

Eye Safety With 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 LED's visible light LED components in accordance with these standards. Visible light LED components, as that term is used in this document, include both white LEDs and LED modules and colored 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 LED does not produce a dental blue LED). Additionally, most white packaged LEDs (including Cree LED's) are made using blue-emitting LED die and therefore emit a portion of their total output as blue light.

Cree LED has engaged an independent lab to conduct photobiological testing, also known as eye safety testing, on its blue, royal blue and select white LED components. The results of this testing (explained below in further detail) show significant health risks from some of Cree LED'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.

To date, the testing shows that Cree LED's blue and royal blue LED components (450-485 nm dominant wavelengths) pose a higher potential eye safety hazard than its white LED components. Other colors of LED components, such as green and red LED components, do not pose as significant of an eye safety risk. Regardless of LED color, Cree LED advises users to not look directly at any operating LED component. Further, Cree LED recommends that any manufacturer that is incorporating Cree LED components into its lighting products make an assessment of 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 LED's visible light LED components, the LED solder-point temperature or LED module case 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 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 1¹, the retinal thermal hazard function includes a much broader range of wavelengths than the blue light hazard function.

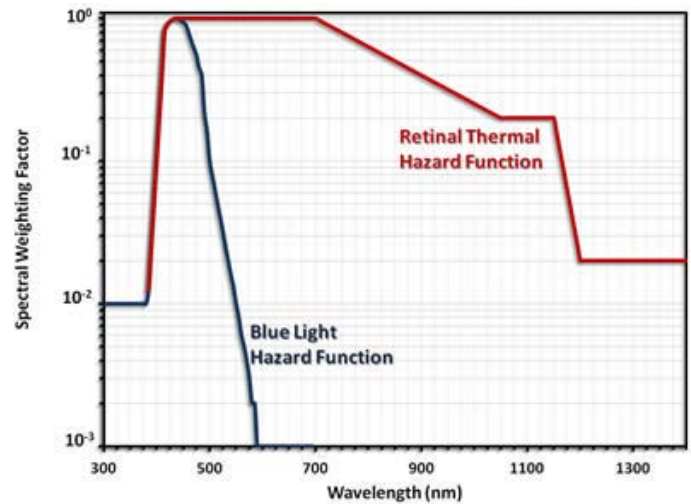


Figure 1: Retinal thermal and blue light hazard functions

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 LED 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 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 to be indicative of all XLamp LEDs and LED modules 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 LED components are incorporated into a luminaire or related LED lighting product, Cree LED 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.

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

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 Cree LED components pursuant to the IEC 62471 classification system. The risks noted below are based on the measured blue light emissions. Upon testing, Cree 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.

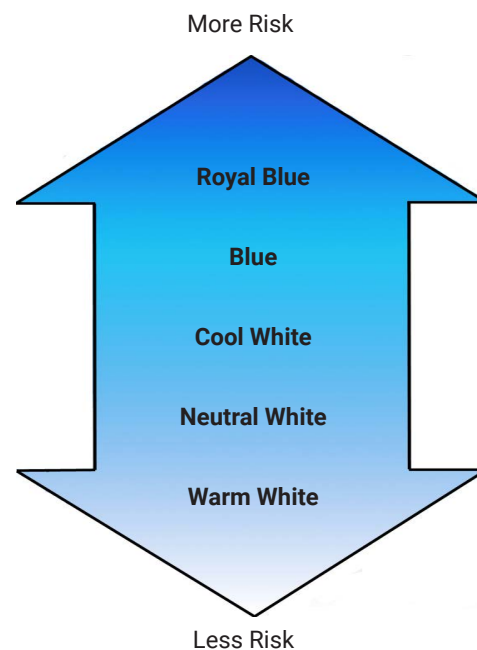


Figure 2: Risk decreases from royal blue to warm white at constant electrical conditions

Cree LED has begun eye safety testing of cool white, neutral white and warm white versions of XLamp 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.

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

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

Table 2: Summary table of XLamp LED eye safety test results

XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E _{thr}	d _{min}	
CHA0304* (21 V)	Neutral White (4000 K)	June 2, 2022	0.300 A	RG-2 Moderate risk	0.175 A	1552 lux (144.2 fc)	254 mm (0.83 ft)	Not applicable
	Neutral White (3500 K)	June 2, 2022	0.300 A	RG-2 Moderate risk	0.224 A	1932 lux (179.5 fc)	227 mm (0.74 ft)	Not applicable
	Warm White (3000 K)	June 2, 2022	0.300 A	RG-2 Moderate risk	0.272 A	2312 lux (214.8 fc)	209 mm (0.69 ft)	Not applicable
	Warm White (2700 K)	June 2, 2022	0.300 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CHA0410* (12 V)	Neutral White (4000 K)	May 31, 2022	0.900 A	RG-2 Moderate risk	0.520 A	1598 lux (148.5 fc)	253 mm (0.83 ft)	Not applicable
	Neutral White (3500 K)	May 31, 2022	0.900 A	RG-2 Moderate risk	0.577 A	1851 lux (172.0 fc)	241 mm (0.79 ft)	Not applicable
	Warm White (3000 K)	May 31, 2022	0.900 A	RG-2 Moderate risk	0.890 A	2691 lux (250.0 fc)	198 mm (0.65 ft)	Not applicable
	Warm White (2700 K)	May 31, 2022	0.900 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CHA0612* (36 V)	Neutral White (4000 K)	May 31, 2022	0.600 A	RG-2 Moderate risk	0.346 A	1789 lux (166.2 fc)	251 mm (0.82 ft)	Not applicable
	Neutral White (3500 K)	May 31, 2022	0.600 A	RG-2 Moderate risk	0.436 A	1914 lux (177.8 fc)	221 mm (0.73 ft)	Not applicable
	Warm White (3000 K)	May 31, 2022	0.600 A	RG-2 Moderate risk	0.571 A	2791 lux (259.3 fc)	196 mm (0.64 ft)	Not applicable
	Warm White (2700 K)	May 31, 2022	0.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CHA0825* (36 V)	Neutral White (4000 K)	May 31, 2022	1.200 A	RG-2 Moderate risk	0.680 A	1836 lux (170.6 fc)	248 mm (0.81 ft)	Not applicable
	Neutral White (3500 K)	May 31, 2022	1.200 A	RG-2 Moderate risk	0.846 A	2319 lux (215.4 fc)	228 mm (0.75 ft)	Not applicable
	Warm White (3000 K)	May 31, 2022	1.200 A	RG-2 Moderate risk	0.964 A	2522 lux (2345.3 fc)	215 mm (0.71 ft)	Not applicable
	Warm White (2700 K)	May 31, 2022	1.200 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMA1303* (9 V)	Cool White	February 11, 2021	1.400 A	RG-2 Moderate risk	0.222 A	409 lux (38.0 fc)	400 mm (1.31ft)	Not applicable
	Neutral White	February 11, 2021	1.400 A	RG-2 Moderate risk	0.628 A	1420 lux (132.0 fc)	260 mm (0.85 ft)	Not applicable
	Warm White	February 11, 2021	1.400 A	RG-2 Moderate risk	0.728 A	1841 lux (171.0 fc)	240 mm (0.79 ft)	Not applicable
CMA1306* (36 V)	Cool White	July 13, 2023	0.600 A	RG-2 Moderate risk	0.162 A	753 lux (70.0 fc)	343 mm (1.13 ft)	Not applicable
	Neutral White	July 13, 2023	0.600 A	RG-2 Moderate risk	0.211 A	1054 lux (97.9 fc)	311 mm (1.02 ft)	Not applicable
	Warm White	July 13, 2023	0.600 A	RG-2 Moderate risk	0.334 A	1773 lux (164.7 fc)	252 mm (0.83 ft)	Not applicable

* Products tested are Standard versions. Test results apply to both Standard and Pro9™ versions of these LEDs since the Pro9 versions of these LEDs are dimmer than the tested Standard version samples.

XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E _{thr}	d _{min}	
CMA1516* (36 V)	Cool White	February 1, 2018	1.050 A	RG-2 Moderate risk	0.248 A	925 lux (85.9 fc)	1359 mm (4.46 ft)	Not applicable
	Neutral White	February 1, 2018	1.050 A	RG-2 Moderate risk	0.403 A	1473 lux (136.8 fc)	1013 mm (3.32 ft)	Not applicable
	Warm White	February 1, 2018	1.050 A	RG-2 Moderate risk	0.631 A	2290 lux (212.7 fc)	1824 mm (2.70 ft)	Not applicable
CMA1825* (36 V)	Cool White	February 1, 2018	1.600 A	RG-2 Moderate risk	0.442 A	860 lux (79.9 fc)	1634 mm (5.36 ft)	Not applicable
	Neutral White	February 1, 2018	1.600 A	RG-2 Moderate risk	0.828 A	1633 lux (151.7 fc)	1225 mm (4.02 ft)	Not applicable
	Warm White	February 1, 2018	1.600 A	RG-2 Moderate risk	1.363 A	2595 lux (241.1 fc)	959 mm (3.15 ft)	Not applicable
CMA1840* (36 V)	Cool White	February 1, 2018	2.300 A	RG-2 Moderate risk	0.589 A	854 lux (79.3 fc)	1990 mm (6.53 ft)	Not applicable
	Neutral White	February 1, 2018	2.300 A	RG-2 Moderate risk	1.075 A	1580 lux (146.8 fc)	1433 mm (4.70 ft)	Not applicable
	Warm White	February 1, 2018	2.300 A	RG-2 Moderate risk	1.570 A	2216 lux (205.9 fc)	1228 mm (4.03 ft)	Not applicable
CMA2550 (36 V)	Cool White	February 1, 2018	3.300 A	RG-2 Moderate risk	1.684 A	849 lux (78.9 fc)	2347 mm (7.70 ft)	Not applicable
	Neutral White	February 1, 2018	3.300 A	RG-2 Moderate risk	1.059 A	1430 lux (132.9 fc)	1803 mm (5.92 ft)	Not applicable
	Warm White	February 1, 2018	3.300 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMA3090* (72 V)	Cool White	February 1, 2018	2.400 A	RG-2 Moderate risk	0.813 A	830 lux (77.1 fc)	2627 mm (8.62 ft)	Not applicable
	Neutral White	February 1, 2018	2.400 A	RG-2 Moderate risk	1.502 A	1489 lux (138.3 fc)	1990 mm (6.53 ft)	Not applicable
	Warm White	February 1, 2018	2.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMB1306* (36-V)	Cool White	January 29, 2024	0.600 A	RG-2 Moderate risk	0.184 A	908 lux (84.4 fc)	343 mm (1.13 ft)	Not applicable
	Neutral White	January 29, 2024	0.600 A	RG-2 Moderate risk	0.239 A	1180 lux (109.6 fc)	298 mm (0.98 ft)	Not applicable
	Warm White	January 29, 2024	0.600 A	RG-2 Moderate risk	0.375 A	2039 lux (189.4 fc)	242 mm (0.79 ft)	Not applicable
CMB1516* (36-V)	Cool White	January 29, 2024	1.200 A	RG-2 Moderate risk	0.331 A	814 lux (75.6 fc)	362 mm (1.19 ft)	Not applicable
	Neutral White	January 29, 2024	1.200 A	RG-2 Moderate risk	0.636 A	1495 lux (138.9 fc)	269 mm (0.88 fc)	Not applicable
	Warm White	January 29, 2024	1.200 A	RG-2 Moderate risk	0.821 A	2092 lux (194.4 fc)	233 mm (0.76 mm)	Not applicable
CMB1825* (36-V)	Cool White	April 28, 2023	1.800 A	RG-2 Moderate risk	0.365 A	1099 lux (102.1 fc)	272 mm (0.89 fc)	Not applicable
	Neutral White	April 28, 2023	1.800 A	RG-2 Moderate risk	0.589 A	1927 lux (179.0 fc)	225 mm (0.74 ft)	Not applicable
	Warm White	April 28, 2023	1.800 A	RG-2 Moderate risk	1.337 A	2464 lux (228.9 fc)	193 mm (0.63 ft)	Not applicable

* Products tested are Standard versions. Test results apply to both Standard and Pro9™ versions of these LEDs since the Pro9 versions of these LEDs are dimmer than the tested Standard version samples.

XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E _{thr}	d _{min}	
CMB1840* (36-V)	Cool White	January 29, 2024	2.400 A	RG-2 Moderate risk	0.916 A	860 lux (79.9 fc)	293 mm (0.96 ft)	Not applicable
	Neutral White	January 29, 2024	2.400 A	RG-2 Moderate risk	1.321 A	1529 lux (142.0 fc)	252 mm (0.83 ft)	Not applicable
	Warm White	January 29, 2024	2.400 A	RG-1 Low risk	Not applicable	2301 lux (213.8 fc)	194 mm (0.64 ft)	Not applicable
CMB2550* (36-V)	Cool White	April 28, 2023	3.600 A	RG-2 Moderate risk	0.365 A	1058 lux (98.3 fc)	252 mm (0.83 ft)	Not applicable
	Neutral White	April 28, 2023	3.600 A	RG-2 Moderate risk	0.589 A	1628 lux (151.2 fc)	200 mm (0.66 ft)	Not applicable
	Warm White	April 28, 2023	3.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMB3090* (72 V)	Cool White	April 28, 2023	2.400 A	RG-2 Moderate risk	1.438 A	1133 lux (105.3 fc)	239 mm (0.78 ft)	Not applicable
	Neutral White	April 28, 2023	2.400 A	RG-2 Moderate risk	1.928 A	1467 lux (136.3 fc)	212 mm (0.70 ft)	Not applicable
	Warm White	April 28, 2023	2.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMT1407 (36-V)	Cool White	April 4, 2018	0.500 A	RG-2 Moderate risk	0.322 A	982 lux (91.2 fc)	1009 mm (3.31 ft)	Not applicable
	Neutral White	April 4, 2018	0.500 A	RG-2 Moderate risk	0.495 A	1578 lux (146.6 fc)	745 mm (2.44 ft)	Not applicable
	Warm White	April 4, 2018	0.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMT1412 (36-V)	Cool White	April 4, 2018	0.750 A	RG-2 Moderate risk	0.274 A	987 lux (91.7 fc)	1141 mm (3.74 ft)	Not applicable
	Neutral White	April 4, 2018	0.750 A	RG-2 Moderate risk	0.415 A	1631 lux (151.5 fc)	938 mm (3.08 ft)	Not applicable
	Warm White	April 4, 2018	0.750 A	RG-2 Moderate risk	0.703 A	2100 lux (195.1 fc)	730 mm (2.40 ft)	Not applicable
CMT1420 (36-V)	Cool White	April 11, 2018	1.300 A	RG-2 Moderate risk	0.299 A	952 lux (88.4 fc)	1359 mm (4.46 ft)	Not applicable
	Neutral White	April 11, 2018	1.300 A	RG-2 Moderate risk	0.475 A	1511 lux (140.4 fc)	1109 mm (3.64 ft)	Not applicable
	Warm White	April 11, 2018	1.300 A	RG-2 Moderate risk	0.730 A	2192 lux (203.6 fc)	923 mm (3.03 ft)	Not applicable
CMT1922 (36-V)	Cool White	April 17, 2018	1.500 A	RG-2 Moderate risk	0.486 A	903 lux (83.9 fc)	1618 mm (5.31 ft)	Not applicable
	Neutral White	April 17, 2018	1.500 A	RG-2 Moderate risk	1.260 A	1629 lux (151.3 fc)	1179 mm (3.87 ft)	Not applicable
	Warm White	April 17, 2018	1.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMT1925 (36-V)	Cool White	March 16, 2018	1.700 A	RG-2 Moderate risk	0.741 A	886 lux (82.3 fc)	1653 mm (5.42 ft)	Not applicable
	Neutral White	March 16, 2018	1.700 A	RG-2 Moderate risk	1.241 A	1376 lux (127.8 fc)	1293 mm (4.24 ft)	Not applicable
	Warm White	March 16, 2018	1.700 A	RG-2 Moderate risk	1.656 A	2117 lux (196.7 fc)	449 mm (1.47 ft)	Not applicable

* Products tested are Standard versions. Test results apply to both Standard and Pro9™ versions of these LEDs since the Pro9 versions of these LEDs are dimmer than the tested Standard version samples.

XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
CMT1930 (36-V)	Cool White	April 11, 2018	2.000 A	RG-2 Moderate risk	0.539 A	844 lux (78.4 fc)	1935 mm (6.35 ft)	Not applicable
	Neutral White	April 11, 2018	2.000 A	RG-2 Moderate risk	1.054 A	1639 lux (152.3 fc)	1313 mm (4.31 ft)	Not applicable
	Warm White	April 11, 2018	2.000 A	RG-2 Moderate risk	1.484 A	2144 lux (199.2 fc)	1171 mm (3.84 ft)	Not applicable
CMT1945 (36-V)	Cool White	April 11, 2018	2.500 A	RG-2 Moderate risk	0.586 A	867 lux (80.5 fc)	2011 mm (6.60 ft)	Not applicable
	Neutral White	April 11, 2018	2.500 A	RG-2 Moderate risk	1.065 A	1471 lux (136.7 fc)	1490 mm (4.89 ft)	Not applicable
	Warm White	April 11, 2018	2.500 A	RG-2 Moderate risk	1.522 A	2082 lux (193.4 fc)	1267 mm (4.16 ft)	Not applicable
CMT2850 (36-V)	Cool White	March 21, 2018	3.500 A	RG-2 Moderate risk	1.518 A	926 lux (86.0 fc)	2723 mm (8.93 ft)	Not applicable
	Neutral White	March 21, 2018	3.500 A	RG-2 Moderate risk	2.435 A	1318 lux (122.4 fc)	1986 mm (6.52 ft)	Not applicable
	Warm White	March 21, 2018	3.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMT2870 (36-V)	Cool White	April 11, 2018	2.800 A	RG-2 Moderate risk	0.927 A	889 lux (82.6 fc)	2720 mm (8.92 ft)	Not applicable
	Neutral White	April 11, 2018	2.800 A	RG-2 Moderate risk	1.865 A	1701 lux (158.0 fc)	1929 mm (6.33 ft)	Not applicable
	Warm White	April 11, 2018	2.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMT2890 (36-V)	Cool White	March 20, 2018	3.300 A	RG-2 Moderate risk	1.169 A	885 lux (82.2 fc)	2787 mm (9.14 ft)	Not applicable
	Neutral White	March 20, 2018	3.300 A	RG-2 Moderate risk	1.715 A	1395 lux (129.6 fc)	2161 mm (7.09 ft)	Not applicable
	Warm White	March 20, 2018	3.300 A	RG-2 Moderate risk	3.238 A	2186 lux (203.1 fc)	1811 mm (5.94 ft)	Not applicable
CMU1003* (36-V)	Cool White	August 31, 2020	0.240 A	RG-2 Moderate risk	0.106 A	895 lux (83.1 fc)	160 mm (0.52 ft)	Not applicable
	Neutral White	August 31, 2020	0.240 A	RG-2 Moderate risk	0.182 A	1670 lux (155.1 fc)	220 mm (0.72 ft)	Not applicable
	Warm White	August 31, 2020	0.240 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1006* (36-V)	Cool White	August 31, 2020	0.480 A	RG-2 Moderate risk	0.212 A	895 lux (83.1 fc)	160 mm (0.52 ft)	Not applicable
	Neutral White	August 31, 2020	0.480 A	RG-2 Moderate risk	0.363 A	1670 lux (155.1 fc)	220 mm (0.72 ft)	Not applicable
	Warm White	August 31, 2020	0.480 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1010* (36-V)	Cool White	August 31, 2020	0.720 A	RG-2 Moderate risk	0.318 A	895 lux (83.1 fc)	160 mm (0.52 ft)	Not applicable
	Neutral White	August 31, 2020	0.720 A	RG-2 Moderate risk	0.545 A	1670 lux (155.1 fc)	220 mm (0.72 ft)	Not applicable
	Warm White	August 31, 2020	0.720 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1013* (36-V)	Cool White	March 27, 2023	0.960 A	RG-2 Moderate risk	0.488 A	953 lux (88.5 fc)	270 mm (0.89 ft)	Not applicable
	Neutral White	August 31, 2020	0.960 A	RG-2 Moderate risk	0.726 A	1670 lux (155.1 fc)	220 mm (0.72 ft)	Not applicable
	Warm White	August 31, 2020	0.960 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable

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XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
CMU1516* (36-V)	Cool White	May 3, 2021	1.200 A	RG-2 Moderate risk	0.750 A	1708 lux (158.7 fc)	240 mm (0.79 ft)	Not applicable
	Neutral White	May 3, 2021	1.200 A	RG-2 Moderate risk	1.122 A	2806 lux (260.7 fc)	200 mm (0.66 ft)	Not applicable
	Warm White	May 3, 2021	1.200 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1519* (36-V)	Cool White	May 3, 2021	1.440 A	RG-2 Moderate risk	0.900 A	1708 lux (158.7 fc)	240 mm (0.79 ft)	Not applicable
	Neutral White	May 3, 2021	1.440 A	RG-2 Moderate risk	1.346 A	2806 lux (260.7 fc)	200 mm (0.66 ft)	Not applicable
	Warm White	May 3, 2021	1.440 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1526* (36-V)	Cool White	May 3, 2021	1.920 A	RG-2 Moderate risk	1.200 A	1708 lux (158.7 fc)	240 mm (0.79 ft)	Not applicable
	Neutral White	May 3, 2021	1.920 A	RG-2 Moderate risk	1.795 A	2806 lux (260.7 fc)	200 mm (0.66 ft)	Not applicable
	Warm White	May 3, 2021	1.920 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU1532* (36-V)	Cool White	May 3, 2021	2.400 A	RG-2 Moderate risk	1.500 A	1708 lux (158.7 fc)	240 mm (0.79 ft)	Not applicable
	Neutral White	May 3, 2021	2.400 A	RG-2 Moderate risk	2.244 A	2806 lux (260.7 fc)	200 mm (0.66 ft)	Not applicable
	Warm White	May 3, 2021	2.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU2236* (36-V)	Cool White	May 3, 2021	2.640 A	RG-2 Moderate risk	0.699 A	963 lux (89.5 fc)	350 mm (1.15 ft)	Not applicable
	Neutral White	May 3, 2021	2.640 A	RG-2 Moderate risk	1.300 A	997 lux (92.6 fc)	270 mm (0.89 ft)	Not applicable
	Warm White	May 3, 2021	2.640 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU2239* (36-V)	Cool White	May 3, 2021	2.880 A	RG-2 Moderate risk	0.763 A	963 lux (89.5 fc)	350 mm (1.15 ft)	Not applicable
	Neutral White	May 3, 2021	2.880 A	RG-2 Moderate risk	1.419 A	997 lux (92.6 fc)	270 mm (0.89 ft)	Not applicable
	Warm White	May 3, 2021	2.880 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU2258* (54-V)	Cool White	May 3, 2021	2.880 A	RG-2 Moderate risk	0.763 A	963 lux (89.5 fc)	350 mm (1.15 ft)	Not applicable
	Neutral White	May 3, 2021	2.880 A	RG-2 Moderate risk	1.419 A	997 lux (92.6 fc)	270 mm (0.89 ft)	Not applicable
	Warm White	May 3, 2021	2.880 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CMU2287* (54-V)	Cool White	May 3, 2021	4.320 A	RG-2 Moderate risk	1.144 A	963 lux (89.5 fc)	350 mm (1.15 ft)	Not applicable
	Neutral White	May 3, 2021	4.320 A	RG-2 Moderate risk	2.128 A	997 lux (92.6 fc)	270 mm (0.89 ft)	Not applicable
	Warm White	May 3, 2021	4.320 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA1304 (36 V)	Cool White	September 25, 2015	0.250 A	RG-2 Moderate risk	0.095 A	794 lux (73.8 fc)	569 mm (1.88 ft)	Not applicable
	Neutral White	September 25, 2015	0.250 A	RG-2 Moderate risk	0.188 A	1359 lux (126.3 fc)	459 mm (1.51 ft)	Not applicable
	Warm White	September 25, 2015	0.250 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable

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						E_{thr}	d_{min}	
CXA1507 (36 V)	Cool White	September 4, 2014	0.375 A	RG-2 Moderate risk	0.221 A			Not applicable
	Neutral White	September 4, 2014	0.375 A	RG-2 Moderate risk	0.327 A			Not applicable
	Warm White	September 4, 2014	0.375 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA1512 (18 V)	Cool White	August 18, 2014	1.200 A	RG-2 Moderate risk	0.216 A			Not applicable
	Neutral White	August 18, 2014	1.200 A	RG-2 Moderate risk	0.399 A			Not applicable
	Warm White	August 18, 2014	1.200 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA1816 (36 V)	Cool White	August 20, 2014	0.900 A	RG-2 Moderate risk	0.316 A			Not applicable
	Neutral White	August 20, 2014	0.900 A	RG-2 Moderate risk	0.405 A			Not applicable
	Warm White	August 20, 2014	0.900 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA1820 (36 V)	Cool White	September 10, 2014	1.050 A	RG-2 Moderate risk	0.359 A			Not applicable
	Neutral White	September 10, 2014	1.050 A	RG-2 Moderate risk	0.424 A			Not applicable
	Warm White	September 10, 2014	1.050 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA1830 (36 V)	Cool White	August 13, 2014	1.400 A	RG-2 Moderate risk	0.447 A			Not applicable
	Neutral White	August 13, 2014	1.400 A	RG-2 Moderate risk	0.587 A			Not applicable
	Warm White	August 13, 2014	1.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA2520 (36 V)	Cool White	September 3, 2014	1.250 A	RG-2 Moderate risk	0.980 A			Not applicable
	Neutral White	September 3, 2014	1.250 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	September 3, 2014	1.250 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA2530 (36 V)	Cool White	August 21, 2014	1.600 A	RG-2 Moderate risk	0.936 A			Not applicable
	Neutral White	August 21, 2014	1.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	August 21, 2014	1.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA2540 (36 V)	Cool White	August 5, 2014	2.100 A	RG-2 Moderate risk	1.266 A			Not applicable
	Neutral White	August 5, 2014	2.100 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	August 5, 2014	2.100 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA3050 (36 V)	Cool White	March 30, 2015	2.500 A	RG-2 Moderate risk	1.442 A	898 lux (83.4 fc)	1976 mm (6.48 ft)	Not applicable
	Neutral White	March 30, 2015	2.500 A	RG-2 Moderate risk	2.122 A	1156 lux (107.4 fc)	1768 mm (5.80 ft)	Not applicable
	Warm White	March 30, 2015	2.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA3070 (36 V)	Cool White	January 8, 2015	2.800 A	RG-2 Moderate risk	1.297 A			Not applicable
	Neutral White	January 8, 2015	2.800 A	RG-2 Moderate risk	1.745 A			Not applicable
	Warm White	January 8, 2015	2.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXA3590 (72 V)	Cool White	September 17, 2015	1.800 A	RG-2 Moderate risk	0.895 A	773 lux (71.8 fc)	2173 mm (7.13 ft)	Not applicable
	Neutral White	September 17, 2015	1.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	September 17, 2015	1.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB1304* (9 V)	Cool White	March 4, 2016	1.000 A	RG-2 Moderate risk	0.608 A	1003 lux (93.2 fc)	592 mm (1.94 ft)	Not applicable
	Neutral White	March 4, 2016	1.000 A	RG-2 Moderate risk	0.811 A	1625 lux (151.0 fc)	447 mm (1.47 ft)	Not applicable
	Warm White	March 4, 2016	1.000 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable

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						E_{thr}	d_{min}	
CXB1310 (18 V)	Cool White	July 11, 2016	1.400 A	RG-2 Moderate risk	0.180 A	730 lux (67.8 fc)	1191 mm (3.91 ft)	Not applicable
	Neutral White	July 11, 2016	1.400 A	RG-2 Moderate risk	0.410 A	1438 lux (133.6 fc)	849 mm (2.79 ft)	Not applicable
CXB1310 (36 V)	Warm White	July 11, 2016	0.700 A	RG-2 Moderate risk	0.346 A	2510 lux (233.2 fc)	599 mm (1.97 ft)	Not applicable
CXB1507* (36 V)	Cool White	October 29, 2015	0.375 A	RG-2 Moderate risk	0.277 A	1121 lux (104.1 fc)	725 mm (2.38 ft)	Not applicable
	Neutral White	October 29, 2015	0.375 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	October 29, 2015	0.375 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB1512* (36 V)	Cool White	December 21, 2016	0.600 A	RG-2 Moderate risk	0.239 A	963 lux (89.5 fc)	976 mm (3.20 ft)	Not applicable
	Neutral White	December 21, 2016	0.600 A	RG-2 Moderate risk	0.446 A	1718 lux (159.6 fc)	769 mm (2.52 ft)	Not applicable
	Warm White	December 21, 2016	0.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB1520 (36 V)	Cool White	June 1, 2016	1.400 A	RG-2 Moderate risk	0.297 A	837 lux (77.8 fc)	1554 mm (5.10 ft)	Not applicable
	Neutral White	June 1, 2016	1.400 A	RG-2 Moderate risk	0.391 A	1597 lux (148.4 fc)	1036 mm (3.40 ft)	Not applicable
	Warm White	June 1, 2016	1.400 A	RG-2 Moderate risk	1.049 A	3252 lux (302.1 fc)	781 mm (2.56 ft)	Not applicable
CXB1816* (36 V)	Cool White	March 18, 2016	0.900 A	RG-2 Moderate risk	0.620 A	1196 lux (111.1 fc)	1046 mm (3.43 ft)	Not applicable
	Neutral White	March 18, 2016	0.900 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	March 18, 2016	0.900 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB1820* (36 V)	Cool White	November 5, 2015	1.050 A	RG-2 Moderate risk	0.427 A	958 lux (88.0 fc)	1267 mm (4.16 ft)	Not applicable
	Neutral White	November 5, 2015	1.050 A	RG-2 Moderate risk	0.909 A	1898 lux (176.3 fc)	899 mm (2.95 ft)	Not applicable
	Warm White	November 5, 2015	1.050 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB1830* (36 V)	Cool White	November 6, 2015	1.400 A	RG-2 Moderate risk	0.660 A	1024 lux (95.1 fc)	1224 mm (4.02 ft)	Not applicable
	Neutral White	November 6, 2015	1.400 A	RG-2 Moderate risk	1.101 A	1681 lux (156.2 fc)	1071 mm (3.51 ft)	Not applicable
	Warm White	November 6, 2015	1.400 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB2530* (36 V)	Cool White	March 30, 2016	1.600 A	RG-2 Moderate risk	1.424 A	815 lux (75.7 fc)	1839 mm (6.03 ft)	Not applicable
	Neutral White	March 30, 2016	1.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	March 30, 2016	1.600 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB2540* (36 V)	Cool White	February 5, 2016	2.100 A	RG-2 Moderate risk	1.359 A	2559 lux (237.7 fc)	1096 mm (3.60 ft)	Not applicable
	Neutral White	February 5, 2016	2.100 A	RG-2 Moderate risk	1.948 A	2622 lux (243.6 fc)	1123 mm (3.68 ft)	Not applicable
	Warm White	February 5, 2016	2.100 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable

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						E_{thr}	d_{min}	
CXB3050* (36 V)	Cool White	January 12, 2016	2.500 A	RG-2 Moderate risk	0.660 A	2285 lux (212.3 fc)	1330 mm (4.36 ft)	Not applicable
	Neutral White	January 12, 2016	2.500 A	RG-2 Moderate risk	1.221 A	2308 lux (2124.4 fc)	1353 mm (4.44 ft)	Not applicable
	Warm White	January 12, 2016	2.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB3070*\ (36 V)	Cool White	February 2, 2016	2.800 A	RG-2 Moderate risk	1.506 A	2096 lux (194.7 fc)	1525 mm (5.00 ft)	Not applicable
	Neutral White	February 2, 2016	2.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	February 2, 2016	2.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
CXB3590* (72 V)	Cool White	March 17, 2016	1.800 A	RG-2 Moderate risk	1.510 A	871 lux (80.9 fc)	2554 mm (8.38 ft)	Not applicable
	Neutral White	March 17, 2016	1.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Warm White	March 17, 2016	1.800 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
MHB-A (36 V)	Cool White	March 26, 2015	0.175 A	RG-2 Moderate risk	0.075 A	743 lux (69.0 fc)	560 mm (1.84 ft)	Not applicable
	Neutral White	March 26, 2015	0.175 A	RG-2 Moderate risk	0.109 A	1054 lux (97.9 fc)	460 mm (1.51 ft)	Not applicable
	Warm White	March 26, 2015	0.175 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
MHB-B (18 V)	Cool White	August 2, 2017	0.350 A	RG-2 Moderate risk	0.148 A	987 lux (91.7 fc)	529 mm (1.74 ft)	Not applicable
	Neutral White	August 2, 2017	0.350 A	RG-2 Moderate risk	0.229 A	1461 lux (135.7 fc)	440 mm (1.44 ft)	Not applicable
	Warm White	August 2, 2017	0.350 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
MHD-E (36 V)	Cool White	July 7, 2015	0.350 A	RG-2 Moderate risk	0.128 A	866 lux (80.5 fc)	710 mm (2.33 ft)	Not applicable
	Neutral White	July 7, 2015	0.350 A	RG-2 Moderate risk	0.142 A	985 lux (91.5 fc)	689 mm (2.27 ft)	Not applicable
	Warm White	July 7, 2015	0.350 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
MHD-G (36 V)	Cool White	July 13, 2015	0.500 A	RG-2 Moderate risk	0.175 A	903 lux (83.9 fc)	828 mm (2.72 ft)	Not applicable
	Neutral White	July 13, 2015	0.500 A	RG-2 Moderate risk	0.211 A	1270 lux (118.0 fc)	726 mm (2.38 ft)	Not applicable
	Warm White	July 13, 2015	0.500 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
MK-R (12 V)	Cool White							
	Neutral White							
	Warm White	October 25, 2013	1.250 A	RG-2 Moderate risk	1.200 A			Not applicable
ML-E	Cool White	April 27, 2012	0.150 A	Exempt	Not applicable	Not applicable		Not applicable
	Neutral White							
	Warm White							
	Blue	May 3, 2013	0.350 A	RG-2 Moderate risk				Not applicable
MX-6	Cool White	September 4, 2009	0.350 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Neutral White							
	Warm White							

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XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
XB-D	Cool White	September 10, 2015	1.000 A	RG-2 Moderate risk	0.201 A	827 lux (76.8 fc)	331 mm (1.09 ft)	Not applicable
	Neutral White	September 10, 2015	1.000 A	RG-2 Moderate risk	0.284 A	1182 lux (109.8 fc)	277 mm (0.91 ft)	Not applicable
	Warm White	September 10, 2015	1.000 A	RG-2 Moderate risk	0.494 A	1771 lux (164.5 fc)	221 mm (0.73 ft)	Not applicable
	Royal Blue	September 8, 2015	1.000 A	RG-2 Moderate risk	0.055 A	60 lux (5.6 fc)	509 mm (1.67 ft)	Not applicable
	Green	October 5, 2012	1.000 A	Exempt	Not applicable	Not applicable		Not applicable
	PC Amber	June 5, 2018	1.000 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
XB-H	Cool White	September 17, 2014	1.500 A	RG-2 Moderate risk				Not applicable
	Neutral White							
	Warm White							
XD16	Cool White	February 1, 2018	2.000 A	RG-2 Moderate risk	0.282 A	995 lux (92.4 fc)	421 mm (1.38 ft)	Not applicable
	Neutral White	February 1, 2018	2.000 A	RG-2 Moderate risk	0.702 A	2266 lux (210.5 fc)	271 mm (0.89 ft)	Not applicable
	Warm White	February 1, 2018	2.000 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
XD16 Premium White	Cool White	March 31, 2022	2.000 A	RG-2 Moderate risk	0.243 A	658 lux (61.1 fc)	513 mm (1.68 ft)	Not applicable
	Neutral White	March 31, 2022	2.000 A	RG-2 Moderate risk	0.470 A	1363 lux (126.6 fc)	369 mm (1.21 ft)	Not applicable
	Warm White	March 31, 2022	2.000 A	RG-2 Moderate risk	1.524 A	2242 lux (208.3 fc)	219 mm (0.72 ft)	Not applicable
XE-G	Cool White	May 24, 2022	3.000 A	RG-2 Moderate risk	0.342 A	646 lux (60.0 fc)	518 mm (1.70 ft)	Not applicable
	Neutral White	May 24, 2022	3.000 A	RG-2 Moderate risk	0.725 A	1314 lux (122.1 fc)	357 mm (1.17 ft)	Not applicable
	Warm White	May 24, 2022	3.000 A	RG-2 Moderate risk	1.200 A	1925 lux (178.8 fc)	285 mm (0.94 ft)	Not applicable
	Royal Blue	September 21, 2023	3.000 A	RG-2 Moderate risk	0.108 A	19 lux (1.8 fc)	869 mm (2.85 ft)	Not applicable
	PC Blue	May 24, 2022	3.000 A	RG-2 Moderate risk	0.170 A	102 lux (9.48 fc)	687 mm (2.25 ft)	Not applicable
XH-G	Cool White	November 11, 2013	0.350 A	Exempt	Not applicable	Not applicable		Not applicable
	Neutral White							
	Warm White							
XHP35.2 High Density*	Cool White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.188 A	606 lux (56.3 fc)	496 mm (1.63 ft)	Not applicable
	Neutral White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.297 A	993 lux (92.3 fc)	389 mm (1.28 ft)	Not applicable
	Warm White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.524 A	1631 lux (151.5 fc)	301 mm (0.99 ft)	Not applicable

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						E_{thr}	d_{min}	
XHP35.2 High Intensity*	Cool White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.164 A	736 lux (68.4 fc)	510 mm (1.67 ft)	Not applicable
	Neutral White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.285 A	1407 lux (130.7 fc)	387 mm (1.27 ft)	Not applicable
	Warm White	November 27, 2023	1.500 A	RG-2 Moderate risk	0.411 A	1954 lux (181.5 fc)	342 mm (1.12 ft)	Not applicable
XHP50.2 (12 V)	Cool White	January 3, 2017	1.500 A	RG-2 Moderate risk	0.162 A	601 lux (55.8 fc)	1007 mm (3.30 ft)	Not applicable
	Neutral White	January 3, 2017	1.500 A	RG-2 Moderate risk	0.284 A	1135 lux (105.4 fc)	756 mm (2.48 ft)	Not applicable
	Warm White	January 3, 2017	1.500 A	RG-2 Moderate risk	0.451 A	1778 lux (165.2 fc)	582 mm (1.91 ft)	Not applicable
XHP50.3 High Density (12 V)	Cool White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.358 A	871 lux (80.9 fc)	380 mm (1.25 ft)	Not applicable
	Neutral White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.548 A	1555 lux (144.5 fc)	330 mm (1.08 ft)	Not applicable
	Warm White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.890 A	2732 lux (253.8 fc)	250 mm (0.82 ft)	Not applicable
XHP50.3 High Intensity (12 V)	Cool White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.271 A	948 lux (88.1 fc)	260 mm (0.85 ft)	Not applicable
	Neutral White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.412 A	1843 lux (171.2 fc)	360 mm (1.18 ft)	Not applicable
	Warm White	May 28, 2021	1.500 A	RG-2 Moderate risk	0.824 A	3175 lux (295.0 fc)	440 mm (1.44 ft)	Not applicable
XHP70.2 (12 V)	Cool White	February 1, 2018	2.400 A	RG-2 Moderate risk	0.331 A	685 lux (63.6 fc)	1242 mm (4.07 ft)	Not applicable
	Neutral White	February 1, 2018	2.400 A	RG-2 Moderate risk	0.560 A	1305 lux (121.2 fc)	954 mm (3.13 ft)	Not applicable
	Warm White	February 1, 2018	2.400 A	RG-2 Moderate risk	0.899 A	1791 lux (166.4 fc)	727 mm (2.39 ft)	Not applicable
XHP70.3 High Density (12 V)	Cool White	May 28, 2021	3.600 A	RG-2 Moderate risk	0.768 A	1125 lux (104.5 fc)	210 mm (0.69 ft)	Not applicable
	Neutral White	May 28, 2021	3.600 A	RG-2 Moderate risk	1.615 A	2217 lux (206.0 fc)	240 mm (0.79 ft)	Not applicable
	Warm White	May 28, 2021	3.600 A	RG-2 Moderate risk	2.036 A	2606 lux (242.1 fc)	330 mm (1.08 ft)	Not applicable
XHP70.3 High Intensity (12 V)	Cool White	October 29, 2021	3.600 A	RG-2 Moderate risk	0.416 A	543 lux (50.4 fc)	570 mm (1.87 ft)	Not applicable
	Neutral White	October 29, 2021	3.600 A	RG-2 Moderate risk	0.532 A	986 lux (92.0 fc)	440 mm (1.44 ft)	Not applicable
	Warm White	October 29, 2021	3.600 A	RG-2 Moderate risk	0.823 A	1646 lux (152.9 fc)	360 mm (1.18 ft)	Not applicable

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XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
XM-L® Color Gen 2 High Density	Cool White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.219 A	558 lux (51.9 fc)	522 mm (1.71 ft)	Not applicable
	Neutral White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.429 A	1165 lux (108.2 fc)	373 mm (1.22 ft)	Not applicable
	Warm White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.802 A	2039 lux (189.4 fc)	280 mm (0.92 ft)	Not applicable
	Blue	March 30, 2022	1.750 A	RG-2 Moderate risk	0.066 A	15 lux (1.39 fc)	907 mm (2.98 ft)	Not applicable
XM-L® Color Gen 2 High Intensity	Cool White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.386 A	820 lux (76.2 fc)	386 mm (1.27 ft)	Not applicable
	Neutral White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.515 A	1031 lux (95.8 fc)	348 mm (1.14 ft)	Not applicable
	Warm White	March 30, 2022	1.750 A	RG-2 Moderate risk	0.779 A	1532 lux (142.3 fc)	282 mm (0.93 ft)	Not applicable
	Blue	March 30, 2022	1.750 A	RG-2 Moderate risk	0.104 A	23 lux (21.7 fc)	717 mm (2.35 ft)	Not applicable
XM-L2	Cool White	August 7, 2014	3.000 A	RG-2 Moderate risk	0.320 A			Not applicable
	Neutral White	August 7, 2014	3.000 A	RG-2 Moderate risk	0.499 A			Not applicable
	Warm White	August 7, 2014	3.000 A	RG-2 Moderate risk	0.798 A			Not applicable
XP-C	Cool White	September 5, 2013	0.500 A	RG-2 Moderate risk	0.100 A			Not applicable
	Neutral White							
	Warm White							
XP-E	Cool White	June 26, 2009	1.000 A	RG-2 Moderate risk				Not applicable
	Neutral White							
	Warm White							
	Royal Blue	June 26, 2009	1.000 A	RG-2 Moderate risk				Not applicable
	Blue	June 26, 2009	1.000 A	RG-2 Moderate risk				Not applicable
XP-E2	Cool White	June 29, 2023	1.500 A	RG-2 Moderate risk	0.362 A	680 lux (63.2 fc)	350 mm (1.15 ft)	Not applicable
	Neutral White	June 29, 2023	1.500 A	RG-2 Moderate risk	0.497 A	1251 lux (116.2 fc)	301 mm (0.99 ft)	Not applicable
	Warm White	June 29, 2023	1.500 A	RG-2 Moderate risk	0.869 A	1861 lux (172.9 fc)	283 mm (0.93 ft)	Not applicable
	Royal Blue	July 7, 2023	1.200 A	RG-2 Moderate risk	0.087 A	20 lux (1.9 fc)	647 mm (2.12 ft)	Not applicable
	Blue	August 8, 2018	1.000 A	RG-2 Moderate risk	0.119 A	156 lux (14.5 fc)	439 mm (1.44 ft)	Not applicable
XP-G	Cool White	July 31, 2012	1.500 A	RG-2 Moderate risk				Not applicable
	Neutral White							
	Warm White							
XP-G2	Cool White	February 18, 2022	1.500 A	RG-2 Moderate risk	0.239 A	515 lux (47.8 fc)	489 mm (1.60 ft)	Not applicable
	Neutral White	February 18, 2022	1.500 A	RG-2 Moderate risk	0.342 A	745 lux (69.2 fc)	415 mm (1.36 ft)	Not applicable
	Warm White	February 18, 2022	1.500 A	RG-2 Moderate risk	0.782 A	1493 lux (138.7 fc)	265 mm (0.87 ft)	Not applicable

XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
XP-G2 High Efficacy	Cool White	August 20, 2018	2.000 A	RG-2 Moderate risk	0.085 A	534 lux (49.6 fc)	676 mm (2.22 ft)	Not applicable
	Neutral White	August 20, 2018	2.000 A	RG-2 Moderate risk	0.267 A	819 lux (76.1 fc)	611 mm (2.00 ft)	Not applicable
	Warm White	August 20, 2018	2.000 A	RG-2 Moderate risk	0.480 A	1528 (142.0 fc)	427 mm (1.40 ft)	Not applicable
XP-G3	Cool White	February 21, 2022	2.000 A	RG-2 Moderate risk	0.278 A	458 lux (42.5 fc)	520 mm (1.70 ft)	Not applicable
	Neutral White	February 21, 2022	2.000 A	RG-2 Moderate risk	0.419 A	701 lux (65.1 fc)	436 mm (1.43 ft)	Not applicable
	Warm White	February 21, 2022	2.000 A	RG-2 Moderate risk	0.496 A	958 lux (89.0 fc)	387 mm (1.27 ft)	Not applicable
	Royal Blue	March 15, 2018	2.000 A	RG-2 Moderate risk	0.070 A	26 lux (2.4 fc)	853 mm (2.80 ft)	Not applicable
XP-G4*	Cool White	May 31, 2023	3.000 A	RG-2 Moderate risk	0.220 A	482 lux (44.8 fc)	669 mm (2.19 ft)	Not applicable
	Neutral White	May 31, 2023	3.000 A	RG-2 Moderate risk	0.369 A	888 lux (82.5 fc)	517 mm (1.70 ft)	Not applicable
	Warm White	May 31, 2023	3.000 A	RG-2 Moderate risk	0.556 A	1363 lux (126.6 fc)	419 mm (1.37 ft)	Not applicable
XP-G4 High Intensity	Cool White	January 30, 2024	3.000 A	RG-2 Moderate risk	0.242 A	439 lux (40.8 fc)	634 mm (2.08 ft)	Not applicable
	Neutral White	January 30, 2024	3.000 A	RG-2 Moderate risk	0.395 A	852 lux (79.2 fc)	503 mm (1.65 ft)	Not applicable
	Warm White	January 30, 2024	3.000 A	RG-2 Moderate risk	0.637 A	1289 lux (119.8 fc)	400 mm (1.31 ft)	Not applicable
XP-L High Density	Cool White	April 30, 2015	3.000 A	RG-2 Moderate risk	0.252 A	591 lux (54.9 fc)	748 mm (2.45 ft)	Not applicable
	Neutral White	April 30, 2015	3.000 A	RG-2 Moderate risk	0.390 A	878 lux (81.6 fc)	587 mm (1.93 ft)	Not applicable
	Warm White	April 30, 2015	3.000 A	RG-2 Moderate risk	0.780 A	1797 lux (167.0 fc)	408 mm (1.34 ft)	Not applicable
XP-L High Intensity	Cool White	January 20, 2016	3.000 A	RG-2 Moderate risk	0.278 A	886 lux (82.3 fc)	602 mm (1.98 ft)	Not applicable
	Neutral White	January 20, 2016	3.000 A	RG-2 Moderate risk	0.420 A	1305 lux (121.2 fc)	499 mm (1.64 ft)	Not applicable
	Warm White	January 20, 2016	3.000 A	RG-2 Moderate risk	0.837 A	2303 lux (214.0 fc)	350 mm (1.15 ft)	Not applicable
XP-L2	Cool White	January 3, 2017	3.000 A	RG-2 Moderate risk	0.319 A	578 lux (53.7 fc)	784 mm (2.57 ft)	Not applicable
	Neutral White	January 3, 2017	3.000 A	RG-2 Moderate risk	0.609 A	1190 lux (110.6 fc)	553 mm (1.81 ft)	Not applicable
	Warm White	January 3, 2017	3.000 A	RG-2 Moderate risk	0.854 A	1444 lux (134.2 fc)	461 mm (1.51 ft)	Not applicable
XP-P	Cool White	February 25, 2021	3.000 A	RG-2 Moderate risk	0.739 A	1112 lux (103.3 fc)	34,900 mm (114.5 ft)	Not applicable
	Neutral White							
	Warm White							

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XLamp® LED	Color	Test Report Issue Date	Maximum Drive Condition	Risk Group Classification at Maximum Drive Condition	Exceeds RG-1 Threshold At	RG-1/RG-2 Threshold		Exceeds RG-2 Threshold At
						E_{thr}	d_{min}	
XQ-E High Density	Cool White	November 18, 2014	1.000 A	RG-2 Moderate risk	0.239 A	722 lux (67.1 fc)	393 mm (1.29 ft)	Not applicable
	Neutral White	November 18, 2014	1.000 A	RG-2 Moderate risk	0.638 A	1595 lux (148.2 fc)	243 mm (0.80 ft)	Not applicable
	Warm White	November 18, 2014	1.000 A	RG-2 Moderate risk	0.846 A	2021 lux (187.8 fc)	201 mm (0.66 ft)	Not applicable
	Blue	September 17, 2014	1.000 A	RG-2 Moderate risk				Not applicable
XQ-E High Intensity	Cool White	August 8, 2016	1.000 A	RG-2 Moderate risk	0.304 A	911 lux (84.6 fc)	335 mm (1.10 ft)	Not applicable
	Neutral White	August 8, 2016	1.000 A	RG-2 Moderate risk	0.582 A	1323 lux (122.9 fc)	249 mm (0.82 ft)	Not applicable
	Warm White	August 8, 2016	1.000 A	RG-1 Low risk	Not applicable	Not applicable		Not applicable
	Royal Blue	December 29, 2022	1.500 A	RG-2 Moderate risk	0.092 A	18 lux (1.7 fc)	693 mm (2.27 ft)	Not applicable
	PC Blue	December 29, 2022	1.500 A	RG-2 Moderate risk	0.177 A	166 lux (15.4 fc)	527 mm (1.73 ft)	Not applicable
XR-E	Cool White	June 26, 2009	1.000 A	RG-2 Moderate risk				Not applicable
	Neutral White							
	Warm White							
XT-E	Cool White	August 6, 2014	1.500 A	RG-2 Moderate risk	0.275 A			Not applicable
	Neutral White	August 6, 2014	1.500 A	RG-2 Moderate risk	0.329 A			Not applicable
	Warm White	August 6, 2014	1.500 A	RG-2 Moderate risk	1.053 A			Not applicable
	Royal Blue	October 5, 2012	1.500 A	RG-2 Moderate risk				Not applicable
XT-E High Efficacy	Cool White	March 7, 2018	1.500 A	RG-2 Moderate risk	0.194 A	628 lux (58.3 fc)	519 mm (1.70 ft)	Not applicable
	Neutral White	March 7, 2018	1.500 A	RG-2 Moderate risk	0.310 A	1011 lux (93.9 fc)	396 mm (1.30 ft)	Not applicable
	Warm White	March 7, 2018	1.500 A	RG-2 Moderate risk	0.996 A	2765 lux (256.9 fc)	231 mm (0.76 ft)	Not applicable