LED Eye Safety

PRODUCT DESCRIPTION

This application note explains the current standards and regulations related to LED lamps (also called packaged LEDs) and photobiological safety, as well as providing expected maximum risk group classifications for Cree's visible light LED lamps according to these standards. In this document, visible light LED lamps are defined as color LED lamps with dominant wavelength between 440 nm and 640 nm and all white LED lamps.

All light sources have the potential to be harmful to both the skin and the eyes through UV, blue light (410-480 nm) and IR emission. Independent photobiological testing of Cree visible light LED lamps has confirmed that the only health risk of visible light LED lamps significant enough to warrant advisory is viewing blue light with the eyes. LED lamps that emit blue light may be called multiple names, such as Blue, Royal Blue or Dental Blue. In addition, many white LED lamps, including Cree's, are based on blue LED die and contain significant blue light content. Therefore, Cree has tested its Royal Blue, Blue and White LED lamps for eye safety.

Cree's testing to date indicates that Royal Blue and Blue (450-485 nm dominant wavelength) LED lamps pose a higher eye safety hazard than White LED lamps. Other colors of LED lamps, such as Green or Red, do not pose a defined eye safety risk. **Regardless of LED color, Cree advises users not to look directly at any LED lamp.**

All data provided in this report is intended to represent the maximum possible light output of the LED lamp, and thus the worst-case conditions for eye safety. All LED lamps were tested at the maximum drive current to maximize light output. The LED lamp solder-point temperature was actively controlled to be below what is normally seen in most LED luminaire designs so that relative light output was maximized. The LED lamp samples tested were also the highest flux output for that particular type of LED lamp. The eye safety risk of Cree LED lamps under operating conditions different from the ones tested will vary from the data shown.

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PHOTOBIOLOGICAL STANDARDS AND REGULATIONS FOR LEDS

Before October 2008, most LED lamps required labeling under the IEC 60825 laser safety standard. The 60825 standard conflicted with ANSI Z136.1 (2000), which did not recognize LED lamps as a coherent light emission hazard. To resolve these discrepancies for the use of high brightness LED lamps for general illumination applications, LED lamps were dropped from the IEC 60825 standard and the ANSI/IESNA RP-27 testing standard was adopted, in support of the IEC 62471-2006 standard.

Some portions of the world have not yet changed regulations to reference IEC 62471-2006 and still refer to the IEC/EN 60825 laser standard. The IEC/EN 60825 laser standard defines risk groups for entire luminaires, since the eye safety risk could be increased or decreased by elements that are not the light source, such as collimating lenses or diffusers.

In 2007, Cree tested several XLamp White LED lamps and found all of them to be Class 2 devices under IEC/EN 60825. This classification of the standalone LED has no bearing on the risk classification of the final luminaire, which is required to be tested separately, nor is it meant to be indicative of all XLamp LEDs under all operating conditions.

The test results presented in this document were performed on standalone LED lamps to aid in fixture design and for the general safety of those working with the LEDs in a manufacturing setting. Once Cree LED lamps are incorporated into a luminaire or related LED lighting product, Cree recommends the complete system be tested under ANSI/IESNA RP-27 (or an equivalent standard) to assess the eye safety risk of the entire LED lighting system.

TEST RESULTS - XLAMP XR-E COOL WHITE LEDS

Lamp Type:	XLamp XR-E Cool White
Minimum Flux:	114 lm @ 350 mA
CCT:	6300 K to 7000 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	Yes
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Blue Light, Small Source:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.758 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	9.111 W/m^2		

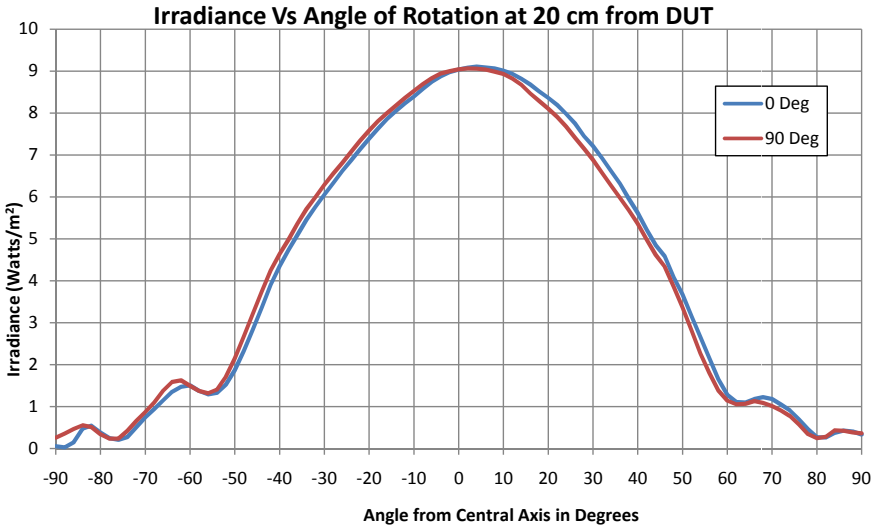


Figure 1: Irradiance Profile at 20 cm

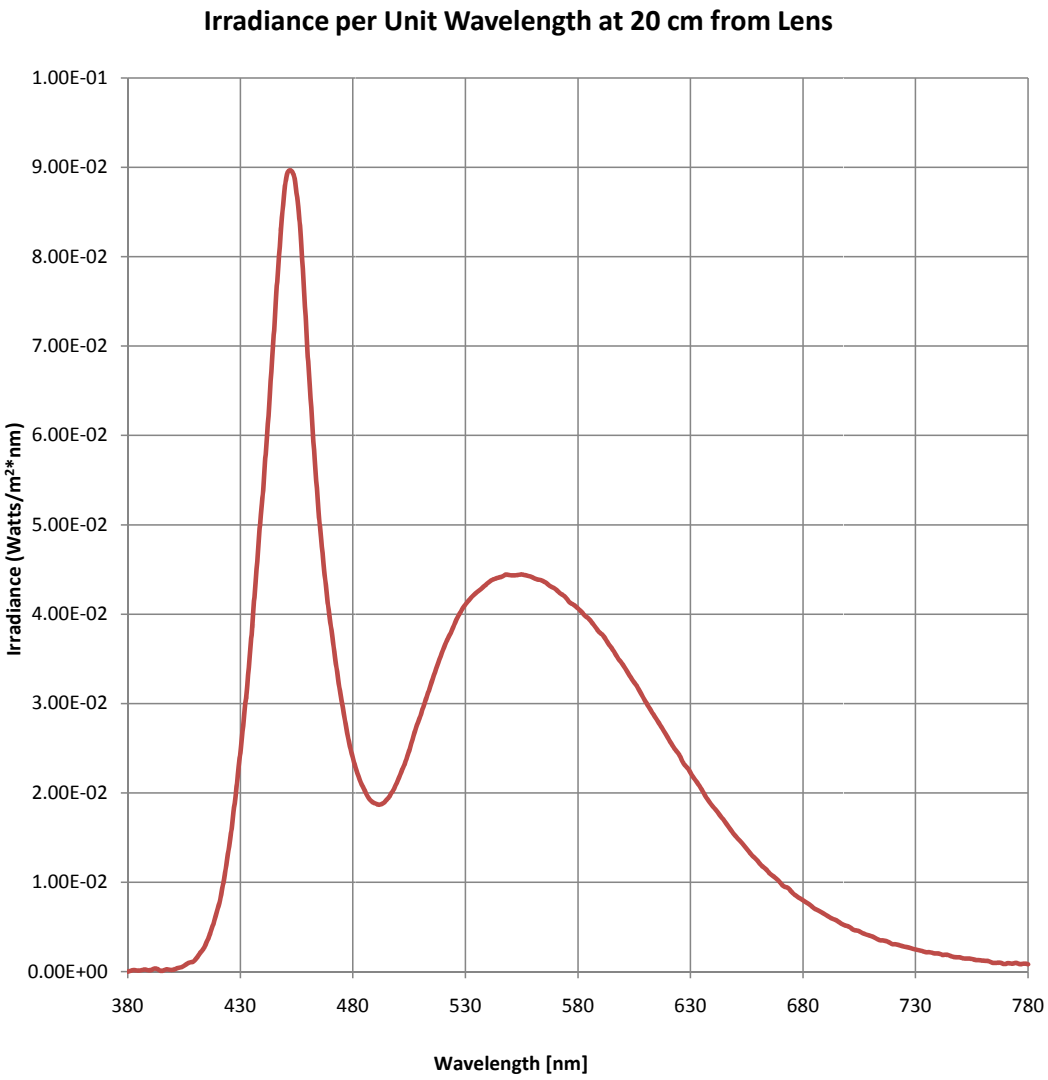
Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.758 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	4. 175 W/cm^2*sr		

PART C (continued): RADIANCE MEASUREMENT

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on www.cree.com.

TEST RESULTS - XLAMP XR-E BLUE LEDS

Lamp Type:	XLamp XR-E Blue
Minimum Flux:	39.8 lm @ 350 mA
Dominant Wavelength:	475-480 nm
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	Yes
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Blue Light, Small Source:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.627 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	7.734 W/m^2		

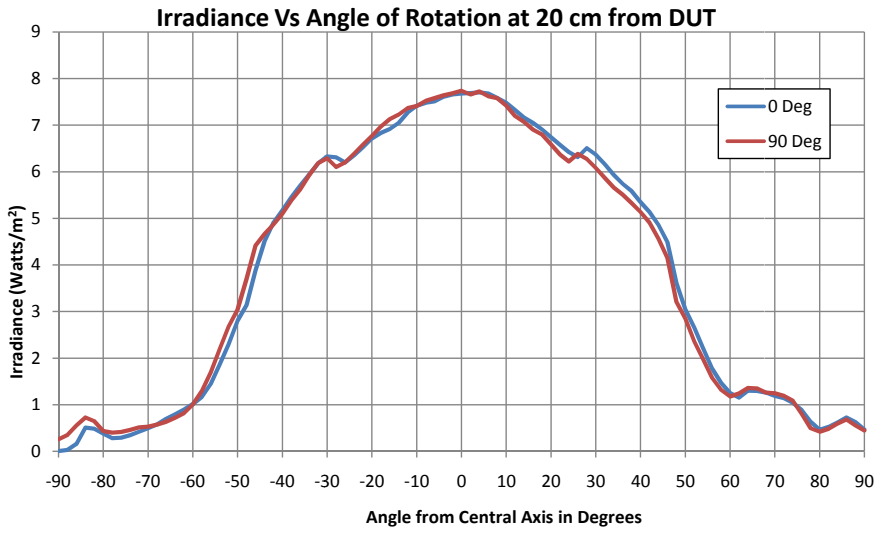


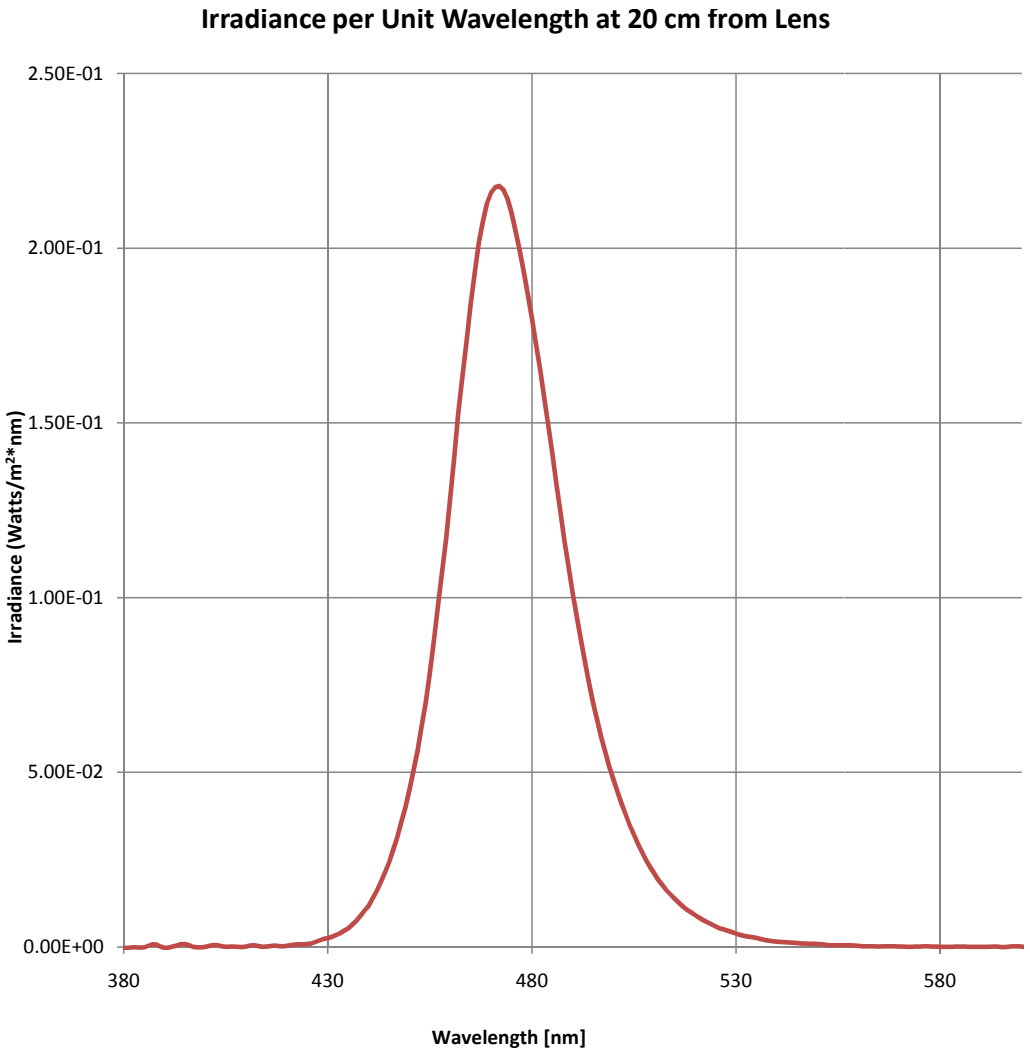
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.627 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	4.72 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP XR-E ROYAL BLUE LEDS

Lamp Type:	XLamp XR-E Royal Blue
Minimum Flux:	500 mW @ 350 mA
Dominant Wavelength:	450-455 nm
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	Yes
Date Measured:	June 30, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Blue Light, Small Source:	RG-3 (High Risk): WARNING. Do not look at exposed lamp in operation. Eye injury can result.
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 567 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	12.56 W/m^2		

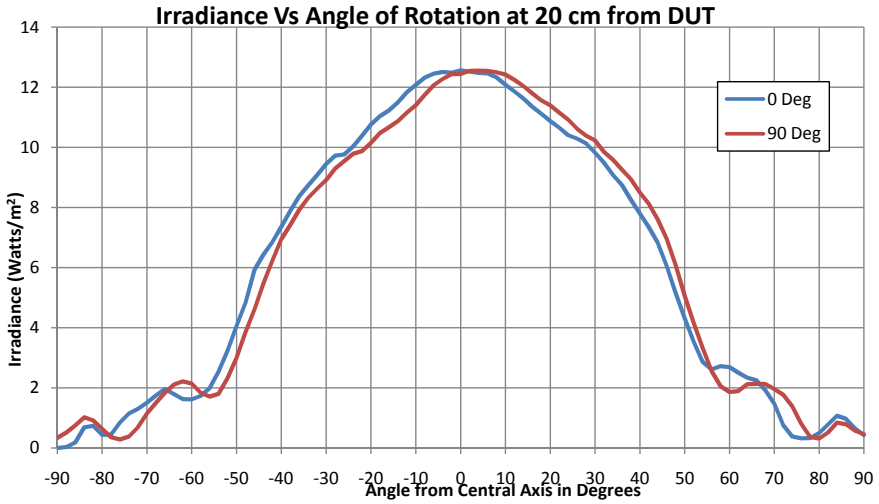


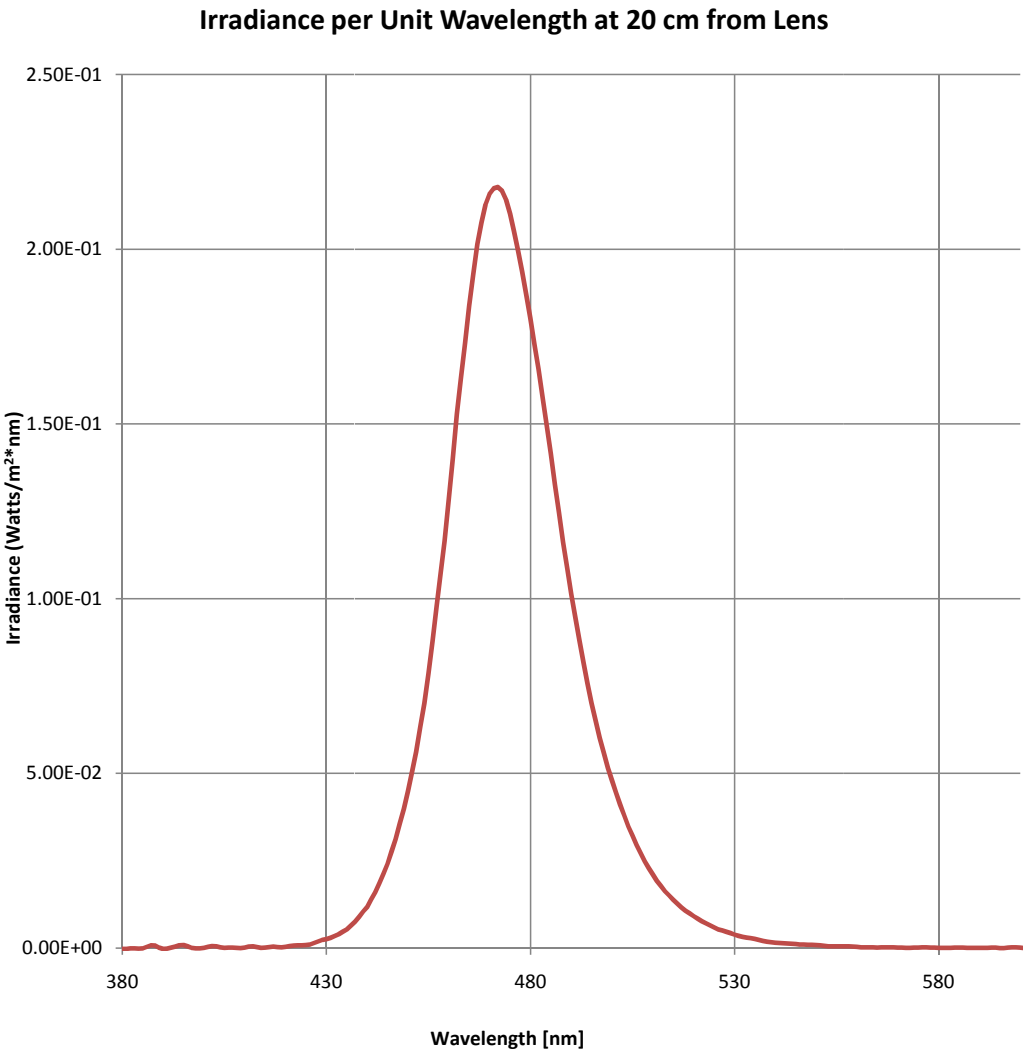
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.000 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 567 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	9.64 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP XP-E COOL WHITE LEDS

Lamp Type:	XLamp XP-E Cool White
Minimum Flux:	114 lm @ 350 mA
CCT:	5700 K - 6300 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-1 (Low Risk)
Blue Light, Small Source:	Not Applicable
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.821 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	4.887 W/m^2		

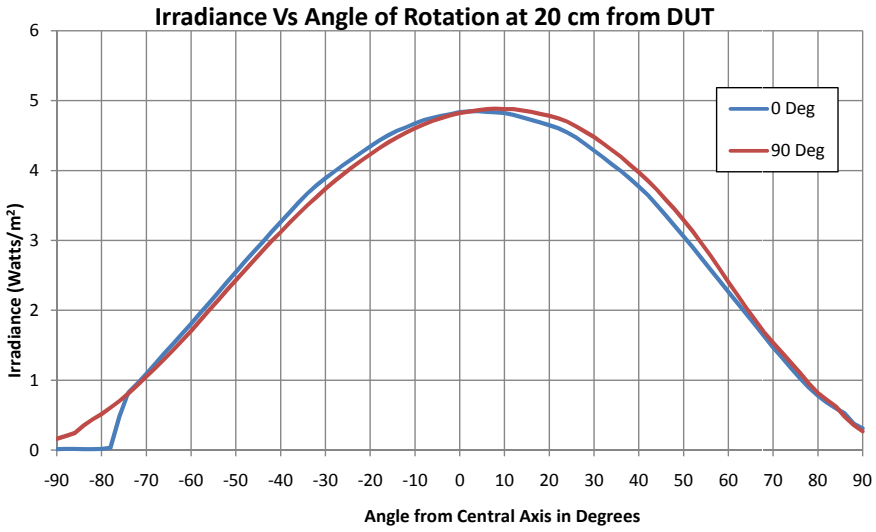


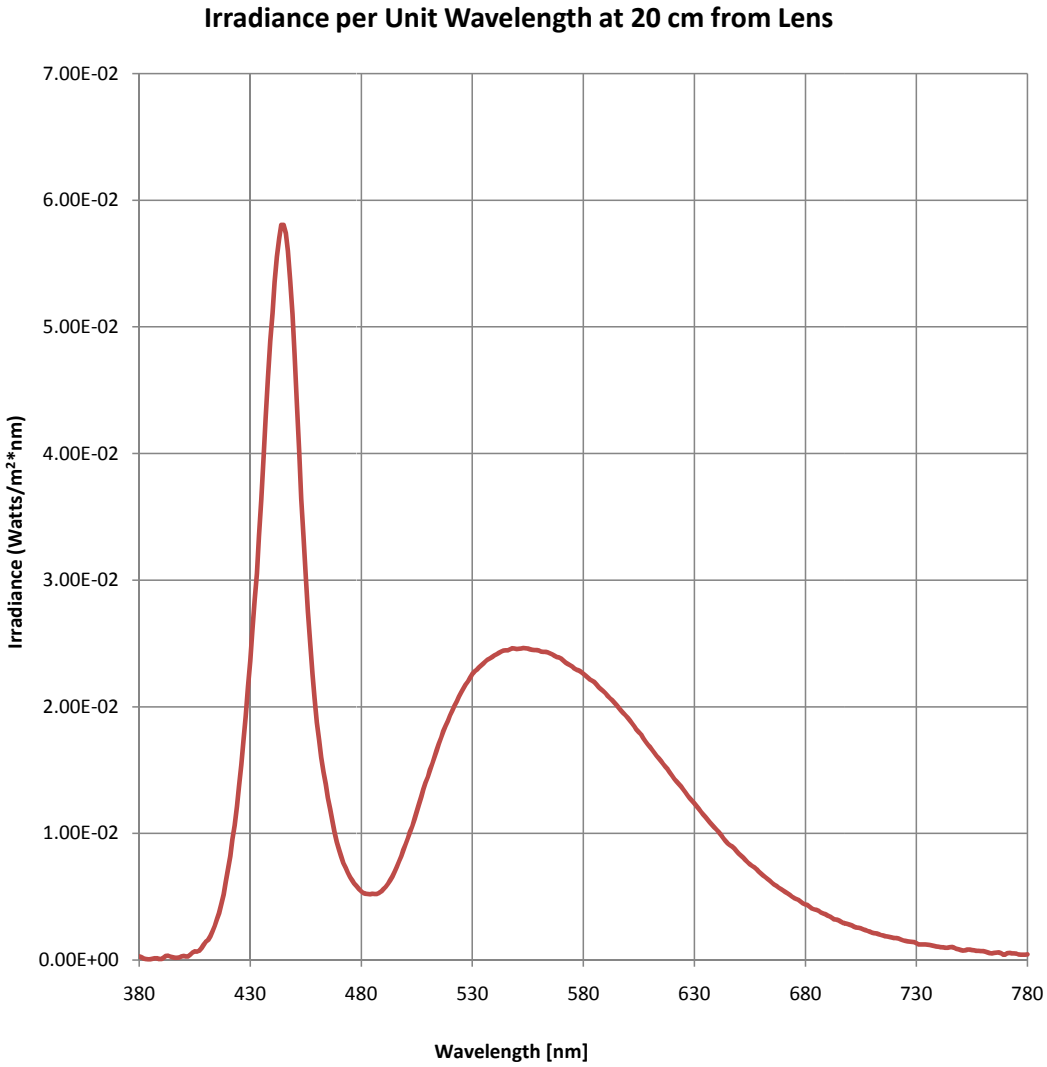
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.812 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	2.99 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP XP-E BLUE LEDS

Lamp Type:	XLamp XP-E Blue
Minimum Flux:	23.5 lm @ 350 mA
Dominant Wavelength:	470-475 nm
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Blue Light, Small Source:	Not Applicable
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 800 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	4.461 W/m^2		

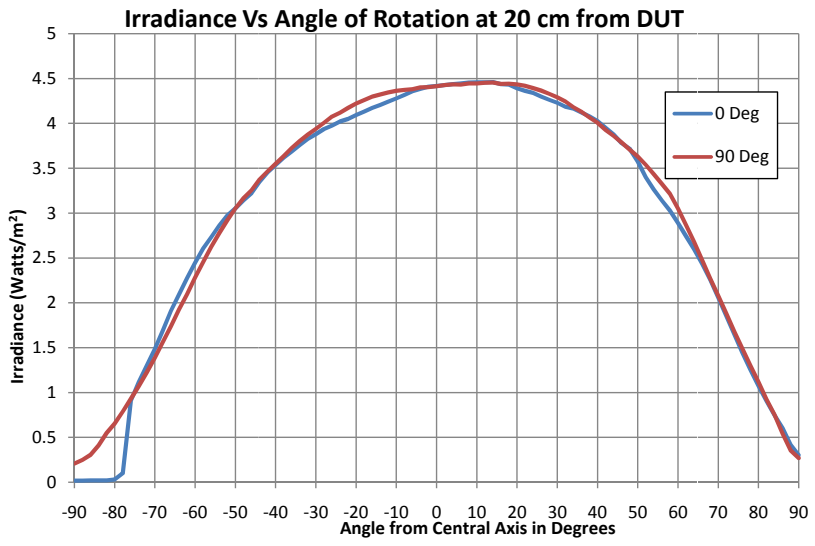


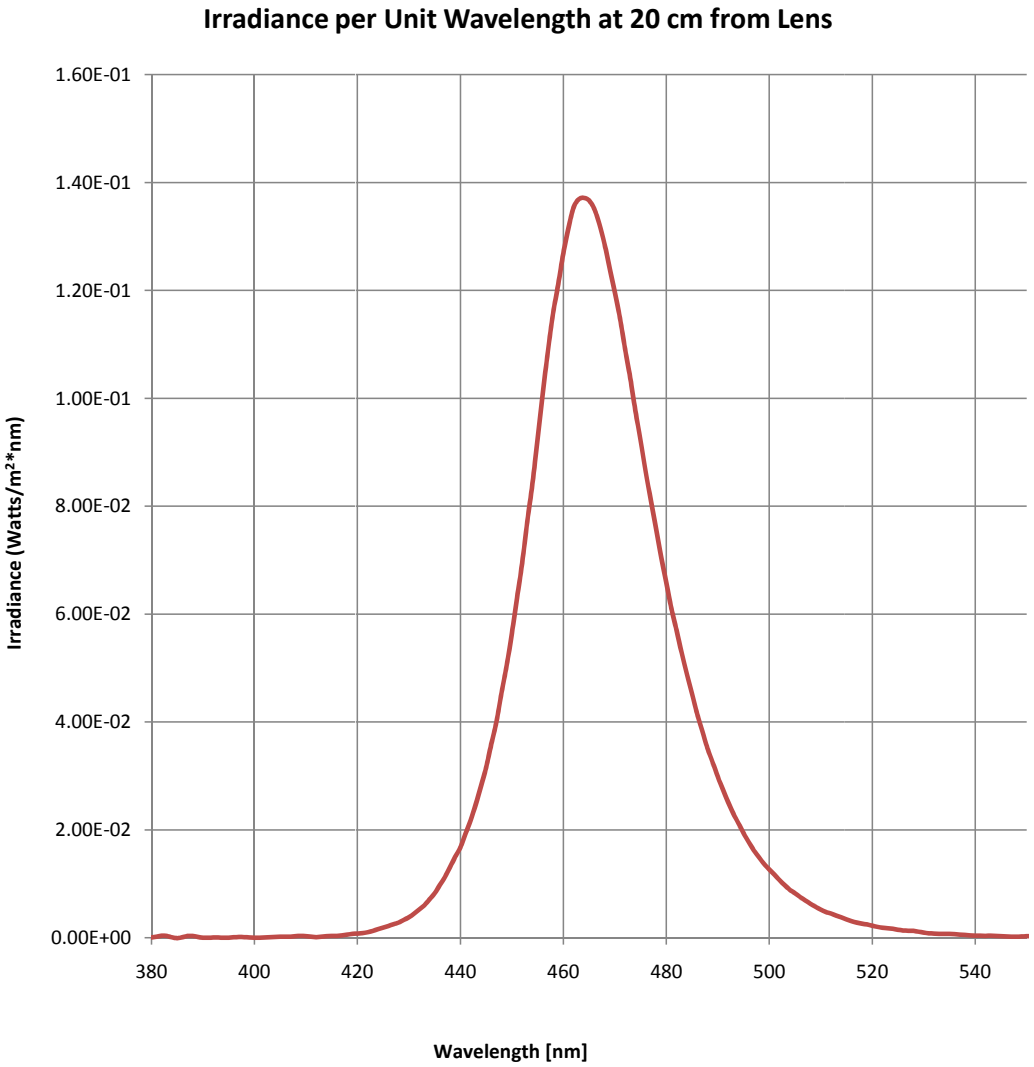
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 800 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	14.43 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP XP-E ROYAL BLUE LEDS

Lamp Type:	XLamp XP-E Royal Blue
Minimum Flux:	350 mW @ 350 mA
Dominant Wavelength:	455-460 nm
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-1 (Low Risk)
Blue Light, Small Source:	Not Applicable
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.280 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	5.29 W/m^2		

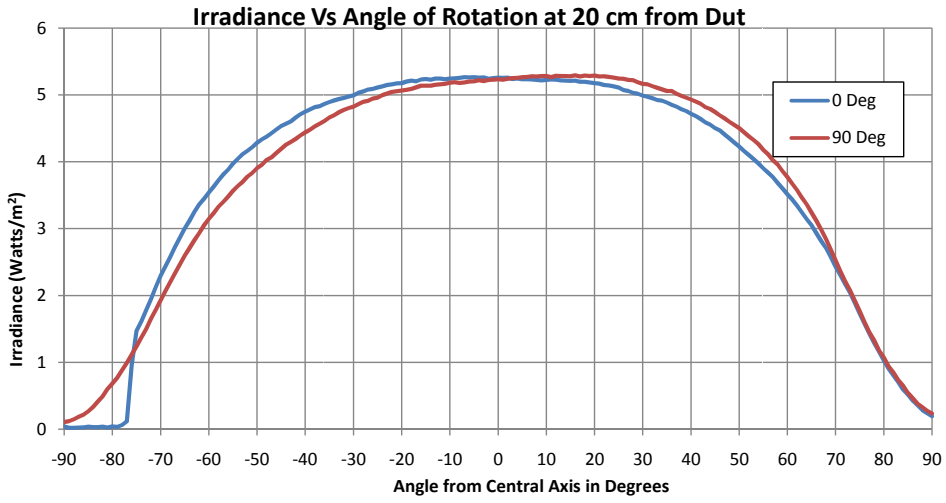


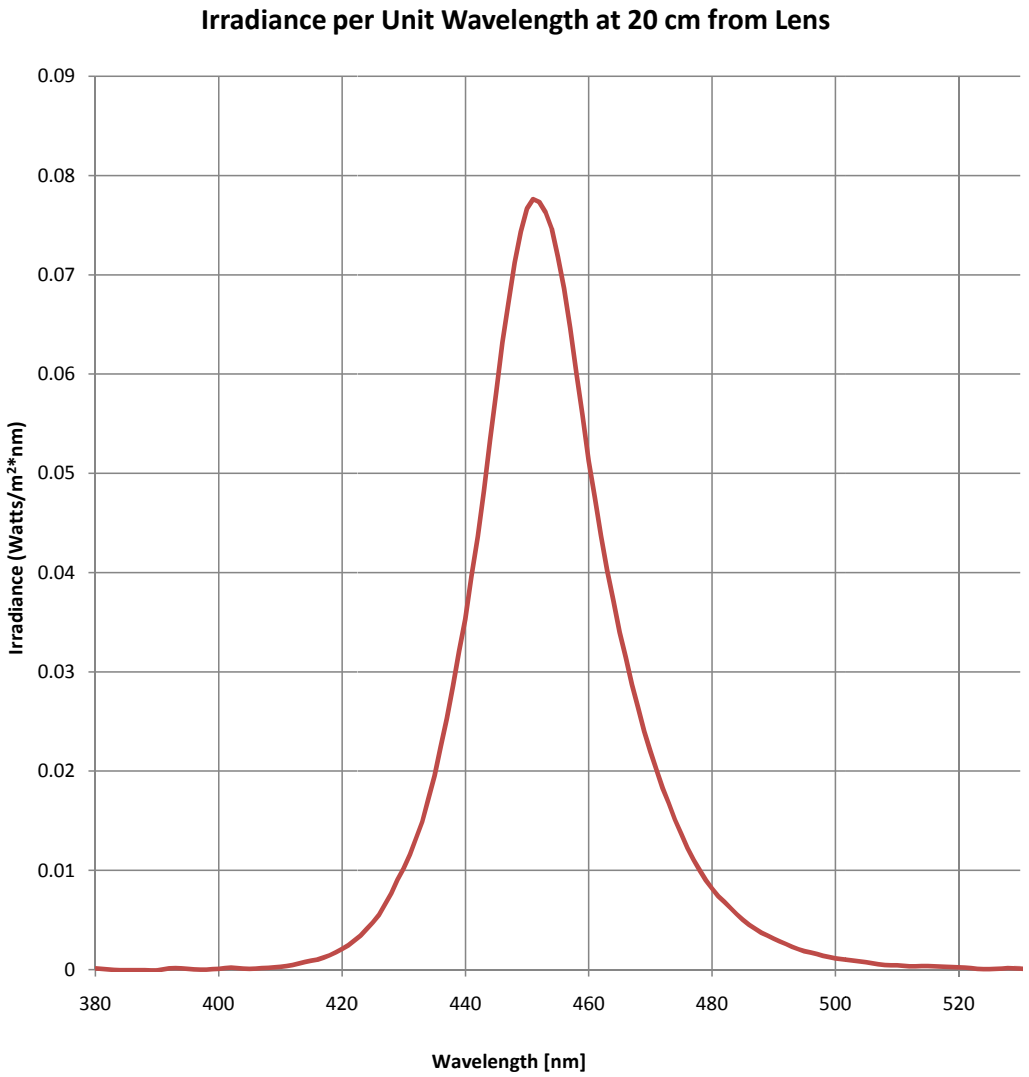
Figure 1: Irradiance Profile at 20 cm

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.700 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.28 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	1.78 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP XP-G COOL WHITE LEDS

Lamp Type:	XLamp XP-G Cool White
Minimum Flux:	130 lm @ 350 mA
CCT:	6300 K - 7000 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-2 (Moderate Risk): CAUTION. Do not stare at exposed lamp in operation. May be harmful to eyes.
Blue Light, Small Source:	Not Applicable
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.500 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 470 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	7.737 W/m^2		

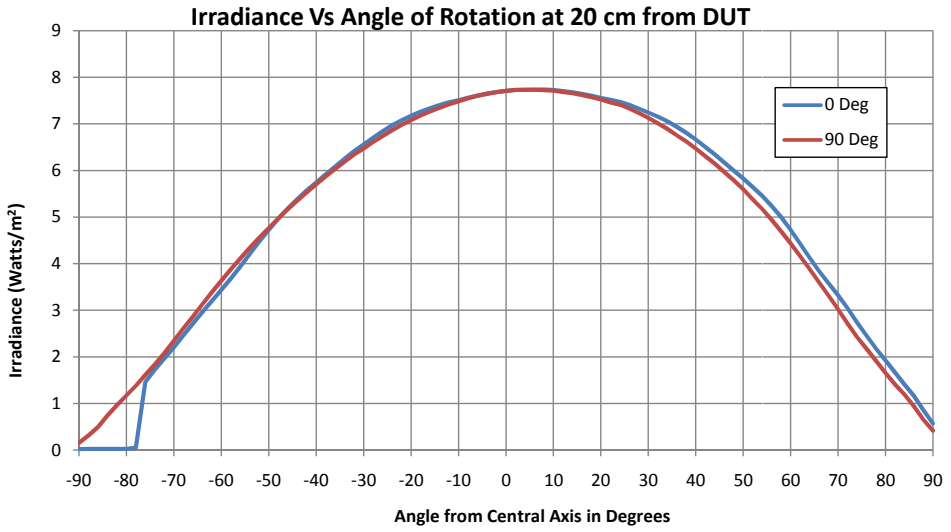


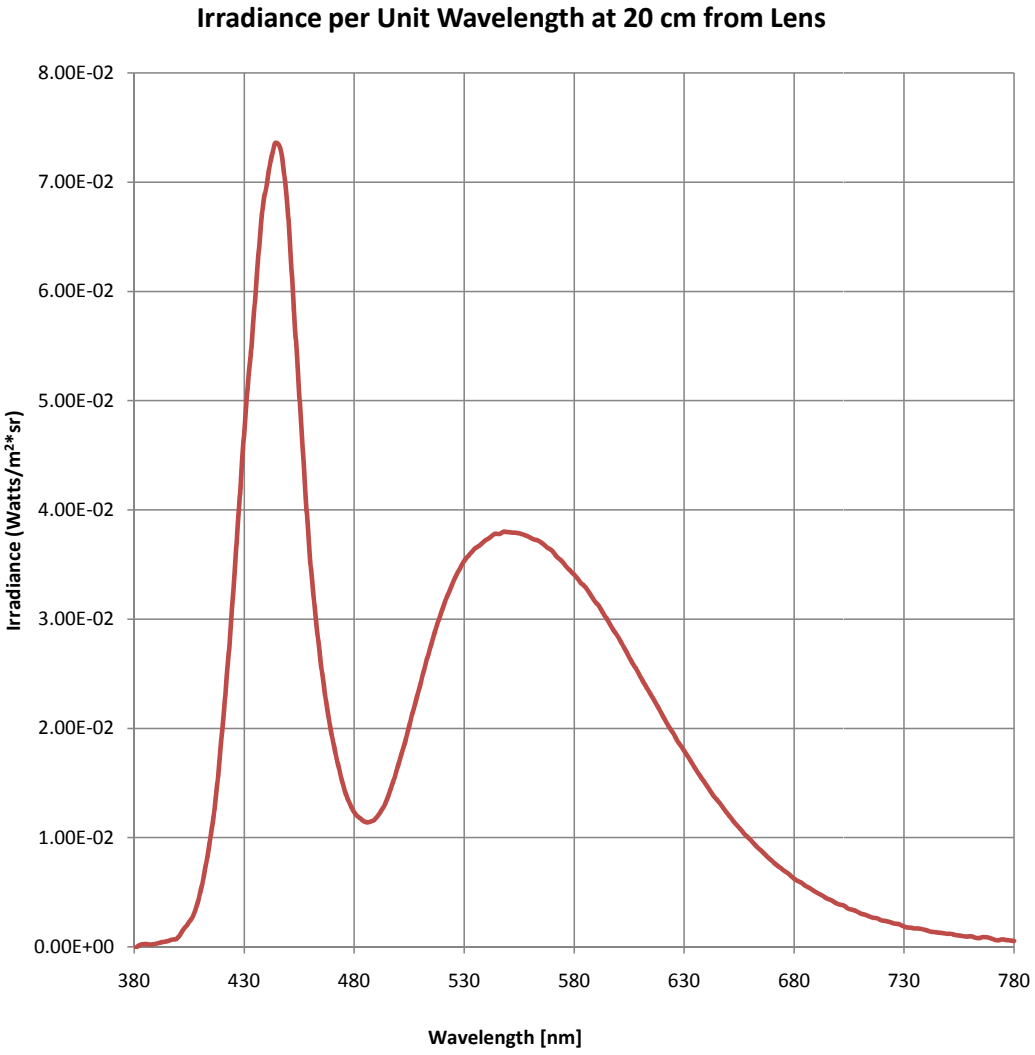
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	1.500 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3. 470 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	6.00 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP MX-6 COOL WHITE LEDS

Lamp Type:	XLamp MX-6 Cool White
Minimum Flux:	107 lm @ 300 mA
CCT:	8300 K - 5000 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	September 4, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-1 (Low Risk)
Blue Light, Small Source:	RG-1 (Low Risk)
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.350 ± 0.001 $A_{regulated}$	Lab Temp:	24.2° ± 1.5° C
Voltage:	3.590 ± 0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Case Temp:	25.0 ± 0.5°C		
Peak Irradiance:	2.765 W/m^2		

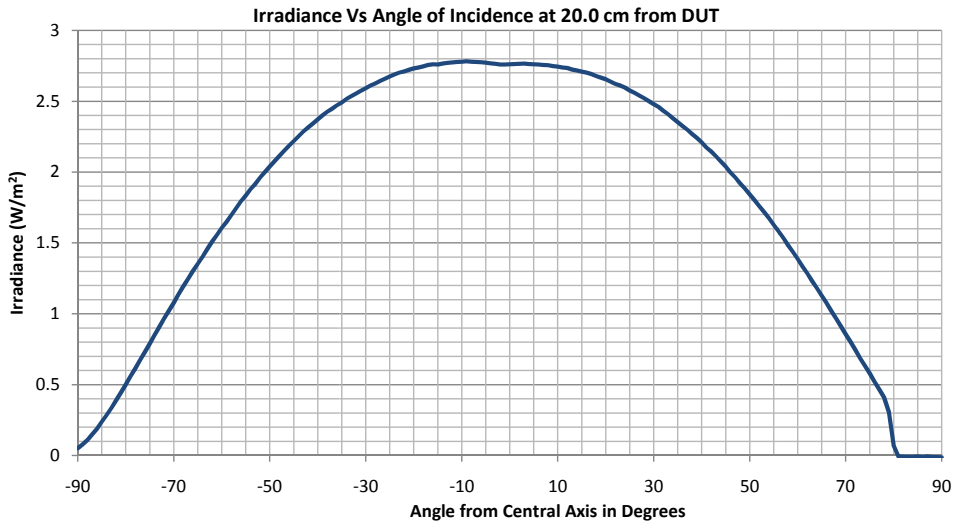


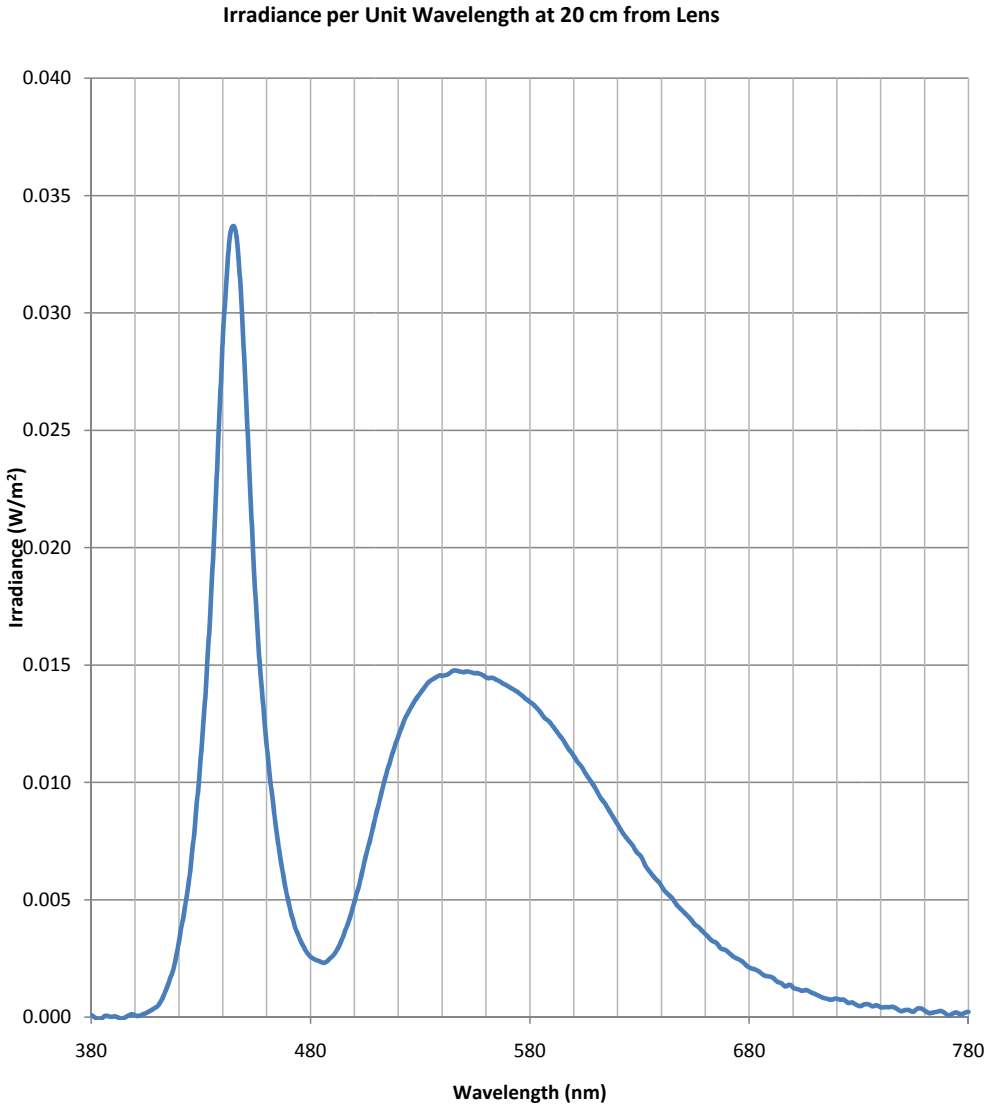
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	.350 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	3.590 ±0.1 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Case Temp:	25.0 ± 0.5°C		
Avg Radiance:	0.818 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 22.2 cm, 3° off-axis

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP MP-L EASYWHITE™ LEDS

Lamp Type:	XLamp MP-L EasyWhite, 30F
Minimum Flux:	700 lm @ 150 mA (per LED string)
CCT:	3000 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	March 5, 2010
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-1 (Low Risk)
Blue Light, Small Source:	RG-1 (Low Risk)
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.250 ± 0.001 $A_{regulated}$	Lab Temp:	24.2° ± 1.5° C
Voltage:	23.45 ± 0.001 $VDC_{unregulated}$	Lab Humidity:	42.0 ± 2.0%
Case Temp:	25.0 ± 0.5°C		
Peak Irradiance:	11.379 W/m^2		

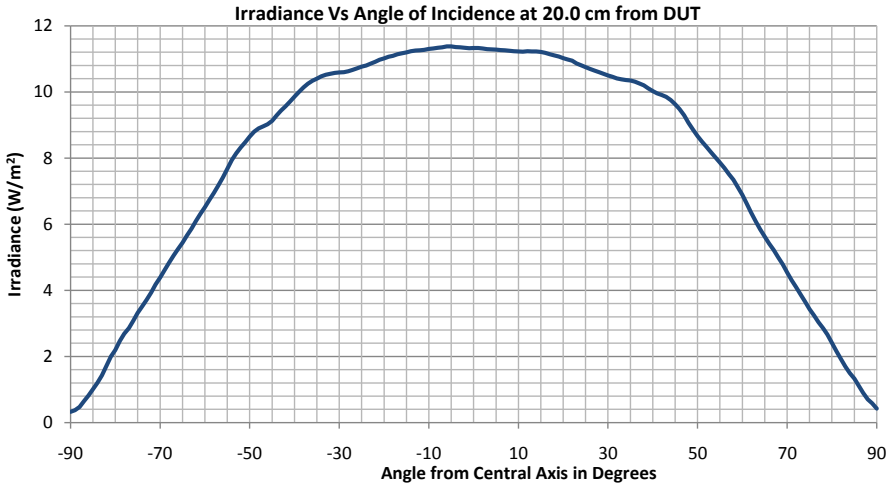


Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	0.250 ±0.001 $A_{regulated}$	Lab Temp:	24.0° ± 1.5° C
Voltage:	23.45 ±0.1 $VDC_{unregulated}$	Lab Humidity:	42.0 ± 2.0%
Case Temp:	25.0 ± 0.5°C		
Avg Radiance:	1.613 W/cm^2*sr		

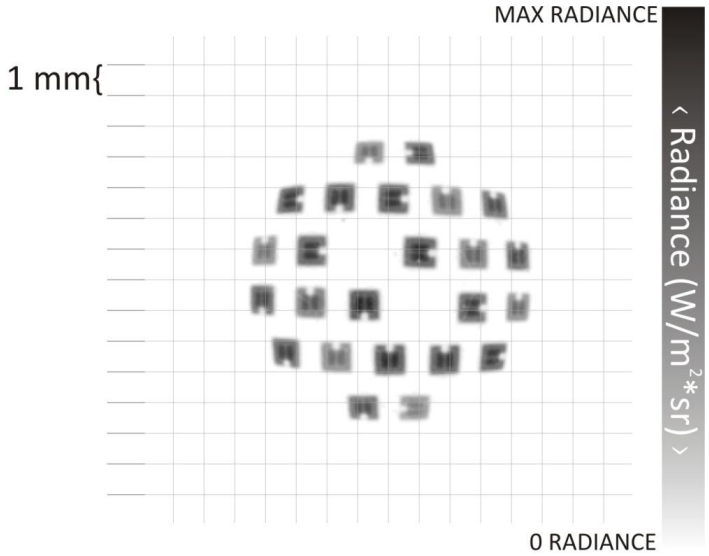
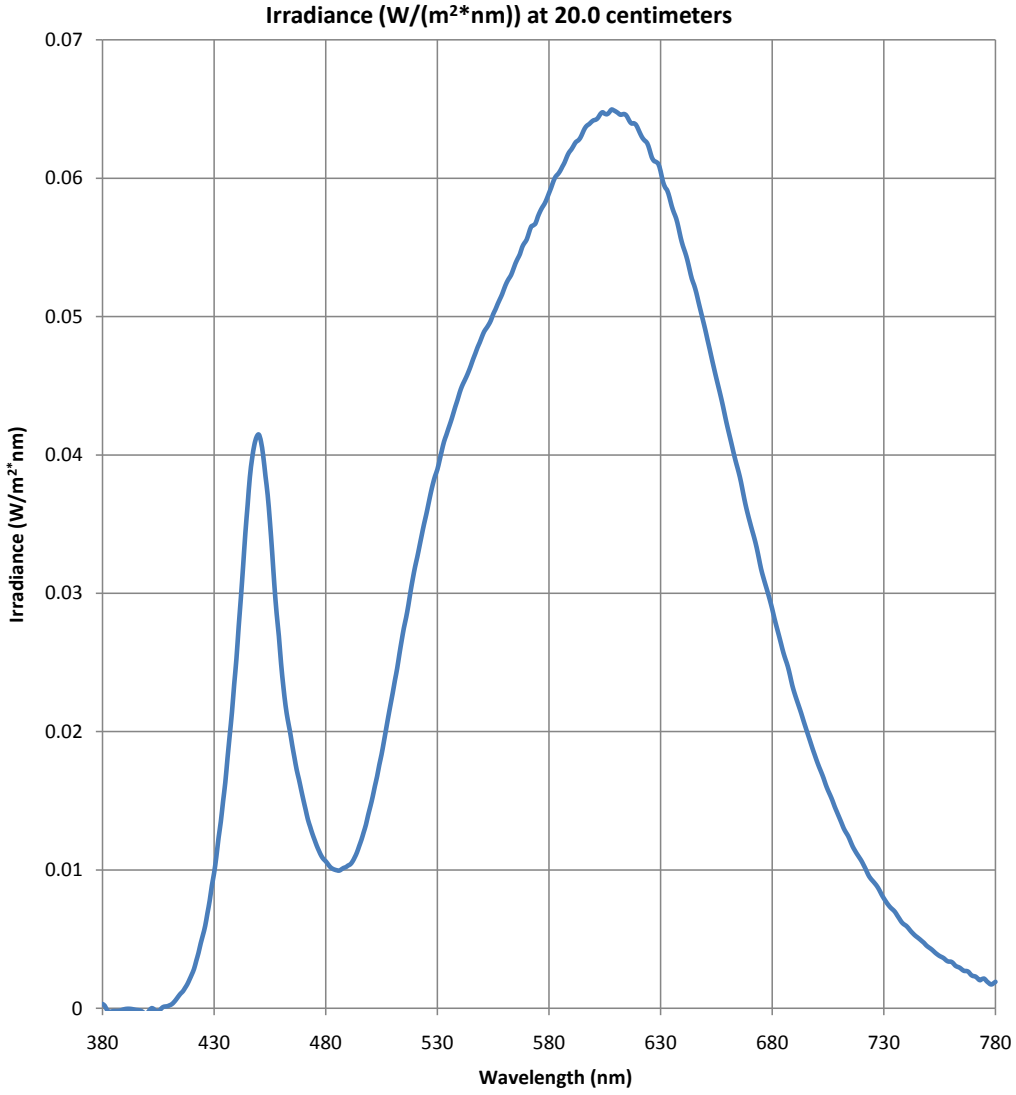


Figure 2: Radiance Profile of source

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.

TEST RESULTS - XLAMP MC-E COOL WHITE LEDS

Lamp Type:	XLamp MC-E Cool White
Minimum Flux:	430 lm @ 350 mA (per die)
CCT:	5700 K - 6300 K
Wavelengths Measured:	300 to 1400 nm
High Luminance:	Yes
Small Source:	No
Date Measured:	June 26, 2009
Testing Laboratory:	Orb Optronix, Inc.

Risk Categories Found (per ANSI / IESNA RP-27.3-07):

Actinic UV:	Exempt **
Near UV:	Exempt **
Retinal Thermal:	Exempt **
Blue Light:	RG-1 (Low Risk)
Blue Light, Small Source:	Not Applicable
Cornea/Lens, IR:	Exempt **
Low Luminance, Retinal IR:	Not Applicable

**Device normally has no emissions in the wavelength range of the listed risk category.

Irradiance Measurement

Test Conditions		Environmental Conditions	
Current:	2.800 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	2.992 ±0.001 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Irradiance:	19.74 W/m^2		

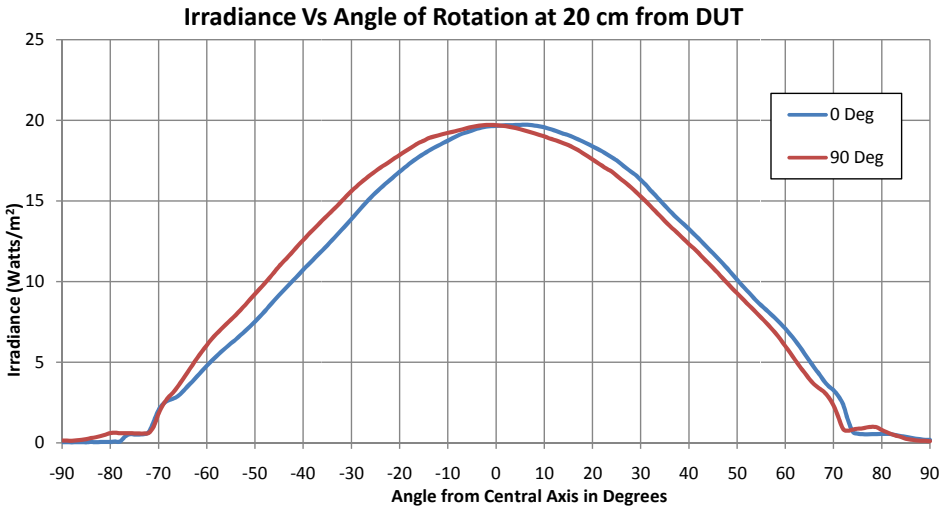


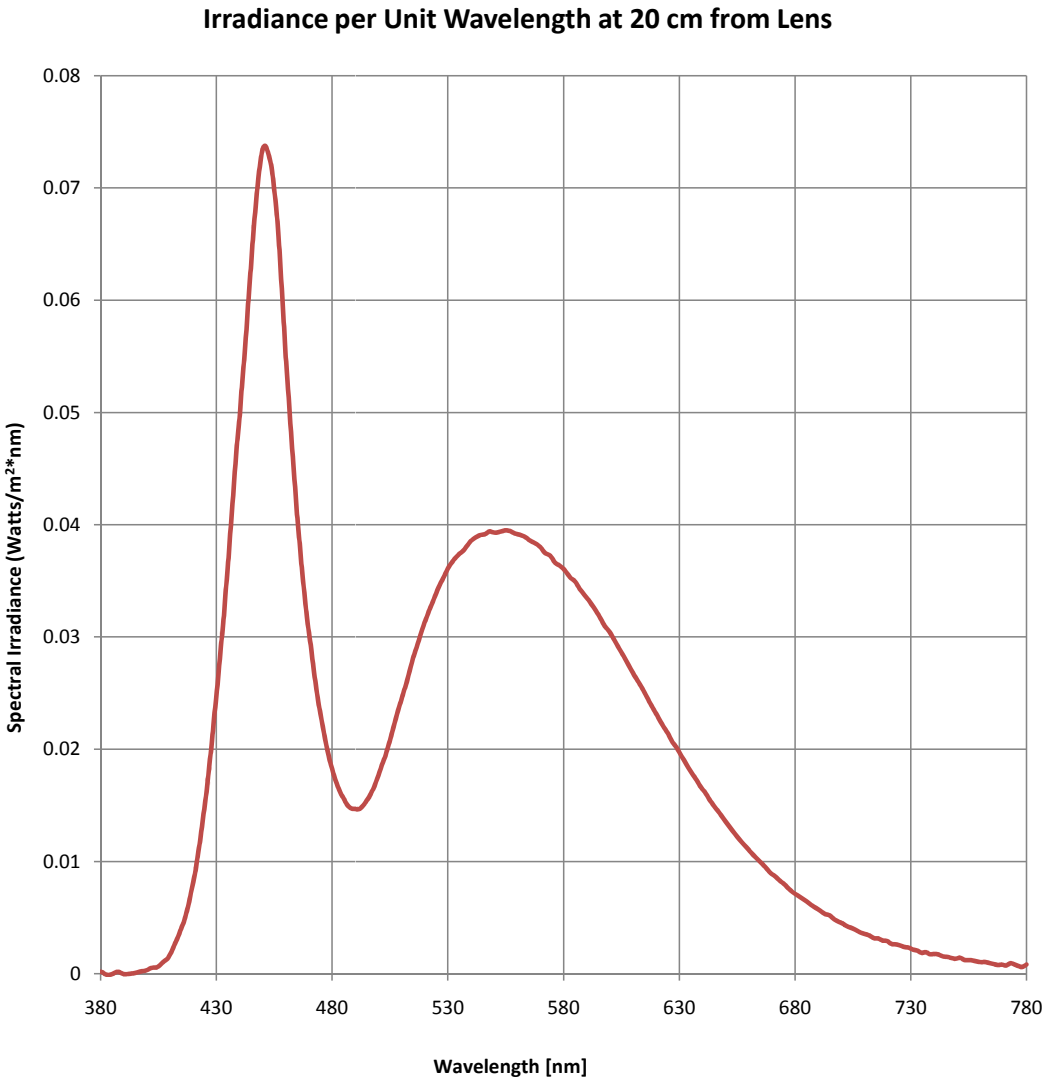
Figure 1: Irradiance Profile at 20 cm

Radiance Measurement

Test Conditions		Environmental Conditions	
Current:	2.800 ±0.001 $A_{regulated}$	Lab Temp:	23.6° ± 1.5° C
Voltage:	2.992 ±0.1 $VDC_{unregulated}$	Lab Humidity:	34.0 ± 2.0%
Temperature:	25.0 ± 0.5°C		
Peak Radiance:	8.362 W/cm^2*sr		

Figure 2: Calibrated Radiance Profile of source at 23.5 cm

Absolute Spectral Power Distribution



Relative spectral power distribution charts can be found in the product data sheets available on cree.com.