Product / Part Description:	Retime™ Glasses V1 – Test Results	Reference documents: ECR ☐ QAN ☐ CCR ☐ Other: Conf. Agreement 17/8/11
Part Number: N/A	Issue: N/A	
Prepared By: Kevin Howard	Date: 9/06/2013	

Scope of Test: *What do you want to test and does this cover the function of the part?*	Determine the optical safety classification for the Retime™ glasses using the provided test results by the client.
Specifications to be Tested: *Refer to the source of the requirement and indicate clearly the pass fail criteria.*	LED light output to the user. Known specifications provided by client: LED Peak Wavelength λ_p : 500nm from Kingbright APT1608WG1C LED data sheet Maximum radiance at each eye L_e: 148 $Wm^{-2}sr^{-1}$ (From the provided maximum measured result of 14.8 $mWcm^{-2}sr^{-1}$.) Duration of use t : Up to 60 minutes continuous exposure Configuration: 2 LED's aimed at each pupil at a 41.2° angle from optical axis

Attachments?	Yes	Details: Retime Radiance Measurements Test Results Light Source Characteristics report – Simon Belcher 13 Apr 2012 Kingbright APT1608WG1C LED data sheet

Proposed Test Method: *Refer to existing procedures if applicable or summarise method to be used.*	Calculation of the blue light weighted radiance using the provided measured maximum radiance and LED light source characteristics. Review of compliance to CEI IEC 62471 Edition 1.	
Attachments?	No	Details:
Expected Outcome(s): *Identify the anticipated results without prejudice to the required result.*	Determine the lamp classification for the Retime Glasses V1 according to the IEC 62471:2002 standard.	
Test Equipment: *List serial numbers and calibration factors etc.*	None	

Results:

From the IEC 62471:2002 standard for biological safety of lamps and lamp systems, clause 4.3.3 details how to calculate and determine the retinal blue light hazard exposure limit.

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 $B(\lambda)$, i.e, the blue light weighted radiance, L_B, shall not exceed the levels defined by:

$$L_B \cdot t = \sum_{300}^{700} \sum_{t} L_\lambda(\lambda, t) \cdot B(\lambda) \cdot \Delta t \cdot \Delta\lambda \leq 10^6 \text{ J·m}^{-2}\text{·sr}^{-1} \quad (\text{for } t \leq 10^4 \text{s}) \cdots\cdots (1)$$

Where:

$L_\lambda(\lambda, t)$ is the spectral radiance of the light source in $\text{W·m}^{-2}\text{·sr}^{-1}\text{·nm}^{-1}$
$B(\lambda)$ is the blue-light hazard weighting function, whose values are given in table 4.2 of IEC 62471:2002
$\Delta\lambda$ is the bandwidth in nm
t is the exposure duration in seconds

From the client provided test measurement data, the maximum radiance L_e is 14.8 $\text{mWcm}^{-2}\text{sr}^{-1}$.

$$i.e.\ L_e = 148 \text{ W·m}^{-2}\text{·sr}^{-1}$$

In order to find a solution to equation (1), the spectral radiance $L_\lambda(\lambda)$ needs to be found from the radiance L_e.

Figure 1, obtained from the Kingbright APT1608WG1C LED data sheet shows the relative radiant intensity of the LED as a function of wavelength.

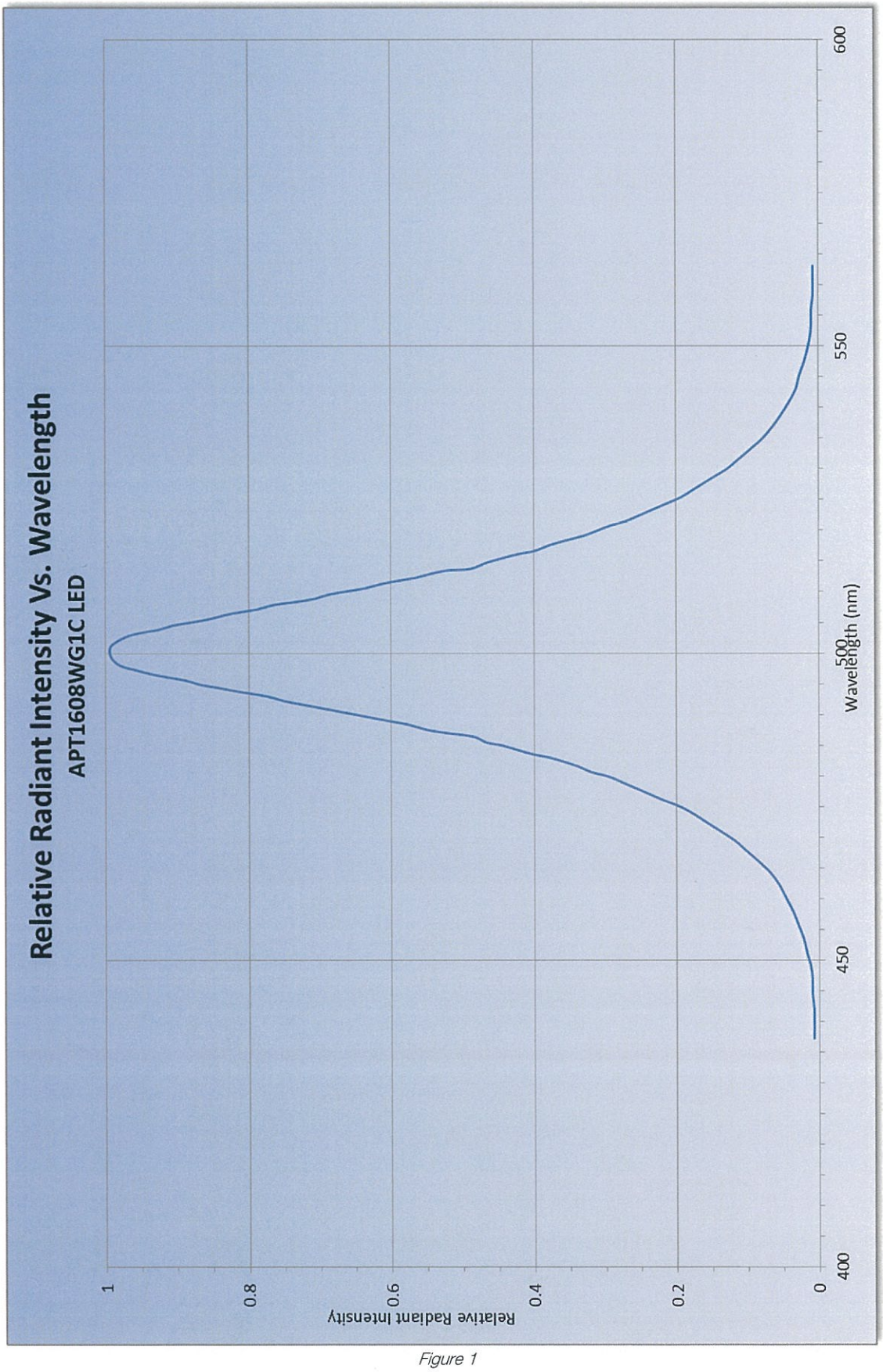

Figure 1

Table 1 below takes the relative radiant intensity values from figure 1 and weights them with the value of radiance $L_e = 148\ \mathrm{W{\cdot}m^{-2}{\cdot}sr^{-1}}$ provided by the client to obtain the spectral radiance values $L_\lambda(\lambda)$ for the wavelength range 440-560nm of the LED.

Wavelength (nm)	Relative Radiant Intensity	Spectral Radiance $L_\lambda(\lambda)$ ($\mathrm{W{\cdot}m^{-2}{\cdot}sr^{-1}{\cdot}nm^{-1}}$)
440	0.0073	0.2
445	0.0097	0.2
450	0.0169	0.4
455	0.0291	0.7
460	0.0460	1.0
465	0.0678	1.5
470	0.1186	2.7
475	0.1961	4.4
480	0.2954	6.6
485	0.4455	10.0
490	0.6634	14.9
495	0.8668	19.5
500	0.9927	22.3
505	0.8814	19.8
510	0.6610	14.9
515	0.4673	10.5
520	0.3148	7.1
525	0.1937	4.4
530	0.1259	2.8
535	0.0799	1.8
540	0.0412	0.9
545	0.0266	0.6
550	0.0121	0.3
555	0.0097	0.2
560	0.0073	0.2
sum =	**6.5763**	**148.0**
Radiance L_e =	$148\ \mathrm{W{\cdot}m^{-2}{\cdot}sr^{-1}}$	

Table 1

Table 2 shows the spectral radiance values $L_\lambda(\lambda)$ and the corresponding Blue-light hazard function values $B(\lambda)$ for each wavelength in the range 300 to 700nm.

In order to obtain the sum $\sum_{300}^{700}\sum_{t} L_\lambda(\lambda,t)\cdot B(\lambda)\cdot \Delta t\cdot \Delta\lambda$ to calculate a value for L_B in equation (1),

the product of $L_\lambda(\lambda)\cdot B(\lambda)$ was found for each wavelength in Table 2 and then the column was summed.

$$\therefore \sum_{300}^{700} L_\lambda(\lambda)\cdot B(\lambda)\cdot \Delta\lambda = 26.5\ \mathrm{J\cdot m^{-2}\cdot sr^{-1}} \quad \cdots\cdots (3)$$

Wavelength (nm)	Spectral Radiance $L_\lambda(\lambda)$ ($\mathrm{W\cdot m^{-2}\cdot sr^{-1}\cdot nm^{-1}}$)	Blue-light hazard function[1] $B(\lambda)$	$L_\lambda(\lambda)\cdot B(\lambda)$ ($\mathrm{W\cdot m^{-2}\cdot sr^{-1}\cdot nm^{-1}}$)
300	0	0.010	0.0
305	0	0.010	0.0
310	0	0.010	0.0
315	0	0.010	0.0
320	0	0.010	0.0
325	0	0.010	0.0
330	0	0.010	0.0
335	0	0.010	0.0
340	0	0.010	0.0
345	0	0.010	0.0
350	0	0.010	0.0
355	0	0.010	0.0
360	0	0.010	0.0
365	0	0.010	0.0
370	0	0.010	0.0
375	0	0.010	0.0
380	0	0.010	0.0
385	0	0.013	0.0
390	0	0.025	0.0
395	0	0.050	0.0
400	0	0.100	0.0
405	0	0.200	0.0
410	0	0.400	0.0
415	0	0.800	0.0
420	0	0.900	0.0
425	0	0.950	0.0
430	0	0.980	0.0
435	0	1.000	0.0
440	0.2	1.000	0.2
445	0.2	0.970	0.2
450	0.4	0.940	0.4
455	0.7	0.900	0.6
460	1.0	0.800	0.8
465	1.5	0.700	1.1
470	2.7	0.620	1.7
475	4.4	0.550	2.4
480	6.6	0.450	3.0
485	10.0	0.400	4.0
490	14.9	0.220	3.3
495	19.5	0.160	3.1
500	22.3	0.100	2.2
505	19.8	0.079	1.6
510	14.9	0.063	0.9

[1] Blue-light hazard function values obtained from Table 4.2 of IEC 62471:2002

Wavelength (nm)	Spectral Radiance $L_\lambda(\lambda)$ ($W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$)	Blue-light hazard function[1] $B(\lambda)$	$L_\lambda(\lambda) \cdot B(\lambda)$ ($W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$)
515	10.5	0.050	0.5
520	7.1	0.040	0.3
525	4.4	0.032	0.1
530	2.8	0.025	0.1
535	1.8	0.020	0.0
540	0.9	0.016	0.0
545	0.6	0.013	0.0
550	0.3	0.010	0.0
555	0.2	0.008	0.0
560	0.2	0.006	0.0
565	0	0.005	0.0
570	0	0.004	0.0
575	0	0.003	0.0
580	0	0.003	0.0
585	0	0.002	0.0
590	0	0.002	0.0
595	0	0.001	0.0
600	0	0.001	0.0
605	0	0.001	0.0
610	0	0.001	0.0
615	0	0.001	0.0
620	0	0.001	0.0
625	0	0.001	0.0
630	0	0.001	0.0
635	0	0.001	0.0
640	0	0.001	0.0
645	0	0.001	0.0
650	0	0.001	0.0
655	0	0.001	0.0
660	0	0.001	0.0
665	0	0.001	0.0
670	0	0.001	0.0
675	0	0.001	0.0
680	0	0.001	0.0
685	0	0.001	0.0
690	0	0.001	0.0
695	0	0.001	0.0
700	0	0.001	0.0
		sum =	26.5 $J \cdot m^{-2} \cdot sr^{-1}$

Table 2

From equation (1) and using the result from equation (3) and a maximum duration of exposure $t = 3600s$ (60 minutes)

$L_B \cdot t = \sum_{300}^{700} \sum_{t} L_\lambda(\lambda, t) \cdot B(\lambda) \cdot \Delta t \cdot \Delta\lambda \leq 10^6$ for a non-time varying spectral radiance of duration 3600s becomes

$$L_B \cdot t = \sum_{300}^{700} L_\lambda(\lambda) \cdot B(\lambda) \cdot \Delta\lambda \cdot \sum_{t=0}^{3600} \Delta t \leq 10^6$$

$$L_B \cdot 3600 = 26.5 \times 3600 \leq 10^6$$

$$\therefore L_B = 26.5 < 278 \ W \cdot m^{-2} \cdot sr^{-1}$$

The calculated value of the blue light weighted radiance from the Retime™ glasses V1 for a continuous exposure of 60 minutes is 26.5 $W \cdot m^{-2} \cdot sr^{-1}$, which is below the retinal blue light hazard exposure limit of 278 $W \cdot m^{-2} \cdot sr^{-1}$ for the same duration of exposure. This does allow the Retime™ glasses to fit into the exempt group as defined in clause 6.1.1 of IEC 62471:2002.

Attachments: *List the attachments*	None
Additional Comments: *Un-expected results?*	None
Summary:	From the measurement test data provided for the Retime light stimulation glasses, the calculated value of the blue light weighted radiance for a continuous exposure of 60 minutes is 26.5 $W \cdot m^{-2} \cdot sr^{-1}$. This figure is below the retinal blue light hazard exposure limit of 278 $W \cdot m^{-2} \cdot sr^{-1}$ for the same duration of exposure and allows the glasses to fit into the exempt lamp classification group. The classification scheme defined in IEC 624771:2002 indicates only the potential risk. Depending on use factors, time of exposure and luminaire effects, these potential hazards may or may not actually become real hazards.
Have all the test and evaluation requirements been met?	Yes
Resulting Actions: *Is it necessary to raise a QAN or an ECR?*	File T&E
Test and Evaluation Performed by:	Signed: Marcus Friebel 2013.06.09 18:21:46 +09'30' Marcus Friebel – Principal Engineer Date: 9/6/2013
Distribution:	KH, DW, DH

Sample No.	Brightest LED No.	S/N	Luminance (Kcd/m^2)	Radiance[Note] ($mW/sr/cm^2$)
1	2	000000038	29.3	13.3
2	2	000000039	26.5	12
3	2	891238261	29.6	13.5
13	2	891237407	28.4	12.9
17	2	891238905	28.6	13
29	2	891239349	32.6	14.8

Note: The LEDs have their peak wavelength at 500nm. Radiance values presented in the test results were calculated from the luminance values measured. This calculation was carried out as follows:

$$\text{Radiance } (mW/sr/cm^2) = \frac{\text{Luminance } (Kcd/m^2)}{\text{Photopic lumen per watt conversion factor @500nm}}$$