Risk of Ignition by Optical Radiation

(Are Water Bottles safe in a Hazardous Location?)

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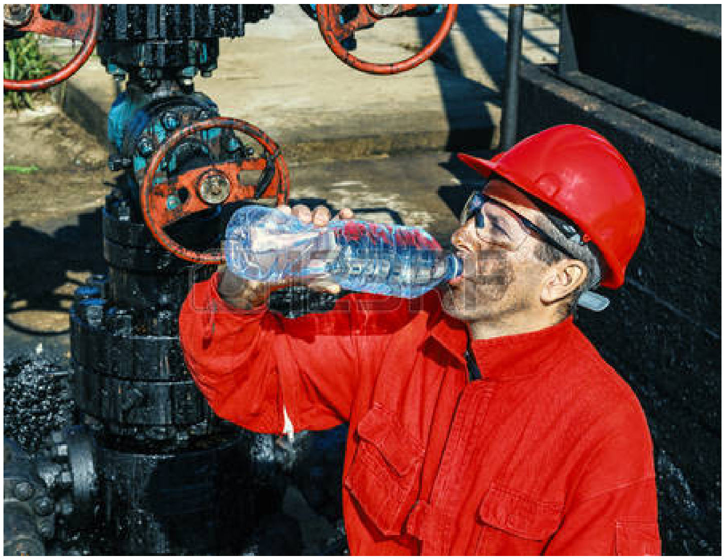
OVERVIEW

This document serves as a proactive investigation into a possible lighting-related liability in hazardous locations. As technology moves forward with super-high brightness LEDs and fixtures, it's worthwhile to look into the safety standards for ignition of flammable gasses due to optical radiation.



A potential equipment hazard could be integrating enhanced technology LEDs with higher lumen output (but the same part number) the same fixture and the same power for the LED's with existing IEC, CSA, or UL approvals may offer the benefit of enhanced brightness as the same LEDs are now brighter, but it may increase the potential of an explosion if the photometric power exceeds a certain threshold. This dynamic may go unnoticed by hazardous location luminaire manufacturers and their certifying bodies as technology changes so fast.

Furthermore, CSA and UL do not test to this specification for hazardous locations, but IEC has done complied a document recently.

Research Benchmark & References:

IEC 60079-28:2006, 1st edition *Risk of ignition by radiation from optical equipment*

This standard contains requirements for optical radiation in the wavelength range from 380 nm to 10 µm and identifiess **5mW/mm2** as a maximum brightness. It covers the following ignition mechanisms:

- optical radiation is absorbed by surfaces or particles, causing them to heat up and, under certain circumstances, this may allow them to attain a temperature which will ignite a surrounding explosive atmosphere;
- direct laser induced breakdown of the gas at the focus of a strong beam, producing plasma and a shock wave both eventually acting as the ignition source. These processes can be supported by a solid material close to the breakdown point.

Discussion:

In particular any concentration of light can heat up a surface or particles. Brightness (or power) limit is 5mW/mm2 which is one design consideration is that when Light Emitting Diodes (LEDs) fail if they are overloaded by excessive power in fault conditions. The failure characteristic of certain optical sources can be used for the necessary power limiting in case of a fault.

As a benchmark reference, the maximum intensity of sunlight at ground level (directly overhead, no smog, etc.) = 1 kW/m2 or 1 mW/mm2. That said, it would be noteworthy to consider if using water bottles (that focus sunlight) onsite could be considered an explosive issue but are currently outside our investigation.

Nemalux Fixture Analysis:

Based on this document, any fixtures we make would be large enough to be in the upper size range where the max power is 5mW/mm2. For a Nemalux XCANLED sized fixture (5” diameter, or 12,668mm2) that works out to a max optical power of 63.3W evenly distributed across the window. This means that for Zone 0, Zone 1, and Zone2, the max drive power we can use in an XCAN size fixture is around 190W (assuming 33% of LED power is converted to light out), or else the light output could be sufficient to cause an explosion (the most frequent ignition source, in this case, seems to be debris or absorbing materials landing on the lens or in the beam path).

- The max optical flux will be at the surface of the TIR lens
- The optical flux may not be uniform across the surface of the lens but by the time it passes through the window any hot spots should have evened out (This is a somewhat questionable assumption, would need to do more modeling to define it better to account for actual beam profile – probably an extra couple hours work)
- Radiometric efficiency is 33% (what I previously measured for a cool while XML at 113lm/W efficacy, should be slightly better than what the Nemalux XCAN or RS LEDs will be operated at)
- All optical power passes within the FWHM cone (a conservative estimate)

XCANLED Ignition Risk Due to Optical Radiation		
Worst Case Assessment		
Cree XTE R5 bin, Cool White, Tj=85°C		
Current	1.50	A
Forward Voltage	3.37	V
Electrical Power	5.06	W
Radiometric Efficiency	0.33	
Optical Power Emitted	1.67	W
Ledil Leila (8°FWHM)		
Diameter	21.60	mm
Area	366.44	mm2
Height	14.6	mm
Optical Efficiency	0.92	
Beam Spread (FWHM)	8	°
Optical Flux @ Lens	4.19	mW/mm2
Window Transmission	0.92	
Board to Air Interface Dist.	23.26	mm
Lens to Air Interface Dist.	8.66	mm
Effective Beam Diameter	22.81	mm
Effective Beam Area	408.57	mm2
Optical Flux @ Window	3.46	mW/mm2
CONCLUSION: NO IGNITION RISK POSSIBLE		

RSLED Ignition Risk Due to Optical Radiation		
Current Case Assessment		
Cree XML T6 bin, Cool White, Tj=85°C		
Current	1.50	A
Forward Voltage	3.01	V
Electrical Power	4.52	W
Radiometric Efficiency	0.33	
Optical Power Emitted	1.49	W
Ledil Cute (19°FWHM)		
Diameter	35.00	mm
Area	962.11	mm2
Height	15	mm
Optical Efficiency	0.92	
Beam Spread (FWHM)	19	°
Optical Flux @ Lens	4.27	mW/mm2
Window Transmission	0.92	
Board to Air Interface Dist.	19.35	mm
Lens to Air Interface Dist.	4.35	mm
Effective Beam Diameter	36.44	mm
Effective Beam Area	1042.68	mm2
Optical Flux @ Window	3.63	mW/mm2
CONCLUSION: NO IGNITION RISK		

RSLED Ignition Risk Due to Optical Radiation		
XML2 Case Assessment		
Cree XML2 T5 bin, Cool White, Tj=85°C		
Current	1.50	A
Forward Voltage	3.04	V
Electrical Power	4.56	W
Radiometric Efficiency	0.33	
Optical Power Emitted	1.50	W
Ledil Cute (19°FWHM)		
Diameter	35.00	mm
Area	962.11	mm2
Height	15	mm
Optical Efficiency	0.92	
Beam Spread (FWHM)	19	°
Optical Flux @ Lens	4.32	mW/mm2
Window Transmission	0.92	
Board to Air Interface Dist.	19.35	mm
Lens to Air Interface Dist.	4.35	mm
Effective Beam Diameter	36.44	mm
Effective Beam Area	1042.68	mm2
Optical Flux @ Window	3.66	mW/mm2
CONCLUSION: NO IGNITION RISK		

RSLED Ignition Risk Due to Optical Radiation		
Worst Case Assessment		
Cree XML2 U3 bin, Cool White, Tj=85°C		
Current	2.50	A
Forward Voltage	3.24	V
Electrical Power	8.10	W
Radiometric Efficiency	0.33	
Optical Power Emitted	2.67	W
Ledil Cute (19°FWHM)		
Diameter	35.00	mm
Area	962.11	mm2
Height	15	mm
Optical Efficiency	0.92	
Beam Spread (FWHM)	19	°
Optical Flux @ Lens	7.67	mW/mm2
Window Transmission	0.92	
Board to Air Interface Dist.	19.35	mm
Lens to Air Interface Dist.	4.35	mm
Effective Beam Diameter	36.44	mm
Effective Beam Area	1042.68	mm2
Optical Flux @ Window	6.51	mW/mm2
CONCLUSION: PROBABLE IGNITION RISK		

Conclusion:

The evolution and continual changes of LED technology are difficult to regulate. Nemalux should remain proactive and vigilant with our consideration of possible optical sources of ignition. It would be easy, with a focussed beam, width to exceed the max power of 5mW/mm2

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