

## LIGHT SOURCE TESTING FORM A.1

**Analyzed for: Designs for Vision, pertaining to Evaluation of LED Light sources to IEC 62471, Photobiological safety of lamps and lamp systems**

### Product Information

<b>Product Type:</b>	<b>LED Lamp</b>
<b>Description: A battery powered LED lamp, with internal lens, and open aperture of 17.5 mm</b>	

### Light Source Testing Results

Number of Specimens Analyzed: 3

### COMPILED HAZARD RISK GROUP CLASSIFICATION

Light Source Hazard	Exempt Risk Group	Risk Group 1	Risk Group 2	Risk Group 3
Ultraviolet hazard 200 nm to 400 nm	EXEMPT			
Near UV (UV-A) hazard 315 – 400 nm	EXEMPT			
Retinal blue light hazard 300 nm to 400 nm	EXEMPT			
Retinal blue light or thermal hazard 400 nm to 780 nm	EXEMPT			
Cornea/lens infrared hazard 780 nm to 3,000 nm	In Process			
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	In Process			
IR radiation, eye 780 – 3000 nm	In Process			

Table 6.11 Emission limits for risk groups of continuous wave lamps

Wavelength Hazard	Action Spectrum	Symbol	Emission Limits (EL)			Units	Limiting aperture radians, (°)
			Exempt	Low risk	Mod Risk		
Actinic UV 200 – 400 nm	$S_{uv}(\lambda)$	$E_s$	.001	.003	.03	W/m <sup>2</sup>	1.4 (80)
Near UV (UV-A) 315 – 400 nm		$E_{UVA}$	10	33	100	W/m <sup>2</sup>	1.4 (80)
Blue Light Radiance 300 – 700 nm	$B(\lambda)$	$L_B$	100	10000	4000000	W/m <sup>2</sup> sr	<0.011
Blue Light Small Source 300 – 700 nm	$B(\lambda)$		1.0*	1.0	400	W/m <sup>2</sup>	1.4 (80)
Retinal Thermal 380-1400 nm	$R(\lambda)$	$L_R$	28000/ $\alpha$	28000/ $\alpha$	71000/ $\alpha$	W/m <sup>2</sup> sr	0.0017
Retinal Thermal, weak visual stimulus 780 -1400 nm	$R(\lambda)$	$L_{IR}$	6000/ $\alpha$	6000/ $\alpha$	6000/ $\alpha$	W/m <sup>2</sup> sr	0.011
IR radiation, eye 780 – 3000 nm		$E_{IR}$	100	570	3200	W/m <sup>2</sup>	1.4 (80)

\* Small source defined as one with a < 0.011 radian. Averaging field of view at 10000 s is 0.1 radian

\*\* Involves evaluation of non-GLS source

## Review of Results

### Section 4.3.1 Actinic UV hazard exposure limit for the skin and eye

<b>IEC62471 COMPLIANCE</b>		<b>Actinic - UV Hazard</b>			<b>200 - 400 nm</b>
<b>t<sub>max</sub> = 30/Es</b>					
The exposure limit for effective radiant exposure is 30 J/m <sup>2</sup>					
t <sub>max</sub> = permissible exposure time in sec.					
Es = Effective UV irradiance in W/m <sup>2</sup>					
Where the Effective UV Irradiance is formed from the sum from 200 to 400 nm of the Actinic UV hazard weighting function					
SAMPLE	S1	S2	S3	AVERAGE	
t <sub>max</sub> , sec	1.17E+07	6.32E+06	7.37E+06	8.45E+06	
Sum of the Actinic UV Hazard Function					
Es W/m <sup>2</sup>	2.57E-06	4.75E-06	4.07E-06	3.80E-06	
RESULT	EXEMPT	EXEMPT	EXEMPT	EXEMPT	

### Section 4.3.2 Near-UV hazard exposure limit for the eye

<b>IEC62471 COMPLIANCE</b>		<b>Near UV-A (315 - 400)</b>		
<b>Near UV Hazard exposure limit for the eye</b>				
EUVA x t < 10,000		J/m <sup>2</sup> for t < 1000 s		
EUVA < 10		W/m <sup>2</sup> for t > 1000 sec (N/A)		
Sample				
SUM Irradiance E(λ) W/m <sup>2</sup>	S1	S2	S3	AVERAGE
	0.0070	0.0136	0.0043	0.0083
MAX Exposure Time (sec)	1434339	735049	2342964	1504117
hours	398	204	651	418
RESULT	EXEMPT	EXEMPT	EXEMPT	EXEMPT

### Section 4.3.3 Retinal blue light hazard exposure limit

Calculate the solid angle to estimate the Radiance from the Irradiance

Field Stop =	7 cm
Distance	12 cm
$\gamma_1 =$	0.583 radians
$\Omega =$	0.267 sr

IEC62471 COMPLIANCE		RETINAL BLUE LIGHT		
The Blue Light weighted Radiance L <sub>B</sub> should not exceed:				
$L_B \times t \leq$	<b>1,000,000</b>	<b>J/m<sup>2</sup> sr</b>	(for t ≤ 10,000 s)	
$L_B \leq$	<b>100</b>	<b>W/m<sup>2</sup> sr</b>	(for t > 10,000 s) N/A	
Blue Light Hazard Function Weighted		Irradiance		
	S1	S2	S3	Average
Irradiance E(W/m <sup>2</sup> ) =	60.13	70.19	68.63	66.31
Evaluate Radiance = Irradiance/Solid Angle	<b>L =</b>		<b>E/Ω</b>	
<b>L =</b>	224.99	262.62	256.79	248.13
For t = 10 sec	2250	2626	2568	2481
For t = 60 sec	13499	15757	15407	14888
For t = 3600 sec	809956	945444	924426	893275
<b>RESULT</b>	<b>EXEMPT</b>	<b>EXEMPT</b>	<b>EXEMPT</b>	<b>EXEMPT</b>

**4.3.4 Retinal blue light hazard exposure limit Light - Small Source**

$$E_s \cdot t \leq 100 \text{ (J/m}^2\text{)} \quad (\text{for } t \leq 100 \text{ s}); \quad \lambda = 300 - 700\text{nm}$$

**4.3.5 Retinal Thermal hazard exposure limit**

$$L_R \leq 50000 / (\alpha t^{0.25}) \text{ [ W/ m}^2 \cdot \text{sr ]} \quad (10\mu\text{s} \leq t \leq 10\text{s}); \quad \lambda = 380 - 1400\text{nm}$$

**4.3.6 Retinal thermal hazard exposure limit – weak visual stimulus**

A weak visual stimulus is defined as a maximum luminance averaged over a circular fov subtending 0.011radian is less than 10 cd • m<sup>2</sup>.

$$L_R \leq 6000 / (\alpha) \text{ [ W/ m}^2 \cdot \text{sr ]} \quad (t > 10\text{s}); \quad \lambda = 780 - 1400\text{nm}$$

**4.3.7 Infrared radiation hazard exposure limits for the eye (Corneal Hazard):**

$$E_R \leq 18000 \cdot t^{-3/4} \text{ (W/m}^2\text{)} \quad (t \leq 1000 \text{ s}); \quad \lambda = 780 - 3000\text{nm}$$

*Unless otherwise stated the sample was tested in the manner for use described by the customer. This report has been prepared in accordance with standard IEC 62471:2006. The results in this report are applicable to the sample tested and may not apply to other batches of the same product. It is a condition of the provision of these test results that you do not use the name of the Test Lab, Solar Light, or any words, marks or devices which may imply a connection with Solar Light, in connection with the promotion or sale of your products, unless Solar Light has given express written authority to do so. This test report may only be reproduced in full and without alteration.*

## INSTRUMENTATION

- Optronic Laboratories Monochromator Model 740A/D, S/N 88200395 configured with 5nm slits, a six-inch diameter integrating sphere at the entrance port, and a calibrated silicon detector at the exit port.
- Optronic Laboratories Radiometer Model 730A, S/N 88200298
- Optronic Laboratories Wavelength Controller Model 740-1C, S/N 88200033
- Optronic Laboratories Constant Current Source Model 65, S/N 88100697
- NIST traceable Standard of Spectral Irradiance; Quartz-Halogen lamp Model OL220M, S/N M1222
- Solar Light PMA2100 Radiometer S/N 2043
- Solar Light PMA2101 Erythemat Detector S/N 14095
- Solar Light PMA2121 Blue Light Safety Detector S/N 17388
- Solar Light PMA2144 Global Pyranometer

## EXPERIMENTAL CONDITIONS

Ambient Temperature 27°C Relative Humidity 31%

### Total Measurement Uncertainty:

Section 4.3.1 Uncertainty << Limit value, since the measurements indicate that only extremely small values of irradiance less than 400nm [ $E_{\max}(280-400) = 4E-11$ ] are emitted by the source.

Section 4.3.2 Uncertainty << Limit value similar to 1.

Section 4.3.3 The uncertainty here is of two parts, the calculation of the field of view and the evaluation of the irradiance. The irradiance values measured are, for the most part  $10^8$  times larger than the noise floor, hence the uncertainty due to the irradiance is << Limit value. By evaluating the field stop measurement, to a precision of  $\sim 5\%$ , and the use of the estimate for the field of view, the combined uncertainty is estimated to be less than 10%. Since the calculated times of exposure to maintain within the safety limit are on the order of an hour, and the variation of the uncertainty does not alter the fact that the values for the exposure dose are still much less than the limit.

Section 4.3.4. Uncertainty << tbd

Section 4.3.5. Uncertainty << tbd

Section 4.3.6. Uncertainty << tbd

Section 4.3.7. Uncertainty << tbd