

## DOCKETED

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**Lumileds Comments on Title 20 Revised 15 Day Language**

*Additional submitted attachment is included below.*



22 January 2016

Re: Docket #: 15-AAER-06: Small Diameter Directional LED Lamps and General Purpose LED Lamps, Revised 15 Day Language (docketed 7 January 2016)

Lumileds is a \$2 billion manufacturer of LED packages, and one of the 3 largest LED manufacturers in the world. Our global headquarters, including research and development and manufacturing facilities, is located in San Jose.

We thank and applaud the CEC for making the requested normative reference to the American National Standard for SSL chromaticity, ANSI C78.377-2015. Referencing standards helps to ensure quality and consistency, and to enable high volume cost reductions that will benefit California consumers and drive adoption of this energy saving technology. This change settles the matter of specifying chromaticity, however, the draft regulation still includes problematic language regarding color rendering.

The revised 15-day language includes the terms CRI,  $R_a$ , and  $R_1$  through  $R_8$ . Lumileds understands these to be references to the color rendering index (CRI) as published by the International Commission on Illumination, also known as the CIE. If Title 20 regulatory compliance is to be based on the specification of minimum performance levels on this index, it is incumbent on the Energy Commission to make normative reference to CIE 13.3-1995, *Method of Measuring and Specifying Color Rendering Properties of Light Sources*. Without this, the terms will be undefined, and the calculations which form the basis of these notations will also be undefined.

Within CIE 13.3, we would like to (re)direct the Commission's attention to section 7.2, *Uncertainties in the determination of R*. Like any metric, the color rendering index has a known range of uncertainty. The uncertainty of the CRI is  $\pm 3$  points, which results from the uncertainties inherent in the measured spectral data entered into the CRI calculation. This means that the actual  $R_a$  value of any product lies within  $\pm 3$  points of its calculated  $R_a$  value. Here are a few examples to illustrate:

- A laboratory technician reporting a calculated  $R_a$  of 89 knows that the actual  $R_a$  value lies between 86 and 92 ( $89 \pm 3$ ).
- A manufacturer's compliance engineer knows that a lamp with a calculated  $R_a$  of 79 has an actual  $R_a$  value between 76 and 82.
- A certification body considering a reported lamp  $R_a$  value of 81 knows that the actual  $R_a$  value lies somewhere between 78 and 84.

The lighting industry at large has a tribal knowledge of the CIE's color rendering index, including the above but also well beyond what is printed within the standard. This knowledge is the result of 50 years of daily use of the metric developed by our industry, for our industry. These additional facts are widely accepted knowledge employed by lighting practitioners daily:

- Special Colour Rendering Indices  $R_1$  through  $R_8$  quantify the derived lengths of the color difference vectors, but they do not indicate the directions of those vectors. The average of those values ( $R_a$ ) also provides no information about the directions of those vectors. Consequently, it is quite possible, and indeed common, for lamps with identical  $R_a$  and CCT values to appear different, and to render object colors differently (see CIE 13.3 section 7.4).
- Most visual perception experts would agree that  $R_a$  values differences of less than 10 points are usually imperceptible, and less than 3 points are imperceptible and statistically insignificant.
- For these reasons, the lighting industry has long specified product minimum CRI specifications in multiples of ten (i.e.  $R_a \geq 60$ ,  $R_a \geq 70$ ,  $R_a \geq 80$ ,  $R_a \geq 90$ ). By way of example, any lamp of any technology on the market with a measured and calculated  $R_a$  value of 82 (or 81, 83, 84, etc.) has in all likelihood been designed to meet a minimum 80  $R_a$  specification. The additional  $\sim 2$  points above 80 are either:
  - Real, and a reflection of manufacturing performance distribution and the manufacturer's intent to achieve a margin above the minimum specified performance threshold; or,
  - Not meaningful, because the 2 points are within the published uncertainty range of the Index.

- The color rendering index was originally designed for linear fluorescent technology, and has significant, widely known shortcomings when it is applied to LED technology.
- The non-LED package components of LED lamps (secondary optics, reflectors, heat sinks, plastics and paints) are known to drag down the calculated  $R_a$  value of an LED lamp. Thus, in the process to design an LED lamp, to meet a minimum 80  $R_a$  specification, a lamp manufacturer must source LED packages with  $R_a$  values that are minimum 80, typical 82 (min 80, typ 82). As an example, if Lumileds ships LED packages with min 80, typ 82 performance, the additional 2 point margin will help to ensure the LED lamp meets the minimum 80  $R_a$  requirement.

With these points in mind, we would like the Commission to understand that for an LED lamp to meet or exceed the proposed minimum 82  $R_a$  specification, the lamp manufacturer must source min 82, typ 84 LED packages. As one of the world's leading LED package manufacturers, Lumileds enjoys deep insight into the LED subcomponent market. It is our estimation that LED package binning for min 85  $R_a$  – or any other min  $R_a$  between 80 and 90 – represents far less than 1% of the total global LED package market.

These are truly rare LED packages, with few suppliers to choose from. The reasons for this are twofold. First, as explained above, the lighting industry has historically specified minimum CRI product performance in tens (i.e.  $R_a \geq 70$ ,  $R_a \geq 80$ ,  $R_a \geq 90$ ). Secondly, for years now, economies of scale across the global LED manufacturing industry have been optimized to support these specifications, around which most North American LED products are designed:

- ENERGY STAR Luminaires V2.0 and ENERGY STAR Lamps V2.0 specifications, and all versions before them: minimum 80  $R_a$  and positive  $R_9$ .
- The Consortium for Energy Efficiency's Specification for Integral Replacement Lamps Sold at Retail, Tier 1: minimum 80  $R_a$  and positive  $R_9$ .
- DesignLights Consortium's V3.1 specification: min 70 and min 80  $R_a$  for indoor applications.

Lumileds and other manufacturers have repeatedly requested but not received the CEC's explanation for the proposed minimum 82  $R_a$  value. In the absence of an explanation from the Commission, the specification of min 82  $R_a$ , with the min 72 requirement for  $R_1$  through  $R_8$ , along with the "minimum compliance score", create the appearance that the Energy Commission is attempting to implement a minimum 90  $R_a$  requirement for LED lamps sold in California. The minimum 82  $R_a$  will force an LED lamp manufacturer to either source rare min 85  $R_a$  LED packages, incurring expenses which are incompatible with the price points consumers expect of light bulbs, or they will select the slightly higher volume min 90  $R_a$  packages.

In a conversation immediately following the CEC's 13 January 2016 Business Meeting, Commissioner McAllister advised me and other NEMA member representatives that the Commission has compromised, and expects the lighting industry to also offer compromises. We would agree that the one year implementation delay proposed by the Commission is a step in the right direction. We would also agree that the CEC's new reference to ANSI C78.377-2015 is an appropriate response to industry requests, while industry adoption of the 4-step tolerances within that standard are also a significant compromise, though it necessarily eliminates 42% of ANSI-compliant LED package binning space, which will certainly drive up costs.

Lumileds certainly supports fostering a cooperative spirit between industry and the Commission. Lumileds and its customers can reasonably be expected to make compromises based on hard facts and reliable data. However it must be acknowledged that in total, the Energy Commission's expectation is for the lighting industry to completely overturn its ways of working – its ways of designing, procuring, manufacturing, and marketing – all to achieve a statistically insignificant, imperceptible, and costly 2 point improvement in CRI score. Underlying this is the Commission's expectation that the lighting industry will create new economies of scale to support this technically unjustifiable specification. Overturning the whole industry is not an acceptable compromise.

It must also be acknowledged that by deciding California consumers must have minimum 90  $R_a$  performance for every application, the CEC is – in every single lamp installed – leaving significant energy savings behind. The additional red conversion materials required to meet the proposed regulation (phosphors and the like which convert blue LED die output to higher wavelengths) typically reduce an LED lamp's luminous efficacy by 15%. The CEC could decide to allow California

consumers to select between min 80 and 90 R<sub>a</sub>, which would allow additional energy savings in applications which do not require higher color rendering, such as in garages, basements, utility rooms, and outdoor lighting.

Finally, throughout this regulatory process Lumileds has noted the wide range of interpretations of the available market performance data. The Commission and the electric utilities seem to have the understanding that the market is already full of products that will meet the proposed regulation. Meanwhile, manufacturers' collective view is that when all of the proposed requirements are applied, exceedingly few products are in fact available. There is clearly a gap to be bridged, and we respectfully submit that in this regulatory process it is the responsibility of the Commission to attempt to resolve such differences to arrive at a common understanding of the facts upon which the regulation will be based.

We respectfully submit these inputs and request that the Commission slow down this process, assemble all stakeholders at one meeting to analyze the market data together, and based on those discussions, establish new 45-day language. We thank you again for the opportunity to provide input, and ask that you consider Lumileds a resource for any questions you may have throughout the remainder of this process.

Sincerely,

**Alex Baker**  
Director of Standards & Regulations