that the report *LED Luminaire Lifetime: Recommendation for Testing and Reporting*[31] explicitly argues that lumen maintenance alone cannot be used as a proxy for the lifetime of LED-based lighting products. (Litecontrol, No. 11 at p. 1; NEMA, No. 16 at p. 5) Radcliffe Advisors and the CA IOUs emphasized that color shift be considered when determining the lifetime because this could also render a lamp un-usable or undesirable to a consumer before the lamp reaches L_{70}. (Radcliffe Advisors,

[29] ''Method of Measuring and Specifying Colour Rendering Properties of Light Sources.'' Approved by CIE in 1995.

[30] In the NOPR, DOE used the term ''rated lifetime.'' For the SNOPR, DOE replaces the term ''rated lifetime'' with ''lifetime'' to refer to the same parameter.

[31] U.S. Department of Energy, ''*LED Luminaire Lifetime: Recommendation for Testing and Reporting,*'' June 2011. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_luminaire-lifetime-guide_june2011.pdf.*

No. 13 at p. 1; CA IOUs, No. 19 at p. 4)

In the absence of industry consensus regarding a definition or test procedure for lifetime, NEMA, Lutron, the CA IOUs, and Radcliffe Advisors emphasized that DOE should wait for industry to develop new and revised standards that address lifetime and then reference them for the purposes of the FTC Lighting Facts label. (NEMA, No. 16 at p. 2; Lutron, Public Meeting Transcript, No. 7 at p. 80; CA IOUs, No. 19 at p. 5; Radcliffe Advisors, No. 13 at p. 1) NEMA indicated that this includes revisions of IES LM–79–2008, IES LM–80–2008,[32] and emerging standards IES LM–84 [33] and IES TM–26.[34] (NEMA, No. 16 at p. 2, 5, 7) The Joint Comment, NEMA, NEEA, and the CA IOUs encouraged DOE to work with industry to develop a test procedure that would quantify the lifetime of an LED lamp system. (Joint Comment, No. 18 at p. 1; NEMA, No. 16 at p. 4; NEEA, No. 20 at pp. 2–3; CA IOUs, No. 19 at p. 5) NEMA, Philips, and Radcliffe Advisors pointed out that there are several industry groups working on this issue, such as the LED Systems Reliability Consortium. (NEMA, No. 16 at p. 4; Philips, Public Meeting Transcript, No. 7 at p. 64; Radcliffe Advisors, No. 13 at p. 1) Other interested parties cited additional efforts; the CA IOUs commented that DOE should coordinate efforts with ENERGY STAR while the Joint Comment recommended that DOE coordinate test procedure development with work in the European Union. (CA IOUs, No. 19 at p. 5; Joint Comment, No. 18 at p. 5)

DOE recognizes that there are degradation mechanisms other than lumen maintenance, such as color shift, that can affect the useful lifetime of LED lamps. However, color shift is not very well-understood, well-studied, or commonly used even for traditional incandescent lamps and CFLs.[31] After conducting thorough research of existing test procedures for all lighting products and industry literature regarding LED lamp lifetime, DOE has tentatively concluded that there is no industry consensus for how to characterize lifetime of LED lamps in terms of performance metrics other than lumen maintenance. Therefore, DOE is not proposing to use metrics such as color shift to determine the lifetime of LED lamps.

Although industry may be working to develop new and revised standards to define lifetime and establish test procedures for measuring this quantity, the timeframe for their development is unknown. DOE reviewed the efforts of other working groups, as suggested by interested parties, but was unable to find any U.S. or international standard that provides a test procedure for measuring and/or projecting LED lamp lifetime. The only publicly available approach for measuring LED lamp lifetime is ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0,[10] which uses a lumen maintenance of 70 percent (i.e. 70 percent of initial lumen output, or L_{70}) as an estimate for lifetime. Therefore, in this SNOPR, DOE proposes to continue to define lifetime as the time at which the lumen output of the LED lamp falls below 70 percent of the initial lumen output.

2. NOPR Proposals

As mentioned above, there are currently no industry standards that address how to measure lifetime for LED lamps. Therefore, DOE reviewed methods to measure lifetime that were contained in industry standards for related components and also investigated recent efforts in DOE and ENERGY STAR working groups. In the NOPR, DOE presented four potential lifetime measurement approaches, all of which characterized the lifetime of LED lamps as the time required to reach a lumen maintenance of 70 percent. 77 FR at 21044–5. Three of these approaches tested an LED lamp to determine the lifetime and the fourth approach tested the LED source as a proxy for the lifetime of the lamp. Ultimately, DOE determines in this SNOPR that the test procedure for lifetime must directly measure the performance of an LED lamp and not the LED source, and proposes the revised lifetime measurement detailed in section III.D.3.

Approach 1, based largely on the procedures in IES LM–79–2008, directed manufacturers to measure the lumen output of the LED lamp until it reaches 70 percent of its initial lumen output. In the NOPR, DOE stated that Approach 1 is advantageous because it does not project the time at which the lamp reaches L_{70} and therefore measures the actual performance of the lamp over its useful life. However, DOE determined that Approach 1 was not practical because it may require up to six years of testing, by which time the LED lamp may be obsolete. *Id.*

Approach 2 called for measuring lumen output of the LED lamp for a specified period of time, 6,000 hours, and then projecting the time at which the lamp reached L_{70} based on the minimum lumen maintenance at 6,000 hours. This method was largely based on the ENERGY STAR Specification for Integral LED Lamps Version 1.4 (*see supra* note 28). In addition, DOE proposed in the NOPR that a rapid-cycle stress test be performed to assess catastrophic lamp failure (*e.g.* when a lamp immediately ceases to emit light, rather than gradually decreasing in light output). Approach 2 also enabled lifetime claims to be based on the performance of an LED lamp, but was less time consuming than Approach 1 because it only required 6,000 hours of testing and then projected the lifetime based on the lumen maintenance at 6,000 hours. However, DOE noted in the NOPR that the method used to develop the ENERGY STAR lifetime projection is unverified and purely theoretical. Furthermore, Approach 2 did not account for catastrophic lamp failure beyond the 6,000 hour testing time. *Id.*

Similar to Approach 2, Approach 3, based on IES LM–79–2008, directed measuring the lumen output of the LED lamp for a minimum of 6,000 hours. In the NOPR, DOE stated that the collected lumen output data would then be used to project the L_{70} lifetime of the LED lamp using an alternative procedure that would be developed by DOE. This method would project lifetime based on the performance of an LED lamp, but would not necessarily be based on a standardized method for projecting lifetime. 77 FR at 21045.

Finally, Approach 4 required measuring the lumen output of LED sources (the component of the LED lamp that produces light) at regular intervals for a minimum of 6,000 hours, based largely on the procedures in IES LM–80–2008. DOE would then project the time at which the lumen output of the source reached 70 percent of its initial lumen output using the projection method in IES TM–21–2011. In the NOPR, DOE indicated that, although the preferred methodology is to project the lifetime of an LED lamp rather than an LED source, an industry standardized method only exists for projecting the lifetime of an LED source and not an LED lamp. For this reason, DOE tentatively concluded in the NOPR that Approach 4 was the most appropriate and proposed that this method be used for estimating the lifetime of an LED lamp. *Id.*

[32] ''Measuring Lumen Maintenance of LED Light Sources.'' Approved by IES on September 22, 2008.

[33] LM–84 ''IES Approved Method for Measuring Lumen and Color Maintenance LED Lamps, Lighting engines, and Luminaires,'' will provide the method for measurement of lumen and color maintenance of LED lamps, light engines, and LED luminaires.

[34] TM–26 ''Projecting Long-Term Lumen Maintenance for LED Lamps and Luminaires,'' will provide an LED lamp and luminaire level counterpart to IES TM–21–2011 using the IES LM–80–2008 (revision) and LM–84 testing data for projecting long-term lumen maintenance.

DOE received many comments regarding its proposal for measuring lifetime. Both Kritzer and Samsung agreed with NOPR Approach 4, as written, for measuring the lifetime of LED lamps. (Kritzer, No. 3 at p. 1, Samsung, No. 14 at p. 1) Kritzer commented that it would be expected that the proposed method would reduce the amount of time needed for testing LED lamps and hence also reduce costs. (Kritzer, No. 3 at p. 1) However, NEMA, Radcliffe Advisors, and the Joint Comment disagreed with all suggested approaches within the NOPR document, including Approaches 1, 2, and 3 which DOE did not adopt as its proposal. (NEMA, No. 16 at p. 4; Radcliffe Advisors, No. 13 at p. 1; Joint Comment, No. 18 at p. 1)

Despite their disagreement, NEMA did offer an interim solution to use until new and revised industry standards are released. Their proposal combined NOPR Approach 2 and 4. They indicated that NOPR Approach 2 could be used by those manufacturers who do not have IES LM–80–2008 data for the LED source within the lamp and that NOPR Approach 4 could be used for those products for which IES LM–80–2008 data does exist. (NEMA, No. 16 at p. 4, 8) In addition, they suggested that DOE not include the rapid cycle stress testing suggested in Approach 2. They indicated that rapid cycle stress testing is practiced for some lighting technologies; however, this technique is not widely practiced by the LED industry and has not been verified as relevant to LED lifetime and performance. (NEMA, No. 16 at p. 9)

DOE appreciates NEMA's interim proposal, but notes that combining Approaches 2 and 4 would result in some manufacturers reporting lifetime based on testing of an LED lamp and others reporting lifetime based on testing of an LED source. The differences between Approaches 2 and 4 would lead to different results for lifetime. DOE cannot adopt alternative test methods that yield different results as there would be no basis for establishing any future energy conservation standards. Furthermore, this combined approach still contains many of the drawbacks related to the individual approaches.

Regarding Approach 4, DOE received several comments that outlined the disadvantages of the NOPR proposal for determining the lifetime of LED lamps. NEMA, Philips, OSI, TUD, the Joint Comment, the CA IOUs, NEEA, Radcliffe Advisors, the Appliance Standards Awareness Project (hereafter referred to as ASAP), and Litecontrol advocated basing the lifetime on measurements of the whole LED lamp and not the LED source component. They commented that it is undesirable for the lifetime of LED lamps to be approximated by the lumen maintenance of the LED source and stated that other components may cause lamp failure before the LED source falls below 70 percent of its initial light output. (NEMA, Public Meeting Transcript, No. 7 at p. 83, 84–85, 85; NEMA, No. 16 at p. 2, 4, 5, 8, 9; Philips, Public Meeting Transcript, No. 7 at pp. 63–64, 83; OSI, Public Meeting Transcript, No. 7 at p. 69, 100–101; TUD, No. 15 at p. 1; Joint Comment, No. 18 at p. 1, 2, 4; CA IOUs, No. 19 at p. 4; NEEA, No. 20 at p. 2, 3; Radcliffe Advisors, No. 13 at p. 1; ASAP, Public Meeting Transcript, No. 7 at pp. 83–84; Litecontrol, No. 11 at p. 1)

Some interested parties suggested additional considerations for a procedure that measured the performance of an LED lamp rather than an LED source. The Joint Comment stated that the test procedure for LED lamp lifetime include measurements and projections of driver lifetime. They explained that industry has developed reliability models to predict theoretical failure rates of LED drivers, and DOE should investigate these models to determine if using them would help better capture system effects of an LED lamp. (Joint Comment, No. 18 at p. 1, 4–5) The CA IOUs also suggested that DOE use accelerated testing based on elevated temperatures, such as the method being explored by the LRC. (CA IOUs, No. 19 at p. 5)

DOE has considered all comments received about the four approaches discussed in the NOPR and has decided to significantly change its approach for determining the lifetime of LED lamps in this SNOPR. DOE agrees that there are several potential issues with requiring lumen maintenance testing of the LED source component, as proposed in Approach 4. DOE has preliminarily concluded in this SNOPR that the test procedure for lifetime must directly measure the performance of an LED lamp. DOE acknowledges that LED driver degradation and interactions between the LED sources and other components are known to affect the lifetime of integrated LED lamps. Regarding the proposal by the Joint Comment, DOE conducted research of existing driver reliability modeling and test procedures, including those specified in the military handbook MIL–HDBK–217F,[35] to determine whether driver failure could be included in the projection of LED lamp lifetime. However, DOE determined that no test procedures are available that use the expected failure of the LED driver to predict the failure of the complete LED lamp system. The CA IOUs suggested that DOE consider accelerated testing based on elevated temperatures for the lifetime test procedure. However, DOE research of existing literature and industry test procedures indicates that accelerated test methods for LED lamp lifetime are not available, and therefore, are not ready for inclusion in the SNOPR.

As mentioned above, DOE has decided to measure directly the performance of an LED lamp and does not propose requiring testing of LED sources or any individual lamp component. The complete SNOPR method is described in section III.D.3. Although DOE has decided to make this change, DOE did receive comments on specific aspects of the NOPR proposal. These comments are discussed in further detail below.

a. Industry Standards

In the NOPR, DOE proposed measuring the lumen output of LED sources based on IES LM–80–2008 and then projecting the time at which the lumen output of the source reached 70 percent of the initial lumen output based on IES TM–21–2011. 77 FR at 21045 NEMA, Cree, Radcliffe Advisors, the CA IOUs, and Philips commented that the NOPR proposal modifies and misapplies industry standards, and argued that both IES LM–80–2008 and IES TM–21–2011 provide procedures to measure lumen maintenance of the LED source and should not be used to estimate the lifetime of LED lamps. (NEMA, No. 16 at p. 2, 5, 7; Cree, Public Meeting Transcript, No. 7 at pp. 95–96, 109; Radcliffe Advisors, No. 13 at p. 1; CA IOUs, No. 19 at p. 5, 6; Philips, Public Meeting Transcript, No. 7 at p. 114) NEMA specified that DOE only reference IES LM–79–2008 because this standard applies to LED lamps, which are the subject of this rulemaking. (NEMA, No. 16 at p. 6)

DOE understands that both IES LM–80–2008 and IES TM–21–2011 are industry standards for measuring and predicting the lumen maintenance of an LED source. In the NOPR, DOE proposed referencing these standards to measure the lumen maintenance of an LED source because DOE believed it would be an adequate approximation for determining the lifetime of LED lamps. However, based on the comments received in response to the NOPR, DOE has changed its proposed procedure to

[35] Society of Reliability Engineers, Reliability Prediction of Electronic Equipment, December 1991. *http://www.sre.org/pubs/Mil-Hdbk-217F.pdf.*

measure the lifetime of LED lamps. In this SNOPR, DOE proposes assessing the lumen maintenance of an LED lamp and does not require testing of LED sources. DOE's lifetime proposal, described in section III.D.3, uses the procedures of IES LM–79–2008 to measure the lumen output of an LED lamp.

b. LED Source In-Situ Temperature

In the NOPR, DOE proposed performing an in-situ temperature measurement test (ISTMT) to determine the case temperature at which the lumen maintenance data shall be obtained to project the lifetime of the LED source. 77 FR at 21047 DOE proposed that the test setup, conditions, test equipment, instrumentation, and test box material and construction for the ISTMT be as specified in UL 1993–2009.[36] UL, GE, Cree, NEMA, and Feit argued that the test setup specified in UL 1993–2009 is designed to represent a worst-case installation scenario. (UL, Public Meeting Transcript, No. 7 at p. 110; GE, Public Meeting Transcript, No. 7 at p. 91; Cree, Public Meeting Transcript, No. 7 at p. 93; NEMA, No. 16 at p. 5; Feit, Public Meeting Transcript, No. 7 at p. 93) Specifically, NEMA expressed concern that the test setup described in UL 1993–2009 would elevate the ambient air to a temperature greater than 25 °C, which conflicts with the requirement to measure photometric characteristics at 25 °C. This increase in temperature could also lead to changes in the photometric performance of the LED sources. Furthermore, NEMA commented that using UL 1993–2009 would force LED lamp manufacturers to increase design margins for lumens and other lamp characteristics to account for the temperature increase of the UL test conditions. This would lead to the over-design of LED lamps. (NEMA, No. 16 at p. 7) GE and NEMA concluded that UL 1993–2009 should not be used as part of the instruction for the ISTMT. (GE, Public Meeting Transcript, No. 7 at p. 91; NEMA, No. 16 at p. 5, 7) The Joint Comment indicated that DOE should carefully consider whether UL 1993–2009 represents an average installation or a worst-case scenario. (Joint Comment, No. 18 at p. 3) However, Intertek argued that UL 1993–2009 is designed to represent typical installation conditions. (Intertek, Public Meeting Transcript, No. 7 at p. 92, 93).

The Joint Comment explained that temperature plays a critical role in the failure of LED lamps. They commented that an appropriate lifetime test method would take careful account of all the real-world installation parameters that could impact the natural operating temperature of the device. The Joint Comment indicated that this would include orientation, natural air circulation around the device, and all the effects from other physical connections/thermal pathways. In contrast with the manufacturers' recommendation, the Joint Comment supported a test procedure that approximates a worst-case installation scenario if knowledge about field installations is missing or insufficient. (Joint Comment, No. 18 at p. 2–3) The Joint Comment recommended that DOE carefully consider whether UL 1993–2009 represents an average U.S. installation or a worst-case scenario and provide justification as to why its use is appropriate. (Joint Comment, No. 18 at p. 3)

In this SNOPR, DOE has proposed a new test procedure for measuring the lifetime of LED lamps that does not require determining the in-situ temperature of the LED source. The test conditions for the new proposal are discussed in section III.D.3.b.

c. LED Source Lumen Maintenance

IES LM–80–2008 requires manufacturers to test LED sources at three temperatures: 55 °C, 85 °C, and a third temperature suggested by the source manufacturer. A lamp manufacturer can then interpolate the performance of the source at any temperature bounded by those three temperatures, avoiding the need to conduct additional LED source testing for their specific LED lamp. However, IES LM–80–2008 does not provide a method for *extrapolating* LED source performance at an in-situ temperature that is not bounded by those three temperatures. In this case (an uncommon situation), DOE proposed in the NOPR that LED lamp manufacturers would need to test the LED sources at the in-situ temperature of their lamp to obtain the lumen maintenance data to project the lifetime. 77 FR at 21046 DOE's NOPR proposal did not modify IES LM–80–2008, instead it provided additional test methods for situations outside the applicability of IES LM–80–2008.

DOE received several comments requesting that DOE not modify IES LM–80–2008 and stating that proposed testing of LED sources would be costly. NEMA, the CA IOUs, and NEEA commented that DOE should not modify the test procedures specified in IES LM–80–2008. (NEMA, No. 16 at p. 5; CA IOUs, No. 19 at pp. 5–6; NEEA, No. 20 at p. 2). Furthermore, NEEA commented that aligning DOE's test procedure and IES LM–80–2008 will reduce the testing burden on manufacturers. (NEEA, No. 20 at p. 2) The CA IOUs elaborated that LED source testing at the case temperature identified during the ISTMT would be impractical and/or costly for industry because LED sources are often brought to market with their IES LM–80–2008 testing already complete. (CA IOUs, No. 19 at pp. 5–6)

Two commenters requested further clarification of IES LM–80–2008. Regarding the temperature requirements, South Korea commented that international standards do not prescribe any specific temperatures at which to measure the lumen maintenance of the LED source. If DOE determines it is important to test the sources at 55 °C and 85 °C, DOE should seek scientific justification for these requirements. (South Korea, No. 17 at p. 3) Samsung also requested that DOE specify the location on the LED source where temperature is measured. (Samsung, No. 14 at p. 1)

DOE also received several comments indicating that DOE's proposal for procurement of LED source lumen maintenance data could require disassembly of a lamp in some cases. GE, OSI, and NEMA commented that manufacturers would need to extract the LED source from the finished lamp product if IES LM–80–2008 data is unavailable. (GE, Public Meeting Transcript, No. 7 at p. 94, 95, 100; OSI, Public Meeting Transcript, No. 7 at pp. 100–101; NEMA, No. 16 at p. 6) To avoid extracting the LED source, GE recommended that DOE consider multiple lifetime measurement approaches depending on the availability of IES LM–80–2008 data. (GE, Public Meeting Transcript, No. 7 at pp. 78–79)

In the NOPR, DOE also proposed using the relevant guidelines from an ENERGY STAR specification document to measure the lumen maintenance for LED sources.[37] 77 FR at 21048 Cree commented that for lamps that use both white and red LED sources there is uncertainty as to whether the IES LM–80–2008 data from the individual sources can be added together to accurately represent their combined performance. Cree also noted ENERGY STAR is currently accepting this practice. (Cree, Public Meeting

[36] ''Self-Ballasted Lamps and Lamp Adapters.'' Published by UL on August 28, 2009.

[37] ENERGY STAR Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products, September 9, 2011. *www.energystar.gov/ia/partners/prod_development/new_specs/downloads/luminaires/ENERGY_STAR_Final_Lumen_Maintenance_Guidance.pdf.*

Transcript, No. 7 at p. 106) Both NEMA and Radcliffe Advisors stated that this is not an issue because DOE's test procedure should not require testing of any individual component of an LED lamp. All testing procedures should measure performance of the complete lamp product. (NEMA, No. 16 at p. 4–5; Radcliffe Advisors, No. 13 at p. 1)

DOE agrees there are drawbacks (including disassembly of the lamp to extract an LED source) to testing the LED source component as a proxy for estimating the lifetime of an LED lamp as outlined in IES LM–80–2008. Therefore, DOE has developed a new proposal that only requires testing of an LED lamp and is no longer using the test procedures in IES LM–80–2008 or IES TM–21–2011. The new test procedure for LED lamps indicates that after the test duration, lumen output must be measured as specified in IES LM–79–2008. The lifetime of the LED lamp can then be projected using an equation. The proposed method for lifetime testing is discussed in more detail in section III.D.3.

d. Test Conditions

In the NOPR, DOE proposed that the temperature of the surrounding air during testing be maintained between the case temperature and 5 °C below the case temperature as specified in section 4.4.2 of IES LM–80–2008. DOE also proposed that airflow around the LED sources be as specified in section 4.4.3 of IES LM–80–2008, which states that the airflow shall be maintained to minimize air drafts but allow some movement of the air to avoid thermal stratification. 77 FR at 21046 NEMA and Cree commented that the upcoming IES LM–80–2008 revisions will include recommendations on best practices for measuring and monitoring air flow through the test system. (NEMA, Public Meeting Transcript, No. 7 at p. 97; Cree, Public Meeting Transcript, No. 7 at p. 97) However, NEMA indicated that current test methods have led industry to believe that the surrounding air temperature and airflow do not have noticeable impact on long-term LED lumen degradation. They suggested that current IES LM–79–2008 air movement requirements are more than adequate to ensure the accuracy of test data. (NEMA, No. 16 at p. 5) TUD disagreed with the specified test conditions, indicating that they cannot sufficiently simulate all real world conditions. (TUD, No. 15 at p. 1)

As previously mentioned, for this SNOPR, DOE has developed a test procedure that only requires testing of an LED lamp. Therefore, DOE no longer references IES LM–80–2008, which applies to LED sources. The SNOPR has proposed less stringent ambient temperature and airflow conditions for periods when a lamp is operating but measurements are not being taken. These requirements are discussed in more detail in section III.D.3.b.

e. LED Source Orientation

In the NOPR, DOE proposed that the LED sources be operated in accordance with section 4.4.4 of IES LM–80–2008, which requires operating LED sources in the orientation specified by the source manufacturer. *Id.* DOE noted that it is not specifying the orientation for testing LED sources and invited interested parties to comment on whether the operating orientation of the LED sources during testing affects the lumen depreciation over time. Cree, Samsung, and NEMA commented that DOE should not require additional marking or testing based on orientation. (Cree, Public Meeting Transcript, No. 7 at p. 98; Samsung, No. 14 at p. 1; NEMA, No. 16 at p. 6) NEMA stated that the orientation specified in IES LM–80–2008 is only provided to establish a common testing protocol, not because there is any evidence that orientation affects performance. In this SNOPR, DOE is not referencing the test procedures provided in IES LM–80–2008, which apply to LED sources. Instead, DOE is proposing a new test procedure for lifetime which measures the performance of LED lamps. Because DOE believes that orientation impacts the performance of LED lamps, DOE is proposing that lamps be tested in both the base-up and base-down positions. The orientation requirements for lifetime are discussed in section III.C.3.b.

f. External Driver Requirements

As specified in IES LM–80–2008, in the NOPR, DOE proposed using an external driver that is compliant with manufacturer's guidance to drive the LED source. 77 FR at 21047 Both Cree and NEMA opposed using external drivers to test LED sources, while Samsung thought the use of an external driver was appropriate. (Cree, Public Meeting Transcript, No. 7 at p. 99; NEMA, No. 16 at p. 6; Samsung, No. 14 at p. 1) NEMA indicated that the FTC label only regulates medium screw-base products (as defined in CFR 430.2). Therefore, if the lamp is to connect to the power supply via an ANSI base, there must be an integrated driver rather than an external driver. (NEMA, No. 16 at p. 6) In this SNOPR, DOE is proposing a new test procedure that measures the performance of an LED lamp and is no longer utilizing the test procedures provided in IES LM–80–2008. The new proposal does not require the use of an external driver because an internal driver is included in an integrated LED lamp. The SNOPR proposal for determining the lifetime of LED lamps is detailed in section III.D.3.

g. Lumen Maintenance Measuring Equipment

IES LM–80–2008 specifies using a spectroradiometer to measure the lumen output of an LED source. In the NOPR, DOE proposed using a sphere-spectroradiometer, sphere-photometer, or a goniophotometer to measure the lumen output of the LED source. 77 FR at 21043 Cree agreed that all three instruments are appropriate to measure the lumen output of LED sources. Cree indicated that IES LM–80–2008 does not specify the use of a goniophotometer because this equipment cannot be used to measure many of the other photometric and electrical characteristics that the standard requires. (Cree, Public Meeting Transcript, No. 7 at p. 103) NEMA disagreed with DOE's proposal and recommended that DOE not modify the IES LM–80–2008 procedures. (NEMA, Public Meeting Transcript, No. 7 at p. 104; NEMA, No. 16 at p. 6) Samsung commented that requiring only a sphere-spectroradiometer would be suitable. (Samsung, No. 14 at p. 1)

For this SNOPR, DOE is no longer proposing to use the test procedures provided in IES LM–80–2008. Because DOE proposes to measure the lifetime of LED lamps rather than LED sources, the SNOPR proposes the use of the lumen output measuring equipment described in IES LM–79–2008. As discussed in section III.C.3.b, DOE proposes that the instrumentation used for lumen output measurement of LED lamps be as described in sections 9.1 and 9.2 of IES LM–79–2008 and that goniometer systems not be used.

h. LED Source Seasoning

Regarding seasoning of the LED source for lifetime measurements, the Joint Comment argued that if DOE proposes a lifetime test method that involves projection of the LED source using the Arrhenius equation as the functional form of lumen degradation, the proposal should include seasoning. (Joint Comment, No. 18 at pp. 5–6) DOE's proposal in the SNOPR (discussed in section III.D.3) involves measurements of the LED lamp, not the LED source. Therefore, DOE is not proposing a seasoning requirement for LED sources in the SNOPR.

i. Maximum Lifetime

In the NOPR, DOE proposed projecting the lifetime as specified in

section 5.0 of IES TM–21–2011. DOE also proposed that if the projected rate lifetime is greater than 25,000 hours, the maximum lifetime is 25,000 hours. If the projected lifetime is less than 25,000 hours, the lifetime is the projected value. 77 FR at 21048

Litecontrol, Radcliffe Advisors, South Korea, Kritzer, an Anonymous commenter, the CA IOUs, NEMA, and Philips disagreed with the proposal to cap lifetime at 25,000 hours, stating that applying an arbitrary cap discourages manufacturer improvements to lifetime. (Litecontrol, No. 11 at p. 1; Radcliffe Advisors, No. 13 at p. 2; South Korea, No. 17 at p. 3; Kritzer, No. 8 at p. 1; Anonymous, No. 8 at p. 1; CA IOUs, No. 19 at p. 4; NEMA, Public Meeting Transcript, No. 7 at p. 65, 72–74; NEMA, No. 16 at p. 5; Philips, Public Meeting Transcript, No. 7 at p. 111) NEMA commented that applying a cap of 25,000 hours is contrary to FTC instruction, contradicts the recent L-Prize winning lamp's lifetime rating,[38] and limits payback analysis for rebate programs. (NEMA, No. 16 at p. 5) The Joint Comment indicated that the lifetime cap leaves little incentive for manufacturers to test for longer periods of time with larger samples to reduce measurement uncertainty. (Joint Comment, No. 18 at p. 5) Kritzer pointed out that LED lamps are rapidly improving in performance and limiting these products to a lifetime of 25,000 hours would affect their ability to compete with fluorescent technologies, which advertise lifetimes as long as 40,000 hours. (Kritzer, No. 8 at p. 1)

Some interested parties suggested alternate proposals for limiting maximum lifetime claims. South Korea proposed that the lifetime cap be raised to 36,000 hours to be consistent with IES TM–21–2011, which specifies that if the LED sources are tested beyond 6,000 hours they can report up to 36,000 hours. (South Korea, No. 17 at p. 3) NIST commented that the lifetime cap should only be raised if manufacturers can provide statistics to prove their reported values. (NIST, Public Meeting Transcript, No. 7 at p. 78) Alternatively, NEMA suggested that methods for projecting lifetime beyond 25,000 hours could be drawn from the ENERGY STAR solid-state lighting (hereafter referred to as SSL) program and other products such as electronic fluorescent ballasts. (NEMA, No. 16 at p. 7) The ENERGY STAR test procedure for lifetime includes a projection method based on lumen maintenance testing of an integrated lamp and does not require testing of the embedded LED source. In addition, their projection method specifies that an LED lamp has the potential to be rated at a lifetime greater than 25,000 hours if additional testing beyond the minimum required 6,000 hours of lumen maintenance testing is conducted (*see supra* note 28). The Joint Comment agreed with the need to limit unreasonable lifetime claims and asked DOE to work with industry to investigate a set of confidence criteria to define a lifetime metric. (Joint Comment, No. 18 at p. 5) The Joint Comment argued that the goal of the FTC Lighting Facts label should be to give customers the most accurate information possible regarding the quality and lifetime of this product, and that establishing proper test procedures will help ensure this happens. (Joint Comment, No. 18 at p. 5)

After considering the comments about the NOPR lifetime cap proposal, DOE has removed the 25,000 hour lifetime cap and developed a proposal where the maximum lifetime of LED lamps depends on the test duration. To prevent unreasonable lifetime claims based on a limited amount of test data, DOE proposes that lifetime claims be limited to no more than four times the duration of the test period. This limit reflects ENERGY STAR's requirements to support lifetime claims beyond 25,000 hours, which require a test duration that is 25 percent of the maximum projection. For example, to report a projected L_{70} lifetime of 30,000 hours, at least 7,500 hours of testing (and a lumen maintenance of at least 70 percent at that time) would be required. Requiring four times the duration of the test period is more conservative than industry standard IES TM–21–2011 for LED sources, which limits the L_{70} projection to no more than 5.5 or 6 times the testing time (depending on sample size). A more conservative approach is reasonable because this test procedure applies to integrated LED lamps rather than LED sources. DOE invites comment on the proposed requirement to limit lifetime claims to four times the duration of the test period.

j. Market Introduction

TUD commented that requiring a minimum test duration of 6,000 hours could delay the market introduction of LED lamp products. (TUD, No. 15 at p. 1) In this SNOPR, DOE is proposing a new test method which does not require a minimum duration of testing. Rather, DOE allows the manufacturer to determine the test duration and then limits lifetime claims to four times the test duration.

3. SNOPR Proposed Lifetime Method

In this SNOPR, DOE proposes a new test procedure for lifetime that addresses many of the stakeholder concerns regarding the NOPR proposal for measuring the lifetime of LED lamps. This proposal is simple, straightforward, and allows significant flexibility if lifetimes of LED products change in the future. As stated in section III.D.1, DOE defines the lifetime of an LED lamp as the time at which a lamp reaches a lumen maintenance of 70 percent (i.e., 70 percent of initial lumen output, or L_{70}). In this SNOPR, DOE proposes to measure the lumen output of an LED lamp rather than the LED source contained in the lamp. Thus, the test procedure directly measures the performance of the actual product rather than an internal component. This considerably simplifies compliance testing and provides a consistent procedure to be used for all products. The methodology proposed in the SNOPR consists of four main steps: (1) measuring the initial lumen output; (2) operating the lamp for a period of time (test duration); (3) measuring the lumen output at the end of the test duration; and (4) projecting L_{70} using an equation adapted from the underlying exponential decay function in ENERGY STAR's most recent specification for integrated LED lamps, Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0. (*see supra* note 10) The equation projects lifetime using the test duration and the lumen maintenance at the end of the test duration as inputs. The following sections discuss the methodology in greater detail.

a. Initial Lumen Output

Initial lumen output is the measured amount of light that a lamp provides at the beginning of its life, after it is initially energized and stabilized using the stabilization procedures in section III.C.4.b. An initial lumen output measurement is required to calculate lumen maintenance, which is an input for the lifetime projection. The test procedure for lumen output is described in section III.B. The methodology, test conditions, and setup requirements are unchanged when measuring initial lumen output for the lifetime test procedure.

b. Test Duration

The period of time starting immediately after the initial lumen output measurement and ending when the final lumen output measurement is

[38] The Philips L-Prize Winning LED Bulb is rated at 30,000 hours and has undergone over 7,000 hours of lumen maintenance testing. *www.lightingprize.org/60watttest.stm.*

recorded, is referred to as the ''test duration'' or time ''t.'' The test duration does not include any time when the lamp is not energized. If lamps are turned off (possibly for transport to another testing area or during a power outage), DOE proposes that the time spent in the off-state not be included in the test duration. DOE does not specify a minimum test duration or measurement interval, so manufacturers can customize the test duration based on the expected lifetime of the LED lamp. During this time, the LED lamps are turned on (energized) and operated for a period of time determined by the manufacturer. To reduce test burden, the operating conditions required during the test duration while measurements are not being taken are less stringent than those required when taking photometric measurements (e.g., ambient temperature). The following sections discuss the required operating conditions for lamp operation between lumen output measurements in more detail.

Ambient Temperature and Air Flow

DOE recognizes that while operating an LED lamp, lumen output can vary with changes in ambient temperature, air flow, vibration, and shock. For this reason, DOE proposes specific requirements for quantities such as ambient temperature and air flow for photometric measurements in section III.C.2. However, because lamps may need to be operated for an extended period of time for the purpose of lifetime testing, DOE proposes less stringent requirements when measurements are not being taken. DOE proposes that ambient temperature be maintained between 15 °C and 40 °C. DOE also proposes minimizing air movement surrounding the test racks, and that the LED lamps not be subject to excessive vibration or shock. These test conditions will enable reliable, repeatable, and consistent test results without significant test burden and are discussed in further detail below:

To determine ambient temperature requirements, DOE reviewed industry standard IES LM–65–10 ''Approved Method Life Testing of Compact Fluorescent Lamps.'' [39] Section 4.3 of IES LM–65–10 requires that ambient temperature be controlled between 15 °C and 40 °C. Although industry standard IES LM–65–10 is intended for compact fluorescent lamps, DOE proposes that this ambient temperature range is appropriate for the operation of LED lamps because NEMA commented that current test methods have led industry to believe that the surrounding air temperature and airflow does not have a noticeable impact on long-term LED lumen degradation. (NEMA, Public Meeting Transcript, No. 7 at pp. 2–3; NEMA, No. 16 at p. 2–3) DOE believes that an ambient temperature range between 15 °C and 40 °C encompasses the majority of possible room temperature conditions while limiting test burden. Therefore, in this SNOPR, DOE proposes that ambient temperature be controlled between 15 °C and 40 °C. DOE requests comments on this proposal.

DOE proposes that LED lamp testing racks be open and designed with adequate lamp spacing and minimal structural components to maintain ambient temperature conditions. Furthermore, similar to the requirements in section 4.2 of IES LM–65–10, DOE proposes minimizing airflow surrounding the LED lamp testing racks and that the lamps not be subjected to excessive vibration or shock. DOE believes that these requirements would minimize the impact of airflow and the physical environment while minimizing test burden. DOE invites comments on the minimization of vibration, shock, and air movement, as well as the requirement for adequate lamp spacing during lamp operation in order to maintain ambient temperature conditions.

Power Supply

DOE proposes that section 3.1 of IES LM–79–2008 be incorporated by reference to specify requirements for both AC and DC power supplies. This section specifies that an AC power supply shall have a sinusoidal voltage waveshape at the input frequency required by the LED lamp such that the RMS summation of the harmonic components does not exceed three percent of the fundamental frequency while operating the LED lamp. Section 3.2 of IES LM–79–2008 also requires that the voltage of an AC power supply (RMS voltage) or DC power supply (instantaneous voltage) applied to the LED lamp shall be within ±0.2 percent of the specified lamp input voltage. However, DOE determined that the IES LM–79–2008 voltage tolerances are too burdensome to maintain for the extended time period for which a lamp may need to be operated to determine lifetime. When not taking measurements, DOE proposes to adopt provisions similar to section 5.3 of IES LM–65–10 which requires that the input voltage be monitored and regulated to within ±2.0 percent of the rated RMS voltage. DOE believes that this requirement is achievable with minimal test burden and provides reasonable stringency in terms of power quality based on its similarity to voltage tolerance requirements for other lamp types. DOE invites comments on the proposal to adopt section 3.1 of IES LM–79–2008 requirements for both AC and DC power supplies. DOE also requests comment on the requirement that input voltage be monitored and regulated to within ±2.0 percent of the rated RMS voltage as specified in section 5.3 of IES LM–65–2010.

Lamp Mounting and Orientation

DOE proposes that the LED lamps be tested in the base-up and base-down orientations for lumen maintenance testing. Section III.C.3.b notes that LED lamp test data provided by ENERGY STAR, as well as PG&E, CLASP, and CLTC, has revealed that there was variation between the base-up, base-down and horizontal orientations (*see supra* note 20). Of the three orientations, analysis revealed that the base-up and base-down orientations represent the best (highest lumen output) and worst (lowest lumen output) case scenarios.

Electrical Settings

DOE proposes adopting the electrical settings in section 7.0 of IES LM–79–2008. Section III.C.3.d details the required electrical settings for input voltage and how to operate lamps with multiple modes of operation, such as variable CCT and dimmable lamps.

Operating Cycle

Lifetime test procedures for other lamp types sometimes require ''cycling,'' which means turning the lamp on and off at specific intervals over the test period. However, industry has stated that unlike other lighting technologies, the lifetime of LED lamps is minimally affected by power cycling.[40] Therefore, in this SNOPR, DOE proposes to operate the LED lamp continuously and requests feedback on the appropriateness of not requiring cycling in the test procedure for lifetime.

c. Lumen Output at the End of the Test Duration

Any lumen output measurement after the measurement of initial lumen output, including that at the end of the test duration, is measured under the

[39] ''Approved Method Life Testing of Compact Fluorescent Lamps.'' Approved by IES on December 13, 2010.

[40] NEMA Comments on ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) Version 1.0, Draft 2*http://energystar.gov/products/specs/sites/products/files/NEMA.pdf.*

conditions and setup described in section III.B. DOE proposes stabilizing the LED lamp before measuring lumen output at the end of the test duration. Section III.C.4.b details the LED lamp stabilization procedure.

d. Lumen Maintenance Calculation and Lifetime Projection

As discussed in section III.D.1, DOE proposes to define LED lamp lifetime as the time required to reach a lumen maintenance of 70 percent (L_{70}). Lumen maintenance is the measure of lumen output after an elapsed operating time, expressed as a percentage of the initial lumen output (the definition of initial lumen output is provided in section III.D.3.a). DOE proposes that the lumen maintenance at the end of the test duration equal the lumen output at the end of the test duration (see section III.D.3.c) divided by the initial lumen output.

DOE developed an equation to project the time at which an LED lamp reaches L_{70} based on the underlying exponential decay function used in the ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0 (*see supra* note 10). ENERGY STAR utilizes an exponential decay function to calculate maximum L_{70} life claims between 15,000 and 50,000 hours at increments of 5,000 hours. The ENERGY STAR procedure requires a 6,000 hour test duration and provides lumen maintenance thresholds for each incremental L_{70} lifetime claim. Unlike ENERGY STAR, DOE does not have minimum lifetime requirements for LED lamps. Therefore, to enable reporting of lifetimes less than 15,000 hours and greater than 50,000 hours, DOE has reorganized the underlying ENERGY STAR equation to calculate L_{70} given the initial lumen output ''x0'', the test duration ''t'', and the final lumen output at the end of the test duration ''x_t'' as inputs. DOE's equation is detailed below.

$$L70 = t * \frac{\ln(0.7)}{\ln(\frac{x_0}{x_t})}$$

L_{70} = Time to Reach 70% Lumen Maintenance
t = Test Duration
x_0 = Initial Lumen Output
x_t = Final Lumen Output at time ''t''

DOE requests comment on the proposed equation for projecting the L_{70} lifetime of LED lamps.

DOE proposes that lifetime claims be limited to no more than four times the test duration ''t.'' For example, if an LED lamp is tested for 6,000 hours and has a lumen maintenance value of 93.1 percent at that time, the L_{70} projection equation indicates that the L_{70} lifetime is about 30,000 hours. However, the maximum that could be reported based on the DOE proposal is only 24,000 hours (four times the testing time of 6,000 hours). For lumen maintenance values less than 70 percent, including lamp failures that result in complete loss of light output, the SNOPR proposes that lifetime must not be projected; instead, the lumen maintenance is equal to the previously recorded lumen output measurement at the test duration where the lumen maintenance is greater than or equal to 70 percent. DOE also recognizes that it is possible that the calculated lumen maintenance at time ''t'' could be greater than or equal to 100 percent. When this occurs, DOE proposes that lifetime claims be determined by the maximum projection limit. Due to the similarity of the DOE and ENERGY STAR lifetime test procedures, manufacturers may choose to utilize lumen maintenance measurements collected for the ENERGY STAR specification. However, measurements must adhere to DOE's electrical setting requirements proposed in section III.C.3.d and manufacturers must include all LED lamps within the 10 lamp sample in the reported results including lamp failures. DOE requests comments on its proposal to limit the maximum lifetime to four times the test duration with no minimum test duration.

Finally, DOE also notes that a manufacturer can report the test duration as measured without applying the projection equation. This approach applies to two scenarios. In the first scenario, a manufacturer can test the lamp until it reaches 70 percent lumen maintenance and use that test duration as the lifetime of the lamp. This is equivalent to using the projection equation, because the output of the projection equation would be the same as the test duration when lumen maintenance of 70 percent is reached. In the second scenario, a manufacturer can use the test duration associated with a lumen maintenance greater than 70 percent. This scenario is equivalent to a manufacturer using the projection equation, but electing to report a more conservative value for business reasons. Reporting of conservative values is permitted and is also discussed in section III.F.3.

E. Proposed Approach for Standby Mode Power

EPCA section 325(gg)(2)(A) in part directs DOE to establish test procedures to include standby mode, ''taking into consideration the most current versions of Standards 62301 and 62087 of the International Electrotechnical Commission . . .'' (42 U.S.C. 6295(gg)(2)(A)) IEC Standard 62087 applies only to audio, video, and related equipment, but not to lighting equipment. Thus, IEC Standard 62087 does not apply to this rulemaking, so DOE developed this SNOPR consistent with procedures outlined in IEC Standard 62301, which applies generally to household electrical appliances. However, to (1) develop a test method that would be familiar to LED lamp manufacturers and (2) maintain consistent requirements to the active mode test procedure, DOE referenced language and methodologies presented in IES LM–79–2008 for test conditions and test setup requirements.

A standby mode power measurement is an input power measurement made while the LED lamp is connected to the main power source, but not generating light (active mode). All test condition and test setup requirements used for active mode measurements (e.g., input power) (see sections III.C.2 and III.C.3) also apply to standby mode power measurements. Once the test conditions and setup have been implemented, the LED lamp should be seasoned and stabilized in accordance with the requirements in sections III.C.4.a and III.C.4.b of this SNOPR. After the lamp has stabilized, the technician should send a signal to the LED lamp instructing it to enter standby mode (which is defined as providing zero light output). Standby power is then measured in accordance with section 5 of IEC 62301.

F. Basic Model, Sampling Plan, and Reported Value

1. Basic Model

In this SNOPR, DOE proposes amendments to the term ''basic model'' to include LED lamps. ''Basic model'' is currently defined (with some exceptions) to mean all units of a given type of covered product (or class thereof) manufactured by one manufacturer, having the same primary energy source, and which have essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; and with respect to general service fluorescent lamps, general service incandescent lamps, and reflector lamps: Lamps that have essentially identical light output and electrical characteristics—including lumens per

watt (lm/W) and color rendering index (CRI). 10 CFR 430.2

DOE proposes to add a specification for LED lamps in the definition of basic model in order to provide further guidance on the electrical, physical, and functional characteristics that constitute a basic model. Specifically, DOE proposes that a basic model for an integrated LED lamp should represent lamps that have essentially identical light output and electrical characteristics including lumens per watt, CRI, CCT, and lifetime. Because these are the general characteristics by which manufacturers identify their lamps in catalogs and marketing material, DOE believes these parameters should be used to group lamps of the same type.

DOE proposes to qualify the term ''basic model'' in 10 CFR 430.2 for LED lamps as lamps that have essentially identical light output and electrical characteristics—including lumens per watt (lm/W), color rendering index (CRI), correlated color temperature (CCT), and lifetime.

DOE requests comments on the revision to the definition of ''basic model'' to address LED lamps.

2. Sampling Plan

In the NOPR, DOE proposed a sampling plan for LED lamps to determine input power, lumen output, and CCT, and a separate sampling plan for LED sources to determine lifetime. DOE proposed testing a minimum of 21 LED lamps to determine the input power, lumen output, and CCT. DOE proposed that manufacturers select a minimum of three lamps per month for seven months of production out of a 12 month period. If lamp production occurs in fewer than seven months of the year, three or more lamps must be selected for each month that production occurs, distributed as evenly as possible to meet the minimum 21 unit requirement. The seven months need not be consecutive and could be a combination of seven months out of the 12 months. Sample sizes greater than 21 must be multiples of three so that an equal number of lamps were tested in each orientation (based on the lamp orientation requirements in the NOPR). 77 FR at 21049 (April 9, 2012)

To determine the lifetime of LED lamps, DOE proposed in the NOPR that the sample size for testing LED sources be as specified in section 4.2 of IES TM–21–2011. The IES TM–21–2011 industry standard requires a minimum of ten units to be tested, but recommends a sample set of 20 units for projecting the lifetime of the LED sources. The method of projection specified in IES TM–21–2011 cannot be used for less than ten units. 77 FR at 21049

Regarding the sampling plan proposal for lumen output, CCT, and wattage testing, NEMA and P.R. China commented that the sampling plan should be based on the ENERGY STAR specification for integral LED lamps, which requires a sample size of 10: five base-up and five base-down. (NEMA, Public Meeting Transcript, No. 7 at p. 49; NEMA, No. 16 at p. 8; P.R. China, No. 12 at pp. 4–5) In addition, ENERGY STAR has no requirements for how lamps are selected for testing. NEMA opposed gathering product samples over the course of a year because the associated time to gather and test samples is much greater than a year. (NEMA, No. 16 at p. 8) NEMA recommended that DOE not copy the sampling requirements from other lighting technology rules. (NEMA, No. 16 at p. 9) In addition, NEMA, Cree, OSI, and South Korea commented that solid-state lighting is still an emerging technology and requiring large test samples and long testing time will significantly delay market introduction. (NEMA, Public Meeting Transcript, No. 7 at p. 51; Cree, Public Meeting Transcript, No. 7 at p. 52; OSI, Public Meeting Transcript, No. 7 at p. 53; South Korea, No. 17 at pp. 2–3) Philips added that LED lamp designs are evolving rapidly and often product models are produced for less than a year before they are replaced by more efficient designs. (Philips, Public Meeting Transcript, No. 7 at p. 53) Lutron and Cree also commented that it is very important that the LED lamp test procedure comply with FTC labeling requirements, which allow for provisional labeling prior to completing all testing. (Lutron, Public Meeting Transcript, No. 7 at pp. 51–52; Cree, Public Meeting Transcript, No. 7 at p. 52) Alternatively, GE suggested that DOE could retain the 21 lamp sample size, remove the requirement to collect products for testing over the course of a year, and only test product samples from initial production. (GE, Public Meeting Transcript, No. 7 at pp. 52–53) Radcliffe Advisors commented that a 21 lamp sample size is small and does not have a rational basis. They recommended that DOE give consideration to the relationship between accuracy and the choice of sample size. (Radcliffe Advisors, No. 13 at p. 1)

In reference to the sampling plan for determining the lifetime of LED lamps, NEMA agreed with DOE's summary of IES TM–21–2011 stating that it recommends a minimum of 20 LED sources be used during IES LM–80–2008 testing to allow for lifetime projections of up to 36,000 hours. IES TM–21–2011 allows fewer LED sources to be used, but reduces the maximum projection value to 25,000 hours. (NEMA, Public Meeting Transcript, No. 7 at pp. 113–114) An Anonymous commenter suggested allowing manufacturers to exclude from the overall average one unit that fails during lifetime testing. (Anonymous, No. 8 at p. 1)

In this SNOPR, DOE proposes a new test procedure for lifetime that measures the performance of an LED lamp and not its subcomponents (i.e., the LED source). Therefore, DOE determined it did not need different sampling requirements for lifetime relative to the non-lifetime metrics. These sampling requirements proposed in the SNOPR for all metrics are described below.

In order to address concerns regarding the sample size requirements in the NOPR proposal, DOE collected photometric test data from two sources, the first data set was provided by ENERGY STAR, and the second from a collaborative effort between PG&E, CLASP, and CLTC (*see supra* note 20). These test data, combined, represent 10 samples of 47 different LED lamp products each. Statistical analysis of the LED lamp test data indicates that a minimum sample size of 10 lamps is appropriate to estimate the average input power, initial lumen output, efficacy, CCT, and CRI given the variation present in the data set. Standby mode power is assumed to vary to the same degree as input power (active mode). In addition, 37 LED lamps from the data set were tested for lumen output after 3,000 hours of operation. DOE used this data to help determine the sample size required for estimating the lifetime of the LED lamp. Analysis of the test data revealed that a minimum sample size of 10 should also be sufficient to estimate lumen output for the LED lamp after an elapsed operating time. In addition, requiring a minimum sample size of 10 LED lamps aligns with ENERGY STAR's sampling procedure. Therefore, the SNOPR proposes testing a minimum of 10 LED lamps to determine the input power, lumen output, efficacy, CCT, CRI, lifetime, and standby mode power. DOE also proposes that all LED lamps within the sample, including those that fail prematurely, be included in the reported results for input power, lumen output, efficacy, CCT, CRI, lifetime, and standby mode power. DOE's view is that LED lamp failure should not be exempt from reporting, because this would potentially mislead consumers, particularly with respect to lamp lifetime. Furthermore, DOE proposes

that no selection process be required for the LED lamp test procedure. Lamps for testing can be selected at any time from production units. DOE invites interested parties to comment on the appropriateness of adopting a minimum sample size of 10 LED lamps for input power, lumen output, efficacy, CCT, CRI, lifetime, and standby mode power.

3. Reported Value

As in the NOPR (77 FR at 21049), DOE proposes that the CCT of the units be averaged and that average be rounded as specified in section III.G. The average CCT is calculated using the following equation:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of units; and x_i is the i^{th} unit.

The LED lamp test data provided by ENERGY STAR as well as PG&E, CLASP, and CLTC (*see supra* note 20) indicates variability within a sample for measured lumen output, both at the initial lumen output reading and after an elapsed operating time. Therefore, DOE proposes that the reported value of lumen output as well as the reported value of lifetime be equal to the lower of the average lumen output of the sample set and the lower 99 percent confidence limit (LCL) of the sample mean divided by 0.97.[41] Additionally, the LED lamp test data indicates that variability in the CRI and efficacy should be expected within a sample. Therefore, DOE proposes that the reported value of CRI be equal to the lower of the average CRI of the sample set and the lower 99 percent confidence limit of the sample mean divided by 0.99, and that the reported value of efficacy be equal to the lower of the average efficacy of the sample set and the lower 99 percent confidence limit of the sample mean divided by 0.98.[42] DOE proposes the following equation to calculate LCL for lumen output, lifetime, CRI, and efficacy:

$$LCL = \bar{x} - t_{0.99}\left(\frac{s}{\sqrt{n}}\right)$$

where, $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.99}$ is the t statistic for a 99 percent one-tailed confidence interval with n − 1 degrees of freedom.

Similarly, the LED lamp test data provided by ENERGY STAR as well as PG&E, CLASP, and CLTC (*see supra* note 20) indicates variability within a sample for measured input power. Therefore, DOE proposes that the reported value of input power and standby mode power be equal to the greater of the average lumen output of the sample set and the upper 99 percent confidence limit (UCL) of the sample mean divided by 1.01.[43] DOE proposes the following equation to calculate UCL:

$$UCL = \bar{x} + t_{0.99}\left(\frac{s}{\sqrt{n}}\right)$$

where, $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.99}$ is the t statistic for a 99 percent one-tailed confidence interval with n − 1 degrees of freedom.

The proposed reported value requirements for lumen output, input power, CRI, lamp efficacy, lifetime, and standby mode power represent the ''best'' value that manufacturers may report. For lumen output, CRI, lamp efficacy, and lifetime, the reported value may be rounded to a lower value. For input power and standby mode power, the reported value may be rounded to higher values. CCT must be reported as calculated, as the concept of a conservative value does not apply to these metrics. If conservative rounding is used, manufacturers must report the conservatively rounded value to DOE so that values reported to DOE match those used in all representations.

DOE invites interested parties to comment on the proposed reported value requirements.

G. Rounding Requirements

In the SNOPR, DOE proposes rounding requirements for determining lumen output, input power, efficacy, CCT, CRI, estimated annual energy cost, lifetime, and standby mode power. Each of these is discussed in the following sections.

1. Lumen Output

In the NOPR, DOE proposed that the lumen output of all units be averaged and the value be rounded to the nearest tens digit. 77 FR at 21044 NEMA, OSI, and Cooper Lighting indicated that tight tolerances on rounding requirements are undesirable. (NEMA, No. 16 at p. 4; OSI, Public Meeting Transcript, No. 7 at pp. 55–56; Cooper, Public Meeting Transcript, No. 7 at p. 56) NEMA commented that this will only set up unrealistic expectations of accuracy and repeatability. (NEMA, No. 16 at p. 4) In their written comment, NEMA suggested that for lumen output DOE round values of 0–499 to the nearest five lumens, 500–999 to the nearest ten lumens, and 1000–9999 lumens to three significant digits. If the lumen output is greater than or equal to 10,000, NEMA recommended that DOE round to two significant digits. (NEMA, No. 16 at p. 4) ASAP offered another solution, suggesting that DOE determine appropriate rounding requirements based on the resolution of the test measurement. (ASAP, Public Meeting Transcript, No. 7 at p. 56)

DOE agrees that rounding requirements should reflect realistic expectations of accuracy and repeatability. Based on a review of commercially available LED lamp products as well as testing equipment measurement capabilities, DOE determined that three significant figures is an achievable level of accuracy for LED lamps. Therefore, for this SNOPR, DOE proposes rounding of three significant figures[44] so that lumen outputs of all sizes are provided a similar level of specificity.

2. Input Power

In the NOPR, DOE proposed that the input power of all test units be averaged and the average value be rounded to the nearest tenths digit. 77 FR at 21044 NEMA agreed that this is acceptable. (NEMA, No. 16 at p. 4) In the SNOPR, DOE maintains its proposal for the rounding requirements for input power.

[41] Based on the collected LED lamp test data, provided by ENERGY STAR as well as PG&E, CLASP, and CLTC, DOE expects that the variability for measured lumen output is within a margin of 3 percent. Thus, DOE proposes to divide the LCL value by 0.97 to adjust for this expected variation. For example, if the mean lumen output of 10 LED lamp units is 100 lumens with a standard deviation of three, the LCL value will be three percent lower than the mean, and dividing by 0.97 would result in a value that is equal to the lumen output mean of 100 lumens. In this case, the LCL divided by 0.97 is equal to the sample mean, and 100 lumens would be reported. If the variation within a sample set exceeds DOE's expectation, the sample set would have a smaller LCL, such that a value less than 100 lumens would be reported.

[42] Based on the collected LED lamp test data, provided by ENERGY STAR as well as PG&E, CLASP, and CLTC, DOE expects that variability for CRI is within a margin of 1 percent and for efficacy is within a margin of 2 percent. Thus, DOE proposes to divide the LCL value for CRI by 0.99 and the LCL value for efficacy by 0.98 to adjust for this expected variation.

[43] Based on the collected LED lamp test data, provided by ENERGY STAR as well as PG&E, CLASP, and CLTC, DOE expects that the variability for measured input power is within a margin of 1 percent. Thus, DOE proposes to divide the UCL value by 1.01 to adjust for this expected variation.

[44] If the number 3,563 is rounded to three significant digits it becomes 3,560—with the 3, 5, and 6 being the significant digits.

3. Lamp Efficacy

In the SNOPR, DOE proposes that the efficacy of LED lamps be rounded to the nearest tenth as this is consistent with rounding for other lighting technologies and is achievable with today's equipment.

4. Correlated Color Temperature

In the NOPR, DOE proposed that the CCT of all units be averaged and the value be rounded to the tens digit. 77 FR at 21044 However, NEMA argued that most consumers can only distinguish lamp color temperature variations on the order of 100 K. Therefore, NEMA suggested that any CCT rating be rounded to the nearest hundreds digit. They stated that DOE's proposal of rounding CCT values to the nearest tens digit would cause undue consumer confusion when comparing products. (NEMA, No. 16 at p. 4)

In rulemakings for other lamp types, DOE established CCT rounding requirements to the nearest tens place based on the precision of the test procedure. In a rulemaking for general service fluorescent lamps, DOE consulted with NIST and concluded that, because all laboratories are able to measure CCT to three significant figures (a typical value is four digits), DOE should require manufacturers to round CCT to the nearest ten kelvin. 74 FR 31829, 31835 (July 6, 2009). In this SNOPR, DOE continues this requirement and proposes rounding to the nearest tens digit for measurements of individual lamp units.

However, DOE also recognizes NEMA's comment that consumers may not be able to distinguish changes in CCT as small as 10 K. By using CCT values rounded to the nearest 10 K, consumers could be confused, since products with different CCT values may not have a perceptible difference in appearance. DOE does not have data or market studies quantifying the smallest difference in CCT that can be perceived by consumers, but welcomes comment on this topic. DOE has observed that the vast majority of CCT values provided in LED product literature are rounded to the nearest hundreds place. DOE proposes to round the reported value (i.e., certified or rated value) of the entire sample (all lamp units collectively) to the nearest hundreds place to avoid consumer confusion around any representations of CCT. DOE seeks comment on this proposal.

5. Color Rendering Index

In the SNOPR, DOE proposes that the CRI of LED lamps be rounded to the nearest whole number as this is consistent with rounding for other lighting technologies.

6. Annual Energy Cost

Consistent with FTC's final rule that established the Lighting Facts label (75 FR 41702 (July 19, 2010)), in the NOPR DOE proposed calculating the estimated annual energy cost for LED lamps, expressed in dollars per year, as the product of the average input power, in kilowatts, the electricity cost rate of 11 cents per kilowatt-hour, and the estimated average annual use at three hours per day, which is 1,095 hours per year. 77 FR at 21044 DOE proposed that the estimated annual energy cost be rounded to the nearest cent because the cost of electricity is specified to the nearest cent.

Although NEMA pointed out that the usage patterns and associated hours used in the NOPR do not agree with DOE's 2010 U.S. Lighting Market Characterization,[45] NEMA agreed with DOE's proposed formula to calculate annual energy cost and the associated rounding to the nearest cent. (NEMA, No. 16 at p. 4) For consistency with FTC's calculations for other lamp types, DOE proposes to maintain the rounding requirements for estimated annual energy cost.

7. Lifetime

In the SNOPR, DOE proposes that lifetime be rounded to the nearest whole hour. This is consistent with the unit of time used for lifetime metrics for other lamp technologies and is a level of accuracy a laboratory is capable of measuring with a standard time-keeping device.

8. Life

In the NOPR, DOE proposed that the life of LED lamps be calculated in terms of years based on three hours per day of operation. 77 FR at 21048 This is consistent with the FTC Lighting Facts label requirements for other lamp technologies. DOE also proposed that the resulting value be rounded to the nearest tenth of a year. Cooper Lighting recommended that DOE consider rounding to two significant digits rather than to tenths of a year to better capture the range in product lifetimes across the different lighting technologies. (Cooper, Public Meeting Transcript, No. 7 at p. 109) NEMA stated that tight rounding tolerances only set up unrealistic expectations for the performance of LED lamps and indicated that rounding the lifetime to the nearest tenth of a year can be confusing to customers if they do not realize that the lifetime values are based on three hours of use per day. (NEMA, No. 16 at p. 4, 8) Furthermore, both NEMA and the CA IOUs argued that lifetime be reported in hours, because year-ratings are confusing to consumers, who might assume a calendar lifetime rather than a lifetime based on hourly use. (NEMA, No. 16 at p. 8; CA IOUs, No. 19 at p. 4) DOE proposes to retain the rounding requirements provided in the NOPR which states that the life of LED lamps be calculated in terms of years based on three hours per day of operation and that the resulting value be rounded to the nearest tenth of a year. As stated previously, this is consistent with the FTC Lighting Facts label requirements for other lamp technologies. FTC determines how the prescribed metrics appear on its Lighting Facts label, as well as the overall format of the label. Interested parties may contact FTC for concerns regarding the Lighting Facts label.

9. Standby Mode Power

In the SNOPR, DOE proposes rounding standby mode power to the nearest tenths place, consistent with its proposal for rounding input power for active mode in section III.G.2.

H. Acceptable Methods for Initial Certification or Labeling

Because testing for lifetime could require six months or more from start to finish, DOE anticipates the potential need for initial certification requirements (such as those currently provided in 10 CFR 429.12(e)(2)) or early or interim labeling requirements. Any initial certification requirements, if adopted, would be established by the ongoing general service lamp energy conservation standard rulemaking. *See* 78 FR 73737 (Dec. 9, 2013) Early labeling requirements, if adopted, would be established by FTC. However, to support these potential needs, DOE considered acceptable methods for use with initial certification or labeling.

Test methods with shorter overall start to finish time requirements are not available for measuring or projecting lifetime. Therefore, initial certification and labeling is best substantiated by comparisons to similarly designed lamps produced by the same manufacturer. A future rulemaking addressing standards for LED lamps could require manufacturers to provide a description of why the comparison to another lamp is valid, including a description of the expected impact of design differences on lifetime (if any).

[45] Navigant Consulting, Inc., ''2010 U.S. Lighting Market Characterization'' Prepared for the DOE Solid-State Lighting Program, January, 2012. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.*

DOE requests comment on the notion of early certification and labeling, and the acceptable methods for substantiating those claims.

I. Laboratory Accreditation

In the NOPR, DOE did not require testing LED lamps by an accredited laboratory. DOE received several comments during the May 2012 public meeting as well as written comment submissions inquiring whether DOE plans to require using accredited laboratory facilities.

Cree commented that DOE should consider requiring certification of laboratories that are performing these tests as this is a requirement for the ENERGY STAR program. (Cree, Public Meeting Transcript, No. 7 at p. 57) OSI clarified that DOE should consider laboratory accreditation, and not a certification program. Accreditation is the process by which an authoritative third party gives formal recognition that a body or person is competent to carry out specific testing. Certification is a procedure by which a third party gives written assurance (certificate of conformity) that a product, process, or service conforms to specified requirements. (OSI, Public Meeting Transcript, No. 7 at pp. 60–61) NIST commented that laboratories are accredited for industry standards. If testing in accredited laboratories is required for the DOE's LED test procedure, this could confuse clients expecting industry standards to be followed without modification. (NIST, Public Meeting Transcript, No. 7 at p. 104) South Korea requested that in the final rule DOE detail its certification procedures, its requirements for testing laboratories, its designation process for testing laboratories, and future prospects concerning these matters. (South Korea, No. 17 at p. 4) Finally, Samsung suggested that DOE accept testing by existing laboratories that have received accreditation from the International Laboratory Accreditation Cooperation (ILAC). They argued that the ILAC promotes international acceptance of test results and inspection reports. (Samsung, No. 14 at p. 2)

Regarding the National Voluntary Laboratory Accreditation Program (NVLAP) accreditation, DOE proposes in the SNOPR to require lumen output, input power, lamp efficacy, CCT, CRI, lifetime, and standby mode power (if applicable) testing be conducted by test laboratories accredited by NVLAP or an accrediting organization recognized by ILAC. NVLAP is a member of the ILAC organization, so test data collected by any laboratory accredited by an accrediting body recognized by ILAC would be acceptable. DOE requests comment on its proposal to require accreditation by NVLAP or an entity recognized by ILAC, and on the costs and benefits associated with such a requirement.

The FTC has developed a Lighting Facts Label to help inform consumers about the efficiency and performance attributes of general service lamp products. The label became effective January 1, 2012, and requires that a lamp's lumen output, energy cost, lifetime, CCT and wattage appear on the product packaging. Concerns regarding the FTC Lighting Facts Label requirements were raised at the May 2012 NOPR public meeting and in several comment submissions. These comments pertained to the physical appearance and content displayed on the FTC Lighting Facts Label, the time it would take for FTC to certify LED lamp testing results, and whether using lumen maintenance as a proxy for lifetime could confuse or mislead consumers. The comments received are highlighted below:

- OSI commented that FTC needs to take into account that product information on small packages is often printed too small, making the information illegible and/or difficult to identify. (OSI, Public Meeting Transcript, No. 7 at p. 81)
- An Anonymous commenter asked for DOE to indicate how long it would take FTC to certify the results and grant permission to advertise the lifetime values required for the FTC Lighting Facts label. (Anonymous, No. 8 at p. 1)
- NEMA, Radcliffe Advisors, OSI, Cooper Lighting, NEEA, the Joint Comment, and the CA IOUs commented that the proposed definition of lifetime would not be directly comparable to other general service lamp products, which could mislead or confuse consumers. (NEMA, Public Meeting Transcript, No. 7 at pp. 76–77; NEMA, No. 16 at p. 2; Radcliffe Advisors, No. 13 at p. 1; OSI, Public Meeting Transcript, No. 7 at pp. 74–75; Cooper Lighting, Public Meeting Transcript, No. 7 at p. 77; NEEA, No. 20 at p. 2; Joint Comment, No. 18 at pp. 1–2; CA IOUs, No. 19 at p. 4) Cree, Radcliffe Advisors, and the CA IOUs recommend that for LED lamps, FTC consider changing its label to ''lumen maintenance'' rather than ''lifetime,'' or not provide a lifetime value at all. (Cree, Public Meeting Transcript, No. 7 at p. 66, 67; Radcliffe Advisors, No. 13 at p. 1; CA IOUs, No. 19 at p. 4, 5) OSI pointed out that the FTC Lighting Facts label provides the opportunity to educate consumers on the meaning of lumen maintenance and how this differs from metrics used to define lifetime for other lighting products. (OSI, Public Meeting Transcript, No. 7 at pp. 74–75)

DOE recognizes these concerns about the FTC Lighting Facts label. However, DOE does not have authority over how to display metrics on the FTC Lighting Facts label or the format of the label. Interested parties may contact FTC about these issues.

J. State Preemption for Efficiency Metrics

In the NOPR, DOE proposed test procedures for measuring lumen output and input power, and also specified testing dimmable lamps at full light output. 77 FR 21028 (April 9, 2012) Only those metrics required for the FTC Lighting Facts label were included in the NOPR test procedure. The FTC Lighting Facts label does not require reporting of metrics such as power factor, total harmonic distortion (THD), and dimming; therefore none were included in the NOPR test procedure for LED lamps. However, commenters noted that these metrics may appear in state mandates in the future, and therefore recommended they be included in DOE's test procedure for LED lamps in order to avoid state preemption.

The CA IOUs commented that DOE not preempt California from developing test procedures for other performance metrics such as efficacy, power factor, THD, and dimming. The CA IOUs commented that including in DOE's proposal test methods for power factor, THD, and dimming would likely require significant additional time and industry coordination. They asked that DOE specifically identify these metrics and procedures as exempt from preemption. (CA IOUs, No. 19 at p. 2, 3)

Representations about the energy consumption of an LED lamp must fairly disclose the results of testing in accordance with the DOE test procedure. *See* 42 U.S.C. 6293(c). The DOE test procedure for LED lamps will preempt any state regulation regarding the testing of the energy efficiency of LED lamps. *See* 42 U.S.C. 6297(a)(1). States that have regulations mandating efficiency standards for LED lamps must therefore use the DOE test procedure when providing for the disclosure of information with respect to any measure of LED lamp energy consumption. To support the general service lamp rulemaking, DOE proposes to define a calculation for the efficacy of an LED lamp as measured initial lamp lumen output in lumens divided by measured lamp input power in watts. See section III.C.4.d for details regarding the calculation for efficacy of an LED lamp.

K. Effective and Compliance Date

If adopted, the effective date for this test procedure would be 30 days after publication of the test procedure final rule in the **Federal Register**. Pursuant to EPCA, manufacturers of covered products must use the applicable test procedure as the basis for determining that their products comply with the applicable energy conservation standards adopted pursuant to EPCA and for making representations about the efficiency of those products. (42 U.S.C. 6293(c); 42 U.S.C. 6295(s)) For those energy efficiency or consumption metrics covered by the DOE test procedures, manufacturers must make representations in accordance with the DOE test procedure methodology and sampling plan beginning 180 days after publication of the final rule in the **Federal Register**.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget (OMB) has determined that test procedure rulemakings do not constitute ''significant regulatory actions'' under section 3(f) of Executive Order 12866, Regulatory Planning and Review, 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget.

B. Review under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site: *http://energy.gov/gc/office-general-counsel*.

DOE reviewed the test procedures considered in this SNOPR under the provisions of the Regulatory Flexibility Act (RFA) and the policies and procedures published on February 19, 2003. As discussed in more detail below, DOE found that because the proposed test procedures have not previously been required of manufacturers, all manufacturers, including small manufacturers, may potentially experience a financial burden associated with this new testing requirement. While examining this issue, DOE determined that it could not certify that the proposed rule, if promulgated, would not have a significant impact on a substantial number of small entities. Therefore, DOE has prepared an IRFA for this rulemaking. The IRFA describes the potential impacts on small businesses associated with LED lamp testing and labeling requirements. DOE has transmitted a copy of this IRFA to the Chief Counsel for Advocacy of the Small Business Administration (SBA) for review.

1. Estimated Small Business Burden

SBA has set a size threshold for electric lamp manufacturers to describe those entities that are classified as ''small businesses'' for the purposes of the RFA. DOE used the SBA's small business size standards to determine whether any small manufacturers of LED lamps would be subject to the requirements of the rule. 65 FR 30836, 30849 (May 15, 2000), as amended at 65 FR 53533, 53545 (Sept. 5, 2000) and codified at 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *www.sba.gov/sites/default/files/Size_Standards_Table.pdf.* LED lamp manufacturing is classified under NAICS 335110, ''Electric Lamp Bulb and Part Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

In the NOPR, DOE identified 17 potential small businesses that manufacture LED lamps. In total, DOE estimated that the use of the NOPR test method for determining light output, input power, and CCT would result in testing-related labor costs of $57,000 for each of the identified small businesses. In addition, DOE estimated that the test method described in the NOPR for determining lifetime would result in related labor costs of $11,000 for each manufacturer. Finally, in the NOPR, DOE estimated initial setup costs of $12,000. DOE also indicated that the setup cost would be a one-time cost to manufacturers and that the labor costs to perform testing would be smaller than $68,000 after the first year of testing. 77 FR at 21050–1 (April 9, 2012)

OSI indicated that they believe the number of impacted small businesses is greater than DOE's estimate of 17 and speculated that the actual number could be between two and ten times greater. (OSI, Public Meeting Transcript, No. 7 at pp. 117–118) NEMA suggested that DOE contact Jim Brodrick, Program Manager of the U.S. DOE SSL program, to help determine a better estimate for the total number of small businesses that will likely be affected by implementing this test procedure. (NEMA, Public Meeting Transcript, No. 7 at p. 119)

For this SNOPR, DOE reexamined the number of small businesses that will potentially be affected by the LED lamps test procedure. This reevaluation indicated that the test procedure requirements proposed in this SNOPR will apply to about 41 small business manufacturers of LED lamps. DOE compiled this revised list of manufacturers by reviewing the DOE LED Lighting Facts label list of partner manufacturers,[46] the SBA database, ENERGY STAR's list of qualified products,[47] and performing a general search for LED manufacturers. DOE determined which companies manufacture LED lamps by reviewing company Web sites, the SBA Web site when applicable, calling companies directly, and/or reviewing the Hoovers Inc. company profile database. Through this revised process, DOE identified 41 small businesses that manufacture LED lamps. DOE was also able to collect annual revenue estimates for several of the small business LED lamp manufacturers using the Hoovers.com company profile database. DOE determined that the median revenue of the identified small business manufacturers is $890,000.[48] DOE requests comment on the estimated number of small businesses that would be impacted by the proposed rulemaking.

DOE also received several comments about the estimate of testing burden. GE, Feit, and OSI expressed concern that DOE was underestimating the cost burden to small manufacturers because the costs associated with NOPR Approach 4 for lifetime testing would be significant if IES LM–80–2008 data were unavailable. (GE, Public Meeting Transcript, No. 7 at p. 117; Feit, Public Meeting Transcript, No. 7 at p. 120; OSI,

[46] DOE LED Lighting Facts Partner List, *http://www.lightingfacts.com/Partners/Manufacturer.*

[47] ENERGY STAR Qualified Lamps Product List, *http://downloads.energystar.gov/bi/qplist/Lamps_Qualified_Product_List.xls?dee3-e997.*

[48] According to Hoovers.com, there are some small business LED lamp manufacturers with revenue as little as $120,000 per year.

Public Meeting Transcript, No. 7 at p. 117) ICF International commented that DOE's estimate for the cost of initial setup was low. ICF International estimated that if a manufacturer were to purchase all required testing equipment, train personnel to operate it, and then go through the accreditation process, it could cost more than $100,000. (ICF International, Public Meeting Transcript, No. 7 at p. 119, 120) Cree and Intertek also commented that instrumentation costs could be significant, pointing out that a Type C goniophotometer could cost as much as $200,000 and that a two meter integrating sphere with accessories could cost about $60,000. (Cree, Public Meeting Transcript, No. 7 at p. 120; Intertek, Public Meeting Transcript, No. 7 at pp. 121–122) In addition to instrumentation costs, an anonymous commenter also indicated that the cost of storing inventory during lifetime testing would be significant and should be included in the cost burden estimate. (Anonymous, No. 8 at p. 1) When estimating the burden to small manufacturers, NEMA suggested that DOE also include FICA taxes, unemployment taxes, workman's compensation, health care insurance, holiday and vacation time, and retirement benefits in addition to the office, laboratory, equipment, and other overhead costs for the engineers and their support staff. (NEMA, No. 16 at p. 8) Finally, GE commented that it would be unlikely that small business manufacturers would want to set up an accredited laboratory for testing. They speculated that small manufacturers would likely send their LED lamps out for third party testing. (GE, Public Meeting Transcript, No. 7 at p. 115)

In the NOPR, DOE determined that the labor rate to create the initial setup and conduct the testing for input power, lumen output, CCT, and lifetime of LED lamps would be $39.79 per hour.[49] 77 FR at 21050 However, in its analysis for the SNOPR, DOE determined that an electrical engineer is likely over qualified, and would not be hired by manufacturers to conduct these required tasks. DOE's view is that an electrical engineering technician is a better representation of the personnel likely to perform the initial setup and required tests for LED lamps. DOE estimated that the wages for an electrical engineering technician are $24.18 per hour.[49] This cost is only representative of the hourly billing rate for an electrical engineering technician and does not include any other compensation costs. DOE estimated that providing additional benefits[50] would add 31 percent[51] to the overall cost to the manufacturer, increasing the cost of employing an electrical engineering technician to $31.68 per hour. For the SNOPR, DOE also applied this labor rate to measurement of standby mode power.

DOE estimates that the labor costs associated with conducting the input power, lumen output, CCT, CRI, and standby mode power testing contribute to overall burden. However, DOE believes that calculating the efficacy of an LED lamp does not result in any incremental testing burden beyond the cost of carrying out lumen output and input power testing. DOE estimates that testing for input power, lumen output, CCT, CRI, and standby mode would require approximately four hours per lamp by an electrical engineering technician. DOE expects standby mode power testing to require a negligible incremental amount of time in addition to the time required for the other metrics. Therefore, DOE maintained its estimate of four hours per lamp used in the NOPR (77 FR at 21050) for testing for input power, lumen output, CCT, and CRI. DOE estimates about 41 small business manufacturers of LEDs would be impacted, each offering about 23 different basic models. In total, using the DOE test method to determine light output, input power, CCT, CRI, and standby mode power would result in an estimated incremental labor burden of $29,140 for each manufacturer. DOE expects that the majority of manufacturers are already testing for lumen output, input power, CCT, and CRI as these metrics are well established and required within the industry standard IES LM–79–2008. However, DOE's sample size, input power, and orientation settings may differ from those selected for a manufacturer's existing data. Therefore, DOE included the cost of carrying out these tests in its assessment of testing burden.

In addition, DOE estimates that lifetime testing would also contribute to overall cost burden. The initial setup would require a custom-built rack to mount up to 120 lamps for testing, which may require up to 120 hours of labor to build. The cost for an electrical engineering technician to build such a rack would be approximately $3,800. Similar to the NOPR analysis, DOE estimated that the material cost to build a custom-built rack holding 120 sockets would be $3,600, and the power supply and regulator costs would be $4,000 and $1,500 respectively. Therefore, the revised SNOPR estimate for the total cost to build one rack is approximately $12,900. DOE estimated that a total of two racks would be needed to hold about 23 different LED lamp models, each tested in sample sets of 10 lamps (a total of 230 LED lamps). Therefore, DOE estimates the total cost to build two test racks to be $25,800. However, DOE notes that LED lamp manufacturers may already have sufficient testing racks for their own internal uses and for FTC labeling requirement testing. DOE expects that manufacturers of LED lamps would already have other instrumentation necessary for testing because IES LM–79–2008 is the recommended standard for testing LED lamps for the FTC Lighting Facts label. The labor cost for lifetime testing also contributes to overall burden. DOE estimates that the combination of monitoring the lamps during the test duration, measuring lumen maintenance, and calculating lifetime at the end of the test duration would require approximately four hours per lamp by an electrical engineering technician. This estimate does not include the initial lumen output measurement required for the lifetime test procedure, because the testing burden for that measurement is already included in the estimate for input power, lumen output, CCT, and CRI testing. DOE estimates about 41 small business manufacturers of LEDs, each offering about 23 different basic models, would be affected. In total, DOE expects that using this test method to determine lifetime would result in testing-related labor costs of $29,140 for each manufacturer.

As discussed in section III.I, DOE is also proposing to require test facilities conducting LED lamp light output, input power, CCT, CRI, lifetime, and standby mode power (if applicable) testing to be NVLAP-accredited or accredited by an organization recognized by NVLAP. However, NVLAP imposes a variety of fees during the accreditation process including fixed administrative fees, variable assessment fees, and proficiency testing fees. If a laboratory already has NVLAP accreditation for other industry standards, there would be no

[49] Obtained from the Bureau of Labor Statistics (National Compensation Survey: Occupational Earnings in the United States 2008, U.S. Department of Labor (August 2009), Bulletin 2720, Table 3 (''Full-time civilian workers,'' mean and median hourly wages) *http://bls.gov/ncs/ocs/sp/nctb0717.pdf.*

[50] Additional benefits include; paid leave, supplemental pay, insurance, retirement and savings, Social Security, Medicare, unemployment insurance and workers compensation.

[51] Obtained from the Bureau of Labor Statistics (News Release: Employer Cost For Employee Compensation—December 2012, U.S. Department of Labor (December 2012), *www.bls.gov/news.release/ecec.nr0.htm.*

incremental administrative fees associated with the SNOPR proposal. However, if a laboratory does not already have NVLAP accreditation for other industry standards, there would be an administrative fee of $5,050 assessed annually. NVLAP also collects an assessment fee corresponding to the amount of time the assessor requires to complete evaluation of the laboratory. A laboratory seeking to expand its scope of accreditation to include IES LM–79–2008 as well as DOE's lifetime test procedure for LED lamps would most likely not experience an increase in cost. However, a laboratory with no existing NVLAP accreditations would likely require two full days of an assessor's time at the cost of $7,470 per assessment. Assessments are required during the initial accreditation, on the first anniversary (year 1), and then every other year following the first anniversary (year 3, 5, 7, etc.). Finally, every laboratory seeking accreditation to IES LM–79–2008 is required to participate in SSL proficiency testing. A $2,800 fee is involved with this proficiency testing.

For each manufacturer producing 23 basic models, assuming testing instrumentation is already available, DOE's estimate of the first year NVLAP accreditation cost would be $15,320, initial setup cost would be $25,800, and the labor costs to carry out testing would be approximately $58,280. Therefore, in the first year, for manufacturers without testing racks or NVLAP accreditation who choose to test in-house, DOE estimates a total cost burden of $99,400 or about $432 per LED lamp tested. DOE expects the setup cost to be a onetime cost to manufacturers. Further, DOE expects that the labor costs to perform testing would be smaller than $58,280 after the first year because only new products or redesigned products would need to be tested. Alternatively, if a manufacturer opts to send lamps to a third-party test facility, DOE estimates testing of lumen output, input power, CCT, CRI, lifetime, and standby mode power to cost $500 per lamp. In total, the LED lamp test procedure would result in expected third party testing costs of $115,000 for each manufacturer of 23 basic models.

DOE was able to collect annual revenue estimates for several of the small business LED lamp manufacturers using the Hoovers.com company profile database. DOE determined that the median revenue of the identified small business manufacturers is $890,000, therefore, initial testing costs would represent about 11.2 percent of revenue when completed in a manufacturer's own laboratory, and 12.9 percent when completed through a third-party test facility. As mentioned earlier, the setup cost would be a one-time cost to manufacturers, and the labor costs to perform testing would be smaller after the first year of testing. Furthermore, when amortized over subsequent years, testing costs would be significantly less. DOE requests comments on its analysis of initial setup and labor costs as well as the average annual burden for conducting testing of LED lamps.

2. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the proposed rule being considered today.

3. Significant Alternatives to the Proposed Rule

DOE tentatively determined that there are no alternatives to the proposed test procedure, including test procedures that incorporate industry test standards other than the proposed standards. IES LM–79–2008, the test procedure referenced in this SNOPR, is the most commonly used industry standard that provides instructions for the electrical and photometric measurement of LED lamps. DOE also reviewed the efforts of other working groups, as suggested by interested parties, but was unable to find any U.S. or international standard that provides a test procedure for measuring and/or projecting LED lamp lifetime. The only publicly available approach for measuring LED lamp lifetime is the ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0 (*see supra* note 10).

C. Review Under the Paperwork Reduction Act of 1995

DOE established regulations for the certification and recordkeeping requirements for certain covered consumer products and commercial equipment. 76 FR 12422 (March 7, 2011). The collection-of-information requirement for the certification and recordkeeping was subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement was approved by OMB under OMB Control Number 1910–1400. Public reporting burden for the certification was estimated to average 20 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

There is currently no information collection requirement related to certifying compliance for LED lamps. Notwithstanding any other provision of the law, no person is required to respond to, nor must any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

In this proposed rule, DOE is proposing a test procedure for LED lamps that will be used to support the upcoming general service lamps energy conservation standard rulemaking as well as FTC's Lighting Facts labeling program. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this proposed rule would adopt existing industry test procedures for LED lamps, so it would not affect the amount, quality or distribution of energy usage, and, therefore, would not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A5 under 10 CFR part 1021, subpart D. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 4, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various

levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, the proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *http://energy.gov/gc/office-general-counsel*. DOE examined this proposed rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights'' 53 FR 8859 (March 18, 1988), that this regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any proposed significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This proposed regulatory action to establish a test procedure for measuring the lumen output, input power, efficacy, CCT, CRI, lifetime, and standby mode power of LED lamps is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the

Attorney General and the Chairman of the FTC concerning the impact of the commercial or industry standards on competition.

The proposed rule incorporates test methods contained in the following commercial standards: ANSI/IESNA RP–16–2010 ''Nomenclature and Definitions for Illuminating Engineering'' and IES LM–79–2008 ''Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.'' The Department has evaluated these standards and is unable to conclude whether they fully comply with the requirements of section 32(b) of the FEAA, (*i.e.,* that they were developed in a manner that fully provides for public participation, comment, and review). DOE will consult with the Attorney General and the Chairman of the FTC concerning the impact of these test procedures on competition prior to prescribing a final rule.

V. Public Participation

A. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments using any of the methods described in the **ADDRESSES** section at the beginning of this notice.

Submitting comments via regulations.gov. The regulations.gov Web page will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to regulations.gov information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through regulations.gov cannot be claimed as CBI. Comments received through the Web site will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through regulations.gov before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that regulations.gov provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery, or mail. Comments and documents submitted via email, hand delivery, or mail also will be posted to regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information on a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery, please provide all items on a CD, if feasible. It is not necessary to submit printed copies. No facsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are written in English, free of any defects or viruses, and not secured. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery two well-marked copies: one copy of the document marked confidential including all the information believed to be confidential, and one copy of the document marked non-confidential with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

B. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on its characterization of the modes of operation (active, standby, and off modes) that apply to LED lamps.

2. DOE requests comment on the proposal for an equal number of lamps to be operated in the base-up and base-down orientations during lumen output, input power, CCT, CRI, lifetime, and standby mode testing.

3. DOE invites interested parties to comment on the proposal to require all photometric values, including lumen output, CCT, and CRI, be measured by an integrating sphere (via photometer or spectroradiometer) and that goniometer systems must not be used.

4. DOE invites interested parties to comment on the proposal to remain consistent with section 4.0 of IES LM–79–2008, which indicates no seasoning is required for LED lamps before beginning photometric measurements.

5. DOE requests comments on the test conditions when lamps are operating but no measurements are being taken. Specifically, DOE requests comment on requiring ambient temperature to be controlled between 15 °C and 40 °C; the minimization of vibration, shock, and air movement, as well as the requirement for adequate lamp spacing; the proposal to adopt the section 3.1 of IES LM–79–2008 requirements for both AC and DC power supplies; and the requirement that input voltage be monitored and regulated to within ±2.0 percent of the rated RMS voltage as specified in section 5.3 of IES LM–65–2010.

6. DOE requests comment on the proposed test method for CRI.

7. DOE requests comment on the proposed calculation for lamp efficacy.

8. For lifetime testing, DOE proposes to continuously operate the LED lamp and requests feedback on the appropriateness of not requiring an operating cycle during lumen maintenance testing.

9. DOE requests comment on the proposed equation to project the L_{70} lifetime of LED lamps.

10. DOE requests comment on the revision to the definition of ''basic model'' to address LED lamps.

11. DOE requests comment on the appropriateness of adopting a minimum sample size of 10 LED lamps for input power, lumen output, CCT, CRI, lifetime, and standby mode.

12. DOE requests comment on the proposal to allow measurements collected for the ENERGY STAR Program Requirements for Lamps (Light Bulbs): Eligibility Criteria—Version 1.0 to be used for calculating reported values of lumen output, input power, lamp efficacy, CCT, CRI, and lifetime.

13. DOE requests comment on the proposal to round CCT values for individual units to the tens place; and the proposal to round the certified CCT values for the sample to the hundreds place.

14. DOE requests comment on its proposal to require accreditation by NVLAP or an entity recognized by ILAC, and on the costs and benefits associated with laboratory accreditation.

15. DOE requests comment on the estimated number of entities that would be affected by the proposed rulemaking and the number of these companies that are ''small businesses.''

16. DOE requests comments on its analysis of initial setup and labor costs as well as the average annual burden for conducting testing of LED lamps.

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this proposed rule.

List of Subjects

10 CFR Part 429

Confidential business information, Energy conservation, Household appliances, Imports, Reporting and recordkeeping requirements.

10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on May 16, 2014.

Kathleen B. Hogan,

Deputy Assistant Secretary for Energy Efficiency, Energy Efficiency and Renewable Energy.

For the reasons stated in the preamble, DOE is proposing to amend parts 429 and 430 of Chapter II of Title 10, Subchapter D of the Code of Federal Regulations to read as set forth below:

PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

§ 429.12 [Amended]

■ 2. Section 429.12(b)(13) is amended by removing ''429.54'' and adding ''429.69'' in its place.

■ 3. Section 429.56 is added to read as follows:

§ 429.56 Integrated light-emitting diode lamps.

(a) *Determination of Represented Value.* (1) Manufacturers must determine the represented value, which includes the certified rating, for each basic model of integrated light-emitting diode lamps by testing, in conjunction with the following sampling provisions:

(i) *Units to be tested.* (A) The general requirements of § 429.11(a) are applicable except that the sample must be comprised of production units; and

(B) For each basic model of integrated light-emitting diode lamp, the minimum number of units tested shall be no less than 10 and the same units must be used for testing all metrics. If more than 10 units are tested as part of the sample, the total number of units must be a multiple of two. For each basic model, a sample of sufficient size shall be randomly selected and tested to ensure that:

(*1*) Represented values of initial lumen output, lifetime, lamp efficacy, and color rendering index (CRI) of a basic model for which consumers would favor higher values must be less than or equal to the lower of:

(*i*) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of units; and x_i is the i^{th} unit;

Or,

(*ii*) The lower 99 percent confidence limit (LCL) of the true mean divided by 0.97 for initial lumen output, life, and lifetime; the lower 99 percent confidence limit (LCL) of the true mean divided by 0.98 for lamp efficacy; and the lower 99 percent confidence limit (LCL) of the true mean divided by 0.99 for CRI, where:

$$LCL = \bar{x} - t_{0.99}\left(\frac{s}{\sqrt{n}}\right)$$

and, $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.99}$ is the t statistic for a 99 percent one-tailed confidence interval with n −1 degrees of freedom (from Appendix A of this part).

(*2*) Represented values of input power and standby mode power of a basic model for which consumers would favor lower values must be greater than or equal to the higher of:

(*i*) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of units; and x_i is the i^{th} unit;

Or,

(*ii*) The upper 99 percent confidence limit (UCL) of the true mean divided by 1.01, where:

$$UCL = \bar{x} + t_{0.99}\left(\frac{s}{\sqrt{n}}\right)$$

and, $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.99}$ is the t statistic for a 99 percent one-tailed confidence interval with n − 1 degrees

of freedom (from Appendix A of this part);

(*3*) Represented values of correlated color temperature (CCT) of a basic model must be equal to the mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and, $\bar{x}$ is the sample mean; n is the number of units; and x_i is the i^{th} unit.

(ii) [Reserved]

(2) [Reserved]

(b) [Reserved]

(c) *Rounding requirements for representative values, including certified and rated values, of lumen output, input power, efficacy, CCT, CRI, lifetime, standby mode power, and estimated annual energy cost.* (1) The represented value of input power must be rounded to the nearest tenth of a watt.

(2) The represented value of lumen output must be rounded to three significant digits.

(3) The represented value of lamp efficacy must be rounded to the nearest tenths place.

(4) The represented value of correlated color temperature must be rounded to the nearest 100 Kelvin.

(5) The represented value of color rendering index must be rounded to the nearest whole number.

(6) The represented value of lifetime must be rounded to the nearest whole hour.

(7) The represented value of standby mode power must be rounded to the nearest tenth of a watt.

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

■ 4. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 5. Section 430.2 is amended by revising the definition of ''Basic model'' and adding in alphabetical order the definition of ''Integrated light-emitting diode lamp'' to read as follows:

§ 430.2 Definitions.

* * * * *

Basic model means all units of a given type of covered product (or class thereof) manufactured by one manufacturer, having the same primary energy source, and which have essentially identical electrical, physical, and functional (or hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency; and

(1) With respect to general service fluorescent lamps, general service incandescent lamps, and incandescent reflector lamps: Lamps that have essentially identical light output and electrical characteristics—including lumens per watt (lm/W) and color rendering index (CRI).

(2) With respect to integrated light-emitting diode lamps: Lamps that have essentially identical light output and electrical characteristics—including lumens per watt (lm/W), color rendering index (CRI), correlated color temperature (CCT), and lifetime.

(3) With respect to faucets and showerheads: Have the identical flow control mechanism attached to or installed within the fixture fittings, or the identical water-passage design features that use the same path of water in the highest flow mode.

(4) With respect to furnace fans: Are marketed and/or designed to be installed in the same type of installation.

* * * * *

Integrated light-emitting diode lamp means an integrated LED lamp as defined in ANSI/IESNA RP–16 (incorporated by reference; see § 430.3).

* * * * *

■ 6. Section 430.3 is amended by:

■ a. Adding paragraphs (n)(8) and (n)(9); and

■ b. Removing ''and X'' in paragraph (o)(4) and adding in its place, ''X and BB'' .

The additions read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(n) *IESNA.* * * *

(8) ANSI/IESNA RP–16–2010, Nomenclature and Definitions for Illuminating Engineering, approved October 15, 2005; IBR approved for § 430.2.

(9) IES LM–79–2008 (''IES LM–79''), Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products, approved December 31, 2007; IBR approved for Appendix BB to subpart B of this part.

* * * * *

■ 7. Section 430.23 is amended by adding paragraph (dd) to read as follows:

§ 430.23 Test procedures for the measurement of energy and water consumption.

* * * * *

(dd) *Integrated light-emitting diode lamp.* (1) The input power of an integrated light-emitting diode lamp must be measured in accordance with section 3 of Appendix BB of this subpart. Individual unit input power must be rounded to the nearest tenth of a watt.

(2) The lumen output of an integrated light-emitting diode lamp must be measured in accordance with section 3 of Appendix BB of this subpart. Individual unit lumen output must be rounded to three significant digits.

(3) The lamp efficacy of an integrated light-emitting diode lamp must be calculated in accordance with section 3 of Appendix BB of this subpart. Individual unit lamp efficacy must be rounded to the nearest tenths place.

(4) The correlated color temperature of an integrated light-emitting diode lamp must be measured in accordance with section 3 of Appendix BB of this subpart. Individual unit correlated color temperature must be rounded to the nearest 10 Kelvin.

(5) The color rendering index of an integrated light-emitting diode lamp must be measured in accordance with section 3 of Appendix BB of this subpart. Individual unit color rendering index must be rounded to the nearest whole number.

(6) The lifetime of an integrated light-emitting diode lamp must be measured in accordance with section 5 of Appendix BB of this subpart. Individual unit lifetime must be rounded to the nearest hour.

(7) The life of an integrated light-emitting diode lamp must be calculated by dividing the represented rated lifetime (see 10 CFR 429.56) by the estimated annual operating hours as specified in 16 CFR 305.15(b)(3)(iii). The life must be rounded to the nearest tenth of a year.

(8) The estimated annual energy cost for an integrated light-emitting diode lamp, expressed in dollars per year, must be the product of the average input power in kilowatts as determined in accordance with Appendix BB to this subpart, an electricity cost rate as specified in 16 CFR 305.15(b)(1)(ii), and an estimated average annual use as specified in 16 CFR 305.15(b)(1)(ii). The resulting estimated annual energy cost for an individual unit must be rounded to the nearest cent per year.

(9) The standby mode power must be measured in accordance with section 5 of Appendix BB of this subpart. Individual unit standby mode power must be rounded to the nearest tenth of a watt.

■ 8. Section 430.25 is revised to read as follows:

§ 430.25 Laboratory Accreditation Program.

(a) Testing for general service fluorescent lamps, general service

incandescent lamps, and incandescent reflector lamps must be performed in accordance with Appendix R to this subpart. Testing for medium base compact fluorescent lamps must be performed in accordance with Appendix W to this subpart. Testing for fluorescent lamp ballasts must be performed in accordance with Appendix Q1 to this subpart. This testing, with the exception of lifetime testing of general service incandescent lamps, must be conducted by test laboratories accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) or an accrediting organization recognized by International Laboratory Accreditation Cooperation (ILAC). NVLAP is a program of the National Institute of Standards and Technology, U.S. Department of Commerce. NVLAP standards for accreditation of laboratories that test are set forth in 15 CFR part 285. The following metrics should be measured by test laboratories accredited by NVLAP or an accrediting organization recognized by International Laboratory Accreditation Cooperation (ILAC):

(1) Fluorescent lamp ballasts: ballast luminous efficiency (BLE);

(2) General service fluorescent lamps: lamp efficacy, color rendering index;

(3) General service incandescent reflector lamps: lamp efficacy;

(4) General service incandescent lamps: lamp efficacy; and

(5) Medium base compact fluorescent lamps: initial efficacy, lamp life. Testing for BLE may also be conducted by laboratories accredited by Underwriters Laboratories or Council of Canada. Testing for fluorescent lamp ballasts performed in accordance with Appendix Q to this subpart is not required to be conducted by test laboratories accredited by NVLAP or an accrediting organization recognized by NVLAP.

(b) Testing of integrated light-emitting diode lamps must be performed in accordance with Appendix BB of this subpart. Testing must be conducted in test laboratories accredited by NVLAP or an accrediting organization recognized by International Laboratory Accreditation Cooperation (ILAC) for the following metrics: input power, lumen output, lamp efficacy, correlated color temperature, color rendering index, lifetime, and standby mode power. A manufacturer's own laboratory, if accredited, may conduct the testing.

■ 9. Appendix BB to subpart B of part 430 is added to read as follows:

Appendix BB to Subpart B of Part 430—Uniform Test Method for Measuring the Input Power, Lumen Output, Lamp Efficacy, Correlated Color Temperature (CCT), Color Rendering Index (CRI), Lifetime, and Standby Mode Power of Integrated Light-Emitting Diode (LED) Lamps

Note: After [DATE 180 DAYS AFTER PUBLICATION OF FINAL RULE IN THE **Federal Register**], any representations made with respect to the energy use or efficiency of light-emitting diode lamps must be made in accordance with the results of testing pursuant to this appendix. Given that after [DATE 180 DAYS AFTER PUBLICATION OF FINAL RULE IN THE **Federal Register**] representations with respect to the energy use or efficiency of light-emitting diode lamps must be made in accordance with tests conducted pursuant to this appendix, manufacturers may wish to begin using this test procedure as soon as possible.

1. *Scope:* This appendix specifies how to measure input power, lumen output, lamp efficacy, CCT, CRI, lifetime, and standby mode power for integrated LED lamps.

2. Definitions

2.1. The definitions specified in section 1.3 of IES LM–79 except section 1.3(f) (incorporated by reference; see § 430.3) apply.

2.2. *Initial lumen output* means the measured lumen output after the lamp is initially energized and stabilized using the stabilization procedures in section 3 of Appendix BB of this subpart.

2.3. *Rated input voltage* means the voltage(s) marked on the lamp as the intended operating voltage. If not marked on the lamp, assume 120 V.

2.4. *Lamp efficacy* means the ratio of measured initial lumen output in lumens to the measured lamp input power in watts, in units of lumens per watt.

2.5. *CRI* means color rendering index as defined in § 430.2.

2.6. *Test duration* means the operating time of the LED lamp after the initial lumen output measurement and before, during, and including the final lumen output measurement.

2.7. *Lifetime* means the time at which the lumen output is equal to 70 percent of the initial lumen output measured using section 4 of Appendix BB of this subpart.

3. Active Mode Test Method for Determining Lumen Output, Input Power, CCT, CRI, and Lamp Efficacy

In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over IES LM–79 (incorporated by reference; see § 430.3).

3.1. Test Conditions and Setup

3.1.1. The ambient conditions, power supply, electrical settings, and instrumentation must be established in accordance with the specifications in sections 2.0, 3.0, 7.0, and 8.0 of IES LM–79 (incorporated by reference; see § 430.3), respectively.

3.1.2. An equal number of integrated LED lamps must be positioned in the base up and base down orientations throughout testing.

3.1.3. The integrated LED lamp must be operated at the rated voltage throughout testing. For an integrated LED lamp with multiple rated voltages including 120 volts, the integrated LED lamp must be operated at 120 volts. If an integrated LED lamp with multiple rated voltages is not rated for 120 volts, the integrated LED lamp must be operated at the highest rated input voltage. Additional tests may be conducted at other rated voltages.

3.1.4. The integrated LED lamp must be operated at maximum input power. If multiple modes occur at the same maximum input power (such as variable CCT or CRI), the manufacturer can select any of these modes for testing; however, all measurements described in section 3 and section 4 must be taken at the same selected mode.

3.2. Test Method, Measurements, and Calculations

3.2.1. The integrated LED lamp must be stabilized prior to measurement as specified in section 5.0 of IES LM–79 (incorporated by reference; see § 430.3). The stabilization variation is calculated as [maximum − minimum)/minimum] of at least three readings of the input power and lumen output over a period of 30 minutes, taken 15 minutes apart.

3.2.2. The input power in watts must be measured as specified in section 8.0 of IES LM–79 (incorporated by reference; see § 430.3).

3.2.3. Lumen output must be measured as specified in section 9.1 and 9.2 of IES LM–79 (incorporated by reference; see § 430.3). Goniometers must not be used.

3.2.4. CCT must be determined according to the method specified in section 12.0 of IES LM–79 (incorporated by reference; see § 430.3) with the exclusion of section 12.2 of IES LM–79. Goniometers must not be used.

3.2.5. CRI must be determined according to the method specified in section 12.0 of IES LM–79 (incorporated by reference; see § 430.3) with the exclusion of section 12.2 of IES LM–79. Goniometers must not be used.

3.2.6. Lamp efficacy must be determined by dividing measured initial lumen output by the measured input power.

4. Active Mode Test Method for Lifetime

In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over IES LM–79 (incorporated by reference; see § 430.3).

4.1. Measure Initial Lumen Output. Measure the Initial Lumen Output According to Section 3 of This Appendix

4.2. *Test Duration.* Operate the integrated LED lamp for a period of time (the test duration) after the initial lumen output measurement and before, during, and including the final lumen output measurement.

4.2.1. There is no minimum test duration requirement for the integrated LED lamp. The test duration is selected by the manufacturer. See section 4.5.3 for instruction on the maximum lifetime.

4.2.2. The test duration only includes time when the integrated LED lamp is energized and operating.

4.2.3. Operating conditions and setup during the test duration other than time during which lumen output measurements are being conducted are specified in section 4.3 of this appendix.

4.3. Operating Conditions and Setup Between Lumen Output Measurements

4.3.1. Ambient temperature must be controlled between 15 °C and 40 °C.

4.3.2. The integrated LED lamps must be spaced to allow airflow around each lamp.

4.3.3. The integrated LED lamps must not be subjected to excessive vibration or shock during lamp operation.

4.3.4. Line voltage waveshape must be as described in section 3.1 of IES LM–79 (incorporated by reference; see § 430.3).

4.3.5. Input voltage must be monitored and regulated to within ±2 percent of the voltage required in section 3.1.3 for the duration of the test.

4.3.6. Electrical settings must be as described in section 7.0 IES LM–79 (incorporated by reference; see § 430.3).

4.3.7. An equal number of integrated LED lamps must be positioned in the base up and base down orientations throughout testing.

4.3.8. The integrated LED lamp must be operated at maximum input power. If multiple modes occur at the same maximum input power (such as variable CCT and CRI), the manufacturer can select any of these modes for testing. Measurements of all quantities described in sections 3 and 4 of this appendix must be taken at the same selected mode.

4.4. Measure Final Lumen Output. Measure the lumen output at the end of the test duration according to section 3.

4.5.Calculate Lumen Maintenance and Lifetime

4.5.1. Calculate the lumen maintenance of the lamp after the test duration ''t'' by dividing the final lumen output ''x_t'' by the initial lumen output ''x_0''. Initial and final lumen output must be measured in accordance with sections 4.1 and 4.4 of this appendix, respectively.

4.5.2. For lumen maintenance values greater than 1, the lifetime (in hours) is limited to a value less than or equal to four times the test duration.

4.5.3. For lumen maintenance values less than 1 but greater than or equal to 0.7, the lifetime (in hours) is calculated using the following equation:

$$Lifetime = t * \frac{\ln(0.7)}{\ln(\frac{x_t}{x_0})}$$

Where: t is the test duration in hours; x_0 is the initial lumen output; x_t is the final lumen output at time t, and ln is the natural logarithm function.

The maximum lifetime is limited to four times the test duration t.

4.5.4. For lumen maintenance values less than 0.7, including lamp failures that result in complete loss of light output, lifetime is equal to the previously recorded lumen output measurement at a shorter test duration where the lumen maintenance is greater than or equal to 70 percent, and lifetime shall not be calculated in accordance with section 4.5.3 of this appendix.

5. Standby Mode Test Method for Determining Standby Mode Power

In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over IES LM–79 (incorporated by reference; see § 430.3) and IEC 62301 (incorporated by reference; see § 430.3).

5.1. Test Conditions and Setup

5.1.1. The ambient conditions, power supply, electrical settings, and instrumentation must be established in accordance with the specifications in sections 2.0, 3.0, 7.0, and 8.0 of IES LM–79 (incorporated by reference; see § 430.3), respectively.

5.1.2. An equal number of integrated LED lamps must be positioned in the base up and base down orientations throughout testing.

5.1.3. The integrated LED lamp must be operated at the rated voltage throughout testing. For an integrated LED lamp with multiple rated voltages, the integrated LED lamp must be operated at 120 volts. If an integrated LED lamp with multiple rated voltages is not rated for 120 volts, the integrated LED lamp must be operated at the highest rated input voltage.

5.2. Test Method, Measurements, and Calculations

5.2.1. Standby mode power consumption must be measured for integrated LED lamps if applicable.

5.2.2. The integrated LED lamp must be stabilized prior to measurement as specified in section 5.0 of IES LM–79 (incorporated by reference; see § 430.3). The stabilization variation is calculated as [maximum—minimum)/minimum] of at least three readings of the input power and lumen output over a period of 30 minutes, taken 15 minutes apart.

5.2.3. The integrated LED must be configured in standby mode by sending a signal to the integrated LED lamp instructing it to have zero light output.

5.2.4. The standby mode power in watts must be measured as specified in section 5 of IEC 62301 (incorporated by reference; see § 430.3).

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