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: Final rule.

SUMMARY: This final rule adopts a test procedure for integrated light-emitting diode (LED) lamps (hereafter referred to as LED lamps) to support the implementation of labeling provisions by the Federal Trade Commission (FTC), as well as the ongoing general service lamps rulemaking, which includes LED lamps. The final rule adopts test procedures for determining the lumen output, input power, lamp efficacy, correlated color temperature (CCT), color rendering index (CRI), power factor, lifetime, and standby mode power for LED lamps. The final rule also adopts a definition for time to failure to support the definition of lifetime. This final rule incorporates by reference four industry standards, including two recently published industry standards that describe a process for taking lumen maintenance measurements and projecting those measurements for use in the lifetime test method.

DATES: The effective date of this rule is August 1, 2016. The incorporation by reference of certain publications listed in this rule was approved by the Director of the Federal Register as of August 1, 2016. Representations must be based on testing in accordance with the final rule starting December 28, 2016.

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

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 will contain simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact Ms. Lucy deButts at (202) 287–1604 or by email: *Lucy.deButts@ee.doe.gov.*

FOR FURTHER INFORMATION CONTACT: Ms. Lucy deButts, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 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–33, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 287–6122. Email: *Celia.Sher@hq.doe.gov.*

SUPPLEMENTARY INFORMATION: This final rule incorporates by reference into part 430 the following industry standards:

1. IEC [1] 62301, ''Household electrical appliances—Measurement of standby power'' (Edition 2.0, 2011–01).

2. ANSI [2]/IES [3] RP–16–2010, ''Nomenclature and Definitions for Illuminating Engineering,'' approved July 15, 2005.

3. IES LM–79–08, ''Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products,'' approved December 31, 2007.

4. IES LM–84–14, ''Approved Method: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires,'' approved March 31, 2014.

5. IES TM–28–14, ''Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires,'' approved May 20, 2014.

You may purchase a copy of IEC 62301 from International Electrotechnical Commission, available from the American National Standards Institute, 25 W. 43rd Street, 4th Floor, New York, NY 10036, (212) 642–4900, or go to *http://webstore.ansi.org.*

Copies of IES standards may be obtained from the Illuminating Engineering Society of North America, 120 Wall Street, Floor 17, New York, NY 10005–4001, 212–248–5000, or go to *http://www.iesna.org.* Industry standards can also be reviewed in person at U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza SW., Suite 600, Washington, DC, 20024. For further information on accessing IBR standards, contact Ms. Lucy deButts at (202) 287–1604 or by email: *Lucy.deButts@ee.doe.gov.*

See section IV.M for a further discussion of these standards.

[1] International Electrotechnical Commission.

[2] American National Standards Institute

[3] Illuminating Engineering Society.

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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 Energy Efficiency Improvement Act of 2015

(EEIA 2015), Public Law 114–11 (April 30, 2015). 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 rulemaking establishes test procedures that manufacturers of integrated LED lamps (hereafter referred to as ''LED lamps'') must 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, test procedures in this rulemaking 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 developing energy conservation standards for general service lamps (GSLs), a category of lamps that includes general service LED lamps. 79 FR 73503 (Dec. 11, 2014).

Second, this rulemaking 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 rulemaking 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).

DOE previously published four **Federal Register** documents pertaining to the test procedure for LED lamps. On April 9, 2012, DOE published a test procedure NOPR (hereafter the April 2012 NOPR). 77 FR 21038. Following the publication of the NOPR, DOE held a public meeting on May 3, 2012, to receive feedback from interested parties. On June 3, 2014, DOE published a test procedure SNOPR (hereafter the June 2014 SNOPR) primarily revising its proposal for lifetime measurements. 79 FR 32020. Then, on June 26, 2014, DOE published a second SNOPR (hereafter the lifetime SNOPR) revising the definition of lifetime for LED lamps. 79 FR 36242. Finally, on July 9, 2015, DOE published a third SNOPR (hereafter July 2015 SNOPR) adding a method for determining power factor and revising the proposed method of measuring and projecting the time to failure of integrated LED lamps. 80 FR 39644 (July 9, 2015).

II. Synopsis of the Final Rule

This final rule adopts methods for determining lumen output, input power, lamp efficacy, correlated color temperature (CCT), color rendering index (CRI), power factor, lifetime, and standby power and for measuring and projecting the time to failure of integrated LED lamps.

Representations of energy efficiency must be based on testing in accordance with this rulemaking within 180 days after the publication of the final rule.

III. Discussion

A. Scope of Applicability

EPCA defines an LED as a p-n junction[4] solid-state device, the radiated output of which, either in the infrared region, visible region, or ultraviolet region, is a function of the physical construction, material used, and exciting current[5] of the device. (42 U.S.C. 6291(30)(CC)) In the June 2014 SNOPR, DOE stated that this rulemaking applies to LED lamps that meet DOE's proposed definition of an integrated LED lamp, which is based on the term as defined by ANSI/IES RP–16–2010. This standard defines an integrated LED lamp as an integrated assembly that comprises LED packages (components) or LED arrays (modules) (collectively referred to as an LED source), an LED driver, an 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 socket. 79 FR 32020, 32021 (June 3, 2014).

DOE received comments supporting the LED lamps test procedure. The California Investor Owned Utilities (hereafter referred to as CA IOUs) expressed approval for the LED lamps test procedure rulemaking and noted the importance of establishing a test procedure to support the adoption of high quality LED lamps. (CA IOUs, No. 44 pp. 1, 7)[6] DOE appreciates the supporting comments from CA IOUs. The intent of a comprehensive test procedure is to produce consistent and repeatable test results.

B. Industry Standards Incorporated by Reference

In the July 2015 SNOPR, DOE proposed incorporating by reference four industry standards to support the proposed definitions and test methods for LED lamps. 80 FR 39644 (July 9, 2015). The National Electrical Manufacturers Association (hereafter referred to as NEMA) and Philips Lighting (hereafter referred to as Philips) commented that they disagreed with copying portions of text from industry standards protected under copyright (*e.g.,* IES LM–80 or IES LM–84) directly into the Code of Federal Regulations. NEMA and Philips stated that DOE should adopt industry standards in their entirety without modification instead of incorporating individual sections, noting that this would reduce the risk of misinterpretation and confusion during testing when interrelated sections are omitted. NEMA concluded that incorporating the full standards by reference is more appropriate because the standards are reasonably available, are the result of industry consensus, and provide full context for the reader. (NEMA, No. 42 at pp. 2–3; Philips, No. 41 at p. 3)

While DOE's proposed language in Appendix BB to subpart B of part 430 references sections of industry standards, it does not copy text from those standards. Rather, DOE provides comprehensive test procedures for multiple test metrics and, in doing so, DOE often has to clarify, limit, or add further specification to industry standards that are referenced to ensure a consistent, repeatable result. Therefore, instead of incorporating an industry standard in its entirety, DOE references the relevant sections of the industry standard and clearly states any directions that differ from those in the industry standard. For example, DOE references sections 5.2 and 5.4 of IES LM–84–14 to specify power supply requirements for lifetime measurements. However, DOE does not reference section 5.3 of the industry standard in the test procedure because it is listed as

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

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

[6] A notation in this form provides a reference for information that is in the docket of DOE's rulemaking to develop test procedures for integrated LED lamps (Docket No. EERE–2011–BT–TP–0071), which is maintained at *www.regulations.gov.* This notation indicates that the statement preceding the reference is in document number 44 filed in the docket for the integrated LED lamps test procedure rulemaking, and appears at pages 1 and 7 of that document.

optional by IES and lacks specific restrictions regarding power supply impedance. Selectively referencing relevant sections of industry standards in this way ensures a consistent, repeatable test procedure. Thus, DOE adopts this approach in the final rule.

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

IES LM–79–08 specifies the methodology for measuring lumen output, input power, CCT, and CRI for LED lamps. IES LM–79–08 also specifies the test conditions and setup at which the measurements and calculations must be performed. The July 2015 SNOPR proposed to reference IES LM–79–08 for determining lumen output, input power, CCT, CRI, and power factor of LED lamps, with some modifications. 80 FR at 39645. Power factor is not described directly in IES LM–79–08, but the measurement values necessary for calculating power factor are specified. Sections III.C.1 through III.C.3 discuss comments received on this proposal.

1. Test Conditions

In the July 2015 SNOPR, DOE proposed that the ambient conditions for testing LED lamps be as specified in section 2.0 [7] of IES LM–79–08. 80 FR at 39645–39646. These conditions include provisions for setup and ambient temperature control, as well as air movement requirements. Both are discussed in further detail in the following paragraphs.

Section 2.2 of IES LM–79–08 specifies that photometric measurements must be taken at an ambient temperature of 25 degrees Celsius (°C) ± 1 °C, and that the temperature must 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.

In the July 2015 SNOPR, DOE noted that the operating temperature of LED lamps varies depending on the application for which they are installed. However, testing at an ambient temperature of 25 °C ± 1 °C is consistent with other lighting products such as general service fluorescent lamps (GSFLs), compact fluorescent lamps (CFLs), and incandescent reflector lamps (IRLs). Measuring at an ambient temperature of 25 °C ± 1 °C will enable DOE, industry, and consumers to compare general service lamp products across different technologies. 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. 80 FR at 39646.

In the July 2015 SNOPR, DOE also proposed that the requirement for air movement around the LED lamp be as specified in section 2.4 of IES LM–79–08, which requires that the airflow around the LED lamp be such that it does not affect the lumen output measurements of the tested lamp. This requirement ensures that air movement is minimized to acceptable levels and applies to lamps measured in both active mode and standby mode. *Id.*

DOE did not receive any comments on the proposed ambient condition requirements and therefore adopts them as described in this final rule.

2. Test Setup

a. Power Supply

In the July 2015 SNOPR, DOE proposed that power supply characteristics be as specified in section 3.0 of IES LM–79–08. 80 FR at 39666. Section 3.1 specifies that the alternating current (AC) power supply must 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 3.0 percent of the fundamental frequency while operating the LED lamp. Section 3.2 requires, in part, that the voltage of the AC power supply (RMS voltage) or direct current (DC) power supply (instantaneous voltage) applied to the LED lamp be regulated to within ±0.2 percent under load.

DOE did not receive any comments on the proposed power supply requirements and therefore adopts them as described in this final rule.

b. Electrical Settings

In the July 2015 SNOPR, DOE proposed to test LED lamps according to the electrical settings as specified in section 7.0 of IES LM–79–08. Section 7.0 specifies, in part, that the LED lamp must be operated at the rated voltage throughout testing. DOE also specified that, for an integrated LED lamp with multiple rated voltages including 120 volts, the lamp must be operated at 120 volts. If an integrated LED lamp with multiple rated voltages is not rated for 120 volts, the lamp must be operated at the highest rated input voltage. Additional tests may be conducted at other rated voltages. Section 7.0 also requires the LED lamp to be operated at the maximum input power during testing. 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 active-mode measurements must be taken at the same selected settings. The manufacturer must also indicate in the test report which mode was selected for testing and include sufficient detail such that another laboratory could operate the lamp in the same mode. *Id.*

Also in the July 2015 SNOPR, DOE proposed instructions for the electrical instrumentation setup to be as specified in section 8.0 of IES LM–79–08. Section 8.1 specifies that for DC-input LED lamps, a DC voltmeter and a DC ammeter are to be connected between the DC power supply and the LED lamp. The voltmeter is to be connected across the electrical power inputs of the LED lamp. For AC-input LED lamps, an AC power meter is to be connected between the AC power supply and the LED lamp, and AC power, in addition to input voltage and current, is measured. Section 8.2 specifies calibration uncertainties for the instruments used for measuring AC input power, voltage, and current. It also prescribes the calibration uncertainty for DC voltage and current. The calibration uncertainty of the AC power meter is to be less than or equal to 0.5 percent and that of the instruments used for AC voltage and current is to be less than or equal to 0.2 percent. Lastly, the calibration uncertainty of the meter used for DC voltage and current is to be less than or equal to 0.1 percent. *Id.*

DOE did not receive any comments on the proposed electrical settings during testing and therefore adopts them as described in this final rule.

c. Operating Orientation

In the July 2015 SNOPR, DOE proposed that LED lamps be positioned such that an equal number of units are oriented in the base-up and base-down orientations during testing. DOE collected test data for several LED lamps tested in base-up, base-down, and horizontal orientations, and analyzed the data to determine the variation of input power, lumen output, CCT, and CRI in each of these three orientations. The analysis of the test data revealed that some lamp models exhibited variation between the three orientations.

[7] 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 rule refers to each IES section exactly as it is referenced in the IES standard.

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, respectively. Therefore, there is no need to test horizontally. Testing LED lamps in the base-up and base-down orientations would apply to lamps measured in both active mode and standby mode. 80 FR at 39646. For an LED lamp that is developed, designed, labeled, and advertised as restricted to a particular position, DOE proposed that the lamp be tested in only the manufacturer-specified position. *Id.*

DOE did not receive any comments on the proposed operating orientation requirements and therefore adopts them as described in this final rule.

3.Test Method

a. Stabilization Criteria

DOE proposed in the July 2015 SNOPR that integrated LED lamps be stabilized prior to measurement as specified in section 5.0 of IES LM–79–08. The ambient conditions and operating orientation while stabilizing is as specified in sections III.C.1 and III.C.2. DOE also proposed in the July 2015 SNOPR that stability of the LED lamp is reached when the stabilization variation [(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, is less than 0.5 percent. DOE included this calculation to add clarification to the method specified in section 5.0 of IES LM–79–08. DOE also proposed that stabilization of multiple products of the same model can be carried out as specified in section 5.0 of IES LM–79–08. 80 FR at 39666.

DOE did not receive any comments on the proposed stabilization criteria and therefore adopts them as described in this final rule.

b. Input Power Metric

DOE proposed in the July 2015 SNOPR that input power (in watts), input voltage (in volts), and input current (in amps) be measured as specified in section 8.0 of IES LM–79–08. For DC-input LED lamps, the product of the measured voltage and the current gives the input electrical power. For AC-input LED lamps, the input power is measured using a power meter connected between the AC power supply and the LED lamp. *Id.*

DOE did not receive any comments on the proposed test method for measuring input power and therefore adopts it as described in this final rule.

c. Lumen Output Metric

DOE proposed in the July 2015 SNOPR that goniophotometers may not be used for photometric measurements. As a result, DOE proposed in the July 2015 SNOPR that the method for measuring lumen output be as specified in sections 9.1 and 9.2 of IES LM–79–08, and proposed the same lumen output measurement method for all LED lamps, including directional [8] LED lamps. 80 FR at 39646–47.

DOE did not receive any comments on the proposed test method for measuring lumen output and therefore adopts it as described in this final rule.

d. Lamp Efficacy Metric

As discussed in section I, this 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, in the July 2015 SNOPR, DOE proposed that the efficacy of an LED lamp (in units of lumens per watt) be calculated by dividing measured initial lamp lumen output in lumens by the measured lamp input power in watts. 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. This approach also increases clarity as it specifies the calculation using the naming conventions for measured parameters established by DOE. *Id* at 39647.

DOE did not receive any comments on the proposed calculation for lamp efficacy and therefore adopts it as described in this final rule.

e. Measuring Correlated Color Temperature

In the July 2015 SNOPR, DOE proposed that the CCT of an LED lamp be calculated as specified in section 12.4 of IES LM–79–08. 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. DOE did not propose a nominal CCT method because nominal CCT values do not address all regions of the chromaticity diagram. DOE proposed that the setup for measuring the relative spectral distribution, which is required to calculate the CCT of the LED lamp, be as specified in section 12.0 of IES LM–79–08. That section describes the test method to calculate CCT using a sphere-spectroradiometer system and a spectroradiometer or colorimeter system. Furthermore, DOE also proposed in the July 2015 SNOPR to require all photometric measurements (including CCT) be carried out in an integrating sphere, and that goniophotometer systems must not be used. Therefore, DOE proposed that the instrumentation used for CCT measurements be as described in section 12.0 of IES LM–79–08 with the exclusion of sections 12.2 and 12.5 of IES LM–79–08. *Id.*

DOE did not receive any comments on the proposed test method for measuring CCT and therefore adopts it as described in this final rule.

f. Measuring Color Rendering Index

In the July 2015 SNOPR, DOE proposed to add a requirement that the CRI of an LED lamp be determined as specified in section 12.4 of IES LM–79–08, and to require all photometric measurements (including CRI) be carried out in an integrating sphere. As proposed, the setup for measuring the relative spectral distribution, which is required to calculate the CRI of the LED lamp, would be as specified in section 12.0 of IES LM–79–08 with the exclusion of sections 12.2 and 12.5 of IES LM–79–08, as goniophotometer systems would not be used. Section 12.4 of IES LM–79–08 also specifies that CRI be calculated according to the method defined in the International Commission on Illumination (CIE) 13.3–1995.[9] There are currently no industry standards that define or provide instructions for color quality metrics other than the CRI of LED lamps. DOE proposed 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. 80 FR at 39647–48.

NEMA requested DOE to remove test requirements for CRI from the LED lamps test procedure, citing that they are not necessary for FTC labeling purposes. NEMA noted that because DOE has removed other parameters from the test procedure to be consistent with FTC labeling parameters, it should remove CRI as well. NEMA also commented that limiting the parameters addressed in this test procedure to just those needed for the FTC Lighting Facts Label will shorten the time to complete this test procedure rulemaking and enable the FTC to utilize this test

[8] 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.

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

procedure earlier. (NEMA, No. 42 at p. 3)

Removing parameters already addressed in this rulemaking to date will not shorten the time needed to complete the final rule. DOE's proposals have already received several rounds of comments and the majority of proposals in the most recent SNOPR received no comments from stakeholders, indicating general agreement.

DOE's proposal in the April 2012 NOPR was originally intended to support the FTC Lighting Facts program. 77 FR 21040. However, over the course of this rulemaking, DOE expanded the scope of the test procedure to also support the general service lamps energy conservation standards rulemaking. While FTC does not require CRI to be reported on the FTC Lighting Facts Label, EPA has requirements for CRI in Version 2.0 of the ENERGY STAR Program Requirements: Product Specification for Lamps (Light Bulbs) (hereafter ''ENERGY STAR Lamps Specification V2.0'') [10] and the version currently in effect (hereafter ENERGY STAR Lamps Specification V1.1).[11] Because the test methods for CRI described earlier have been reviewed and vetted by industry stakeholders, DOE maintained CRI in this test procedure in support of the ENERGY STAR Lamps Specification V2.0.

The Appliance Standards Awareness Project, Natural Resources Defense Council and the American Council for an Energy-Efficient Economy (hereafter referred to as EEAs) and NEMA both noted an updated industry standard for color, IES TM–30–15, in their comments regarding color testing. NEMA commented that TM–30–15 is intended to identify and better quantify consumer preferences regarding color rendition, and that DOE should not set a minimum standard using the metric described in this standard until it is finalized. (NEMA, No. 42 at p. 2) EEAs indicated that the new standard is intended to eventually replace CRI, and while there should be no immediate minimum value specified in a rulemaking, manufacturers should be required to provide color rendering information based on TM–30–15. (EEAs, No. 43 at pp. 3–4)

Having reviewed the newly published industry standard, DOE will not require manufacturers to provide color rendering information based on TM–30–15 at this time. DOE notes that the metrics described in the standard are not required by DOE, FTC, or ENERGY STAR. DOE will continue to monitor industry acceptance of TM–30–15 and the requirements for ENERGY STAR. DOE can initiate a rulemaking and incorporate TM–30–15 at a later time, if needed.

CA IOUs also requested that DOE modify the LED lamps test procedure to require manufacturers to report the entire set of test color samples, R1 through R14, when measuring and reporting CRI. CA IOUs described the process for calculating CRI, which is an average color metric based on the first eight test color samples, R1 through R8. CA IOUs asked DOE to specify the reporting of the entire set of test color samples because the average CRI value may not always accurately depict color performance of a lamp. In other words, lamps can have similar CRI values but the color performance may vary depending on the desired design criteria of the consumer. CA IOUs presented an example of two lamps with similar light output, CCT, and CRI, but that have significantly different R8 values. Each lamp would have a different saturation in the pink/red hue, leading to varying consumer satisfaction depending on the desired application. Therefore, CA IOUs recommended DOE to specifically include the measurements of R1 through R14 in the DOE test procedure to enhance consumer satisfaction. (CA IOUs, No. 44 at pp. 6–7)

DOE understands the importance of consumer satisfaction regarding lamp color. Although FTC does not require CRI to be reported, and DOE may not require the metric in its rulemaking for general service lamps, ENERGY STAR has minimum CRI requirements for both CFL and LED lamps. The requirements are in terms of the average metric rather than the individual values of the first eight color samples. Therefore, although the referenced standard for CRI provides a method for measuring the fourteen different color samples described by the CA IOUs, DOE is providing certification provisions in this test procedure for only the average metric based on the first eight values (*i.e.,* CRI). As described in a previous response in this section, DOE will continue to monitor the use of color metrics in the industry and can revise the certification provisions for color rendering values at a future point in time.

g. Measuring Power Factor

In the July 2015 SNOPR, DOE proposed to include a test procedure for power factor, because power quality can impact energy consumption. Power factor is a dimensionless ratio of real power to apparent power that applies only to AC-input lamps, where real power is the measured input power of the LED lamp and apparent power is equal to the product of measured input current and input voltage. As mentioned previously, a test procedure for power factor is not described directly in IES LM–79–08, but the instrumentation for measuring the values necessary for calculating power factor is specified.

DOE proposed to calculate power factor by dividing measured input power by the product of input current and input voltage. Following seasoning and stabilization, input power, input current, and input voltage to the LED lamp would be measured using the instrumentation specified in section 8.0 of IES LM–79–08. Input power, input current, and input voltage would be measured using the same test conditions and test setup as for lumen output, lamp efficacy, CCT, and CRI as proposed in the July 2015 SNOPR. 80 FR at 39655.

DOE received several comments from stakeholders regarding DOE's proposed measurement and calculation of power factor. CA IOUs supported DOE's addition of a power factor test method, noting that higher power factor requirements in a standards rulemaking should increase energy savings. (CA IOUs, No. 44 at pp. 1–2) However, NEMA asserted that DOE should not set requirements for power factor, and consequently DOE should not have test methods for power factor in the LED lamps test procedure. (NEMA, No. 42 at p. 6)

DOE included power factor in this test procedure to potentially support the general service lamps rulemaking. If that rulemaking does not establish requirements for power factor, DOE notes that ENERGY STAR has requirements for power factor in its current and draft specifications for Lamps. Thus, DOE will continue to provide a test method for power factor in this final rule.

Although NEMA disagreed with the inclusion of the metric, NEMA agreed with DOE's proposed method for determining power factor. (NEMA, No. 42 at p. 6) CA IOUs recommended, however, that DOE incorporate by reference ANSI C82.77, which is referenced by the ENERGY STAR Lamps Specification V2.0 and by the California Energy Commission Title 24 Part 6 (Building Energy Efficiency Standards).[12] CA IOUs noted that this

[10] ''ENERGY STAR Program Requirements: Product Specification for Lamps (Light Bulbs) Version 2.0.'' U.S. Environmental Protection Agency, February 2016.

[11] ''ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) Version 1.1.'' U.S. Environmental Protection Agency, August 28, 2014.

[12] California Energy Commission, ''Building Energy Efficiency Standards for Residential and Nonresidential Buildings,'' June 2015. *http://*

standard includes more detailed specifications of test equipment capabilities and guidance related to error tolerances. (CA IOUs, No. 44 at pp. 1–2)

DOE reviewed the equipment specifications and error tolerances in IES LM–79–08 and ANSI C82.77 and determined that IES LM–79–08 provides more stringent specifications related to error tolerances than ANSI C82.77. IES LM–79–08, which specifically applies to LED lamps, provides explicit equipment specifications and error tolerances for measuring each component of the power factor calculation (*i.e.,* input power, input current, and input voltage). ANSI C82.77 specifies tolerances for input voltage and current characteristics. However, it does not detail any tolerances or uncertainties for the input power supply or power measuring device. IES LM–79–08 specifies that the calibration uncertainty of the AC power meter must be less than or equal to 0.5 percent. Further, the tolerance specified for the voltage supplied to the tested product is more stringent in IES LM–79–08. ANSI C82.77 specifies that the input voltage must be within ±2 percent of the rated value, while IES LM–79–08 specifies that the input voltage applied to the LED lamp must be within ±0.2 percent of the rated lamp input voltage. Because IES LM–79–08 contains specifications that comprehensively address LED lamps and are more stringent for determining power factor, DOE maintained its approach in this final rule for measuring power factor.

D. Adopted Approach for Lifetime Measurements

In the July 2015 SNOPR, DOE proposed a new test procedure for measuring and projecting the time to failure of LED lamps that addressed many of the stakeholder concerns received regarding the June 2014 and lifetime SNOPR proposals. The new proposal was largely based on the IES LM–84–14 and IES TM–28–14 industry standards, and provided a simple, straightforward, and flexible test procedure. 80 FR at 39651. IES LM–84–14 provides a method for lumen maintenance measurement of integrated LED lamps and specifies the operational and environmental conditions during testing such as operating cycle, ambient temperature, airflow, and orientation. Lumen maintenance is the measure of lumen output after an elapsed operating time, expressed as a percentage of the initial lumen output. IES TM–28–14 provides methods for projecting the lumen maintenance of integrated LED lamps depending on the available data and test duration. DOE determined that the lifetime projection method in IES TM–28–14 would lead to more accurate lifetime projections than the June 2014 and lifetime SNOPR proposals, ENERGY STAR Lamps Specification V1.1,[11] and ENERGY STAR Lamps Specification V2.0 [10] (when it requires compliance) because IES TM–28–14 specifies a method that projects time to failure using multiple lumen maintenance measurements collected over a period of time, rather than a single measurement at the end of the test duration. 80 FR at 39646–39647. These requirements, and any modifications proposed by DOE, are further discussed in sections III.D.1 through III.D.4.

1. Test Conditions

In the July 2015 SNOPR, DOE proposed that the conditions for lamp operation between lumen output measurements be as specified in section 4.0 of IES LM–84–14, with some modifications. Lumen output of LED lamps can vary with changes in ambient temperature and air movement around the LED lamp. However, to reduce test burden, DOE proposed that the operating conditions (*e.g.,* ambient temperature) required while measurements are not being taken be less stringent than those required when taking photometric measurements. The test conditions outlined in IES LM–84–14, as modified, ensure reliable, repeatable, and consistent test results without significant test burden. 80 FR at 39650–36951. These conditions are discussed in further detail in the paragraphs that follow.

Specifically, DOE discussed referencing section 4.1 of IES LM–84–14, which specifies that LED lamps should be handled according to the manufacturer's instructions and should be checked and cleaned prior to lumen output measurement and maintenance testing. Section 4.1 of IES LM–84–14 further states that unusual environmental conditions, such as thermal interference from heating, ventilation and air conditioning systems or solar loading, are to be reduced to levels reasonably expected to minimize influence.

DOE also proposed to adopt the instructions in section 4.2 of IES LM–84–14, which state that the lamp should be mounted in accordance with manufacturer specifications. DOE expanded on this, proposing that if lamps can operate in multiple orientations, an equal number of LED lamps should be positioned in the base-up and base-down orientations throughout testing, but that if the manufacturer restricts the position, the units should be tested in the manufacturer-specified position.

In addition, DOE proposed to include section 4.4 of IES LM–84–14, which specifies that photometric measurements should be taken at an ambient temperature of 25 °C ± 5 °C. A tolerance of 5 °C for the ambient temperature during lumen maintenance testing is practical, limits the impact of ambient temperature, and is not burdensome. Section 4.4 of IES LM–84–14 also indicates that the temperature variation of the operating environment must be monitored with a sufficient number of appropriately located temperature measurement points, and that the sensors used for measurements must 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. Section 4.4 of IES LM–84–14 further states that if the ambient temperature falls outside the allowed range, the lumen maintenance test must be terminated. This setup for measuring and controlling ambient temperature would result in appropriate testing conditions as the lamp would be tested at room temperature and in an environment that is used most commonly for testing lamp technologies. *Id.*

DOE discussed requiring that vibration and air movement around the LED lamp be as specified in sections 4.3 and 4.6 of IES LM–84–14, which require that the LED lamps not be subjected to excessive vibration or shock during operation or handling, and that the air flow surrounding the LED lamp be minimized. This is a requirement in relevant industry standards for the test setup of other lamp types such as GSFLs, and would ensure consistent LED lamp measurements. DOE also proposed that humidity of the environment around the LED lamp shall be maintained to less than 65 percent relative humidity during the lumen maintenance test as specified in section 4.5 of IES LM–84–14. *Id.*

DOE did not receive any comments on the proposed test conditions when determining lifetime and therefore adopts them as described in this final rule.

2. Test Setup

a. Power Supply

DOE proposed that line voltage waveshape and input voltage of AC power supplies be as specified in sections 5.2 and 5.4 of IES LM–84–14, respectively. Section 5.2 specifies that

www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf.

an AC power supply must 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 3.0 percent of the fundamental frequency while operating the LED lamp. Section 5.4 requires, in part, that the voltage of an AC power supply (RMS voltage) applied to the LED lamp be less than or equal to 2.0 percent of the rated RMS voltage. Lastly, DOE proposed to not reference section 5.3 of IES LM–84–14, which provides line impedance guidelines, because the procedures are listed as optional by IES and lack specific line impedance restrictions. 80 FR at 39651–52.

DOE did not receive any comments on the proposed power supply requirements and therefore adopts them as described in this final rule.

b. Test Rack Wiring

DOE proposed that test rack wiring requirements during lumen maintenance testing of LED lamps be as specified in section 5.5 of IES LM–84–14. This section specifies that wiring of test racks should be in accordance with national, state or provincial, and local electrical codes, and in accordance with any manufacturer operation and condition recommendations for the LED lamp. This section also requires that an inspection of electric contacts including the lamp socket contacts be performed each time the LED lamps are installed in the test rack. 80 FR at 39652.

DOE did not receive any comments on the proposed test rack wiring requirements and therefore adopts them as described in this final rule.

c. Electrical Settings

DOE proposed requiring lumen maintenance testing of LED lamps at the rated voltage as specified in section 5.1 of IES LM–84–14. For lamps with multiple operating voltages, DOE proposed that the integrated LED lamp be operated at the rated voltage throughout testing. For an integrated LED lamp with multiple rated voltages including 120 volts, DOE proposed that the lamp be operated at 120 volts. For cases where an integrated LED lamp with multiple rated voltages is not rated for 120 volts, DOE proposed that the lamp be operated at the highest rated input voltage. For LED lamps with multiple modes of operation, DOE proposed incorporating section 7.0 of IES LM–79–08, which specifies that dimmable LED lamps should be tested at maximum input power. For cases where multiple modes (such as multiple CCTs and CRIs) occur at the maximum input power, DOE proposed that the manufacturer can select any of these modes for testing. For certification, DOE proposed that all measurements (lumen output, input power, efficacy, CCT, CRI, power factor, lifetime, and standby mode power) be conducted at the same mode of operation. *Id.*

DOE did not receive any comments on the proposed electrical settings during lumen maintenance testing and therefore adopts them as described in this final rule.

d. Operating Orientation

DOE proposed to incorporate the instructions in section 4.7 of IES LM–84–14, which specifies that the operating orientation of the lamp be the same as during photometric measurement. Lamp operating orientation during photometric measurement is discussed in section III.C.2.c. *Id.*

DOE did not receive any comments on the proposed operating orientation requirements and therefore adopts them as described in this final rule.

3. Test Method

DOE proposed that the lumen maintenance test procedure for LED lamps be as specified in section 7.0 of IES LM–84–14 and section 4.2 of IES TM–28–14. The test methods outlined in IES LM–84–14 and IES TM–28–14 ensure reliable, repeatable, and consistent test results without significant test burden. 80 FR at 39652. The lumen maintenance test method is discussed in further detail in sections III.D.3.a through III.D.3.g.

a. Initial Lumen Output Measurements

DOE proposed requiring an initial lumen output measurement consistent with section 7.6 of IES LM–84–14, which states that an initial lumen output measurement is required prior to starting the maintenance test. Initial lumen output is the measured amount of light that an LED lamp provides at the beginning of its life after it is initially energized and stabilized using the stabilization procedures described in section III.C.3.a. The methodology, test conditions, and setup requirements described in section III.C.3.c would be used when measuring initial lumen output for the lifetime test procedure. Manufacturers testing an LED lamp for lifetime would be required to use the same value of initial lumen output as used in the lamp efficacy calculation. *Id.*

DOE did not receive any comments on the proposed initial lumen output measurement requirements for time to failure testing and therefore adopts them as described in this final rule.

b. Interval Lumen Output Measurements

DOE also proposed requiring that additional lumen output measurements (known as interval lumen output measurements) be made after the initial lumen output measurement and continue at regular intervals, consistent with the requirements of section 7.6 of IES LM–84–14. Interval lumen output is measured after the lamp is energized and stabilized using the stabilization procedures in section III.C.3.a. 80 FR 39652. The methodology, test conditions, and setup requirements described in section III.C.3.c would be required when measuring interval lumen output for the lifetime test procedure. *Id.*

DOE did not receive any comments on the stabilization, methodology, test conditions, or setup for measuring interval lumen output and therefore adopts them as described in this final rule. The frequency of interval lumen output measurements is discussed in section III.D.4.a.

c. Test Duration

In the July 2015 SNOPR, DOE proposed that 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. 80 FR at 39649. During lumen maintenance testing, the LED lamps must operate for an extended period of time, referred to as the ''elapsed operating time.'' The entirety of elapsed operating time starting immediately after the initial lumen output measurement and ending with the recording of the final interval lumen output measurement is then 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 proposed that the time spent in the off state not be included in the test duration. DOE did not specify minimum test duration requirements so manufacturers can customize the test duration based on the expected lifetime of the LED lamp. However, DOE acknowledged that the test duration has a significant impact on the reliability of the lumen maintenance prediction and thus proposed maximum time to failure claims that increase as the test duration increases. 80 FR at 39649–39650. These lumen maintenance calculation requirements are discussed further in section III.D.4.

DOE did not receive any comments on the proposed test duration criteria and

therefore adopts them as described in this final rule.

d. Lamp Handling and Tracking

DOE proposed that LED lamps be handled, transported, and stored as specified in Section 7.2 of IES–LM–84–14, which states that care should be taken to prevent any damage or contamination that may affect the test results. These handling requirements are practical, prevent lamp damage that could affect the measured results, and would not be burdensome to manufacturers.

DOE also proposed that the requirements for LED lamp marking and tracking during lumen maintenance testing be as specified in section 7.3 of IES–LM–84–14. Section 7.3 of IES–LM–84–14 specifies that each LED lamp must be tracked during the maintenance test and identified by marking applied directly to the LED lamps or by labels that can be attached during transport, operation, and evaluation, or to the test rack position occupied by the LED lamp. It further provides that the chosen identification method should also consider the effect of exposure to light and heat, as this may alter or compromise the marking or label. Section 7.3 of IES–LM–84–14 also offers several possible marking methods and materials, including durable bar coding, ceramic ink marking, high-temperature markers, or any other method that endures or can be periodically renewed for the duration of the test. These requirements ensure that the LED lamp can be tracked and identified correctly throughout lumen maintenance testing. 80 FR at 39652–39653.

DOE did not receive any comments on the proposed lamp handling and tracking requirements and therefore adopts them as described in this final rule.

e. 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.[13] Thus, in the July 2015 SNOPR, DOE proposed that cycling of the LED lamp not be required during lumen maintenance testing by referencing section 7.4 of IES LM–84–14, which states the LED lamps should be operated continuously. 80 FR at 39653.

DOE did not receive any comments on the proposal to maintain continuous operation. However, in order to require continuous operation rather than recommend it, DOE removes the reference to section 7.4 of IES LM–84–14 and adopts language in its place that states to operate the integrated LED lamp continuously. This requirement aligns with previous industry comments and eliminates any confusion regarding operating cycle. 80 FR 39644, 39653 (July 9, 2015).

f. Time Recording

Accurate recording of the elapsed operating time is critical for the lumen maintenance test procedure. Therefore, DOE proposed to adopt section 7.5 of IES LM–84–14, which states that elapsed time recording devices must be connected to the particular test positions and accumulate time only when the LED lamps are operating. The LED lamp is operating only when the lamp is energized. If lamps are turned off (possibly for transport to another testing area or during a power outage), DOE proposed that the time spent in the off state not be included in the recorded elapsed operating time. Section 7.5 of IES LM–84–14 also indicates that video monitoring, current monitoring, or other means can be used to determine elapsed operating time. All equipment used for measuring elapsed operating time would be calibrated and have a total minimum temporal resolution of ± 0.5 percent. These requirements are achievable with minimal testing burden and provide reasonable stringency that is achievable via commercially available time recording instrumentation. *Id.*

DOE did not receive any comments on the proposed time recording requirements and therefore adopts them as described in this final rule.

g. Lamp Failure

DOE also proposed that LED lamps be checked regularly for failure as specified in section 7.8 of IES LM–84–14, which requires that checking for LED lamp operation either by visual observation or automatic monitoring be done at a minimum at the start of lumen maintenance testing and during every interval measurement. Section 7.8 of IES LM–84–14 further specifies that each non-operational LED lamp must be investigated to make certain that it is actually a failure, and that it is not caused by improper functioning of the test equipment or electrical connections. DOE proposed that if lumen maintenance of the LED lamp is measured at or below 0.7 or an LED lamp fails resulting in complete loss of light output, time to failure has been reached and therefore it must not be projected using the procedures described in the following section III.D.4. Instead, the time to failure is equal to the last elapsed time measurement for which the recorded lumen output measurement is greater than or equal to 70 percent of initial lumen output. *Id.*

Regarding DOE's proposal in section 4.6.2 of appendix BB to subpart B of part 430, NEMA recommended changing the text to read ''For lumen maintenance values less than 0.7, including lamp failures that result in complete loss of light output, time to failure is equal to the midpoint of the last monitoring interval where the lumen maintenance is greater than or equal to 70 percent.'' (NEMA, No. 42 at p. 5)

DOE notes that if a lamp fails earlier than expected, manufacturers may not know exactly when the LED lamp reached 70 percent lumen maintenance. NEMA's proposal to calculate that time as the midpoint of the last monitoring interval where the lumen maintenance is greater than or equal to 70 percent may overestimate the time to failure. DOE's approach ensures that the actual time to failure is equal to or greater than the value used in calculations. Therefore, DOE maintains its proposal in the July 2015 SNOPR, which ensures that the time to failure represents a lumen maintenance value of 70 percent or greater.

h. Stress Testing

In the July 2015 SNOPR, DOE noted that industry has stated that, unlike other lighting technologies, the lifetime of LED lamps is minimally affected by power cycling.[13] Further, DOE research of existing literature and industry test procedures indicated that none are available that use rapid-cycle stress testing to predict the failure of the complete LED lamp. Therefore, in the July 2015 SNOPR, DOE proposed to retain the testing conditions that LED lamps operate without rapid-cycle stress testing. DOE also did not propose to modify the testing conditions to accommodate a stress testing method based on elevated temperatures. 80 FR 39650.

DOE received comments from EEAs and CA IOUs on its proposed testing conditions for LED lamps, stating that it should reconsider adopting an accelerated life test method for LED lamps. The organizations noted that accelerated life testing is commonly used in other electronic industries to identify product flaws under stressed

[13] 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.*

operating conditions (*e.g.,* high temperature and high humidity). (EEAs, No. 43 at p. 2; CA IOUs, No. 44 at p. 6) EEAs commented that because integrated LED lamps are primarily constructed of electronic components, their lifetime is often affected by extreme ambient conditions. (EEAs, No. 43 at p. 2) CA IOUs agreed, adding that LED lamps utilize electronic drivers to regulate current, which may vary in performance under different ambient conditions. (CA IOUs, No. 44 at p. 6)

CA IOUs and EEAs referenced prior studies on stress testing in the LED industry. CA IOUs noted that 85/85 testing has been utilized in the industry, which is when the LED lamp is subjected to an ambient environment of 85°C and 85% relative humidity during testing. (CA IOUs, No. 44 at p. 6) CA IOUs and EEAs cited a study published by DOE that used a 75/75 testing method for analyzing LED luminaire lifetime under stressed conditions.[14] The study concluded that lumen depreciation alone is not a proxy for predicting LED lifetime and recommended the use of stress testing to identify product flaws and manufacturing defects. CA IOUs and EEAs also referenced the most recent draft of the ENERGY STAR Lamps Specification V2.0,[10] detailing EPA's plan to include elevated temperature testing for lamps intended to operate in recessed or enclosed fixtures. In order to identify and prevent manufacturing defects and poor quality products, CA IOUs and EEAs requested that DOE develop an accelerated life test method to align with EPA's ENERGY STAR program or one based on the LED luminaire research study. (EEAs, No. 43 at pp. 2–3; CA IOUs, No. 44 at p. 6) CA IOUs noted that the current lifetime test method as proposed by DOE does not address operating conditions for lamps that are installed in recessed or enclosed fixtures and recommended that DOE address this in its test procedure. (CA IOUs, No. 44 at p. 6)

DOE notes that it is important to maintain high quality products on the market. However, DOE is not adopting a stress test or elevated temperature test in this test procedure. DOE's research of existing literature and industry test procedures indicate that none are available that predict the failure of the complete LED lamp. The study published by DOE analyzing LED luminaire lifetime under stressed conditions [14] is not applicable to this test procedure for several reasons. While the study provided valuable insights on LED luminaires, it did not determine specific wear-out mechanisms, quantify failure modes, or determine acceleration factors to provide lifetime estimates for LED lamps. Further, the study specifically notes that its goal was to provide insight into failure modes of luminaires and was not intended to be a universal accelerated life test for luminaires. Therefore, DOE cannot use this study to develop an accelerated lifetime test method for the LED lamps test procedure at this time. Lastly, DOE notes that the adopted approach for lifetime measurements adequately tests all LED lamps, including lamps intended to operate in enclosed or recessed fixtures. DOE included lifetime in this test procedure to support the FTC Lighting Facts Label, and a consistent test method across all lamp types enables consumers to directly compare lamp lifetimes. Thus, DOE is not adopting a stress test or an elevated temperature test in this test procedure.

4. Projection Method

In the July 2015 SNOPR, DOE proposed a new lumen maintenance projection procedure that addressed many of the stakeholder concerns regarding the June 2014 and lifetime SNOPR proposals. The proposal was largely based on the IES TM–28–14 industry standard and provided a simple, straightforward, and flexible calculation based on the recorded trend in lumen maintenance of an LED lamp. However, DOE proposed certain modifications so that the projection method meets DOE's need for a test procedure that ensures consistent, repeatable results. 80 FR at 39653.

EEAs and CA IOUs supported DOE's inclusion of IES LM–84–14 and IES TM–28–14, citing the importance of measuring and projecting lumen maintenance for LED lamps rather than just LED sources. (EEAs, No. 43 at p. 2; CA IOUs, No. 44 at p. 4) CA IOUs added that DOE's proposal will encourage longer test durations, which will identify early product failures during testing. CA IOUs also noted that the proposal will help manufacturers make more accurate lifetime claims. (CA IOUs, No. 44 at p. 4)

However, Philips and NEMA disagreed with DOE's proposal to reference IES LM–84–14 and IES TM–28–14 for lumen maintenance testing and lifetime projections. They commented that industry is still widely using IES LM–80–08 and IES TM–21–11 and indicated that the current proposal would cause significant certification and testing delays, result in manufacturer test burden, and ultimately stifle innovation in a rapidly evolving product cycle. (Philips, No. 41 at p. 3; NEMA, No. 42 at p. 3) NEMA also noted that IES LM–80–08 and IES TM–21–11 allow for test results of one LED source to be used for each product that uses that LED, which shortens test time for the entire product line. NEMA asserted that because IES LM–84–14 is a new standard and manufacturer experience with it is low, it is unknown if IES LM–84–14 will more accurately predict lumen maintenance than IES LM–80–08. Lastly, NEMA recommended DOE give manufacturers the option to certify lamps under IES LM–80–08 and IES TM–21–11 or IES LM–84–14 and IES TM–28–14, which would give the lighting industry sufficient time to be familiarized with the new standards. (NEMA, No. 42 at pp. 3–4)

DOE notes, as it has in several previous SNOPRs, that measuring and projecting the performance of the entire lamp rather than the LED source is more accurate for a test procedure concerning lamp metrics. Other LED lamp components may cause lamp failure before the LED source falls below 70 percent of its initial light output, and therefore, it is undesirable for the lifetime of LED lamps to be approximated by the lumen maintenance of only the LED source. While NEMA notes that IES LM–80–08 and IES TM–21–11 allow for test results of one LED source to be used for each product that uses that LED source, that approach may not accurately characterize the lifetime of those products. For example, other electrical components included in the assembled lamp may also affect the lifetime but this effect would not be captured when testing only the LED source. Although NEMA claims that industry is still widely using the LED source to approximate lifetime, ENERGY STAR requires testing of the whole lamp to determine lifetime and the majority of integrated LED lamps are already certified to ENERGY STAR.[15] Finally, DOE must adopt a test procedure that provides reliable, repeatable, and consistent results. As such, DOE cannot allow two different methods (*i.e.,* LM–80–08/TM–21–11 and LM–84–14/TM–28–14) to be used because they will

[14] U.S. Department of Energy, ''Hammer Testing Findings for Solid-State Lighting Luminaires,'' December 2013. *http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/hammer-testing_Dec2013.pdf.*

[15] ENERGY STAR estimated the market penetration of ENERGY STAR certified integrated LED lamps to be 75 percent in the 2014 ENERGY STAR Unit Shipment and Market Penetration Report, found at *http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2014_USD_Summary_Report.pdf?8691-0d73.*

generate different results for the same lamp.

a. Interval Lumen Output Measurement Collection Instructions

In the July 2015 SNOPR, DOE proposed that all interval lumen output measurements meet the requirements specified in section 4.2, 4.2.1, and 4.2.2 of IES TM–28–14. For test durations greater than or equal to 6,000 hours, DOE proposed that section 4.2.1 of IES TM–28–14 be followed. Section 4.2.1 of IES TM–28–14 specifies that lumen maintenance data used for direct extrapolation must be collected initially and at least once every 1,000 hours thereafter. For test durations greater than or equal to 3,000 hours and less than 6,000 hours, DOE proposed section 4.2.2 of IES TM–28–14 be followed, except that lumen maintenance data of LED packages and modules would not be collected. Section 4.2.2 of IES TM–28–14 specifies that lumen maintenance data must be collected initially after 1,000 hours, and at least once every 500 hours thereafter.

Lumen maintenance data collected at intervals greater than those specified in the previous paragraph must not be used as this may compromise the accuracy of the projection results. In addition, section 4.2 of IES TM–28–14 indicates that lumen maintenance data must be collected within a ± 48 hour window of each measurement point, *e.g.,* for 1000-hour intervals, between 952 hours and 1048 hours, between 1952 and 2048 hours, etc. This ± 48 hour data collection window is also applicable to other intervals smaller than 1,000 hours. Furthermore, section 4.2 specifies that lumen maintenance data used for the projection calculation must be equally dispersed in time (to within ± 48 hours), and that no two consecutive data collection intervals after the initial 1,000 hours shall differ by more than 96 hours in length. Therefore, data may be used in the projection calculation if they are collected every 1,000 hours (± 48 hours), every 500 hours (± 48 hours), etc., but not every 1,000 hours and occasionally at 500 hours, as this will give excessive statistical weight to certain data points. *Id.*

CA IOUs and EEAs agreed with DOE's proposal, stating that regular data collection intervals, such as 1,000 hours, allow for the identification of early lamp failures. (CA IOUs, No. 44 at p. 4; EEAs, No. 43 at p. 2) However, NEMA disagreed with DOE's proposal for lumen maintenance collection at 1,000 hour intervals. NEMA stated that 1,000 hour test intervals are not common in practice because industry is using IES LM–80–08 and ENERGY STAR has test collection points at the 3,000 and 6,000 hour intervals. Further, NEMA commented that any change would invalidate current ENERGY STAR certification data and result in retesting of many products. (NEMA, No. 42 at p. 5) Philips agreed with NEMA's comments, adding that FTC also does not typically collect lumen maintenance data at 1,000 hour intervals and that if the test procedure is not modified, manufacturer burden will be significant due to retesting and recertification costs. (Philips, No. 41 at p. 3)

DOE disagrees with NEMA's point that industry is not familiar with gathering data at 1,000 hour intervals. Industry standards IES LM–80–08 and TM–21–11, recommended by NEMA, require and encourage lumen maintenance collection intervals of 1,000 hours or less. Thus, LED source manufacturers should already be conducting tests using 1,000 hour intervals at a minimum. DOE also notes that lamp manufacturers certify many of their lamps with the ENERGY STAR program, which, as NEMA states, requires more than one measurement of lumen maintenance. While DOE requires additional measurements of lumen maintenance, DOE notes that interval measurements, in general, improve the overall quality of the lifetime projection. DOE is aware that additional measurements may increase the burden on manufacturers and accounted for the testing of lamps in the test burden calculations discussed in section IV.B. Finally, the ENERGY STAR program references DOE's test procedures where they exist and has stated its intention to adopt DOE's test procedure for LED lamps once it is finalized.[16] Thus, data can be shared between the two programs. For these reasons, DOE maintained its approach to collect lumen output measurements at the described intervals.

b. Projection Calculation

Section 5.0 of IES TM–28–14 provides guidance for how to determine time to failure for an integrated LED lamp. For short test durations (less than 3,000 hours), IES TM–28–14 does not provide a projection method so time to failure is determined using actual test data. For test durations of 3,000 hours or greater, IES TM–28–14 provides two different methods for projecting time to failure, depending on test duration. The first is a direct extrapolation method for projecting time to failure based on lumen maintenance data of a whole LED lamp. The second is a combined extrapolation method based on both whole LED lamp and LED source lumen maintenance data. DOE discusses these provisions of IES TM–28–14 in more detail in this section.

IES TM–28–14 does not provide a lumen maintenance projection method if IES LM–84–14 testing has been completed for a total elapsed operating time of less than 3,000 hours. IES TM–28–14 indicates that the prediction may be unreliable since the spread of prediction estimates increases significantly for data sets that do not meet the minimum test duration requirements for the either the direct or combined extrapolation methods. On the basis of the limited dataset potentially yielding unreliable projections, DOE proposed in the July 2015 SNOPR no projection of time to failure for test durations less than 3,000 hours. Instead, time to failure would equal the test duration. 80 FR at 39653.

For test durations of at least 6,000 hours, the IES TM–28–14 procedures recommend use of a direct extrapolation method. The direct extrapolation method uses an exponential least squares curve-fit to extrapolate lumen maintenance measurements of the complete integrated LED lamp to the time point where lumen maintenance decreases to 70 percent of its initial lumen output. 80 FR at 39653–54.

The direct extrapolation method described in section 5.1 of IES TM–28–14 for projecting time to failure based on lumen maintenance data of a whole LED lamp is similar to DOE's June 2014 SNOPR proposal. 79 FR 32035. However, where DOE's June 2014 SNOPR projected time to failure based on the underlying exponential decay function in ENERGY STAR's Program Requirements Product Specification for Lamps (Light Bulbs) Version 1.0,[17] IES TM–28–14 projects time to failure based on the data obtained for each individual LED lamp. Thus, in the July 2015 SNOPR, DOE proposed to incorporate the direct extrapolation method provided in section 5.1 of IES TM–28–14, as this should result in more accurate projections. 80 FR at 39654.

Although DOE proposed referencing the direct extrapolation method specified in section 5.1 of IES TM–28–14 for projecting time to failure of LED lamp lumen maintenance data (tested as

[16] See page 3 of Draft 3 of the ENERGY STAR Program Requirements: Product Specification for Lamps (Light Bulbs) Version 2.0, *http://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.0%20Draft%203%20Specification.pdf.*

[17] ''ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) Version 1.0.'' U.S. Environmental Protection Agency, August 28, 2013.

described in sections III.D.1 through III.D.3), the July 2015 SNOPR also proposed the following modification for consistency with DOE's reporting requirements: Measured lumen maintenance data of all the LED lamp samples must not be averaged, and the averaging procedures specified in section 5.1.2 of IES TM–28–14 must not be used. Instead, DOE proposed that the projection calculation be completed for each individual LED lamp and the projected time to failure values be used to calculate the lifetime of the sample using proposed alternative procedures, which are discussed in section III.F.3. *Id.*

If at least 3,000 hours but less than 6,000 hours of whole-lamp lumen maintenance data is available, IES TM–28–14 recommends a combined extrapolation method. This method uses IES TM–21–11 to project the data collected from IES LM–80–08, which measures lumen maintenance of the LED source component. This method then corrects for additional lumen maintenance losses in the complete integrated LED lamp, if they are observed during whole-lamp testing.

DOE proposed not to reference the combined extrapolation method described in section 5.2 of IES TM–28–14 for tests where at least 3,000 hours, but less than 6,000 hours, of whole-lamp lumen maintenance test data are available. The requirement to use lumen maintenance data of the LED source component would require disassembly of the lamp, which could necessitate irreversible modifications to the lamp and introduce potential for error and variation in the measurements. *Id.* Furthermore, failure of an integrated LED lamp is often determined by components other than the LED source, as many stakeholders described in comments to the NOPR test procedure. 79 FR 32030.

In place of the combined extrapolation method for test durations of at least 3,000 hours but less than 6,000 hours, DOE proposed to use the direct extrapolation method specified in section 5.1 of IES TM–28–14 but to lower the maximum allowed time to failure claim. Section 5.1.5 of IES TM–28–14 provides instruction for how to limit time to failure claims depending on sample size. Because DOE requires a sample size of a least ten LED lamps, the projected time to failure, as specified in Table 1 in section 5.1.5 of IES TM–28–14, would be limited to no more than six times the test duration for test durations greater than or equal to 6,000 hours. However, to account for the increased uncertainty in lowering the threshold for the direct extrapolation method to 3,000 hours, DOE proposed to reduce the maximum time to failure claims based on the test duration. For this test duration range, DOE proposed a maximum projection limit that scales linearly from one times the test duration (the effective limit for test durations less than 3,000 hours) to approximately six times the test duration (the limit for test durations greater than or equal to 6,000 hours). 80 FR at 39654.

In summary, DOE proposed to determine time to failure using the following procedures:

(1) If the test duration is less than 3,000 hours:

No projection of lumen maintenance data is permitted, and time to failure equals the test duration or the recorded time at which the lamp reaches 70 percent lumen maintenance, whichever is of lesser value. See section III.D.3.g for more details on how lamp failure is recorded during lumen maintenance testing.

(2) If the test duration is greater than or equal to 3,000 and less than 6,000 hours:

The direct extrapolation method specified in sections 5.1.3 and 5.1.4 of IES TM–28–14 must be utilized. The maximum time to failure claim is determined by multiplying the test duration by the limiting multiplier calculated in the following equation:

$$Limiting\ multiplier = \frac{1}{600} * test\ duration - 4$$

Where *test duration* is expressed in hours.

This equation is a linear function that equals one when the test duration is equal to 3,000 hours and six at 6,000 hours. As an example, if an LED lamp is tested for 4,500 hours, the maximum time to failure that could be reported based on this approach is 15,750 hours (3.5 times the test duration of 4,500 hours). The limiting multiplier increases as the test duration increases until the test duration equals 6,000 hours where it is set at a value of six.

(3) If the test duration is greater than or equal to 6,000 hours:

The direct extrapolation method specified in sections 5.1.3 and 5.1.4 of IES TM–28–14 must be utilized. The projected time to failure is limited to no more than six times the test duration.

DOE received several comments regarding the proposed lifetime projection methods for the LED lamps test procedure. EEAs supported DOE's proposal of not allowing lamps with test durations less than 3,000 hours to project time to failure. (EEAs, No. 43 at p. 2) CA IOUs agreed, adding that the formulas provided by DOE to identify the maximum allowable lifetime claim are appropriate, and they would not recommend the maximum allowable lifetime claim to be increased based only on test duration. (CA IOUs, No. 44 at p. 4–5)

Regarding lamps with test durations greater than or equal to 3,000 and less than 6,000 hours, DOE is removing the reference to section 5.1.3 of IES TM–28–14 to describe the data used for the direct extrapolation method. DOE notes that most of that section refers to test durations of 6,000 hours or greater and is therefore not relevant. However, DOE is maintaining the instruction to disregard data collected prior to 1,000 hours of operating time as this requirement would be applicable to lamps with test durations greater than or equal to 3,000 and less than 6,000 hours.

NEMA commented that IES TM–28–14 should not be used to project lifetime for the entire lamp, as the standard is intended to project lumen maintenance and not electronic failures that may occur in the lamp. (NEMA, No. 42 at p. 6) CA IOUs similarly noted that DOE's proposal has the potential to derive misleading results in lifetime claims, as it currently does not account for the durability of the electronics that drive the LED source. CA IOUs cited a study that claimed LED electronics are more likely to fail before the LED sources.[18] (CA IOUs, No. 44 at p. 3)

DOE is aware that electronic components in lamps may fail before the LEDs themselves. As described in section III.D.4, this is why DOE is adopting a test procedure that measures performance of the whole lamp rather than just the LED component. While there may be a general belief in the industry that electrical components will fail before the LED component, there remains no method in existing literature or industry standards to predict the

[18] Sarah D. Shepherd, *et al.,* ''New understandings of failure modes in SSL luminaires,'' September 2014. *http://spie.org/Publications/Proceedings/Paper/10.1117/12.2062243.*

failure of the electronic components of the LED lamp. DOE will continue to monitor industry publications and may update the test procedure to include such a method if it is introduced in the future. In this final rule, DOE is adopting the lumen maintenance projection methods described earlier to determine time to failure.

E. Adopted Approach for Standby Mode Power

As explained in the July 2015 SNOPR, EPCA section 325(gg)(2)(A) 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. As IEC Standard 62087 does not apply to this rulemaking, in the July 2015 SNOPR, DOE proposed procedures consistent with those outlined in IEC Standard 62301, which applies generally to household electrical appliances. 80 FR at 39654–39655. However, to develop a test method that would be familiar to LED lamp manufacturers and maintain consistent requirements to the active mode test procedure, DOE referenced language and methodologies presented in IES LM–79–08 for test conditions and test setup requirements.

DOE received several comments questioning whether the test procedure is intended to address smart or connected lamps (*i.e.,* lamps that are controlled via wireless network communication). EEAs and CA IOUs requested that the test procedure specifically address smart or connected LED lamps in its test procedure for measuring standby power. The organizations noted that these particular LED lamps are increasing in popularity and suggested that it is imperative for DOE to incorporate them into the test procedure. (EEAs, No. 43 at p. 3; CA IOUs, No. 44 at p. 2) CA IOUs also suggested DOE solicit feedback from industry stakeholders regarding the test procedure's applicability to connected LED lamps. They requested, though, that if the test procedure is not addressing these lamps, then DOE should specifically exclude them from the scope of coverage. (CA IOUs, No. 44 at p. 3)

To further support including connected lamps in this test procedure, CA IOUs noted that in some scenarios these lamp types may consume more annual energy in standby mode than in active mode, therefore standby mode power must be adequately measured and accounted for to prevent consumers from being misled by the yearly energy cost label on purchased products. CA IOUs also commented that as currently written, the DOE test procedure may not be addressing connected lamps in its reference of IEC 62301. CA IOUs asked DOE to reference IEC 62301 in its entirety and specifically discuss its relation to testing smart or connected LED lamps. They noted that section 5 of IEC 62301, which DOE incorporated by reference, does not specifically mention connected products. CA IOUs also indicated that section 5 may not specifically cover instructions for connecting a lamp to a wireless network or for measuring the faster ''cyclic'' power conditions, as described by IEC 62301,[19] of these product types. They commented that the cyclic nature of these lamps is likely as fast as several times per second. (CA IOUs, No. 44 at pp. 2–3)

DOE agrees with CA IOUs and EEAs that the LED lamps test procedure needs to address the standby mode power of smart or connected LED lamps. The lamps described by CA IOUs and EEAs meet DOE's definition of an integrated LED lamp, and, therefore, they are included in the scope of this test procedure. Further, DOE's definition of standby mode includes the mode by which connected lamps operate, and the test procedures found in section 5 of IEC 62301 can be applied to these lamps. The DOE test procedure outlines the necessary steps to use the IEC test method for these lamp types.

Regarding the cyclic nature of these lamps, DOE clarifies that, although IEC 62301 states a regular sequence of power states may occur over minutes or hours, IEC 62301 contains procedures to collect power fluctuations within those power states. DOE agrees that power fluctuations of connected lamps are of concern, and IEC 62301 specifies to collect data at equal intervals of 0.25 seconds or faster for power loads that are unsteady or where there are any regular or irregular power fluctuations. Therefore, IEC 62301 is appropriate for testing connected lamps.

In the July 2015 SNOPR, DOE noted that a standby mode power measurement is an input power measurement made while the LED lamp is connected to the main power source, but is not generating light (an active mode feature). DOE proposed in the July 2015 SNOPR that all test condition and test setup requirements used for active mode measurements (*e.g.,* input power) (see sections III.C.1 and III.C.2) also would apply to standby mode power measurements. However, because DOE proposed to measure the power consumed, not the light output (light output is zero in standby mode by definition), the stabilization procedures are required for input power only and not lumen output. After the lamp has stabilized, the technician would send a signal to the LED lamp instructing it to provide zero light output. The technician would then measure standby power in accordance with section 5 of IEC 62301. 80 FR at 39655. In the July 2015 SNOPR, DOE also proposed to clarify that standby mode measurements may be taken before or after active mode measurements of lumen output, input power, CCT, CRI, power factor, and lamp efficacy, but must be taken before the active mode measurement of and calculation of time to failure. *Id.*

NEMA commented that it agreed with DOE's proposal to determine stabilization for standby mode measurements using power measurements only. (NEMA, No. 42 at p. 6)

Since the publication of the July 2015 SNOPR, DOE has discovered that the stabilization criteria in IES LM–79–08 may result in a scenario where lamps operating in standby mode are unable to be stabilized, due to the variable nature of standby mode power in LED lamps. Therefore, DOE has modified its approach for stabilizing lamps to use the stabilization criteria specified in section 5 of IEC 62301 instead of IES LM–79–08. The criteria detailed in IEC 62301 were designed to specifically address power patterns that occur in a standby state. IEC 62301 specifies to take the average power of several comparison periods (rather than picking individual power measurements as in IES LM–79–08), and to determine that stabilization has occurred after the power difference between the two comparison periods divided by the time difference of the midpoints of the comparison periods has a slope less than 10 mW/h (for products with input powers less than or equal to 1 W) or 1 percent of the measured input power per hour (for products where the input power is greater than 1 W). Using the average power of the comparison periods when determining stabilization accounts for power fluctuations during standby mode. Thus, DOE is requiring in this final rule that LED lamps be stabilized per section 5 of IEC 62301 prior to standby mode power measurements.

CA IOUs requested that DOE define network mode and suggested that if a product is designed to be connected to

[19] IEC 62301 describes cyclic as ''a regular sequence of power states that occur over several minutes or hours.''

a wireless network in order to fully operate, then the test procedure should specify that the lamp is to be connected to the network before standby mode testing begins. Connected lamps may require the use of an external control system or hub to serve as a communication point between the lamp and end user, and CA IOUs asked DOE to specify a maximum permissible distance the control system can be from the lamp during testing. (CA IOUs, No. 44 at p. 3)

DOE agrees that the test procedure needs additional detail to specify that the lamp must remain connected to the communication network through the entirety of the standby mode test. If the lamp becomes disconnected, the lamp may exit standby mode or otherwise have its power consumption impacted, which would yield inaccurate test results. Therefore, DOE is adding detail to section 5 of appendix BB to subpart B of part 430 to specify that the integrated LED lamp must be connected to the communication network prior to testing and must remain connected throughout the entire duration of the test. DOE did not specify a maximum distance the lamp can be from the control system or hub during testing. DOE's requirement for the lamp to remain connected throughout the entire duration of the test ensures that if a lamp is moved to a distance such that it disconnects from the communication network, the test results are invalid.

CA IOUs also commented that connected lamps may experience cycles or power fluctuations when lamps are communicating with the wireless network, so the test procedure should specifically provide instructions to account for this in an average power metric over a minimum five minute test duration. (CA IOUs, No. 44 at p. 3) DOE notes that section 5 of IEC 62301 gives manufacturers the flexibility to choose the measurement method that best applies to the nature of their products' power supply. Further, each of the methods available for use in IEC 62301 specify that the product must have test durations of at least ten minutes, which is an adequate test duration to ensure wattage fluctuations have been recorded.

Lastly, CA IOUs provided several general recommendations for DOE to enhance the standby portion of the test procedure. They recommended DOE review EU Regulation 801/2013,[20] which has made advancements in standby power measurements for household electronic equipment. Additionally, CA IOUs advised DOE to conduct testing on connected lamps to further develop the test procedure based on the results from testing and CA IOUs' suggestions. (CA IOUs, No. 44 at p. 3)

DOE appreciates the feedback from CA IOUs on the standby mode test procedure. DOE notes it is required by statute, as previously mentioned, to consider IEC 62301 or IEC 62087 to establish test procedures for standby mode power consumption. Thus, if DOE were to include provisions from EU Regulation 801/2013, it would be supplementary material that DOE has determined is necessary for accurately measuring the standby power consumption of LED lamps. DOE reviewed EU Regulation 801/2013 and found several similarities between it and IEC 62301. For example, EU Regulation 801/2013 indicates tests are to be conducted at ambient temperatures, directs the test unit to be put into a standby state for testing, and requires the lamp to remain connected to the network throughout testing. DOE's test procedure, which references IEC 62301, also includes these directions. Although EU Regulation 801/2013 addresses how to test products with multiple network connections, DOE has not identified any integrated LED lamps at this time with multiple network ports. In its review, DOE did not find any instruction in EU Regulation 801/2013 that would more accurately measure standby mode power and, therefore, DOE is not adding specific methodology from EU Regulation 801/2013 to this test procedure. DOE notes that it conducted testing on connected lamps [21] and modified this test procedure as appropriate using results from testing (*e.g.,* the modified stabilization criteria), suggestions from stakeholders, and additional research into commercially available LED lamps that can operate in standby mode.

F. Basic Model, Minimum Sample Size, and Determination of Represented Values

1. Basic Model

In the June 2014 SNOPR, DOE proposed to revise the term ''basic model'' in 10 CFR 430.2 for LED lamps; however upon further review, DOE determined in the July 2015 SNOPR that a revised definition of basic model specific to integrated LED lamps is not necessary for the general service lamp energy conservation rulemaking (see public docket EERE–2013–BT–STD–0051). LED lamps with different CCT, CRI, or lifetime could be categorized as the same basic model if they have the same efficacy. DOE noted that all products included in a basic model must comply with the certified values, and products in the same basic model must also have the same light output and electrical characteristics (including lumens per watt) when represented in manufacturer literature. 80 FR at 39655.

2. Minimum Sample Size

In the July 2015 SNOPR, DOE maintained its proposal to require a sample size of at least ten LED lamps. DOE proposed that a minimum of ten LED lamps must be tested to determine the input power, lumen output, efficacy, power factor, CCT, CRI, lifetime, and standby mode power. 80 FR at 39655–56. DOE also proposed that the general requirements of 429.11(a) are applicable except that the sample must be comprised of production units. 80 FR at 39664. Regarding inclusion of all 10 lamps in the reported results, DOE maintained in the July 2015 SNOPR that LED lamp failure should not be exempt from reporting because this would potentially mislead consumers, particularly with respect to lamp lifetime. 80 FR at 39656.

3. Determination of Represented Values

In the July 2015 SNOPR, DOE proposed calculations to determine represented values for CCT, lumen output, efficacy, power factor, and CRI using a lower confidence limit (LCL) equation, and input power and standby mode power using an upper confidence limit (UCL) equation. 80 FR at 39656–57. LED lamp test data provided by ENERGY STAR as well as Pacific Gas and Electric Company (hereafter referred to as PG&E), the Collaborative Labeling and Appliance Standards Program (hereafter referred to as CLASP), and California Lighting Technology Center (hereafter referred to as CLTC) were used to derive the confidence level and sample maximum divisor for each metric. Because certification testing is permitted to take place at one test laboratory, the sample set is unlikely to include inter-lab variability. Therefore, as stated in the July 2015 SNOPR, DOE does not include an inter-lab variability parameter in its calculation of the divisor when establishing rating requirements that are based on certification testing for which the manufacturer chooses the lab to

[20] European Union, ''Commission Regulation No 801/2013,'' August 2013. *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:225:0001:0012:en:PDF.*

[21] DOE conducted testing on connected LED lamps for the GSL energy conservation standards NOPR to determine standby power consumption for these lamp types. Test results are discussed in detail in the GSL NOPR TSD, which can be found at *http://www.regulations.gov/#!docketDetail;D=EERE-2013-BT-STD-0051.*

conduct such testing. 80 FR at 39657. Descriptions of each of the LCL and UCL calculations are provided as follows.

DOE proposed in the July 2015 SNOPR that the CCT of the units be averaged and that average be rounded as specified in the July 2015 SNOPR. 80 FR at 39656. The average CCT would be calculated using the following equation:

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

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

DOE proposed in the July 2015 SNOPR that the represented values of lumen output or efficacy be equal to or less than the lower of the average lumen output or efficacy of the sample set and the 99 percent LCL of the true mean divided by 0.96. Additionally, DOE proposed that the represented value of CRI or power factor be equal to or less than the lower of the average CRI or power factor of the sample set and the 99 percent LCL of the true mean divided by 0.98. 80 FR at 39656–57. DOE proposed the following equation to calculate LCL for lumen output, efficacy, CRI, and power factor:

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

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.

DOE also proposed in the July 2015 SNOPR that the represented value of input power and standby mode power be equal to or greater than the greater of the average lumen output of the sample set and the 99 percent UCL of the true mean divided by 1.02. *Id.* DOE proposed 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.

Regarding DOE's proposed LCL/D and UCL/D statistical methodology to determine represented values, NEMA asked DOE to instead consider using just the sample mean for statistical estimation. NEMA asserted that DOE's current approach is not an unbiased methodology, because the choice of divisor, D, is fixed through an assumed standard deviation of the sample population. Therefore, NEMA noted that if the actual standard deviation varies from that assumed in calculating the fixed divisor, then bias or inaccuracies in the statistical representation may occur. (NEMA, No. 42 at pp. 6–7)

DOE notes that the statistical divisors are based on multiple data sources and are based on the average expected standard deviation in a sample set of lamps. If a manufacturer finds its sample set of lamps has higher standard deviation than DOE's average estimate, the LCL/D is likely to be the lower value. If the standard deviation is less than DOE's estimate, then the mean is expected to be the lower value. This system does not bias the represented value, rather the represented value is in part a function of the variability in the sample of lamps. Samples of lamps with higher than expected variability are expected to report a value equal to or lesser than the LCL/D to limit the degree to which consumers experience less than advertised performance in any given lamp unit. DOE further notes that NEMA's suggestion, using only the sample mean, will not account for the variability that was observed within each data set. Thus, the proposed represented value requirements present the ''best'' value that manufacturers may report, and DOE maintains the statistical approach that was proposed in the July 2015 SNOPR.

Similarly, DOE received comment on the data provided by ENERGY STAR, PG&E, CLASP, and CLTC that DOE used to derive the confidence level and sample mean divisor for lumen output, input power, efficacy, CRI, and power factor. NEMA disagreed with the use of these data as the sample sets used do not account for inter-lab variation. NEMA noted that this may create an unbalanced testing and verification system where labs that generate more favorable results for manufacturers will be used more often than their counterparts. NEMA asked DOE to consider inter-lab variation in the standards rulemaking or incorporate it into the LED lamps test procedure. (NEMA, No. 42 at p. 7) DOE notes that manufacturers must use the test procedures adopted in this rulemaking to both certify compliance with applicable energy conservation standards and make representations for integrated LED lamps. A manufacturer may choose any lab that meets the accreditation requirements adopted in 10 CFR 430.25 to test its products. Regardless of the lab chosen, the manufacturer must follow the relevant sampling requirements and calculations in 10 CFR 429 to determine the represented values, which use statistical methods to account for test procedure and production variability based upon a multi-unit sample. In addition, if DOE has reason to believe that a basic model does not comply with the applicable energy conservation standard, then DOE may initiate an enforcement investigation to determine whether a particular basic model complies. As to NEMA's concern regarding inter-lab variation, DOE notes that its enforcement provisions address inter-lab variability because they use a confidence limit that is broader than the one used for certification testing and also require a multi-unit sample to determine compliance. Therefore, DOE is not revising its test procedure at this time because the existing enforcement provisions already account for inter-lab variation with regards to determining compliance and address NEMA's concern.

NEMA also disagreed with DOE's proposal for power factor variability in the July 2015 SNOPR, citing that the input power in the numerator and the product of input current and input voltage in the denominator are highly correlated. As an alternative, NEMA noted that it is in the process of revising LSD–63 to include a direct measurement of power factor at four independent labs. Lastly, NEMA recommended for DOE to gather power factor measurements from a random production sample, measure the lamps at several different labs to correctly estimate inter-lab variation, specify the reporting of the sample mean in the LED lamps test procedure, and add a tolerance for inter-lab variation in the standards rulemaking. (NEMA, No. 42 at p. 7)

DOE disagrees with NEMA's assertion that power factor variability was incorrectly accounted for in the July 2015 SNOPR. DOE used a power factor divisor of 0.98 (same divisor as input power) because power factor is a ratio of power measurements and is expected to have comparable variability to input power. Therefore, DOE maintained the proposal in the July 2015 SNOPR. DOE also notes that it will review LSD–63 as it becomes available and that DOE has addressed inter-lab variation as described above.

Additionally in the July 2015 SNOPR, DOE proposed that the definition of lifetime should be revised to better align with the EPCA definition of lifetime in 42 U.S.C. 6291(30)(P). 80 FR 39656. Therefore, DOE added that the lifetime of an integrated LED lamp is calculated

by determining the median time to failure of the sample (calculated as the arithmetic mean of the time to failure of the two middle sample units when the numbers are sorted in value order).

DOE received comments from EEAs and CA IOUs regarding the proposed method for determining LED lamp lifetime. EEAs and CA IOUs disagreed with DOE's proposal, which calculates lifetime as the median time to failure of a sample of 10 lamps. EEAs cited early failure concerns with LED lamps as a deterrent for having the lifetime test method based only on lumen maintenance and median time to failure. EEAs pointed to the CFL early failure study (as discussed in section III.D.4.b) as a possible reason for concern with LED lamps. (EEAs, No. 43 at pp. 1–2) EEAs and CA IOUs requested that DOE reinterpret its definition of lifetime, which is currently based on the statutory definition of lifetime in 42 U.S.C. 6291(30)(P). EEAs and CA IOUs noted that DOE's current proposal (*i.e.,* median time to failure) can create a situation in which manufacturers can project a typical lifetime for an LED lamp based on a sample that actually had four early failures. They cautioned DOE that manufacturers may be able to take advantage of this potential loophole in the test procedure and avoid having to account for early failures. EEAs and CA IOUs recommended DOE interpret the statute so that it can define failure of 50 percent of the sample units as the mean time to failure of the entire sample set, instead of the mean of the middle two units. (EEAs, No. 43 at p. 2; CA IOUs, No. 44 at pp. 4–5) Alternatively, CA IOUs suggested using a calculation to project out the rate at which 50 percent of the sample would be expected to fail for a sample set that had multiple products fail before the end of the test duration. (CA IOUs, No. 44 at p. 5)

DOE understands the concern from EEAs and CA IOUs regarding the effect of lamps with early failures on overall lifetime projections. However, the definition of lamp lifetime is set by statute in 42 U.S.C. 6291(30)(P). DOE notes that the current definition is also consistent with other lighting products. Further, DOE expects that if there is an issue with consistent early failures for a particular lamp model, then the whole sample would generally be impacted. If a product line often has early failures, it would be very unlikely for manufacturers to be able to manipulate the sample by selecting only a few lamps that do not fail early and represent an inflated lifetime. Additionally, it is impossible to determine if a lamp will fail early by visibly inspecting the lamp unless there is obvious physical damage. Such lamps would not qualify to be tested so manufacturers cannot employ this strategy in their test samples.

In the July 2015 SNOPR, DOE also proposed that the represented value of life (in years) of an integrated LED lamp be calculated by dividing the lifetime by the estimated annual operating hours as specified in 16 CFR 305.15(b)(3)(iii). Further, DOE proposed that the represented value of estimated annual energy cost (expressed in dollars per year) must be the product of the input power in kilowatts, 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). 80 FR 39664–39665.

DOE received comments from NEMA asking DOE to incorporate a three percent tolerance in measured lumen output values, which would align with the ENERGY STAR Lamps Specification V2.0. NEMA reasoned that this would improve consistency between the two programs and reduce burden on manufacturers. (NEMA, No. 42 at p. 8) DOE notes that it does not incorporate tolerances into test procedures and variability is accounted for in the sampling plan discussed previously. Therefore, DOE did not adopt a three percent tolerance in measured lumen output values in this test procedure.

G. Rounding Requirements

In the July 2015 SNOPR, DOE proposed individual unit and sample rounding requirements for lumen output, input power, efficacy, CCT, CRI, lifetime, time to failure, standby mode power, and power factor. In this final rule, DOE removed all individual unit rounding requirements for these metrics and maintained rounding requirements for only the represented values.

DOE proposed that the active mode and standby mode input power of integrated LED lamps be rounded to the nearest tenths of a watt. DOE also proposed that the efficacy of LED lamps be rounded to the nearest tenth of a lumen per watt as this is consistent with rounding for other lighting technologies and is achievable with today's equipment. 80 FR at 39665. Based on a review of commercially available LED lamps as well as testing equipment measurement capabilities, DOE proposed that the lumen output of LED lamps be rounded to three significant figures as this is an achievable level of accuracy for LED lamps. DOE further proposed that lifetime of LED lamps be rounded to the nearest whole hour. Rounding to the nearest whole hour 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. 80 FR at 39657.

DOE only received comments on the proposals for CCT and power factor and therefore adopts the rounding requirements for the other metrics in this final rule. The following sections describe the specific comments on the proposals for rounding CCT and power factor in the July 2015 SNOPR.

1. Correlated Color Temperature

In the July 2015 SNOPR, DOE proposed to round CCT values for individual units to the tens place and round the certified CCT values for the sample to the hundreds place. DOE is not following a nominal CCT methodology and therefore proposed rounding to the nearest tens digit for measurements of individual lamp units, and proposed rounding certified CCT values for the complete sample to the hundreds place. 80 FR at 39657.

NEMA commented that the text in CFR 430.23(dd)(4) should be modified to round CCT to the nearest 100 Kelvin. (NEMA, No. 42 at p. 8) DOE notes that in this final rule it is removing the rounding requirements for individual units and requiring the represented value of CCT to be rounded to the nearest 100 Kelvin.

The Republic of Korea raised a concern to DOE regarding the measurement uncertainty of LED lamps with high CCTs. They cited a study from the International Energy Agency [22] and noted that lamps with CCTs above 6,500 K have measurement uncertainty over ±100 K. The Republic of Korea commented that the proposed rounding requirements may lead to a certified CCT range of approximately ±50 K from the individual lamp units. Due to the possibility of high CCT measurement uncertainty, the Republic of Korea requested DOE to provide a range of CCT values that are considered for tolerance and measurement uncertainty. (Republic of Korea, No. 45 at p. 2)

As mentioned previously, DOE does not incorporate measurement tolerances into test methods. Tolerances are accounted for in the sampling provisions and requirements for representations. Further, this test procedure has been developed to ensure reliable results across varying color temperatures. The same test method must be used for lamps of all possible

[22] International Energy Agency, ''Solid State Lighting Annex 2013 Interlaboratory Comparison Final Report,'' September 2014. *http://ssl.iea-4e.org/files/otherfiles/0000/0067/IC2013_Final_Report_final_10.09.2014a.pdf.*

CCT values in order for manufacturers to make consistent representations of CCT on product labels and marketing materials. When measuring CCT, the represented value of the sample is equal to the mean of the sample. DOE notes that in this final rule, DOE has removed rounding requirements for individual units and maintained rounding requirements for only represented values. As DOE is requiring the represented value to be rounded to the nearest 100 K, this should account for the potential range of values cited by the Republic of Korea.

2. Power Factor

In the July 2015 SNOPR, DOE proposed that power factor be rounded to the nearest hundredths place, consistent with common usage in industry literature. 80 FR at 39657.

NEMA noted a discrepancy in two sections of the test procedure language in the July 2015 SNOPR, indicating DOE proposed to round power factor for individual test units to the nearest tenths place in 10 CFR 430.23(dd)(7) and to the nearest hundredths place in 10 CFR 429.56(c)(6). NEMA recommended rounding power factor to the nearest tenths place. (NEMA, No. 42 at pp. 7–8)

The proposal to round an individual unit value to a lower degree of specificity than what was required for the larger sample was an unintended error. However, DOE notes that it has removed the requirement to round individual test units in this final rule, thus no longer requiring individual test units to be rounded to the nearest tenths place. DOE is maintaining the proposal from the July 2015 SNOPR to round power factor for the sample to the nearest hundredths place to be consistent with common usage in industry literature and other lighting test procedures. DOE notes that these rounding requirements are consistent with the CFL test procedure rulemaking. 80 FR 45723, (July 31, 2015).

H. Interaction With ENERGY STAR

In the June 2014 SNOPR, to reduce test burden, DOE proposed allowing measurements collected for the ENERGY STAR Program Requirements Product Specification for Lamps (Light Bulbs) Version 1.0 to be used for calculating represented values of lumen output, input power, lamp efficacy, CCT, CRI, and lifetime. In the July 2015 SNOPR, DOE proposed a new test procedure for lifetime that was largely based on the IES LM–84–14 and IES TM–28–14 industry standards and provided a simple, straightforward, and flexible test procedure to account for potential future changes in the lifetime of LED products. DOE noted that the proposal in the July 2015 SNOPR projected time to failure based on data obtained for each individual LED lamp rather than assuming the same relationship between test duration and lumen maintenance applies to every LED lamp. Because DOE revised its approach for lifetime measurement and projection, there was no longer significant similarity between the DOE and ENERGY STAR lifetime test procedures. DOE noted it will work with ENERGY STAR to revise the test procedures for lifetime accordingly. 80 FR at 39657–58.

DOE received comments from NEMA regarding differences between the LED lamps test procedure and the ENERGY STAR Lamps Specification V2.0. NEMA requested that DOE analyze the increased burden of the LED lamps test procedure with respect to potential deviations from existing practices (*e.g.,* ENERGY STAR). NEMA noted that a test procedure with significant differences from existing methods will affect existing products, in addition to new products, and many products on the market would have to be retested. Therefore, NEMA asked DOE to minimize changes between the ENERGY STAR Lamps Specification V2.0 and DOE's LED lamps test procedure. (NEMA, No. 42 at p. 2) NEMA also cautioned that because the ENERGY STAR program accommodates DOE test procedures in its specifications, any additional revisions to the LED lamps test procedure will delay the finalization of the ENERGY STAR Lamps Specification V2.0. (NEMA, No. 42 at pp. 5–6)

As mentioned in section III.D.4.a, ENERGY STAR has stated that it will reference DOE's test procedure upon completion.[16] DOE further notes that measurements collected for the ENERGY STAR Lamps Specification V1.1 and ENERGY STAR Lamps Specification V2.0 (when it requires compliance) can be used for calculating represented values of energy efficiency or consumption metrics covered by the DOE test procedure as long as those measurements were collected in accordance with the DOE test procedure. Manufacturers must make representations in accordance with the DOE test procedure and represented value determination method beginning 180 days after publication of the final rule in the **Federal Register**.

I. Laboratory Accreditation

Regarding the National Voluntary Laboratory Accreditation Program (NVLAP) accreditation, in the July 2015 SNOPR DOE proposed to require lumen output, input power, lamp efficacy, power factor, CCT, CRI, lifetime, and standby mode power (if applicable) testing be conducted by test laboratories accredited by NVLAP or an accrediting organization recognized by the International Laboratory Accreditation Cooperation (ILAC). NVLAP is a member of ILAC, so test data collected by any laboratory accredited by an accrediting body recognized by ILAC would be acceptable. DOE also proposed to state directly that accreditation by an Accreditation Body that is a signatory member to the ILAC Mutual Recognition Arrangement (MRA) is an acceptable means of laboratory accreditation. 80 FR at 39658.

DOE received comments on a possible issue with test laboratories achieving accreditation to the DOE test procedure. NEMA recommended that DOE adopt industry standards and test procedures without modification, citing that this would reduce burden and prevent issues with laboratory accreditation to the LED TP. NEMA also commented that labs accredited to an industry standard by NVLAP must conduct testing using that particular standard rather than a test procedure styled after an industry standard. (NEMA, No. 42 at p. 4) DOE notes that laboratories and other testing bodies can obtain accreditation directly to a DOE test procedure through NVLAP (*e.g.,* the fluorescent lamp ballast test procedure), thus DOE maintains the lab accreditation requirements from the July 2015 SNOPR.

J. Certification

In the July 2015 SNOPR, DOE proposed certification requirements for LED lamps. Manufacturers will not have to certify values to DOE unless standards are promulgated for LED lamps as part of the rulemaking for general service lamps. However, DOE provided certification requirements and the ability to certify by CCMS to enable FTC to allow manufacturers to submit data through DOE's Compliance Certification Management System (CCMS) related to FTC labeling requirements. *Id.*

DOE recognized that testing of LED lamp lifetime can require considerably more time than testing of other LED lamp metrics. Therefore, DOE proposed to allow new basic models of LED lamps to be distributed prior to completion of the full testing for lifetime. Similar to treatment of GSFLs and incandescent reflector lamps in 10 CFR 429.12(e)(2), DOE proposed that prior to distribution of a new basic model of LED lamp, manufacturers must submit an initial

certification report. If testing for time to failure is not complete, manufacturers may include estimated values for lifetime and life. If reporting estimated values, the certification report must describe the prediction method and the prediction method must be generally representative of the methods specified in appendix BB to subpart B of part 430. Manufacturers are also required to maintain records per 10 CFR 429.71 of the development of all estimated values and any associated initial test data. If reporting estimated values for lifetime and life, the certification report must indicate that the values are estimated until testing for time to failure is complete. 80 FR at 39665. If, prior to completion of testing, a manufacturer ceases to distribute in commerce a basic model, the manufacturer must submit a full certification report and provide all of the information listed in 10 CFR 429.12(b), including the product-specific information required by 10 CFR 429.56(b)(2), as part of its notification to DOE that the model has been discontinued. 80 FR at 39664. For any metrics covered by the LED lamps test procedure, manufacturers must make representations in accordance with the DOE test procedure and represented value determination method beginning 180 days after publication of the final rule in the **Federal Register**.

DOE received comments on the quality of LED lamps entering the market. EEAs illustrated this concern to DOE, noting the LED lamps test procedure should ensure that poor quality LED lamps cannot be sold to consumers. They presented a series of CFL verification tests, known as the Program for the Evaluation and Assessment of Residential Lighting (PEARL), which determined compliance rates of ENERGY STAR qualified CFLs. The program tested commercially-available CFLs from 2000–2009, ultimately concluding there were a significant amount of non-compliant CFLs that were ENERGY STAR qualified. EEAs paired this with a discussion of CFL early failure rates, emphasizing that there were high early failure rates in the PEARL results for products that should have long lifetimes. The full discussion of the PEARL analysis can be found in EEAs' public comment on *regulations.gov* under docket number EERE–2011–BT–TP–0071. Ultimately, EEAs urged DOE to learn from prior experiences, such as this issue with CFLs, to prevent similar issues from occurring with LED lamps. EEAs emphasized that LED lamps are rapidly developing products and continually demanded at lower prices, which may lead manufacturers to release poor quality products. (EEAs, No. 43 at pp. 4–6)

DOE understands EEAs' concern regarding the prevention of poor quality LED lamps entering the market. DOE's adoption of a reliable, repeatable test procedure helps to ensure that the performance characteristics of integrated LED lamps are accurately represented. DOE's general service lamp rulemaking addresses energy conservation standards for certain metrics (*i.e.,* lamp efficacy and power factor). Lastly, DOE has the Compliance Certification and Enforcement (CCE) program to ensure manufacturers are testing their products and making accurate representations.

K. Effective and Compliance Date

The effective date for this test procedure will be 30 days after publication of this 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 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 procedure, manufacturers must make representations, including certification of compliance with an applicable standard, in accordance with the DOE test procedure beginning 180 days after publication of this final rule in the **Federal Register**.

Philips expressed concern in response to the July 2015 SNOPR that the 180 day period is not sufficient based on the current LED lamp lifetime projection methods in the test procedure. Philips noted that DOE is not taking into account the additional time required to expand existing test infrastructure, estimating this expansion would take at least four months to complete. Therefore, Philips suggested that DOE modify the certification period to one year. (Philips, No. 41 at p. 3) The Republic of Korea followed with a similar concern, claiming the test duration for some lamps will require a test period of ten months and also requested that DOE set its certification period to one year. (Republic of Korea, No. 45 at p. 2)

DOE did not modify the 180 day certification period in this final rule. If the in-house testing infrastructure expansion has not been completed in sufficient time, DOE has accounted for any third party testing costs that may be required for manufacturers that are unable to test their products themselves. Further, DOE notes that there is no minimum test duration for the time to failure test procedure. While DOE agrees that some tests would take at least ten months to project certain LED lamp lifetimes, DOE notes that manufacturers may submit certification reports with estimated values of lifetime until time to failure testing is complete. See section III.J for a more detailed description of the certification process.

L. Ceiling Fan Light Kits Using LED Lamps

DOE proposed to harmonize the test procedures for lamps, including LEDs, used in ceiling fan lights kits in a notice published on October 31, 2014. 79 FR 64688 (Docket EERE–2013–BT–TP–0050). The comments received as part of that docket were generally supportive of this approach and are discussed as part of that rulemaking docket. In the July 2015 SNOPR, DOE proposed to add the appropriate cross-references in the ceiling fan light kit test procedures at 429.33 and 430.23 to the integrated LED lamp test procedures. 80 FR at 39659; 39664–65. DOE received no comments on these cross references and therefore adopts them in this final rule.

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 OMB.

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, and a final regulatory flexibility analysis (FRFA) for any such rule that an agency adopts as a final rule, 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 July 2015 SNOPR and today's final rule under the provisions of the Regulatory Flexibility Act (RFA) and the policies and procedures published on February 19, 2003. DOE certifies that the rule will not have a significant economic impact on a substantial number of small entities. The factual basis for this certification is set forth in the following sections.P≤The Small Business Administration (SBA) considers a business entity to be a small business, if, together with its affiliates, it employs less than a threshold number of workers specified in 13 CFR part 121. These size standards and codes are established by the North American Industry Classification System (NAICS). The threshold number for NAICS classification code 335110, which applies to electric lamp manufacturing and includes LED lamps, is 1,250 or fewer employees.

For the July 2015 SNOPR, DOE examined the number of small businesses that will potentially be affected by the LED lamps test procedure. This evaluation revealed that the test procedure requirements proposed in the July 2015 SNOPR will apply to about 41 small business manufacturers of LED lamps. DOE compiled this list of manufacturers by reviewing the DOE LED Lighting Facts label list of partner manufacturers,[23] the SBA database, ENERGY STAR's list of qualified products,[24] performing a general search for LED manufacturers, and conferring with representatives of the DOE's solid state lighting program. 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 process, DOE identified 41 small businesses that manufacture LED lamps.

NEMA commented that DOE should confirm the number of basic models used in its calculations of testing burden including test setup and testing costs. NEMA stated that DOE did not appear to account for the different lamps that need to be tested, such as lamps of varying CCT or beam angle. NEMA further reasoned that because the LED lamp market is rapidly evolving, manufacturers produce lamps that may not reach the market but are still subject to testing as part of the development process. NEMA noted that using a number of basic models that is too low risks underweighting actual burden. (NEMA, No. 42 at pp. 2, 4)

For this final rule, DOE reviewed its estimated number of small businesses. DOE updated its list of small businesses by reviewing the DOE LED Lighting Facts Database, ENERGY STAR's list of qualified products, individual company Web sites, SBA's database, and market research tools (*e.g.,* Hoover's reports [25]). DOE screened out companies that do not offer products covered by this rulemaking, do not meet the definition of a ''small business,'' or are completely foreign owned and operated. DOE determined that seven companies were small businesses that maintain domestic production facilities for the integrated LED lamps covered by this rulemaking.

DOE understands NEMA's concerns regarding underestimating testing burden. In this final rule, DOE reports the cost of testing per basic model rather than using an average number of basic models because manufacturers may offer a greater or fewer number of basic models than the average value. DOE notes that while manufacturers may test a higher number of models than the number that are commercially available, these testing costs are not attributable to DOE's testing and certification requirements and instead are the costs associated with the typical product development cycle. DOE only accounts for testing costs that are a direct result of compliance with its test procedures and standards. Additionally, DOE notes that as discussed in section III.F, LED lamps with different CCT, CRI, lifetime, or other performance characteristics could be categorized as the same basic model provided all products included in the basic model comply with the certified values and have the same light output and electrical characteristics (including lumens per watt) when represented in manufacturer literature.

In the July 2015 SNOPR, DOE estimated that the labor costs associated with conducting the input power, lumen output, CCT, CRI, and standby mode power testing is $31.68 per hour. 80 FR 39659. Calculating efficacy and power factor of an LED lamp was determined not to result in any incremental testing burden beyond the cost of carrying out lumen output and input power testing. 80 FR 39659–39660. DOE also expected standby mode power testing to require a negligible incremental amount of time in addition to the time required for the other metrics. In total, DOE estimated that using the July 2015 SNOPR 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.

The July 2015 SNOPR also estimated that lifetime testing would contribute to overall cost burden. The initial setup including the cost to custom build test racks capable of holding 23 different LED lamp models, each tested in sample sets of ten lamps (a total of 230 LED lamps) would be $25,800. 80 FR 39660. The labor cost for lifetime testing was also determined to contribute to overall burden. For the revised lifetime test procedure proposed in the July 2015 SNOPR, a lumen output measurement is required to be recorded for multiple time intervals at a minimum of every 1,000 hours of elapsed operating time. This represented an increase in the number of required measurements in the lifetime test procedure compared to the previous proposal. DOE estimated that the combination of monitoring the lamps during the test duration, measuring lumen maintenance at multiple time intervals, and calculating lifetime at the end of the test duration would require approximately eight hours per lamp by an electrical engineering technician. DOE estimated that using this test method to determine lifetime would result in testing-related labor costs of $58,280 for each manufacturer. *Id.*

NEMA requested clarification on DOE's burden calculation. Specifically, NEMA stated that DOE's estimate of lifetime testing labor costs of $29,140 per manufacturer was debatable since the number of products varies significantly between manufacturers and is constantly changing due to the evolving nature of LED lamps. (NEMA, No. 42 at p. 8) DOE understands that the LED market is dynamic and products are continuing to evolve, however as stated previously, DOE only accounts for testing costs attributable to compliance with DOE test procedures and standards. Product development costs are not factored into this analysis. Further, DOE notes that in the July 2015 SNOPR, the estimated labor cost for lifetime testing per manufacturer was increased from $29,140 to $58,280 to reflect the additional testing intervals and increased test duration required.

Additionally, for this final rule, DOE updated its calculations to reflect an increase in labor rates and to report the

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

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

[25] Hoovers|Company Information|Industry Information|Lists, *http://www.hoovers.com.*

cost per basic model. DOE also updated its calculations to include a cost for standby power testing. DOE estimates the time needed for standby power testing to be approximately one hour per lamp. DOE estimates that the labor costs associated with conducting the input power, lumen output, CCT, CRI, and standby mode power testing is $41.68 per hour. In total, DOE estimates that using the final rule test method to determine light output, input power, CCT, CRI, and standby mode power would result in an estimated incremental labor burden of $2,080 per basic model. DOE maintains that calculating efficacy and power factor of an LED lamp would not result in any incremental testing burden beyond the cost of carrying out lumen output and input power testing. Further, DOE notes that although the cost for standby mode power testing is included, only a small portion of LED lamps are capable of standby operation and this cost would not be recognized by all manufacturers.

For this final rule, DOE also updated the lifetime testing costs based on the revised labor rates and to report a cost per basic model. DOE determined the initial setup, including the cost to custom build test racks, would be $1,410 per basic model. DOE again estimated that the combination of monitoring the lamps during the test duration, measuring lumen maintenance at multiple time intervals, and calculating lifetime at the end of the test duration would require approximately eight hours per lamp by an electrical engineering technician. Based on the revised labor rate, DOE estimates that using this test method to determine lifetime would result in testing-related labor costs of $3,330 per basic model.

Because NVLAP [26] imposes a variety of fees during the accreditation process, including fixed administrative fees, variable assessment fees, and proficiency testing fees, DOE also provided cost estimates in the July 2015 SNOPR for 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. Assuming testing instrumentation is already available, in the July 2015 SNOPR, DOE estimated 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 $87,420 for each manufacturer producing 23 basic models. *Id.* Therefore, in the first year, for manufacturers without testing racks or NVLAP accreditation who choose to test in-house, DOE estimated a maximum total cost burden of $128,540, or about $559 per LED lamp tested. DOE expected the setup cost to be a onetime cost to manufacturers. Further, the labor costs to perform testing would likely be smaller than $87,420 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 estimated testing of lumen output, input power, CCT, CRI, lifetime, and standby mode power to cost $600 per lamp. In total, DOE estimated in the July 2015 SNOPR that the LED lamp test procedure would result in expected third-party testing costs of $138,000 for each manufacturer for 23 basic models. DOE noted this would not be an annual cost. *Id.*

NEMA expressed concern that DOE's calculations for test burden do not account for normal process issues involved with third party testing and noted the calculation appears to be based only on the time required to perform the testing. NEMA commented that if a manufacturer does not have the ability to test in-house and uses a third-party lab for testing, the costs increase three to four times. (NEMA, No. 42 at p. 8) DOE agrees that testing costs at third party labs are typically higher than in-house testing and therefore, as stated previously, DOE estimated both in-house testing costs and third-party testing costs to represent the range of testing costs experienced by manufacturers.

For this final rule, DOE updated the labor rate used to calculate in-house testing costs and also updated the third-party testing costs to reflect any changes since the July 2015 SNOPR was published. DOE also reviewed the fee structure published by NVLAP,[27] which includes annual fees, assessment fees, and proficiency tests. Assuming testing instrumentation is already available, DOE estimates the average NVLAP accreditation cost per year would be $370 per basic model and, as discussed previously in this section, initial setup cost would be $1,410 per basic model and the labor costs to carry out testing would be approximately $5,420 per basic model. Therefore, in the first year, for manufacturers without testing racks or NVLAP accreditation who choose to test in-house, DOE estimates a maximum total cost burden of about $7,190 per basic model tested. Further, after the first year, the testing cost would decrease to about $5,780 per basic model tested, because the setup cost would be a onetime cost to manufacturers. For this final rule, DOE estimates the third-party testing costs would be about $7,880 per basic model.

NEMA also noted that with the inclusion of IES LM–84–14, manufacturers will incur increased costs associated with a larger test setup required for testing whole LED lamps instead of LED chips. Additionally, NEMA asked DOE to include in its test burden calculations the added lab capacity required from adopting LM–84 because an LED lamp manufacturer may now have to equip and staff a lab when it previously relied on LED chip testing from the supplier. (NEMA, No. 42 at p. 4) DOE understands there are additional costs incurred by the manufacturers as a result of this rulemaking. As discussed previously, DOE factored in the costs of testing in-house including a new test setup for testing LED lamps, NVLAP accreditation, and labor costs. In addition, manufacturers also have the option to test at a third-party lab if they prefer which DOE provided estimated costs for in this final rule.

As described in the July 2015 SNOPR, DOE notes that the cost estimates described are much larger than the actual cost increase most manufacturers will experience. 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–79–08. The IES LM–79–08 standard is also the recommended standard for testing LED lamps for the FTC Lighting Facts Label as well as the ENERGY STAR program. DOE notes that manufacturers test integrated LED lamps to provide performance characteristics for these lamps in catalogs. This testing is likely conducted according to the relevant industry standards because they represent best practice. DOE's test procedures for integrated LED lamps adopted in this final rule largely reference those industry standards. Therefore, testing integrated LED lamps according to DOE's test procedure should not be substantially different in setup and methodology.

Further, most manufacturers of integrated LED lamps already participate in the ENERGY STAR program, which includes requirements for lifetime, input power, lumen output, CCT, and CRI. 80 FR at 39660. DOE maintains that while its adopted test procedure differs from ENERGY STAR in some respects, DOE expects the

[26] As discussed in section III.I, laboratories can be accredited by any accreditation body that is a signatory member to the ILAC MRA. DOE based its estimate of the costs associated with accreditation on the NVLAP accreditation body.

[27] NVLAP Fee Structure *http://www.nist.gov/nvlap/nvlap-fee-policy.cfm*—last accessed Feb. 10, 2016

incremental difference in testing costs under the two test procedures to be significantly less than full cost of testing under the adopted DOE test procedure. This is because most manufacturers already own the requisite test equipment (*e.g.,* test racks) and already have labor expenditures corresponding to carrying out testing for ENERGY STAR. DOE and ENERGY STAR testing costs would not be additive because ENERGY STAR references DOE test procedures where they exist and revises its specification to reference new DOE test procedures when they are finalized.[28] Based on these revisions, manufacturers would not need to complete separate testing for the ENERGY STAR and DOE programs.

In summary, DOE does not consider the test procedures adopted in this final rule to have a significant economic impact on small entities. The final cost per manufacturer primarily depends on the number of basic models the manufacturer offers. The quantified testing costs are not annual costs because DOE does not require manufacturers to retest a basic model annually. The test results used to generate a certified rating for a basic model remain valid as long as the basic model has not been modified from the tested design in a way that makes it less efficient or more consumptive, which would require a change to the certified rating. If a manufacturer has modified a basic model in a way that makes it more efficient or less consumptive, new testing is required only if the manufacturer wishes to make representations of the new, more efficient rating.

Based on the criteria outlined earlier and the reasons discussed above, DOE certifies that the test procedures adopted in this final rule would not have a significant economic impact on a substantial number of small entities, and the preparation of a final regulatory flexibility analysis is not warranted. DOE has submitted a certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b).

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. 10 CFR part 429, subpart B. This collection-of-information requirement was approved by OMB under OMB Control Number 1910–1400.

DOE requested OMB approval of an extension of this information collection for three years, specifically including the collection of information in the present rulemaking, and estimated that the annual number of burden hours under this extension is 30 hours per company. In response to DOE's request, OMB approved DOE's information collection requirements covered under OMB control number 1910–1400 through November 30, 2017. 80 FR 5099 (January 30, 2015).

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 final rule, DOE adopts 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 final rule adopts existing industry test procedures for LED lamps, so it will not affect the amount, quality or distribution of energy usage, and, therefore, will 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 final rule and determined that it will 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 today's final 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, this final rule meets the relevant standards of Executive Order 12988.

[28] ENERGY STAR published a second draft of its Lamps Specification V2.0 on April 10, 2015 and included the following note on page 2: ''In an effort to provide partners with continuity and honor the Agency's intention to harmonize with applicable DOE Test Procedures, this Draft proposes to allow for use of the final test procedure for LED Lamps once it is published by DOE, where applicable.''

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. Pub. L. 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a 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 final 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 finale rule will 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 will 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 final 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 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 significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use if the regulation is implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This regulatory action to establish a test procedure for measuring the lumen output, input power, lamp efficacy, CCT, CRI, power factor, lifetime, and standby mode power of LED lamps is not a significant regulatory action under Executive Order 12866. Moreover, it will 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.

This final rule incorporates test methods contained in the following commercial standards: ANSI/IES RP–16–2010, ''Nomenclature and Definitions for Illuminating Engineering;'' IES LM–84–14, ''Approved Method: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires;'' and IES TM–28–14, ''Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires.'' 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 has consulted with the Attorney General and the Chairman of the FTC concerning the impact of these test procedures on competition and has received no comments objecting to their use.

M. Description of Standards Incorporated by Reference

In this final rule, DOE incorporates by reference the test standard published by IEC, titled ''Household electrical appliances—Measurement of standby power,'' IEC 62301 (Edition 2.0, 2011–01). IEC 62301 is an industry accepted standard that specifies test methods for determination of standby power of household electrical appliances. The test procedure for standby power adopted in this final rule references IEC 62301. IEC 62301 can be purchased from ANSI and is readily available on ANSI's Web site at *http://webstore.ansi.org.*

DOE also incorporates by reference the test standard published by ANSI and

IES, titled ''Nomenclature and Definitions for Illuminating Engineering,'' ANSI/IES RP–16–2010. ANSI/IES RP–16–2010 is an industry accepted standard that specifies definitions related to lighting and is applicable to products sold in North America. The definition of integrated LED lamp adopted in this final rule references ANSI/IES RP–16–2010. ANSI/IES RP–16–2010 is readily available on IES's Web site at *http://www.ies.org/*.

DOE also incorporates by reference the test standard published by IES, titled ''Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products''. IES LM–79–2008. IES LM–79–2008 is an industry accepted standard that specifies test methods for determination of lumen output, input power, lamp efficacy, power factor, CCT, and CRI and is applicable to LED lamp products sold in North America. The test procedure for lumen output, input power, lamp efficacy, power factor, CCT, and CRI adopted in this final rule references IES LM–79–08. IES LM–79–08 is readily available on IES's Web site at *http://www.ies.org/*.

DOE also incorporates by reference the test standard published by IES, titled ''Approved Method: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires,'' IES LM–84–2014. IES LM–84 is an industry accepted standard that specifies test methods for determination of lumen maintenance and is applicable to LED lamp products sold in North America. The test procedure for lifetime adopted in this final rule references IES LM–84. IES LM–84 is readily available on IES's Web site at *http://www.ies.org/*.

DOE also incorporates by reference the test standard published by IES, titled ''Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires,'' IES TM–28–2014. IES TM–28 is an industry accepted standard that specifies test methods for projection of lumen maintenance and is applicable to LED lamp products sold in North America. The test procedure for lifetime adopted in this final rule references IES TM–28. IES TM–28 is readily available on IES's Web site at *http://www.ies.org/*.

N. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule before its effective date. The report will state that it has been determined that the rule is not a ''major rule'' as defined by 5 U.S.C. 804(2).

V. Approval of the Office of the Secretary

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

List of Subjects

10 CFR Part 429

Administrative practice and procedure, 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 June 9, 2016.

Kathleen B. Hogan,

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

For the reasons stated in the preamble, DOE is amending parts 429 and 430 of chapter II, subchapter D, of title 10, of the Code of Federal Regulations, 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.

■ 2. Section 429.12(f) is revised to read as follows:

§ 429.12 General requirements applicable to certification reports.

* * * * *

(f) *Discontinued model filing.* When production of a basic model has ceased and it is no longer being sold or offered for sale by the manufacturer or private labeler, the manufacturer must report this discontinued status to DOE as part of the next annual certification report following such cessation. For each basic model, the report must include the information specified in paragraphs (b)(1) through (b)(7) of this section, except that for integrated light-emitting diode lamps, the manufacturer must submit a full certification report, including all of the information required by paragraph (b) of this section and the product-specific information required by § 429.56(b)(2).

* * * * *

■ 3. Section 429.33 is amended by adding paragraphs (a)(2)(ii), (a)(3)(i)(D), and (a)(3)(i)(F) to read as follows:

§ 429.33 Ceiling fan light kits.

(a) * * *

(2) * * *

(ii) For ceiling fan light kits with medium screw base sockets that are packaged with integrated light-emitting diode lamps, determine the represented values of each basic model of lamp packaged with the ceiling fan light kit in accordance with § 429.56.

* * * * *

(3) * * *

(i) * * *

(D) For integrated LED lamps, § 429.56.

* * * * *

(F) For other SSL lamps (not integrated LED lamps), § 429.56.

* * * * *

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

§ 429.56 Integrated light-emitting diode lamps.

(a) *Determination of Represented Value.* 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 sampling provisions in this section.

(1) *Units to be tested.*

(i) The general requirements of § 429.11 (a) are applicable except that the sample must be comprised of production units; and

(ii) For each basic model of integrated light-emitting diode lamp, the minimum number of units tested must be no less than 10 and the same sample comprised of 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 must be randomly selected and tested to ensure that:

(A) Represented values of initial lumen output, lamp efficacy, color rendering index (CRI), power factor, or other measure of energy consumption of a basic model for which consumers would favor higher values are less than or equal to the lower of:

(*1*) 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 measured value for the i^{th} unit; Or,

(*2*) The lower 99 percent confidence limit (LCL) of the true mean divided by

0.96; or the lower 99 percent confidence limit (LCL) of the true mean divided by 0.98 for CRI and power factor, 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 to this subpart).

(B) Represented values of input power, standby mode power or other measure of energy consumption of a basic model for which consumers would favor lower values are greater than or equal to the higher of:

(*1*) 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 measured value for the i^{th} unit;

Or,

(*2*) The upper 99 percent confidence limit (UCL) of the true mean divided by 1.02, 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 to this subpart);

(C) 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 in the sample; and x_i is the measured CCT for the i^{th} unit.

(D) The represented value of lifetime of an integrated light-emitting diode lamp must be equal to or less than the median time to failure of the sample (calculated as the arithmetic mean of the time to failure of the two middle sample units when the numbers are sorted in value order) rounded to the nearest hour.

(2) The represented value of life (in years) of an integrated light-emitting diode lamp must be calculated by dividing the lifetime of an integrated light-emitting diode lamp by the estimated annual operating hours as specified in 16 CFR 305.15(b)(3)(iii).

(3) The represented value of estimated annual energy cost for an integrated light-emitting diode lamp, expressed in dollars per year, must be the product of the input power in kilowatts, 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).

(b) *Certification reports.* (1) The requirements of § 429.12 are applicable to integrated light-emitting diode lamps;

(2) Values reported in certification reports are represented values. Pursuant to § 429.12(b)(13), a certification report must include the following public product-specific information: The testing laboratory's NVLAP identification number or other NVLAP-approved accreditation identification, the date of manufacture, initial lumen output in lumens (lm), input power in watts (W), lamp efficacy in lumens per watt (lm/W), CCT in kelvin (K), power factor, lifetime in years (and whether value is estimated), and life (and whether value is estimated). For lamps with multiple modes of operation (such as variable CCT or CRI), the certification report must also list which mode was selected for testing and include detail such that another laboratory could operate the lamp in the same mode. Lifetime and life are estimated values until testing is complete. When reporting estimated values, the certification report must specifically describe the prediction method, which must be generally representative of the methods specified in appendix BB. Manufacturers are required to maintain records per § 429.71 of the development of all estimated values and any associated initial test data.

(c) *Rounding requirements.* (1) Round input power to the nearest tenth of a watt.

(2) Round lumen output to three significant digits.

(3) Round lamp efficacy to the nearest tenth of a lumen per watt.

(4) Round correlated color temperature to the nearest 100 Kelvin.

(5) Round color rendering index to the nearest whole number.

(6) Round power factor to the nearest hundredths place.

(7) Round lifetime to the nearest whole hour.

(8) Round standby mode power to the nearest tenth of a watt.

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

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

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

■ 6. Section 430.2 is amended by adding in alphabetical order the definitions of ''Integrated light-emitting diode lamp'' and ''Lifetime of an integrated light-emitting diode lamp'' to read as follows:

§ 430.2 Definitions.

* * * * *

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

* * * * *

Lifetime of an integrated light-emitting diode lamp means the length of operating time between first use and failure of 50 percent of the sample units (as required by § 429.56(a)(1) of this chapter), when measured in accordance with the test procedures described in section 4 of appendix BB to subpart B of this part.

* * * * *

■ 7. Section 430.3 is amended by:

■ a. Removing the text ''appendix V1'' in paragraph (o)(9), and adding in its place, the text ''appendices V1 and BB'';

■ b. Adding paragraphs (o)(10), (o)(11) and (o)(12); and

■ c. Removing the text ''and Z'' in paragraph (p)(5), and adding in its place, the text '', Z, and BB''.

The additions read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(o) * * *

(10) IES LM–84–14, (''IES LM–84''), Approved Method: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires, approved March 31, 2014; IBR approved for appendix BB to subpart B.

(11) ANSI/IES RP–16–10 (''ANSI/IES RP–16''), Nomenclature and Definitions for Illuminating Engineering, approved October 15, 2005; IBR approved for § 430.2.

(12) IES TM–28–14, (''IES TM–28''), Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires, approved May 20, 2014; IBR approved for appendix BB to subpart B.

* * * * *

■ 8. Section 430.23 is amended by adding paragraphs (x)(1)(ii), (x)(2)(iv), and (ee) to read as follows:

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

* * * * *

(x) * * *

(1) * * *

(ii) For a ceiling fan light kit with medium screw base sockets that is packaged with integrated LED lamps, measure lamp efficacy in accordance with paragraph (ee) of this section.

* * * * *

(2) * * *

(iv) For a ceiling fan light kit packaged with integrated LED lamps, measure lamp efficacy in accordance with paragraph (ee) of this section for each lamp basic model.

* * * * *

(ee) *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.

(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.

(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.

(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.

(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.

(6) The power factor of an integrated light-emitting diode lamp must be measured in accordance with section 3 of appendix BB of this subpart.

(7) The time to failure of an integrated light-emitting diode lamp must be measured in accordance with section 4 of appendix BB of this subpart.

(8) The standby mode power must be measured in accordance with section 5 of appendix BB of this subpart.

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

§ 430.25 Laboratory Accreditation Program.

The testing for general service fluorescent lamps, general service incandescent lamps (with the exception of lifetime testing), incandescent reflector lamps, medium base compact fluorescent lamps, fluorescent lamp ballasts, and integrated light-emitting diode lamps must be conducted by test laboratories accredited by an Accreditation Body that is a signatory member to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). A manufacturer's or importer's own laboratory, if accredited, may conduct the applicable testing.

■ 10. 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), Power Factor, Time to Failure, and Standby Mode Power of Integrated Light-Emitting Diode (LED) Lamps

Note: On or after December 28, 2016, any representations made with respect to the energy use or efficiency of integrated light-emitting diode lamps must be made in accordance with the results of testing pursuant to this appendix.

1. *Scope:* This appendix specifies the test methods required to measure input power, lumen output, lamp efficacy, CCT, CRI, power factor, time to failure, and standby mode power for integrated LED lamps.

2. Definitions

2.1. The definitions specified in section 1.3 of IES LM–79–08 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 this appendix.

2.3. *Interval lumen output* means the measured lumen output at constant intervals after the initial lumen output measurement in accordance with section 4 of this appendix.

2.4. *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.

2.5. *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, in units of hours.

2.6. *Time to failure* means the time elapsed between the initial lumen output measurement and the point at which the lamp reaches 70 percent lumen maintenance as measured in section 4 of this appendix.

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

In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over IES LM–79–08 (incorporated by reference; see § 430.3).

3.1. Test Conditions and Setup

3.1.1. Establish the ambient conditions, power supply, electrical settings, and instrumentation in accordance with the specifications in sections 2.0, 3.0, 7.0, and 8.0 of IES LM–79–08 (incorporated by reference; see § 430.3), respectively.

3.1.2. Position an equal number of integrated LED lamps in the base-up and base-down orientations throughout testing; if the position is restricted by the manufacturer, test units in the manufacturer-specified position.

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

3.1.4. Operate the lamp at the 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 sections 3 and 4 of this appendix must be taken at the same selected mode. The test report must indicate which mode was selected for testing and include detail such that another laboratory could operate the lamp in the same mode.

3.2. Test Method, Measurements, and Calculations

3.2.1. The test conditions and setup described in section 3.1 of this appendix apply to this section 3.2.

3.2.2. Stabilize the integrated LED lamp prior to measurement as specified in section 5.0 of IES LM–79–08 (incorporated by reference; see § 430.3). Calculate the stabilization variation 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.

3.2.3. Measure the input power in watts as specified in section 8.0 of IES LM–79–08.

3.2.4. Measure the input voltage in volts as specified in section 8.0 of IES LM–79–08.

3.2.5. Measure the input current in amps as specified in section 8.0 of IES LM–79–08.

3.2.6. Measure lumen output as specified in section 9.1 and 9.2 of IES LM–79–08. Do not use goniophotometers.

3.2.7. Determine CCT according to the method specified in section 12.0 of IES LM–79–08 with the exclusion of section 12.2 and 12.5 of IES LM–79–08. Do not use goniophotometers.

3.2.8. Determine CRI according to the method specified in section 12.0 of IES LM–79–08 with the exclusion of section 12.2 and 12.5 of IES LM–79–08. Do not use goniophotometers.

3.2.9. Determine lamp efficacy by dividing measured initial lumen output by the measured input power.

3.2.10. Determine power factor for AC-input lamps by dividing measured input power by the product of the measured input voltage and measured input current.

4. Active Mode Test Method to Measure Time to Failure

In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over IES LM–84 (incorporated by reference; see § 430.3) and IES TM–28 (incorporated by reference; see § 430.3).

4.1. Lamp Handling, Tracking, and Time Recording

4.1.1. Handle, transport, and store the integrated LED lamp as described in section 7.2 of IES LM–84 (incorporated by reference; see § 430.3).

4.1.2. Mark and track the integrated LED lamp as specified in section 7.3 of IES LM–84.

4.1.3. Measure elapsed operating time and calibrate all equipment as described in section 7.5 of IES LM–84.

4.1.4. Check the integrated LED lamps regularly for failure as specified in section 7.8 of IES LM–84.

4.2. *Measure Initial Lumen Output.* Measure the initial lumen output according to section 3 of this appendix.

4.3. *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.

4.3.1. There is no minimum test duration requirement for the integrated LED lamp. The test duration is selected by the manufacturer. See section 4.6 of this appendix for instruction on the maximum time to failure.

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

4.4. Operating Conditions and Setup Between Lumen Output Measurements

4.4.1. Electrical settings must be as described in section 5.1 of IES LM–84 (incorporated by reference; see § 430.3).

4.4.2. LED lamps must be handled and cleaned as described in section 4.1 of IES LM–84.

4.4.3. Vibration around each lamp must be as described in section 4.3 of IES LM–84.

4.4.4. Ambient temperature conditions must be as described in section 4.4 of IES LM–84. Maintain the ambient temperature at 25 °C ± 5 °C.

4.4.5. Humidity in the testing environment must be as described in section 4.5 of IES LM–84.

4.4.6. Air movement around each lamp must be as described in section 4.6 of IES LM–84.

4.4.7. Position a lamp in either the base-up and base-down orientation throughout testing. An equal number of lamps in the sample must be tested in the base-up and base-down orientations, except that, if the manufacturer restricts the position, test all of the units in the sample in the manufacturer-specified position.

4.4.8. Operate the lamp at the rated input voltage as described in section 3.1.3 of this appendix for the entire test duration.

4.4.9. Operate the lamp at the maximum input power as described in section 3.1.4 of this appendix for the entire test duration.

4.4.10. Line voltage waveshape must be as described in section 5.2 of IES LM–84.

4.4.11. Monitor and regulate rated input voltage as described in section 5.4 of IES LM–84.

4.4.12. Wiring of test racks must be as specified in section 5.5 of IES LM–84.

4.4.13. Operate the integrated LED lamp continuously.

4.5. Measure Interval Lumen Output. Measure interval lumen output according to section 3 of this appendix.

4.5.1. Record interval lumen output and elapsed operating time as described in section 4.2 of IES TM–28 (incorporated by reference; see § 430.3).

4.5.1.1. For test duration values greater than or equal to 3,000 hours and less than 6,000 hours, measure lumen maintenance of the integrated LED lamp at an interval in accordance with section 4.2.2 of IES TM–28.

4.5.1.2. For test duration values greater than or equal to 6,000 hours, measure lumen maintenance at an interval in accordance with section 4.2.1 of IES TM–28.

4.6. Calculate Lumen Maintenance and Time to Failure

4.6.1. Calculate the lumen maintenance of the lamp at each interval by dividing the interval lumen output ''x_t'' by the initial lumen output ''x_0''. Measure initial and interval lumen output in accordance with sections 4.2 and 4.5 of this appendix, respectively.

4.6.2. For lumen maintenance values less than 0.7, including lamp failures that result in complete loss of light output, time to failure is equal to the previously recorded lumen output measurement (at a shorter test duration) where the lumen maintenance is greater than or equal to 0.7.

4.6.3. For lumen maintenance values equal to 0.7, time to failure is equal to the test duration.

4.6.4. For lumen maintenance values greater than 0.7, use the following method:

4.6.4.1. For test duration values less than 3,000 hours, do not project time to failure. Time to failure equals the test duration.

4.6.4.2. For test duration values greater than or equal to 3,000 hours but less than 6,000 hours, time to failure is equal to the lesser of the projected time to failure calculated according to section 4.6.4.2.1 of this appendix or the test duration multiplied by the limiting multiplier calculated in section 4.6.4.2.2 of this appendix.

4.6.4.2.1. Project time to failure using the projection method described in section 5.1.4 of IES TM–28 (incorporated by reference; see § 430.3). Project time to failure for each individual LED lamp. Do not use data obtained prior to a test duration value of 1,000 hours.

4.6.4.2.2. Calculate the limiting multiplier from the following equation:

$$Limiting\ multiplier = \frac{1}{600} * test\ duration - 4$$

4.6.4.3. For test duration values greater than 6,000 hours, time to failure is equal to the lesser of the projected time to failure calculated according to section 4.6.4.3.1 or the test duration multiplied by six.

4.6.4.3.1. Project time to failure using the projection method described in section 5.1.4 of IES TM–28 (incorporated by reference; see § 430.3). Project time to failure for each individual LED lamp. Data used for the time to failure projection method must be as specified in section 5.1.3 of IES TM–28.

5. Standby Mode Test Method for Determining Standby Mode Power

Measure standby mode power consumption for integrated LED lamps capable of operating in standby mode. The standby mode test method in this section 5 may be completed before or after the active mode test method for determining lumen output, input power, CCT, CRI, power factor, and lamp efficacy in section 3 of this appendix. The standby mode test method in this section 5 must be completed before the active mode test method for determining time to failure in section 4 of this appendix. 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. Establish the ambient conditions, power supply, electrical settings, and instrumentation 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. Maintain the ambient temperature at 25 °C ± 1 °C.

5.1.2. Position a lamp in either the base-up and base-down orientation throughout testing. An equal number of lamps in the sample must be tested in the base-up and base-down orientations.

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

5.2. Test Method, Measurements, and Calculations

5.2.1. The test conditions and setup described in section 3.1 of this appendix apply to this section.

5.2.2. Connect the integrated LED lamp to the manufacturer-specified wireless control network (if applicable) and configure the integrated LED lamp in standby mode by sending a signal to the integrated LED lamp instructing it to have zero light output. Lamp must remain connected to the network throughout the duration of the test.

5.2.3. Stabilize the integrated LED lamp as specified in section 5 of IEC 62301 (incorporated by reference; see § 430.3) prior to measurement.

5.2.4. Measure the standby mode power in watts as specified in section 5 of IEC 62301.

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