

Oral Comments on Draft ROC Monograph on Night Shift Work and Light at Night

Submitted by

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Introduction

- **Qualifications to Comment**
 - Former Harvard Medical School professor (1975-1998) with over 150 peer reviewed papers and multiple books on physiology of Circadian Timing System, and pathophysiology and consequences of Circadian Disruption
 - 30 years experience of shiftwork research & consulting across multiple 24/7 industries globally for over 30 years
 - Developed and patented LED light technologies that minimize circadian disruption
- **Opinion: ROC Monograph on LAN Risk is Outstanding, Thorough, and Definitive**
 - Is a major step forward in defining the Shiftwork Light at Night Hazard
- **Suggestions: Strengthen the conclusions and add recommendations**
 - Precisely define the blue light threshold of circadian disruption risk
 - Encourage responsible and practical policies to mitigate identified risk

Lighting must address not only Health, but also Safety and Work Quality

- **Night Shift Work requires minimum levels of illumination**
 - To perform tasks that require visual discrimination
 - To maintain safety – avoid trips & falls, or injuries from equipment
 - To sustain alertness and safe attentive performance
- **Workplace Illumination Levels are set by standards bodies (e.g. IES)**
 - Standards significantly greater than 100-200 lux reported in Draft ROC Monograph
 - 200-500 lux for high contrast, 500-1000 lux for medium contrast tasks
- **Energy Efficiency Standards (DLC, lumens/watt) driving adoption of blue-pump LEDs**
 - Conventional Blue Pump LEDs emit 10-20% circadian disruptive blue content
 - At Workplace Illumination Standard lux levels represent a serious health hazard

Workplace Illumination Standards and Circadian Blue Irradiance Exposure

Recommended Illumination Levels ("desktop" measured 76cm (30 inches) above the floor*)

Type of Activity	Ranges of Illuminations		LED Eye level Blue Irradiance [$\mu\text{W}/\text{cm}^2$] 440-490nm
	Table Top Lux	Eye Level Lux	
Public spaces with dark surroundings	20-50		
Simple orientation for short temporary visits	50-100		
Working spaces where visual tasks are only occasionally performed	100-200		
Performance of visual tasks of high contrast or large scale	200-500	100-250	4-15
Performance of visual tasks of medium contrast or small size	500-1000	250-500	7-29
Performance of visual tasks of low contrast or very small size	1000-2000		
Performance of visual tasks of low contrast and very small size over a prolonged period	2000-5000		
Performance of very prolonged and exacting visual tasks	5000-10000		

Typical LED Workplace Eye Level Blue Irradiance

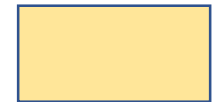
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Circadian Disruption Threshold for Blue Corneal (Eye-Level) Irradiance

Night Workplace Blue Irradiance exposure with Conventional Blue Pump LEDs at current Lighting Standards

MEASURED BLUE CORNEAL IRRADIANCE 440-490nm		CIRCADIAN DISRUPTION MARKER IMPACT NOCTURNAL LIGHTING (SUNSET-SUNRISE)		
$\mu\text{W}/\text{cm}^2$				
25				
24				
23				
22				
21	20.7	Suppressed Melatonin, Disrupted BMal1 and Per2 (12 hour night shift)		Rahman et al 2011
20	20	50% suppression of melatonin with 90 minute monochromatic blue light		West et al 2011
19				
18				
17				
16				
15				
14				
13				
12	12.1	Altered EEG sleep		Munch et al 2006
11	11.8	Suppress & Shift Melatonin, Increased Appetite, Increased Insulin Resistance		Moore-Ede et al 2018
10	10.0	40% suppression of melatonin with 90 minute monochromatic blue light		West et al 2011
9				
8				
7	7.2	Increased drowsiness and energy metabolism, without sleep changes		Kayaba et al 2014
6				
5				
4				
3				
2	2	Minimal suppression of melatonin with 90 minute monochromatic blue light		West et al 2011
1	1.8	Restored Melatonin, BMal1 and Per2 (eyewear filter 12 hour night shift)		Rahman et al 2011
	1	Restored Melatonin, Appetite, and Insulin Resistance (12 hr violet pump white light)		Moore-Ede et al 2018
	0.5	Restored Melatonin (3 hour violet pump white LED light)		Souman et al 2018

CIRCADIAN DISRUPTION



CIRCADIAN STABILITY



THRESHOLD

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SUGGESTIONS for ROC Monograph on Night Shift Work and Light at Night

- **Recognize & encourage New Industry & Regulatory Standards**
 - American Petroleum Institute ANSI RP-755 for petrochemical workplaces (2018)
 - “Workplaces should be well lit to promote alertness and safety”
 - “Night lighting should be selected to minimize circadian disruption”
- **Identify Undesirable or Impractical Responses to Identified Health Risks**
 - Banning shiftwork not practical or feasible in 24/7 economy
 - Reducing lighting intensity is dangerous and impairs performance in workplace
- **Encourage Development and Adoption of Effective Lighting Solutions**
 - Light sources that provide blue rich light in day, but remove blue at night
 - Eyewear that removes circadian disruptive blue at night