Eye Safety With J Series™ LED Components

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INTRODUCTION

This application note explains the current standards and regulations related to LED components (both packaged LEDs and LED light engines or modules) and photobiological safety. It also provides guidance for expected maximum risk group classifications for Cree Venture's visible light LED components in accordance with these standards. Visible light LED components, as that term is used in this document, include white LEDs with the dominant wavelengths between 400 nm and 680 nm.

At a high enough intensity, all light sources have the potential to be harmful to both the skin and the eyes through ultraviolet (UV), blue light (400-480 nm) and/or infrared (IR) emissions. LEDs that emit blue light may be identified by multiple names, such as blue, royal blue or dental blue. (As of the date of this application note, Cree Venture does not produce a dental blue LED). Additionally, most white packaged LEDs (including Cree Venture's) are made using blue-emitting LED die and therefore emit a portion of their total output as blue light.

Cree Venture has engaged an independent lab to conduct photobiological testing, also known as eye safety testing, on select white LED components. The results of this testing (explained below in further detail) show significant health risks from some of Cree Venture's visible light LED components when viewed without diffusers or secondary optical devices. These risks warrant an advisory notice to indicate the potential for eye injury caused by prolonged viewing of blue light from these devices.

Cree Venture advises users to not look directly at any operating LED component. Further, Cree Venture recommends that any manufacturer that is incorporating Cree Venture LED components into its lighting products make an assessment of

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how these components could create a light exposure risk to its employees during the manufacturing process. Such risks can be minimized by using engineering controls (e.g., light-blocking screens or filters, or current-limiting resistors in a test apparatus) or personnel protection equipment (e.g., light-filtering or blocking eyewear).

During the eye safety testing of Cree Venture's visible light LED components, the LED solder-point temperature was controlled to be at or below what is normally observed in most LED luminaire (lighting fixture) designs -- this control ensures maximized, or worst case, light output. Depending on the final luminaire design, the eye safety risks associated with a particular use of Cree J Series LED components could differ from data provided in this application note, or the third party test results, due to differences in operating conditions.

In addition to risk incident to blue light, very bright light can elevate the temperature of retinal tissue and pose a hazard. Retinal thermal hazards are defined by the intensity of visual light radiation focused by the cornea on the retina of the human eye. The image formed on the retina becomes the affected area of the eye subject to thermal damage. As shown in Figure 1[1], the retinal thermal hazard function includes a much broader range of wavelengths than the blue light hazard function.

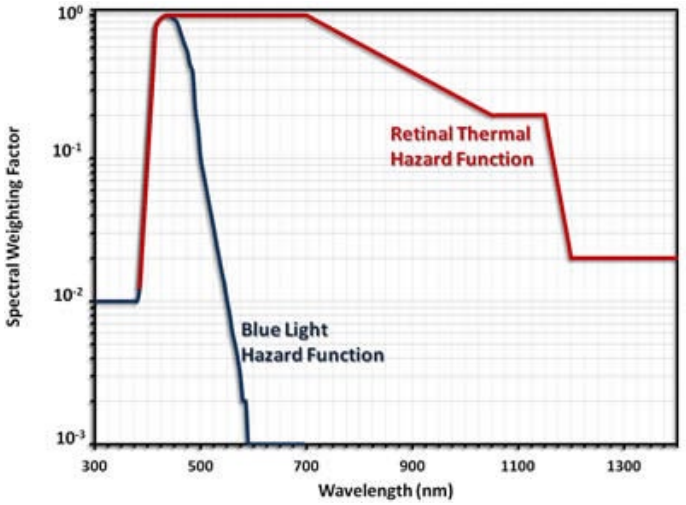

Figure 1: Retinal thermal and blue light hazard functions

PHOTOBIOLOGICAL STANDARDS AND REGULATIONS FOR LED COMPONENTS

Before the fall of 2008, most LEDs were tested and labeled in accordance with the IEC/EN 60825 laser safety (coherent light source) standard. The IEC/EN 60825 standard, however, was not considered appropriate for conventional packaged LEDs because most LEDs are not designed to be coherent light sources (except for laser diodes). Further, the IEC/EN 60825 standard does not define risk groups for LED luminaires, so it does not consider changes in the eye safety risks created by elements other than individual LED components, such as secondary optics, reflectors, or diffusers. As a result, in late 2008 a newer standard, referred to as IEC 62471-2006 (plus the supporting ANSI/IESNA RP-27 testing methodology), was adopted for conventional, or lighting class, LEDs. The detailed photobiological testing results provided below in this application note are based on the new standard and the ANSI/IESNA RP-27 testing methodology.

As of the date of publication of this application note, a few countries may still refer to IEC/EN 60825 as the prevailing standard. Since IEC/EN 60825 was the only safety standard for LED components available for many years, Cree previously tested several of its XLamp® white LEDs in accordance with the IEC/EN 60825 and found that many of them would be considered Class 2 devices under such standard. Products released in 2010 or later likely have not been tested or evaluated using IEC 60825.

The summary of results presented below were performed on standalone Cree Venture LED components to aid in fixture design and to assess the general safety of personnel exposed to LED-based emissions in the manufacturing setting. No single test result is meant

1 Copyright © University of Ottawa, Office of Risk Management; "Photobiological Effects", www.uottawa.ca/services/ehss/IOREffects.html

to be indicative of all J Series LEDs under all operation conditions, i.e., operation within a range of forward currents is possible with any LED. Further, the risk classification of a standalone LED component has little or no bearing on the risk classification of the final luminaire. Accordingly, once Cree Venture LED components are incorporated into a luminaire or related LED lighting product, Cree Venture recommends and EU consumer and commercial directives and the IEC 62471-2006 standard generally require that the assembly be tested under ANSI/IESNA RP-27 (or an equivalent measurement methodology) to assess the eye safety risk of the lighting system.

The IEC 62471-2006 standard specifies four (4) classifications, called risk groups, for lamps and lamp systems (excluding lasers) emitting light in wavelengths from 200 to 3000 nm as set forth in Table 1 below.[2]

Table 1: Risk groups

Risk Group	Risk	Definition
Exempt	None	No photobiological hazard
RG-1	Low Risk	No photobiological hazard under normal behavioral limitation
RG-2	Moderate risk	Does not pose a hazard due to aversion response to bright light or thermal discomfort
RG-3	High risk	Hazardous even for momentary exposure

SUMMARY TEST RESULTS

Table 2 below summarizes the eye safety test results for J Series LED components pursuant to the IEC 62471 classification system. The risks noted below are based on the measured blue light emissions. Upon testing, J Series LED components demonstrated no other hazardous properties defined by IEC 62471-2006 or ANSI/IESNA RP-27.

When electrical conditions are constant, risk rankings for each product tend to decrease in order from royal blue, blue, cool white, neutral white, to warm white. Figure 2 pictorially shows that decrease.

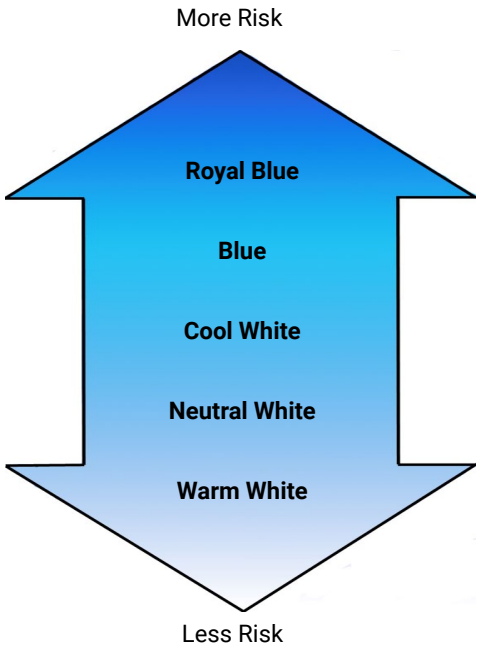

Figure 2: Risk decreases from royal blue to warm white at constant electrical conditions

2 IEC 62471 Photobiological safety of lamps and lamp systems - First edition, 2006-2007

Cree Venture has begun eye safety testing of cool white, neutral white and warm white versions of J Series LEDs. Included in the test results in Table 2, as applicable, are the drive conditions at which an LED exceeds the risk group 1 and risk group 2 thresholds. Also included are the illuminance threshold (E_{thr}), the illuminance at the risk group 1/risk group 2 threshold, and the minimum safe distance (d_{min}), the distance from the light source at which an LED exceeds the risk group 1 threshold. These results will be included in Table 2 as they become available. The E_{thr} and d_{min} test results values shown in Table 2 in lux and millimeters, respectively, have been converted to the foot-candles and feet values shown in parentheses.

Contact a Cree sales representative for more information regarding the J Series LEDs referenced in Table 2.

Table 2: Summary table of J Series LED eye safety test results

J Series™ LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
2835 (6 V, 1 W)	Cool White	November 28, 2017	0.200 A	RG-2 Moderate risk	0.084 A	697 lux (64.8 fc)	288 mm (0.94 ft)	Not applicable
	Neutral White	November 28, 2017	0.200 A	RG-2 Moderate risk	0.144 A	1130 lux (105.0 fc)	222 mm (0.73 ft)	Not applicable
	Warm White	November 28, 2017	0.200 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
3030 (3 V, 1 W)	Cool White	November 28, 2017	0.400 A	RG-2 Moderate risk	0.203 A	756 lux (70.2 fc)	250 mm (0.82 ft)	Not applicable
	Neutral White	November 28, 2017	0.400 A	RG-2 Moderate risk	0.273 A	1178 lux (109.4 fc)	208 mm (0.68 ft)	Not applicable
	Warm White	November 28, 2017	0.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
5050 (36 V, 5 W)	Cool White	Augusst 8, 2018	0.165 A	RG-2 Moderate risk	0.051 A	837 lux (77.8 fc)	591 mm (1.94 ft)	Not applicable
	Neutral White	Augusst 8, 2018	0.165 A	RG-2 Moderate risk	0.082 A	1262 lux (117.2 fc)	509 mm (1.67 ft)	Not applicable
	Warm White	Augusst 8, 2018	0.165 A	RG-2 Moderate risk	0.126 A	2141 lux (198.9 fc)	390 mm (1.28 ft)	Not applicable
5630 (3 V, 0.2 W)	Cool White	April 11, 2018	0.240 A	RG-2 Moderate risk	0.141 A	566 lux (52.6 fc)	257 mm (0.84 ft)	Not applicable
	Neutral White	April 11, 2018	0.240 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	April 11, 2018	0.240 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable