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FINAL STAFF REPORT

Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification 3.0

A Voluntary Minimum Specification for “California
Quality” LED Lamps

California Energy Commission

Edmund G. Brown Jr., Governor



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ABSTRACT

The objective of the Voluntary California Quality Light Emitting Diode (LED) Lamp Specification (the specification) is to promote lighting products that perform better than current mandatory requirements and to prepare the market for the upcoming mandatory efficiency regulations. A minimum level of quality and performance from LED lamps is needed to avoid consumer dissatisfaction and facilitate market transition to more efficient LED technology.

The specification is developed in collaboration with the California Public Utilities Commission (CPUC). CPUC Decision 12-05-015 directs the California investor-owned utilities to propose rebates for LED products that are consistent with the quality specification developed by the California Energy Commission.

The initial version of the specification (Version 1.0) took effect December 2012. The requirements for Version 1.0 were mostly aligned with the ENERGY STAR® 1.0 specifications, with the exception of requirements for color, dimmability, light distribution, and warranty. In November 2014, the Energy Commission published Version 2.0 of the specification, which was updated to align with the ENERGY STAR 1.1 requirements, except for color, dimmability, and warranty. This is the third update to the specification, which will continue driving the market towards higher quality products and prepare for the upcoming appliance efficiency regulations for state-regulated LED lamps. For this purpose, the Voluntary California Quality LED Lamp Specification, Version 3.0, is aligned with the Title 20 standards.

Keywords: California Energy Commission, energy efficiency, LED, LED lamps, lighting, light quality, lighting, specification, quality

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CHAPTER 1: Background and Purpose

History of the Specification

California Energy Commission staff began working on a Voluntary California Quality Lamp LED Specification (specification) in 2012. The various iterations help utilities, the lighting industry, and consumers determine the appropriate level of performance necessary from light-emitting diode (LED) lighting products to meet or exceed consumer expectations for general purpose lighting in homes. Because LED lamps can achieve similar performance to incandescent lamps while using a fraction of the power, LED lamps present a significant opportunity to reduce energy consumption from lighting. However, many California consumers have chosen to continue purchasing halogen products to replace a burned-out light bulb, while others continue to use compact fluorescent lamps (CFLs).

Consumer opinions and perception of early products, and the slow uptake of efficient CFLs in the California market, provided a basis for determining what lighting product features matter to consumers. Addressing these concerns became the initial driver for the specification.

The initial version of the specification (Version 1.0) took effect in December 2012. The requirements for Version 1.0 were mostly aligned with the ENERGY STAR® Version 1.0 specifications. Version 1.0 did go beyond ENERGY STAR specifications in several areas: color, dimmability, light distribution, and warranty. In November 2014, the Energy Commission published Version 2.0 of the specification, which was updated to align more with the ENERGY STAR Version 1.1 requirements.

Lighting Standards

In June 2015, the Energy Commission adopted updates to the energy and water efficiency standards for new construction, located in Part 1, Chapter 10, and Part 6, of Title 24 of the California Code of Regulations. Joint Appendix 8 (JA8) contains requirements for lamps and luminaires installed in residential new construction. The *2016 Building Energy Efficiency Standards* take effect on January 1, 2017.

In January 2016, the Energy Commission adopted appliance efficiency standards for state-regulated LED lamps. These mandatory standards set minimum performance and efficacy requirements for state-regulated LED lamps to ensure that consumers receive a product that performs as expected while driving efficacy improvements in these products generally. The appliance efficiency standards apply to any covered lamp that is sold or offered for sale in California on or after January 1, 2018.

In March 2016, the U.S. Department of Energy proposed standards for general service lamps, including general service LED lamps. The U.S. Department of Energy subsequently released a notice of proposed definition and data availability in October 2016, proposing to include additional lamp types. While not yet finalized, these standards are expected to take effect on January 1, 2020. A final rule is expected at the end of 2016.

Purpose of the Updated Specification

The Voluntary California Quality LED Lamp Specification represents the Energy Commission's recommendation for minimum requirements for an LED light to be considered "California quality." This update to the specification continues efforts to drive the market towards higher quality LED products. The Commission also seeks to prepare the market for the upcoming appliance efficiency regulations for state-regulated LED lamps. For this purpose, the Voluntary California Quality LED Lamp Specification, Version 3.0, aligns with the Title 20 standards for state-regulated LED lamps.

The Energy Commission is essentially encouraging "early adoption" of the Title 20 Appliance Efficiency Regulations that apply to general service LED lamps. The Title 20 requirements are separated into two tiers. Tier 1 becomes effective January 1, 2018, and Tier 2 becomes effective July 1, 2019. This update is similarly divided into two tiers. The same criteria that are needed for Title 20 Tier 1 will apply until January 1, 2018, and the same criteria that are needed for Tier 2 will apply from January 1, 2018, onward.

Chapter 2:

Eligible Lamps

This specification applies to lamps meeting the following four criteria for base, brightness, correlated color temperature (CCT), and chromaticity:

- The lamp must have an American National Standards Institute (ANSI) standard E12, E17, E26, or GU24 base, including LED lamps that are designed for retrofit within existing recessed can housing that contains one of the preceding bases.
- The lamp must be capable of producing a quantity of light suitable for general illumination, meaning a brightness less than or equal to 2,600 lumens, and greater than or equal to 150 lumens (for candelabra bases) or 200 lumens (for other bases).
- The lamp must be capable of producing white light, meaning light with a correlated color temperature between 2,200 K and 7,000 K.
- The lamp must have a Duv ± 0.012 .

The specification includes lamps of any shape that meet the above criteria, including LED downlight retrofit kits and candelabra LEDs with one of the specified bases.

In defining the scope of the specification, the Energy Commission is not intending to exclude other lamp types from being included in utility programs. For example, small diameter directional lamps (SDDL) (with diameters less than or equal to 2.25 inches) are not in the scope of this specification although they are part of the Title 20 Appliance Efficiency Regulations. This is because SDDLs are more commonly used in commercial applications, while this specification is intended to identify characteristics appropriate for residential consumers. However, quality characteristics for SDDLs may be identified through other voluntary specifications, such as ENERGY STAR. The Energy Commission encourages utilities and the Public Utilities Commission to identify appropriate specifications to rebate lamp types that are not included in this specification.

Chapter 3: Elements of the California Quality LED Lamp Specification

The headings below show the detailed requirements of Version 3.0 of the Voluntary California Quality LED Lamp Specification. For easy comparability, the headings are generally ordered according to the structure of the ENERGY STAR Product Specification for Lamps 2.0.

Effective Date

Effective date means the date that the specification is updated to align with the indicated standards. The effective date is only for the purpose of the rebates and is neither the date of manufacture nor the date of sale.

Before January 1, 2018, products complying with Version 3.0 and meeting Title 20 Tier 1 will be considered as having met the Voluntary California Quality LED Lamp Specification.

On January 1, 2018, and after, the energy use requirement (based on an equation that balances efficacy with the average color rendering index (CRI) of the lamp) increases from the Title 20 Tier 1 level to the Title 20 Tier 2 level. On and after this date, products complying with Version 3.0 and meeting the Title 20 Tier 2 level will be considered as having met the Voluntary California Quality LED Lamp Specification.

Future Specification Revisions

The Energy Commission reserves the right to change the Voluntary California Quality LED Lamp Specification.

Definitions

See the glossary for definitions. Where a term is not defined here, use the appropriate definition from either the Illuminating Engineering Society (IES) test procedures noted under “Test Criteria” or in Title 20, Section 1602.

Test Criteria

The sampling provisions are the same as in 10 C.F.R. § 429.56, “Integrated Light-Emitting Diode Lamps.”

The test procedure for input power, lumen output, lumens per watt, correlated color temperature, Duv, CRI, power factor, lumen maintenance, time to failure is 10 C.F.R. §430.23(ee), “Integrated light-emitting diode lamp,” and 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,” consistent with Title 20 (Section 1604(k)) and federal law.

The test procedure for flicker for those lamps that are dimmable is Title 24, Part 6, Joint Appendix 10 (2015) at both 100 percent and 20 percent output. Lamps with a percent amplitude modulation (percent flicker) less than 30 percent at frequencies less than 200Hz are considered “reduced flicker operation.” For audible noise, lamps shall be tested using ENERGY STAR Recommended Practice – Noise (2013) at both 100 percent and 20 percent output.

On and after January 1, 2018, the test procedure for lamp standby power is 10 C.F.R. § 430.23(ee), “Integrated light-emitting diode lamp,” and 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.”

The Energy Commission recognizes that the new federal test procedures for lumen maintenance and time to failure for purposes of reporting rated life take a substantial amount of time to complete. Therefore, manufacturers may report estimated values for the lumen maintenance and time to failure for purposes of Tier 1 of this specification until testing is complete. Manufacturers must update the values using the new federal test procedure once testing is completed, and no later than the effective date of the Title 20 appliance efficiency regulations for state-regulated LEDs.

Photometric Performance

Minimum luminous efficacy: Before January 1, 2018, the minimum luminous efficacy requirement is 68 lumens per watt. On and after January 1, 2018, the minimum luminous efficacy is 80 lumens per watt.

Minimum color rendering: The minimum average color rendering index (R_a) is 82. The minimum individual color score for R1-R8 is 72.

Minimum combined efficacy score: Before January 1, 2018, the sum of the lamp’s luminous efficacy and 2.3 times its CRI must be 282 or higher. On and after January 1, 2018, the sum of the lamp’s luminous efficacy and 2.3 times its CRI must be 297 or higher.

Minimum light distribution: The omnidirectional light distribution requirements for A-shape lamps is ENERGY STAR’s Product Specification for Lamps Version 2.0 (December 2015) for omnidirectional lamps. Lamp shapes B, BA, C, CA, F, and G shall meet the decorative light distribution requirements of ENERGY STAR’s Product Specification for

Lamps Version 1.1 (August 2014). There are no light distribution requirements for other lamp shapes not described here.

Correlated color temperature (CCT): The chromaticity and color consistency requirements are in Table 1 of Annex B of ANSI C78.377-2015, approximately equivalent to a 4-step MacAdam ellipse.

Rated Life

Minimum rated life: 10,000 hours or greater as determined by the lumen maintenance and time to failure test procedures.

Electrical Performance

Minimum power factor: 0.7

Maximum standby power: On and after January 1, 2018, the maximum standby power for connected lamps is 0.2 watts.

Controls Requirements

Dimming behavior: Lamps that claim to be dimmable shall dim down to 10 percent output, have reduced flicker operation, and not produce noise in excess of 24 A-weighted decibels at 100 percent and 20 percent outputs. Reduced flicker operation means that the lamp has percent amplitude modulation (percent flicker) less than 30 percent at frequencies less than 200Hz.

Lamp Labeling and Packaging Requirements

The California Quality LED Specification does not require the inclusion of any particular label or mark. However lamps must meet the criteria below before making any of the following claims in marketing materials, including retail packaging or on the lamp itself:

Dimmable: If the manufacturer claims that the product is “dimmable,” the product must meet the control requirements for dimmable lamps. If the product cannot have reduced flicker operation using a standard phase-cut dimmer, but can reduce flicker operation using another type of dimmer, references to dimmability can be qualified with the phrase “dimmable with LED dimmer.” These lamps shall include instructions describing the type of dimmers that are compatible or recommended for use with the lamp.

Comparison to incandescent performance: If the manufacturer makes any claims of being equivalent in performance to an incandescent, the lamp shall have a CCT of 3000k or less, a lumen output of 310 lumens or greater for E26-base, or 150 lumens or greater for E12 and E17 bases, and meet the controls requirements for dimmable lamps.

Equivalent incandescent wattage: If the manufacturer makes wattage equivalency claims for medium screw-base and GU-24 base omnidirectional lamps, the lamps shall have a minimum lumen output consistent with the following table:

Table 1: Wattage Equivalency

Claimed Equivalent Wattage	Minimum Lumen Output
40 W	310
60 W	750
75 W	1050
100 W	1490
150 W	2500

Glossary

Lighting industry terms used in this report which may not be familiar to some readers, include the following:

ANSI	The American National Standards Institute. ANSI is a nonprofit organization that oversees the development (by others) of voluntary standards in the United States. It coordinates with international bodies such as the International Electrotechnical Commission (IEC) and Commission International de l'Eclairage (CIE).
Connected lamp	An lamp capable of changing its lumen output or spectral power distribution in response to an external control signal other than a change in root mean square (RMS) AC supply voltage or a 0-10 volt DC control signal. Connected lamps include those that can be controlled wirelessly and through power line carrier digital communication.
Duv	A light parameter that is used for color consistency. It is measured as the closest distance from the chromaticity coordinate of the light source to the Planckian locus on the International Commission on Illumination (CIE) (u' , $2/3 v'$) coordinates with "+" sign for above and "-" sign for below the Planckian locus.
Lamp	The source that creates optical radiation, also known as a "light bulb."
Lamp efficacy	The measured lumen output of a lamp in lumens divided by the measured lamp electrical power in watts expressed in units of lumens per watt (LPW).

Luminaire	The housing within which the lamp is held, which provides mechanical support and electrical power to the lamp, and reflects or diffuses the light. This is also referred to as a “light fixture” in commercial applications. Many consumers refer to luminaires as “lamps,” such as “floor lamps” or “desk lamps.”
MacAdam ellipse	The ellipse shaped region on a chromaticity diagram that contains all colors that are indistinguishable to the average human eye, from the color at the center of the ellipse. The contour of the ellipse represents the just noticeable differences of chromaticity. ANSI has developed a measurement that approximates a MacAdam ellipse using quadrangles.
Omnidirectional lamp	When used for LED lamps, refers to a lamp intended to function with isotropic light distribution (that is, to distribute light evenly in all directions) and intended to function as a direct replacement for incandescent A-lamps.
Planckian Locus	Refers to the path or locus that the color of an incandescent black body would take in a particular chromaticity space as the black body temperature changes. It goes from deep red at low temperatures through orange, yellowish white, white, and finally bluish white at very high temperatures.
R_a	Metric in color rendering refers to the average of color palette scores R1 through R8.

Performance Metric Comparison

Table 2: Metric Comparison of Different Revisions

	Effective Date	December 2012	November 2014	December 2016
General	Lamp Types	Omni, flood, spot, & integrated LED lamp recessed can retrofits	Omni, flood, spot, & integrated LED lamp recessed can retrofits	All lamps with brightness of 200 lumens or greater (150 lumens or greater for candelabra bases) and less than or equal to 2,600 lumens, with a Duv ± 0.012
	Base Type	E12, E17, E26, GU-24, GU10, GX5.3, G8, & G9	E12, E17, E26, GU-24, GU10, GX5.3, G8, & G9	E12, E17, E26, GU24
Electrical Performance	Power Factor	≥ 0.9	≥ 0.9	≥ 0.7
Photometric Performance	Efficacy (lm/W)	-	-	Before 1/1/2018: Minimum efficacy of 68 lm/W and, efficacy + 2.3 x CRI ≥ 282 On or after 1/1/2018: Minimum efficacy of 80 lm/W and, efficacy + 2.3 x CRI ≥ 297
	Center Beam Intensity	ENERGY STAR® 1.0, Draft 2	ENERGY STAR 1.1	-
	Distribution	ENERGY STAR 1.0, Draft 2	ENERGY STAR 1.1	For A-shape: ENERGY STAR 2.0 For B, BA, C, CA, F, and G-shape: ENERGY STAR 1.1
	CCT	2700 or 3000	2700 or 3000	2200-7000
	Binning / Duv	4-Step MacAdam	4-Step MacAdam	ANSI C78.377-2015, Table B1
	CRI Minimum	90	90	82
	R1-R8 Minimum	-	-	72
	R9 Minimum	50	50	-
Color Angular Uniformity	ENERGY STAR 1.0, draft 2	ENERGY STAR 1.1	-	

Life Requirements	Color Maintenance	ENERGY STAR 1.0, draft 2	ENERGY STAR 1.1	-
	Min Rated Life	ENERGY STAR 1.0, draft 2	ENERGY STAR 1.0, draft 2	10,000 hours
	Warranty	5 years	5 years	-
Dimming Requirements	Min Dimming Level	10%	10%	10%
	Flicker	Flicker free	Flicker free	Reduced flicker < 30% flicker at f < 200 Hz
	Audible Noise (100% Output)	Noise free	Noise free	<24 dB
	Audible Noise (Min req output)	Noise free	Noise free	<24 dB at 20% output
Markings	Lamp Marking	ENERGY STAR 1.0, draft 2	ENERGY STAR 1.1	-
	Lamp Packaging	ENERGY STAR 1.0, draft 2	ENERGY STAR 1.1, plus intensity	-