Test Report issued under the responsibility of:

TEST REPORT
IEC 62471
Photobiological safety of lamps and lamp systems

Report Reference No. ..... :	3153676.50A
Date of issue ..... :	2014-08-20
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CB Testing Laboratory ..... :	DEKRA Testing and Certification China Ltd.
Address ..... :	10F, #250 Jiangchangsan Road, Building 16, Headquarter Economy Park Shibei Hi-Tech Park, Zhabei District, Shanghai, 200436, China
Applicant's name ..... :	Cree, Inc
Address ..... :	Durham, North Carolina, 27703, USA
Test specification:	
Standard ..... :	IEC 62471:2006 (First Edition)
Test procedure ..... :	CB
Non-standard test method..... :	N/A
Test Report Form No. ..... :	IEC62471A
TRF Originator ..... :	VDE Testing and Certification Institute
Master TRF ..... :	Dated 2009-05

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

Test item description ..... :	Cree Xlamp CXA1816 Series
Trade Mark ..... :	Cree
Manufacturer ..... :	Cree, Inc Durham, North Carolina, 27703, USA
Model/Type reference ..... :	CXA1816
Ratings ..... :	I_F: 900 mA

Testing procedure and testing location:	
☒ **CB Testing Laboratory:**	DEKRA Testing and Certification China Ltd.
Testing location/ address .....:	10F, #250 Jiangchangsan Road, Building 16, Headquarter Economy Park Shibei Hi-Tech Park, Zhabei District, Shanghai, 200436, China
☐ ~~**Associated CB Laboratory:**~~	
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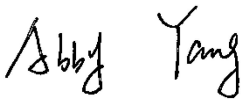
Tested by (name + signature) .....:	Abby Yang 
Approved by (+ signature) .....:	Hanson Zhang 
☐ ~~Testing procedure: TMP~~	
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~~Testing location/ address .....:~~	
☐ ~~Testing procedure: WMT~~	
~~Tested by (name + signature) .....:~~	
~~Witnessed by (+ signature) .....:~~	
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~~Testing location/ address .....:~~	
☐ ~~Testing procedure: SMT~~	
~~Tested by (name + signature) .....:~~	
~~Approved by (+ signature).....:~~	
~~Supervised by (+ signature) .....:~~	
~~Testing location/ address .....:~~	
☐ ~~Testing procedure: RMT~~	
~~Tested by (name + signature) .....:~~	
~~Approved by (+ signature).....:~~	
~~Supervised by (+ signature) .....:~~	
~~Testing location/ address .....:~~	

Summary of testing:

Tests performed (name of test and test clause):	**Testing location:**
These tests Fulfil the requirements of standard ISO/IEC 17025. When determining the test conclusion, the Measurement Uncertainty of test has been considered. The tested sample of Cree Xlamp CXA1816 Series list as below CXA1816 (Cool White & Neutral White) Have been tested according to the IEC 62471(first edition, 2006-07) and been classified as **Risk Group 2 for blue light hazard.** CXA1816 (Warm White) Has been tested according to the IEC 62471(first edition, 2006-07) and been classified as **Risk Group 1 for blue light hazard.**	DEKRA Testing and Certification China Ltd. 10F, #250 Jiangchangsan Road, Building 16, Headquarter Economy Park Shibei Hi-Tech Park, Zhabei District, Shanghai, 200436, China

Summary of compliance with National Differences:

Pass

Copy of marking plate:

According to IEC/TR 62471-2:2009:

When the product(s) is/are operated at the maximum rated drive current, the following warning label should be marked on the product.

Risk Group 2
CAUTION Possibly hazardous optical radiation emitted from this product. Do not stare at operating lamp. May be harmful to the eyes.

When the product(s) is/are operated at a drive current resulting in a risk group ranking below RG-2 (refer to Appendix 6), no additional warning label is required on the product.

If the size or design of the product makes labeling impractical, the warning label should be included in the packaging, and in the user manual.

Manufacturer's product identification: Product labelling is impractical for this LED component, so the following identification markings are included on the packaging in each product shipment.


Item CXA1816-0000-000N00Q265F
Desc Xlamp CXA181 Light Emitting Diode Cool White
Lot # AOHxxxxxxxx-xx
Qty 1
Exp Date:
SubInv MKT - SAMPLE
Locator
Item CXA1816-0000-000N0HP440F
Desc Xlamp CXA181 Light Emitting Diode Neutral White
Lot # AOHxxxxxxxx-xx
Qty 1
Exp Date:
SubInv MKT - SAMPLE
Locator
Item CXA1816-0000-000N00P430H
Desc Xlamp CXA181 Light Emitting Diode Warm White
Lot # AOHxxxxxxxx-xx
Qty 1
Exp Date:
SubInv MKT - SAMPLE
Locator

Test item particulars ..... :	
Tested lamp ..... :	☒ continuous wave lamps ☐ pulsed lamps
Tested lamp system ..... :	N/A
Lamp classification group ..... :	☐ exempt ☒ risk 1 ☒ risk 2 ☐ risk 3
Lamp cap ..... :	N/A
Bulb ..... :	LED
Rated of the lamp ..... :	I_F: 900 mA
Furthermore marking on the lamp ..... :	N/A
Seasoning of lamps according IEC standard ..... :	N/A
Used measurement instrument ..... :	spectroradiometer
Temperature by measurement ..... :	24 °C
Information for safety use ..... :	--

Possible test case verdicts:

– test case does not apply to the test object ..... : N/A

– test object does meet the requirement ..... : P (Pass)

– test object does not meet the requirement ..... : F (Fail)

Testing:

Date of receipt of test item ..... : 2014-07-10

Date (s) of performance of tests ..... : 2014-07-10 to 2014-08-18

General remarks:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(See Enclosure #)" refers to additional information appended to the report.
"(See appended table)" refers to a table appended to the report.
Throughout this report a comma (point) is used as the decimal separator.
List of test equipment must be kept on file and available for review.

The product complied with the following standards:
IEC 62471:2006
IEC/TR 62471-2:2009
EN 62471:2008
IEC/TR 62778:2012
IEC/TR 62778:2014

This report should be read in conjunction with the attached pages concerned with the European group differences and national differences of the standards EN 62471:2008 with the reference number of 3153676.50B. (4 pages)

Factory Location:
Cree Huizhou Solid State Lighting Co., Ltd.
No. 32 Zone, Hechang 6th Rd. Zhongkai High-Tech District, Huizhou City, Guangdong Province, China

General product information:

This test report covered CXA1816 series.

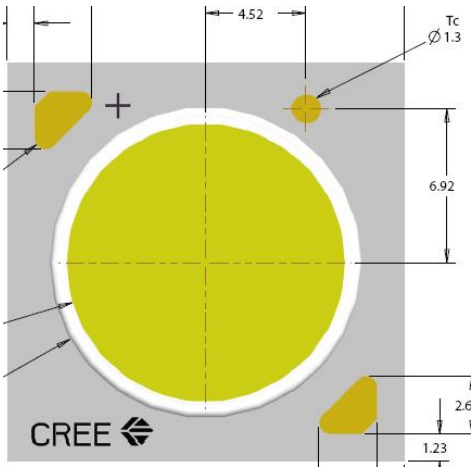
The products have different colors and luminous fluxes.

For details please refer to appendix 3.

The test performed on model CXA1816-0000-000N00Q265F; CXA1816-0000-000N0HP440F and CXA1816-0000-000N00P430H with different CCTs.

The test samples were considered as non-GLS products which should be tested at the distance of 200mm.

During the test, the temperature monitored at the Tc point reached a maximum of 33°C.



The sample of CXA1816-0000-000N00Q265F was tested at 200 mm from the light source. CCT of the spectral irradiance was found at 6782 K (Cool White).

The sample of CXA1816-0000-000N0HP440F was tested at 200 mm from the light source. CCT of the spectral irradiance was found at 5437 K (Neutral White).

The sample of CXA1816-0000-000N00P430H was tested at 200 mm from the light source. CCT of the spectral irradiance was found at 3089 K (Warm White).

According to IEC/TR 62778:2014, the drive current and color temperature of a test sample (LED component product) can have a significant influence on the risk group ranking. When the manufacturer's maximum rated drive current (If) is not used in a final application (i.e.: a luminaire), refer to Appendix 6 to identify the risk group associated with the drive current to be used. This information is presented for each CCT (color temperature) tested.

According to IEC/TR 62471-2:2009, The following information should be provided in the user information:

a) a clear statement that the lamp or lamp system is in excess of the Exempt Group and that the viewer-related risk is dependent upon how the users install and use the product;

b) the most restrictive optical radiation hazard and other optical radiation hazards in excess of Exempt Group;

c) exposure hazard values (EHVs) and the hazard distances with optional graphical presentation of distant-dependent EHV;

d) Hazard distances (HD) for all relevant viewer-related risk groups below the assigned one

e) adequate instructions for proper assembly, installation, maintenance and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous optical radiation;

f) advice on safe operating procedures and warnings concerning reasonably foreseeable malpractices, malfunctions and hazardous failure modes. Where maintenance procedures

are detailed, they should, wherever possible, include explicit instructions on safe procedures to be followed;
g) reproduction of the labelling required in 5.4 and an explanation of its meaning shown in Table 2; and
h) information on what type of user controls may be considered.

The Type test was performed according to IEC 62471:2006 procedure.

IEC 62471			
Clause	Requirement + Test	Result – Remark	Verdict
4	**EXPOSURE LIMITS**		P
4.1	General		P
	The exposure limits in this standard is not less than 0,01 ms and not more than any 8-hour period and should be used as guides in the control of exposure		P
	Detailed spectral data of a light source are generally required only if the luminance of the source exceeds 10^4 cd·m^{-2}	see clause 4.3	P
4.3	Hazard exposure limits		P
4.3.1	Actinic UV hazard exposure limit for the skin and eye		P
	The exposure limit for effective radiant exposure is 30 J·m^{-2} within any 8-hour period		P
	To protect against injury of the eye or skin from ultraviolet radiation exposure produced by a broadband source, the effective integrated spectral irradiance , E_S, of the light source shall not exceed the levels defined by:		P
	$E_s \cdot t = \sum_{200}^{400} \sum_{t} E_\lambda(\lambda,t) \cdot S_{UV}(\lambda) \cdot \Delta t \cdot \Delta\lambda \le 30$ J·m^{-2}		P
	The permissible time for exposure to ultraviolet radiation incident upon the unprotected eye or skin shall be computed by:		P
	$t_{max} = \frac{30}{E_s}$ s		P
4.3.2	Near-UV hazard exposure limit for eye		P
	For the spectral region 315 nm to 400 nm (UV-A) the total radiant exposure to the eye shall not exceed 10000 J·m^{-2} for exposure times less than 1000 s. For exposure times greater than 1000 s (approximately 16 minutes) the UV-A irradiance for the unprotected eye, E_{UVA}, shall not exceed 10 W·m^{-2}.		P
	The permissible time for exposure to ultraviolet radiation incident upon the unprotected eye for time less than 1000 s, shall be computed by:		P
	$t_{max} \le \frac{10\,000}{E_{UVA}}$ s		P
4.3.3	Retinal blue light hazard exposure limit		P
	To protect against retinal photochemical injury from chronic blue-light exposure, the integrated spectral radiance of the light source weighted against the blue-light hazard function, B(λ), i.e., the blue-light weighted radiance , L_B, shall not exceed the levels defined by:		P
	$L_B \cdot t = \sum_{300}^{700} \sum_{t} L_\lambda(\lambda,t) \cdot B(\lambda) \cdot \Delta t \cdot \Delta\lambda \le 10^6$ J · m^{-2} · sr^{-1}	for t ≤ 10^4 s $t_{max} = \frac{10^6}{L_B}$	P

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Clause	Requirement + Test	Result – Remark	Verdict
	$L_B = \sum_{300}^{700} L_\lambda \cdot B(\lambda) \cdot \Delta\lambda \le 100$ $W \cdot m^{-2} \cdot sr^{-1}$	for t > 10^4 s	N/A
4.3.4	Retinal blue light hazard exposure limit - small source		N/A
	Thus the spectral irradiance at the eye E_λ, weighted against the blue-light hazard function B(λ) shall not exceed the levels defined by:	see table 4.2	N/A
	$E_B \cdot t = \sum_{300}^{700} \sum_{t} E_\lambda(\lambda,t) \cdot B(\lambda) \cdot \Delta t \cdot \Delta\lambda \le 100$ $J \cdot m^{-2}$	for t ≤ 100 s	N/A
	$E_B = \sum_{300}^{700} E_\lambda \cdot B(\lambda) \cdot \Delta\lambda \le 1$ $W \cdot m^{-2}$	for t > 100 s	N/A
4.3.5	Retinal thermal hazard exposure limit		P
	To protect against retinal thermal injury, the integrated spectral radiance of the light source, L_λ, weighted by the burn hazard weighting function $R(_\lambda)$ (from Figure 4.2 and Table 4.2), i.e., the burn hazard weighted radiance, shall not exceed the levels defined by:		P
	$L_R = \sum_{380}^{1400} L_\lambda \cdot R(\lambda) \cdot \Delta\lambda \le \frac{50\,000}{\alpha \cdot t^{0,25}}$ $W \cdot m^{-2} \cdot sr^{-1}$	(10 µs ≤ t ≤ 10 s)	P
4.3.6	Retinal thermal hazard exposure limit – weak visual stimulus		N/A
	For an infrared heat lamp or any near-infrared source where a weak visual stimulus is inadequate to activate the aversion response, the near infrared (780 nm to 1400 nm) radiance, L_{IR}, as viewed by the eye for exposure times greater than 10 s shall be limited to:		N/A
	$L_{IR} = \sum_{780}^{1400} L_\lambda \cdot R(\lambda) \cdot \Delta\lambda \le \frac{6\,000}{\alpha}$ $W \cdot m^{-2} \cdot sr^{-1}$	t > 10 s	N/A
4.3.7	Infrared radiation hazard exposure limits for the eye		P
	The avoid thermal injury of the cornea and possible delayed effects upon the lens of the eye (cataractogenesis), ocular exposure to infrared radiation, E_{IR}, over the wavelength range 780 nm to 3000 nm, for times less than 1000 s, shall not exceed:		P
	$E_{IR} = \sum_{780}^{3\,000} E_\lambda \cdot \Delta\lambda \le 18\,000 \cdot t^{-0,75}$ $W \cdot m^{-2}$	t ≤ 1000 s	P
	For times greater than 1000 s the limit becomes:		P
	$E_{IR} = \sum_{780}^{3\,000} E_\lambda \cdot \Delta\lambda \le 100$ $W \cdot m^{-2}$	t > 1000 s	P
4.3.8	Thermal hazard exposure limit for the skin		P
	Visible and infrared radiant exposure (380 nm to 3000 nm) of the skin shall be limited to:		P

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Clause	Requirement + Test	Result – Remark	Verdict
	$E_H \cdot t = \sum_{380}^{3\,000} \sum_{t} E_\lambda(\lambda,t) \cdot \Delta t \cdot \Delta\lambda \le 20\,000 \cdot t^{0,25}$ J · m^{-2}		P
5	**MEASUREMENT OF LAMPS AND LAMP SYSTEMS**		P
5.1	Measurement conditions		P
	Measurement conditions shall be reported as part of the evaluation against the exposure limits and the assignment of risk classification.		P
5.1.1	Lamp ageing (seasoning)		N/A
	Seasoning of lamps shall be done as stated in the appropriate IEC lamp standard.		N/A
5.1.2	Test environment		P
	For specific test conditions, see the appropriate IEC lamp standard or in absence of such standards, the appropriate national standards or manufacturer's recommendations.		P
5.1.3	Extraneous radiation		P
	Careful checks should be made to ensure that extraneous sources of radiation and reflections do not add significantly to the measurement results.		P
5.1.4	Lamp operation		P
	Operation of the test lamp shall be provided in accordance with:		N/A
	– the appropriate IEC lamp standard, or		N/A
	– the manufacturer' s recommendation		P
5.1.5	Lamp system operation		N/A
	The power source for operation of the test lamp shall be provided in accordance with:		N/A
	– the appropriate IEC standard, or		N/A
	– the manufacturer' s recommendation		N/A
5.2	Measurement procedure		P
5.2.1	Irradiance measurements		P
	Minimum aperture diameter 7mm.		P
	Maximum aperture diameter 50 mm.		P
	The measurement shall be made in that position of the beam giving the maximum reading.		P
	The measurement instrument is adequate calibrated.		P
5.2.2	Radiance measurements		P
5.2.2.1	Standard method		P
	The measurements made with an optical system.		P

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Clause	Requirement + Test	Result – Remark	Verdict
	The instrument shall be calibrated to read in absolute radiant power per unit receiving area and per unit solid angle to acceptance averaged over the field of view of the instrument.		P
5.2.2.2	Alternative method		P
	Alternatively to an imaging radiance set-up, an irradiance measurement set-up with a circular field stop placed at the source can be used to perform radiance measurements.		P
5.2.3	Measurement of source size		P
	The determination of α, the angle subtended by a source, requires the determination of the 50% emission points of the source.		P
5.2.4	Pulse width measurement for pulsed sources		N/A
	The determination of Δt, the nominal pulse duration of a source, requires the determination of the time during which the emission is > 50% of its peak value.		N/A
5.3	Analysis methods		P
5.3.1	Weighting curve interpolations		P
	To standardize interpolated values, use linear interpolation on the log of given values to obtain intermediate points at the wavelength intervals desired.	see table 4.1	P
5.3.2	Calculations		P
	The calculation of source hazard values shall be performed by weighting the spectral scan by the appropriate function and calculating the total weighted energy.		P
5.3.3	Measurement uncertainty		P
	The quality of all measurement results must be quantified by an analysis of the uncertainty.	see Annex C in the norm	P
6	**LAMP CLASSIFICATION**		P
	For the purposes of this standard it was decided that the values shall be reported as follows:	see table 6.1	P
	– for lamps intended for general lighting service, the hazard values shall be reported as either irradiance or radiance values at a distance which produces an illuminance of 500 lux, but not at a distance less than 200 mm		N/A
	– for all other light sources, including pulsed lamp sources, the hazard values shall be reported at a distance of 200 mm		P
6.1	Continuous wave lamps		P

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Clause	Requirement + Test	Result – Remark	Verdict
6.1.1	Exempt Group	The test results exceed exempt group	N/A
	In the exempt group are lamps, which does not pose any photobiological hazard. The requirement is met by any lamp that does not pose:	The test results exceed exempt group	N/A
	– an actinic ultraviolet hazard (E_S) within 8-hours exposure (30000 s), nor		P
	– a near-UV hazard (E_{UVA}) within 1000 s, (about 16 min), nor		P
	– a retinal blue-light hazard (L_B) within 10000 s (about 2,8 h), nor	The test results exceed exempt group	N/A
	– a retinal thermal hazard (L_R) within 10 s, nor		P
	– an infrared radiation hazard for the eye (E_{IR}) within 1000 s		P
6.1.2	Risk Group 1 (Low-Risk)		P
	In this group are lamps, which exceeds the limits for the except group but that does not pose:		P
	– an actinic ultraviolet hazard (E_S) within 10000 s, nor		N/A
	– a near ultraviolet hazard (E_{UVA}) within 300 s, nor		N/A
	– a retinal blue-light hazard (L_B) within 100 s, nor		P
	– a retinal thermal hazard (L_R) within 10 s, nor		N/A
	– an infrared radiation hazard for the eye (E_{IR}) within 100 s		N/A
	Lamps that emit infrared radiation without a strong visual stimulus and do not pose a near-infrared retinal hazard (L_{IR}), within 100 s are in Risk Group 1.		N/A
6.1.3	Risk Group 2 (Moderate-Risk)		P
	This requirement is met by any lamp that exceeds the limits for Risk Group 1, but that does not pose:		P
	– an actinic ultraviolet hazard (E_S) within 1000 s exposure, nor		N/A
	– a near ultraviolet hazard (E_{UVA}) within 100 s, nor		N/A
	– a retinal blue-light hazard (L_B) within 0,25 s (aversion response), nor		P
	– a retinal thermal hazard (L_R) within 0,25 s (aversion response), nor		N/A
	– an infrared radiation hazard for the eye (E_{IR}) within 10 s		N/A
	Lamps that emit infrared radiation without a strong visual stimulus and do not pose a near-infrared retinal hazard (L_{IR}), within 10 s are in Risk Group 2.		N/A
6.1.4	Risk Group 3 (High-Risk)		N/A

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Clause	Requirement + Test	Result – Remark	Verdict
	Lamps which exceed the limits for Risk Group 2 are in Group 3.		N/A
6.2	Pulsed lamps		N/A
	Pulse lamp criteria shall apply to a single pulse and to any group of pulses within 0,25 s.		N/A
	A pulsed lamp shall be evaluated at the highest nominal energy loading as specified by the manufacturer.		N/A
	The risk group determination of the lamp being tested shall be made as follows:		N/A
	– a lamp that exceeds the exposure limit shall be classified as belonging to Risk Group 3 (High-Risk)		N/A
	– for single pulsed lamps, a lamp whose weighted radiant exposure or weighted radiance does is below the EL shall be classified as belonging to the Exempt Group		N/A
	– for repetitively pulsed lamps, a lamp whose weighted radiant exposure or weighted radiance dose is below the EL, shall be evaluated using the continuous wave risk criteria discussed in clause 6.1, using time averaged values of the pulsed emission		N/A

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Clause	Requirement + Test	Result – Remark	Verdict

Table 4.1	Spectral weighting function for assessing ultraviolet hazards for skin and eye	

Wavelength[1] λ, nm	**UV hazard function $S_{UV}(\lambda)$**	**Wavelength λ, nm**	**UV hazard function $S_{UV}(\lambda)$**
200	0,030	313*	0,006
205	0,051	315	0,003
210	0,075	316	0,0024
215	0,095	317	0,0020
220	0,120	318	0,0016
225	0,150	319	0,0012
230	0,190	320	0,0010
235	0,240	322	0,00067
240	0,300	323	0,00054
245	0,360	325	0,00050
250	0,430	328	0,00044
254*	0,500	330	0,00041
255	0,520	333*	0,00037
260	0,650	335	0,00034
265	0,810	340	0,00028
270	1,000	345	0,00024
275	0,960	350	0,00020
280*	0,880	355	0,00016
285	0,770	360	0,00013
290	0,640	365*	0,00011
295	0,540	370	0,000093
297*	0,460	375	0,000077
300	0,300	380	0,000064
303*	0,120	385	0,000053
305	0,060	390	0,000044
308	0,026	395	0,000036
310	0,015	400	0,000030

[1] Wavelengths chosen are representative: other values should be obtained by logarithmic interpolation at intermediate wavelengths.
* Emission lines of a mercury discharge spectrum.

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Clause	Requirement + Test	Result – Remark	Verdict

Table 4.2	Spectral weighting functions for assessing retinal hazards from broadband optical sources	

Wavelength nm	**Blue-light hazard function B (λ)**	**Burn hazard function R (λ)**
300	0,01	
305	0,01	
310	0,01	
315	0,01	
320	0,01	
325	0,01	
330	0,01	
335	0,01	
340	0,01	
345	0,01	
350	0,01	
355	0,01	
360	0,01	
365	0,01	
370	0,01	
375	0,01	
380	0,01	0,1
385	0,013	0,13
390	0,025	0,25
395	0,05	0,5
400	0,10	1,0
405	0,20	2,0
410	0,40	4,0
415	0,80	8,0
420	0,90	9,0
425	0,95	9,5
430	0,98	9,8
435	1,00	10,0
440	1,00	10,0
445	0,97	9,7
450	0,94	9,4
455	0,90	9,0
460	0,80	8,0
465	0,70	7,0
470	0,62	6,2
475	0,55	5,5
480	0,45	4,5
485	0,40	4,0
490	0,22	2,2
495	0,16	1,6
500-600	$10^{[(450-\lambda)/50]}$	1,0
600-700	0,001	1,0
700-1050		$10^{[(700-\lambda)/500]}$
1050-1150		0,2
1150-1200		$0{,}2 \cdot 10^{0{,}02(1150-\lambda)}$
1200-1400		0,02

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Clause	Requirement + Test	Result – Remark	Verdict

Table 5.4 Summary of the ELs for the surface of the skin or cornea (irradiance based values)

Hazard Name	Relevant equation	Wavelength range nm	Exposure duration sec	Limiting aperture rad (deg)	EL in terms of constant irradiance $W \cdot m^{-2}$
Actinic UV skin & eye	$E_S = \sum E_\lambda \cdot S(\lambda) \cdot \Delta\lambda$	200 – 400	< 30000	1,4 (80)	30/t
Eye UV-A	$E_{UVA} = \sum E_\lambda \cdot \Delta\lambda$	315 – 400	≤1000 >1000	1,4 (80)	10000/t 10
Blue-light small source	$E_B = \sum E_\lambda \cdot B(\lambda) \cdot \Delta\lambda$	300 – 700	≤100 >100	< 0,011	100/t 1,0
Eye IR	$E_{IR} = \sum E_\lambda \cdot \Delta\lambda$	780 –3000	≤1000 >1000	1,4 (80)	$18000/t^{0,75}$ 100
Skin thermal	$E_H = \sum E_\lambda \cdot \Delta\lambda$	380 – 3000	< 10	2π sr	$20000/t^{0,75}$

Table 5.5 Summary of the ELs for the retina (radiance based values)

Hazard Name	Relevant equation	Wavelength range nm	Exposure duration sec	Field of view radians	EL in terms of constant radiance $W \cdot m^{-2} \cdot sr^{-1}$)
Blue light	$L_B = \sum L_\lambda \cdot B(\lambda) \cdot \Delta\lambda$	300 – 700	0,25 – 10 10-100 100-10000 ≥ 10000	$0,011 \cdot \sqrt{(t/10)}$ 0,011 $0,0011 \cdot \sqrt{t}$ 0,1	$10^6/t$ $10^6/t$ $10^6/t$ 100
Retinal thermal	$L_R = \sum L_\lambda \cdot R(\lambda) \cdot \Delta\lambda$	380 – 1400	< 0,25 0,25 – 10	0,0017 $0,011 \cdot \sqrt{(t/10)}$	$50000/(\alpha \cdot t^{0,25})$ $50000/(\alpha \cdot t^{0,25})$
Retinal thermal (weak visual stimulus)	$L_{IR} = \sum L_\lambda \cdot R(\lambda) \cdot \Delta\lambda$	780 – 1400	> 10	0,011	6000/α

IEC 62471			
Clause	Requirement + Test	Result – Remark	Verdict

Table 6.1	Emission limits for risk groups of continuous wave lamps (CXA1816-0000-000N00Q265F, α=65 mrad)								P
Risk	Action spectrum	Symbol	Units	Emission Measurement					
				Exempt		Low risk		Mod risk	
				Limit	Result	Limit	Result	Limit	Result
Actinic UV	$S_{UV}(\lambda)$	E_s	$W \cdot m^{-2}$	0,001	0,0000	0,003		0,03	
Near UV		E_{UVA}	$W \cdot m^{-2}$	10	0,0000	33		100	
Blue light	B(λ)	L_B	$W \cdot m^{-2} \cdot sr^{-1}$	100	3497,97 (285,9 s)	10000	22913,53 (43,6 s)	4000000	51541,06 (19,4 s)
Blue light, small source	B(λ)	E_B	$W \cdot m^{-2}$	1,0*	--	1,0		400	
Retinal thermal	R(λ)	L_R	$W \cdot m^{-2} \cdot sr^{-1}$	28000/α	261410,17	28000/α		71000/α	
Retinal thermal, weak visual stimulus**	R(λ)	L_{IR}	$W \cdot m^{-2} \cdot sr^{-1}$	6000/α	--	6000/α		6000/α	
IR radiation, eye		E_{IR}	$W \cdot m^{-2}$	100	0,25	570		3200	
* Small source defined as one with α < 0,011 radian. Averaging field of view at 10000 s is 0,1 radian. ** Involves evaluation of non-GLS source									

IEC 62471			
Clause	Requirement + Test	Result – Remark	Verdict

Table 6.1	Emission limits for risk groups of continuous wave lamps (CXA1816-0000-000N0HP440F, α=65 mrad)								P
Risk	Action spectrum	Symbol	Units	Emission Measurement					
				Exempt		Low risk		Mod risk	
				Limit	Result	Limit	Result	Limit	Result
Actinic UV	$S_{UV}(\lambda)$	E_S	$W \cdot m^{-2}$	0,001	0,0000	0,003		0,03	
Near UV		E_{UVA}	$W \cdot m^{-2}$	10	0,0000	33		100	
Blue light	B(λ)	L_B	$W \cdot m^{-2} \cdot sr^{-1}$	100	3053,99 (327,4 s)	10000	18526,13 (54,0 s)	4000000	45563,16 (21,9 s)
Blue light, small source	B(λ)	E_B	$W \cdot m^{-2}$	1,0*	--	1,0		400	
Retinal thermal	R(λ)	L_R	$W \cdot m^{-2} \cdot sr^{-1}$	28000/α	221857,16	28000/α		71000/α	
Retinal thermal, weak visual stimulus**	R(λ)	L_{IR}	$W \cdot m^{-2} \cdot sr^{-1}$	6000/α	--	6000/α		6000/α	
IR radiation, eye		E_{IR}	$W \cdot m^{-2}$	100	0,26	570		3200	
* Small source defined as one with α < 0,011 radian. Averaging field of view at 10000 s is 0,1 radian. ** Involves evaluation of non-GLS source									

IEC 62471			
Clause	Requirement + Test	Result – Remark	Verdict

Table 6.1	Emission limits for risk groups of continuous wave lamps (CXA1816-0000-000N00P430H, α=65 mrad)									P
Risk	Action spectrum	Symbol	Units	Emission Measurement						
				Exempt		Low risk		Mod risk		
				Limit	Result	Limit	Result	Limit	Result	
Actinic UV	$S_{UV}(\lambda)$	E_S	$W \cdot m^{-2}$	0,001	0,0000	0,003		0,03		
Near UV		E_{UVA}	$W \cdot m^{-2}$	10	0,0000	33		100		
Blue light	B(λ)	L_B	$W \cdot m^{-2} \cdot sr^{-1}$	100	1173,04 (852,5 s)	10000	7499,42 (133,3 s)	4000000		
Blue light, small source	B(λ)	E_B	$W \cdot m^{-2}$	1,0*	--	1,0		400		
Retinal thermal	R(λ)	L_R	$W \cdot m^{-2} \cdot sr^{-1}$	28000/α	118044,83	28000/α		71000/α		
Retinal thermal, weak visual stimulus**	R(λ)	L_{IR}	$W \cdot m^{-2} \cdot sr^{-1}$	6000/α	--	6000/α		6000/α		
IR radiation, eye		E_{IR}	$W \cdot m^{-2}$	100	0,33	570		3200		

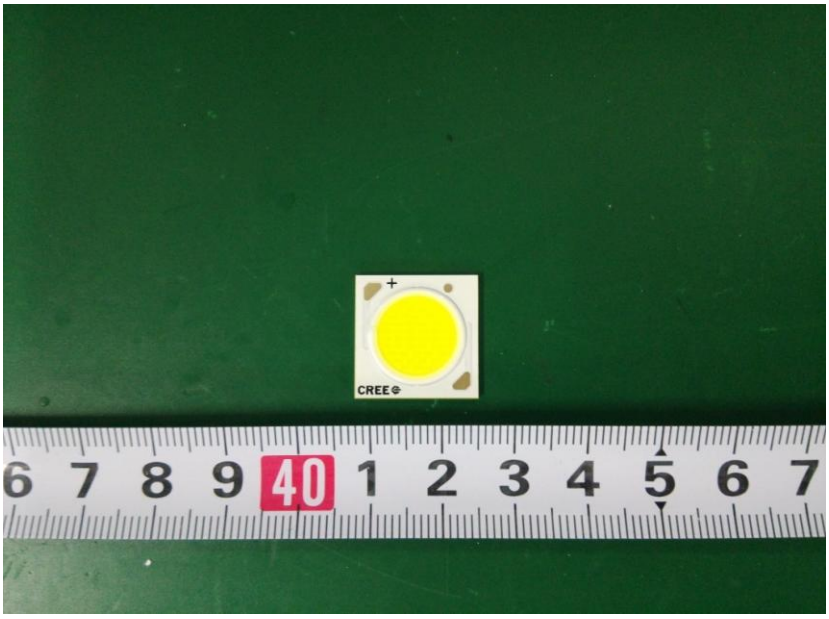
* Small source defined as one with α < 0,011 radian. Averaging field of view at 10000 s is 0,1 radian.
** Involves evaluation of non-GLS source

Furthermore remarks:

Appenix 1: List of test equipment used:

Clause	Measurement/ testing	Registration Number	Testing/measuring equipment/material used	Range used
5	Irradiance measurements Radiance measurements	SH 344	MONOCHROMATOR	200-3000nm
5	Radiance measurements	SH 345	S009 TELESCOPE	300-1400nm
5	Irradiance measurements	SH 346	S400_417 DETECTION ELECTRONIC	--
5	Irradiance measurements Radiance measurements	SH 347	608 CONSTANT CURRENT	--
5	Radiance measurements	SH 348	SRS12 RADIANCE	300-1400nm
5	Irradiance measurements	SH 349	705 DEUTERIUM SUPPLY	200-400nm
5	Irradiance measurements	SH 350	CL6 STANDARD	300-3000nm
5	Irradiance measurements	SH 351	CL7 STANDARD	200-400nm
5	Irradiance measurements Radiance measurements	SH 352	PHOTOMULTIPLIER	200-850nm
5	Irradiance measurements Radiance measurements	SH 353	INGAAS DETECTOR	800-1700nm
5	Irradiance measurements Radiance measurements	SH 354	SILICON DETECTOR	200-1100nm
5	Irradiance measurements	SH 355	PBS-TE DETECTOR	1000-3000nm
5	Irradiance measurements	SH 356	RELAY OPTIC	--
5	Irradiance measurements Radiance measurements	SH 357	D8 INTEGRATING SPHER	1000-3000nm
5	Irradiance measurements	SH 358	D7 COSINE DIFFUSER	200-1100nm
5	Irradiance measurements	SH 359	PHOTOMETRIC DETECTOR	380nm-800nm
5	Irradiance measurements Radiance measurements	SH070	WATTMETER	500 V, 40 A

Appendix 2: Photo documentation



Overview

Appendix 3: Model list

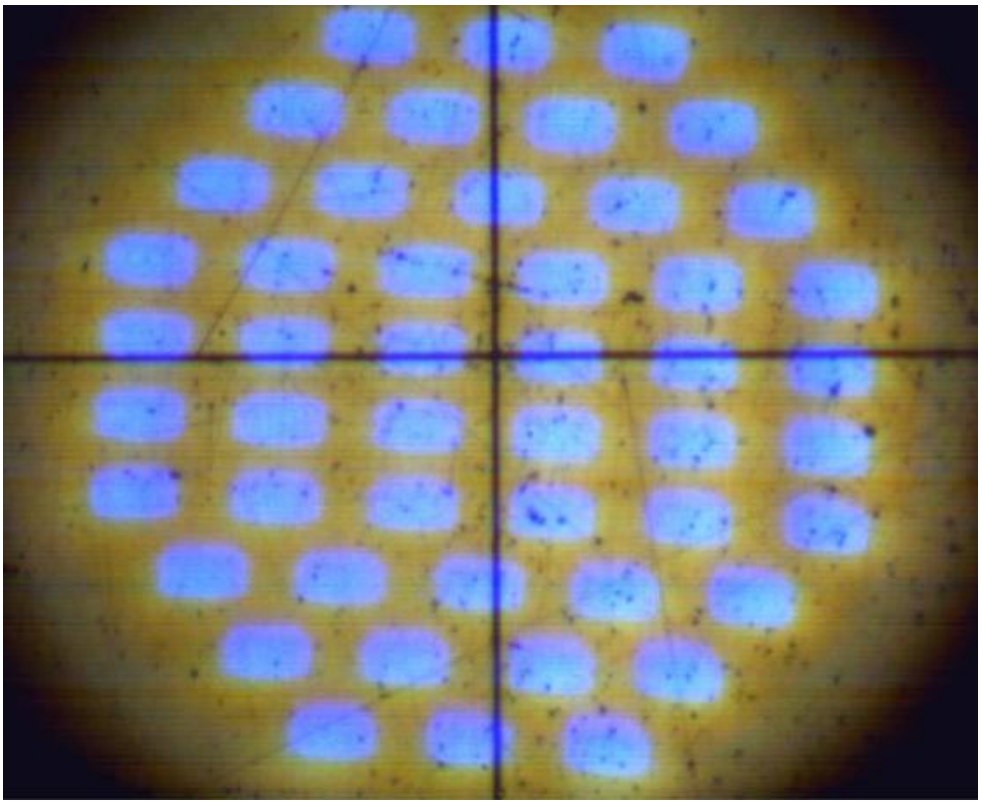
I_F=450 mA, T_J = 85 °C

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			2-Step Order Code		4-Step Order Code	
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	Chromaticity Region		Chromaticity Region	
6500 K	70	75	P2	1830	2028			65F	CXA1816-0000-000N00P265F
			P4	1965	2177				CXA1816-0000-000N00P465F
			Q2	2100	2327				CXA1816-0000-000N00Q265F
	80	---	N4	1710	1895			65F	CXA1816-0000-000N0HN465F
			P2	1830	2028				CXA1816-0000-000N0HP265F
			P4	1965	2177				CXA1816-0000-000N0HP465F
			Q2	2100	2327				CXA1816-0000-000N0HQ265F
5700 K	70	75	P2	1830	2028			57F	CXA1816-0000-000N00P257F
			P4	1965	2177				CXA1816-0000-000N00P457F
			Q2	2100	2327				CXA1816-0000-000N00Q257F
			Q4	2260	2542				CXA1816-0000-000N00Q457F
	80	---	N4	1710	1895			57F	CXA1816-0000-000N0HN457F
			P2	1830	2028				CXA1816-0000-000N0HP257F
			P4	1965	2177				CXA1816-0000-000N0HP457F
			Q2	2100	2327				CXA1816-0000-000N0HQ257F
5000 K	70	75	P2	1830	2028	50H	CXA1816-0000-000N00P250H	50F	CXA1816-0000-000N00P250F
			P4	1965	2177		CXA1816-0000-000N00P450H		CXA1816-0000-000N00P450F
			Q2	2100	2327		CXA1816-0000-000N00Q250		CXA1816-0000-000N00Q250F
			Q4	2260	2542		CXA1816-0000-000N00Q450H		CXA1816-0000-000N00Q450F
	80	---	N4	1710	1895	50H	CXA1816-0000-000N0HN450H	50F	CXA1816-0000-000N0HN450F
			P2	1830	2028		CXA1816-0000-000N0HP250H		CXA1816-0000-000N0HP250F
			P4	1965	2177		CXA1816-0000-000N0HP450H		CXA1816-0000-000N0HP450F
			Q2	2100	2327		CXA1816-0000-000N0HQ250H		CXA1816-0000-000N0HQ250F
	90	95	M4	1485	1645	50H	CXA1816-0000-000N0UM450H	50F	CXA1816-0000-000N0UM450F
			N2	1590	1762		CXA1816-0000-000N0UN250H		CXA1816-0000-000N0UN250F
			N4	1710	1895		CXA1816-0000-000N0UN450H		CXA1816-0000-000N0UN450F

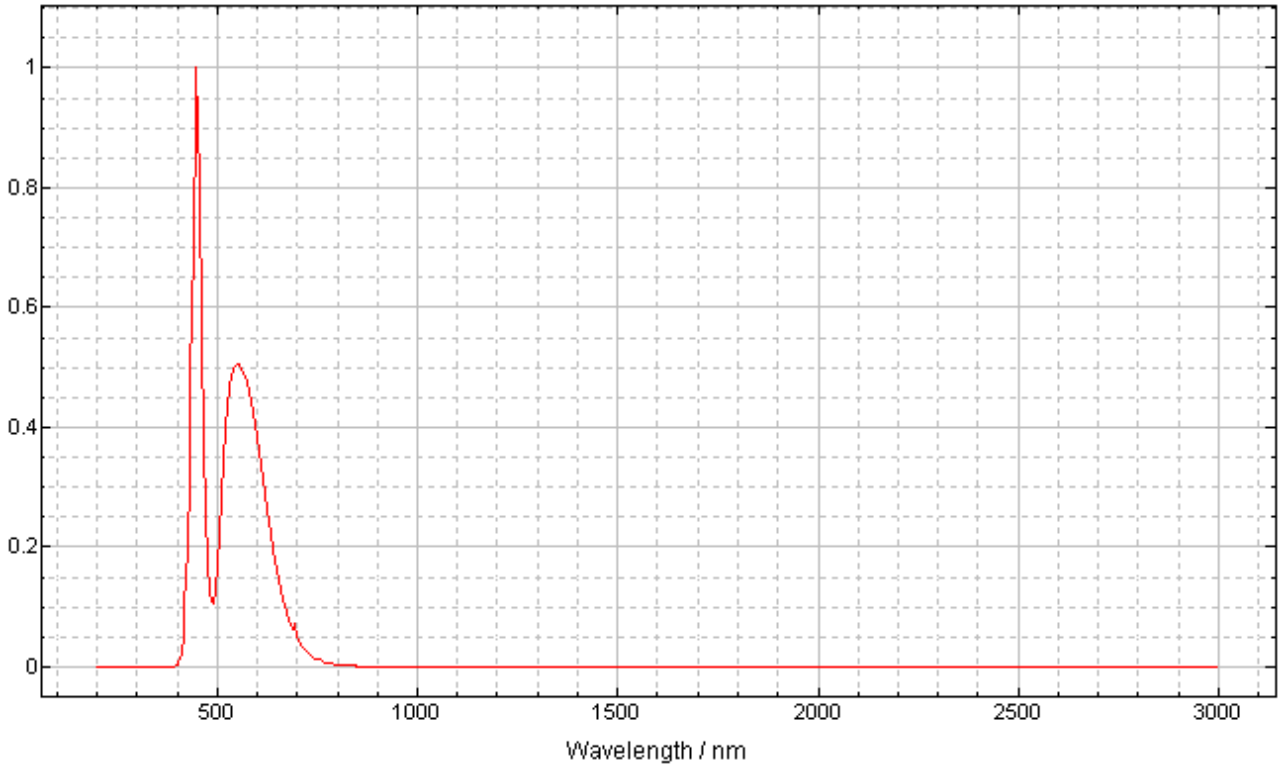
I_F=450 mA, T_J = 85 °C - Continued

CCT Range	CRI		Base Order Codes Min. Luminous Flux @ 450 mA			2-Step Order Code		4-Step Order Code	
	Min	Typ	Group	Flux (lm) @ 85 °C	Flux (lm) @ 25 °C*	Chromaticity Region		Chromaticity Region	
4000 K	70	75	N4	1710	1895	40H	CXA1816-0000-000N00N440H	40F	CXA1816-0000-000N00N440F
			P2	1830	2028		CXA1816-0000-000N00P240H		CXA1816-0000-000N00P240F
			P4	1965	2177		CXA1816-0000-000N00P440H		CXA1816-0000-000N00P440F
			Q2	2100	2327		CXA1816-0000-000N00Q240H		CXA1816-0000-000N00Q240F
	80	---	N2	1590	1762	40H	CXA1816-0000-000N0HN240H	40F	CXA1816-0000-000N0HN240F
			N4	1710	1895		CXA1816-0000-000N0HN440H		CXA1816-0000-000N0HN440F
			P2	1830	2028		CXA1816-0000-000N0HP240H		CXA1816-0000-000N0HP240F
			P4	1965	2177		CXA1816-0000-000N0HP440H		CXA1816-0000-000N0HP440F
	90	95	M2	1380	1537	40H	CXA1816-0000-000N0UM240H	40F	CXA1816-0000-000N0UM240F
			M4	1485	1645		CXA1816-0000-000N0UM440H		CXA1816-0000-000N0UM440F
			N2	1590	1762		CXA1816-0000-000N0UN240H		CXA1816-0000-000N0UN240F
3500 K	80	---	N4	1710	1895	35H	CXA1816-0000-000N00N435H	35F	CXA1816-0000-000N00N435F
			P2	1830	2028		CXA1816-0000-000N00P235H		CXA1816-0000-000N00P235F
			P4	1965	2177		CXA1816-0000-000N00P435H		CXA1816-0000-000N00P435F
	93	95	K4	1290	1437	35H	CXA1816-0000-000N0YK435H	35F	CXA1816-0000-000N0YK435F
			M2	1380	1537		CXA1816-0000-000N0YM235H		CXA1816-0000-000N0YM235F
			M4	1485	1645		CXA1816-0000-000N0YM435H		CXA1816-0000-000N0YM435F
3000 K	80	---	N2	1590	1762	30H	CXA1816-0000-000N00N230H	30F	CXA1816-0000-000N00N230F
			N4	1710	1895		CXA1816-0000-000N00N430H		CXA1816-0000-000N00N430F
			P2	1830	2028		CXA1816-0000-000N00P230H		CXA1816-0000-000N00P230F
			P4	1965	2177		CXA1816-0000-000N00P430H		CXA1816-0000-000N00P430F
	93	95	K2	1200	1337	30H	CXA1816-0000-000N0YK230H	30F	CXA1816-0000-000N0YK230F
			K4	1290	1437		CXA1816-0000-000N0YK430H		CXA1816-0000-000N0YK430F
			M2	1380	1537		CXA1816-0000-000N0YM230H		CXA1816-0000-000N0YM230F
			M4	1485	1645		CXA1816-0000-000N0YM430H		CXA1816-0000-000N0YM430F
2700 K	80	---	M4	1485	1645	27H	CXA1816-0000-000N00M427H	27F	CXA1816-0000-000N00M427F
			N2	1590	1762		CXA1816-0000-000N00N227H		CXA1816-0000-000N00N227F
			N4	1710	1895		CXA1816-0000-000N00N427H		CXA1816-0000-000N00N427F
			P2	1830	2028		CXA1816-0000-000N00P227H		CXA1816-0000-000N00P227F
	93	95	J4	1120	1248	27H	CXA1816-0000-000N0YJ427H	27F	CXA1816-0000-000N0YJ427F
			K2	1200	1337		CXA1816-0000-000N0YK227H		CXA1816-0000-000N0YK227F
			K4	1290	1437		CXA1816-0000-000N0YK427H		CXA1816-0000-000N0YK427
			M2	1380	1537		CXA1816-0000-000N0YM227H		CXA1816-0000-000N0YM227F

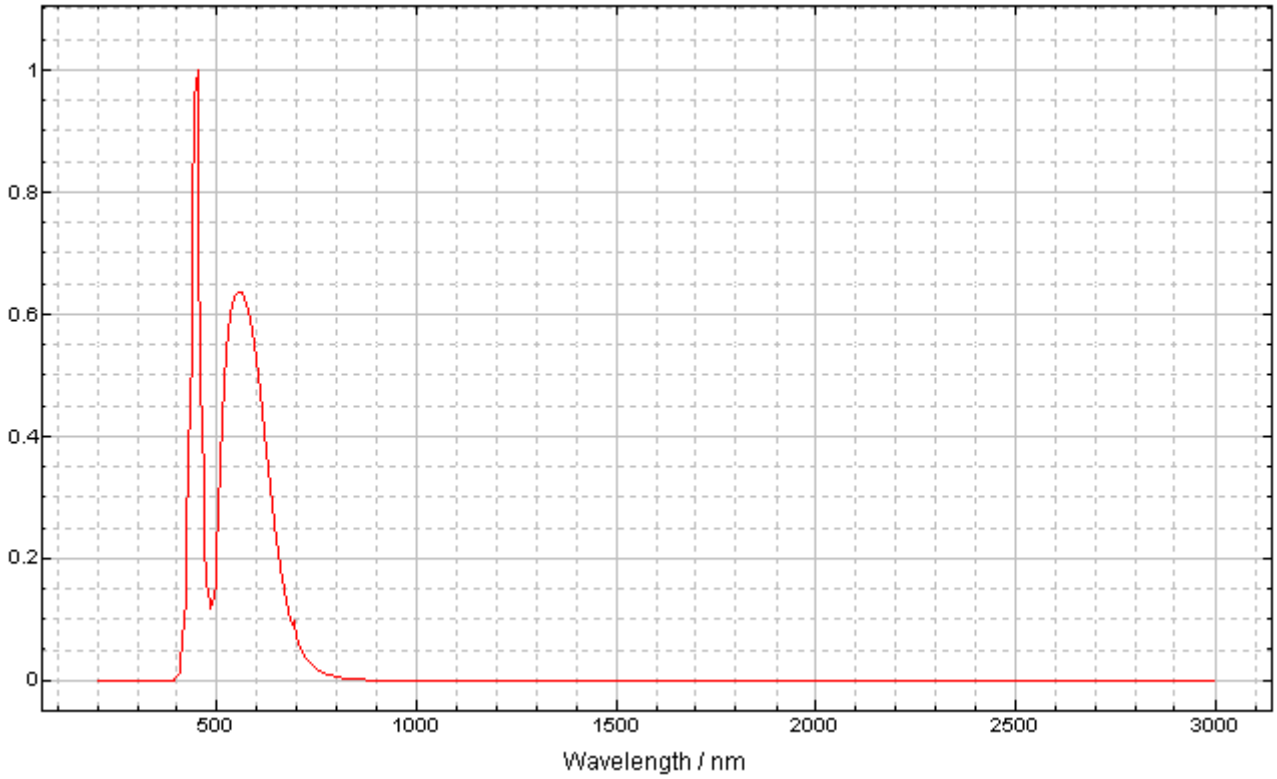
Appendix 4: LED source



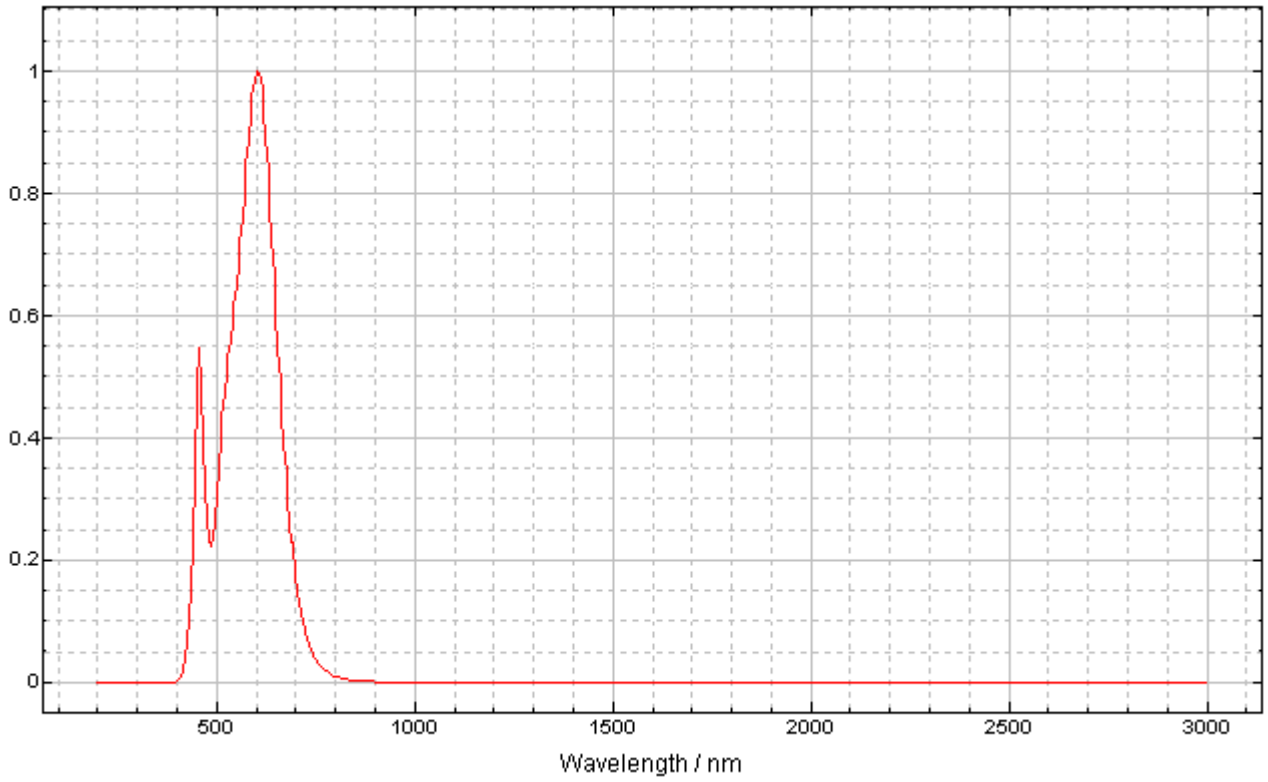
Appendix 5: Relative spectrum of tested sample



CXA1816-0000-000N00Q265F



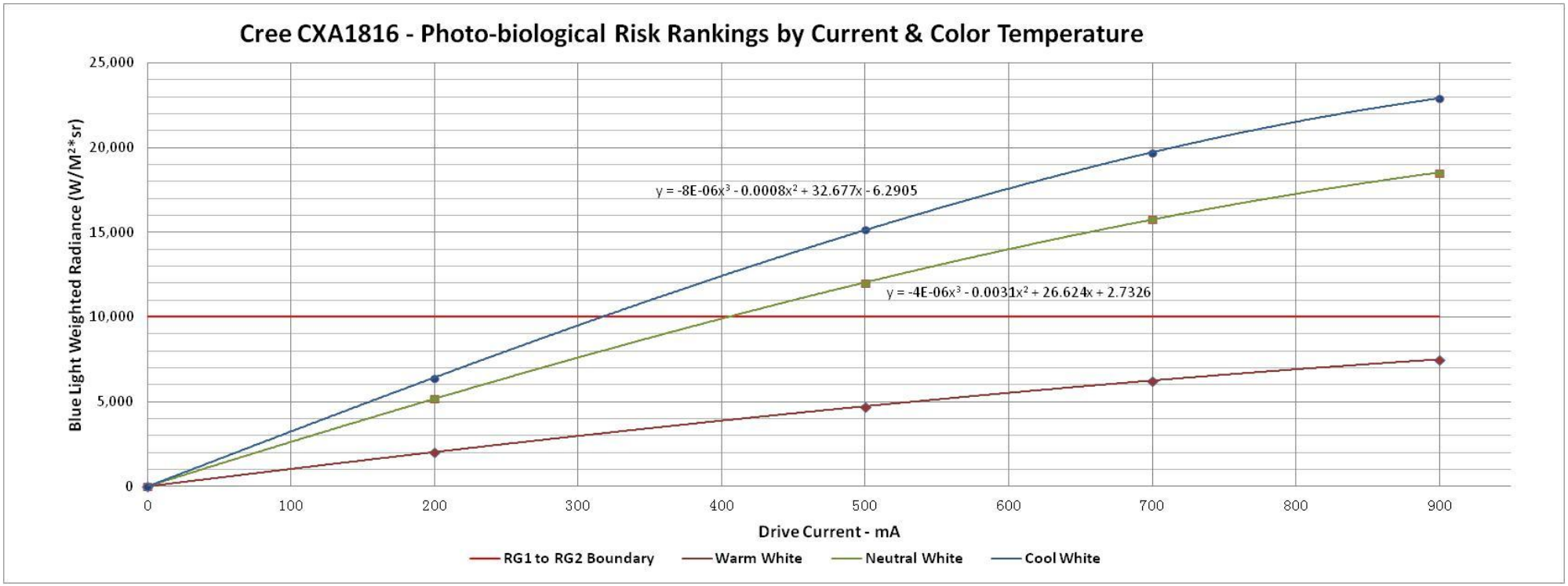
CXA1816-0000-000N0HP440F



CXA1816-0000-000N00P430H

Appendix 6: Blue light hazard-forward current relation (Non-mandatory Information)

The diagram blow shows the different blue light hazard against different forward current. It is the additional information just for reference.
All the test data performed at radiance 11mrad 200mm.



			Drive Currents (mA)							
CCT Group:	Product ID:	Measured CCT:	0	200	500	700	900	Regression Formula:	Fit to RG2 Line:	Current @ RG-1 to RG-2 Boundary, mA:
Warm White	CXA1816-0000-000N00P430H	3089K	0	2027	4732	6250	7499	--	--	--
Neutral White	CXA1816-0000-000N0HP440F	5437K	0	5181	12029	15762	18526	$y = -4E-06x^3 - 0.0031x^2 + 26.624x + 2.7326$	10000	405
Cool White	CXA1816-0000-000N00Q265F	6782K	0	6414	15162	19695	22914	$y = -8E-06x^3 - 0.0008x^2 + 32.677x - 6.2905$	10000	316