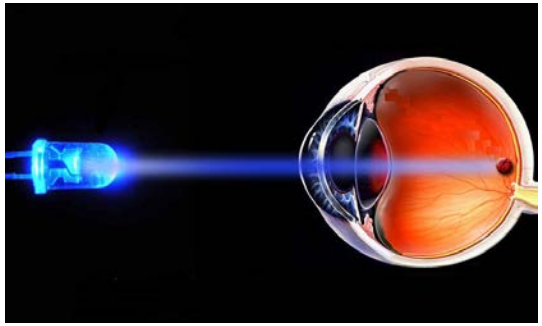


The Blue Light Hazard – A Risk Oddity?

Prof. Dino Pisaniello

School of Public Health

University of Adelaide

RACP Congress 2016

The Health Problem

Photochemical damage to visual sensory cells

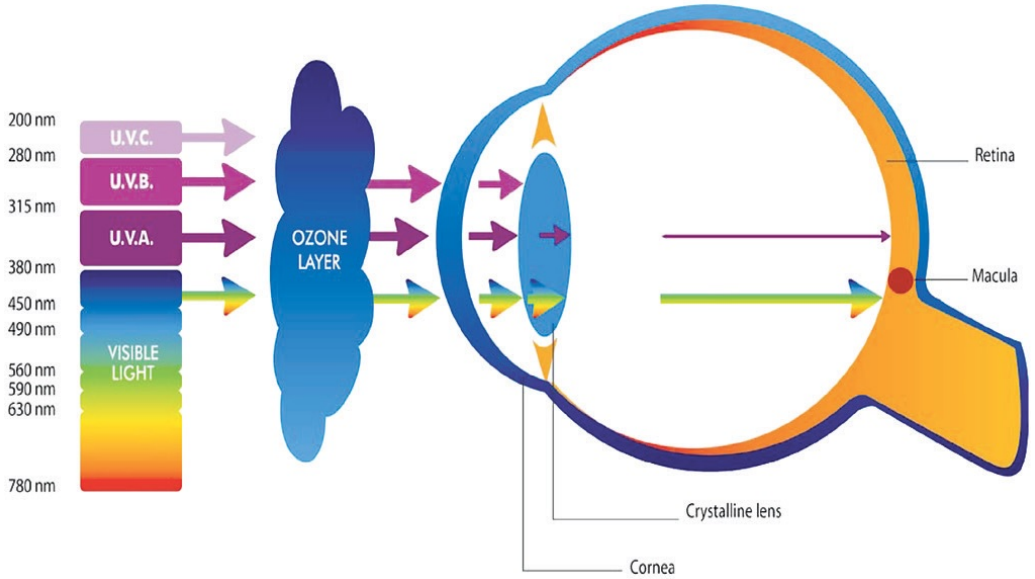
Mum said

“Don’t look at the sun”

“Eyes are not designed to look directly at light — they are designed to see *with* light”

Dr Celia Sánchez-Ramos
Complutense University, Madrid

Light Transmission of the Human Eye



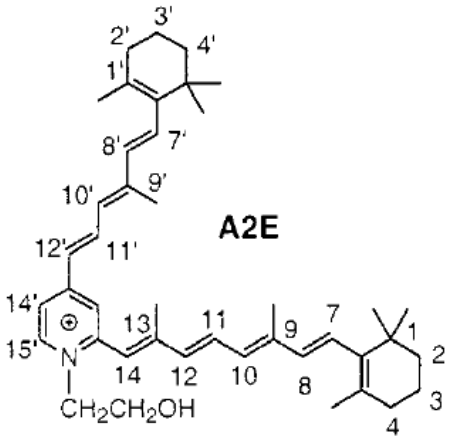
(Picture by Essilor, 2013)

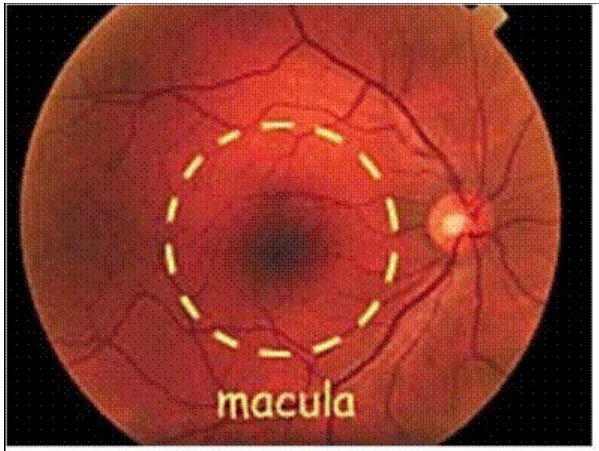
Transmission of Light **Young children > Adults** (Gaillard et al., 2000)

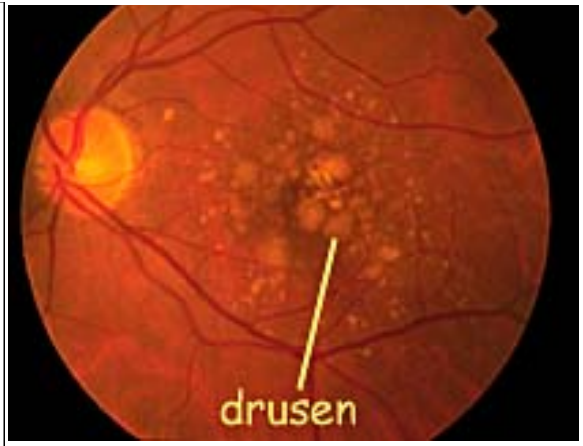
Blue light effects (photochemical only)

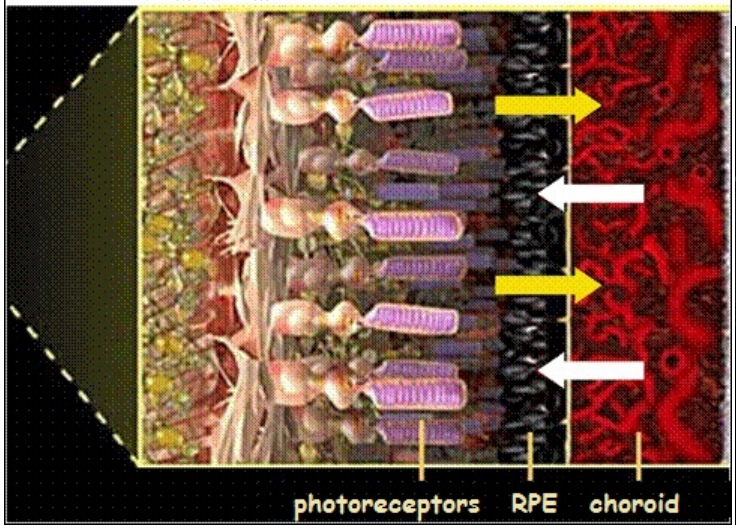
- **Lesion: photoreceptor deterioration**
- **Physiology: “hyperactivity” of Wald’s visual cycle *(photoreversal of bleaching)***
- **Damage evidence (histological etc.): accumulation of lipofuscin (cellular debris) and of A2E in the retinal pigment epithelium**
- **Probable increase of drüsen prevalence**

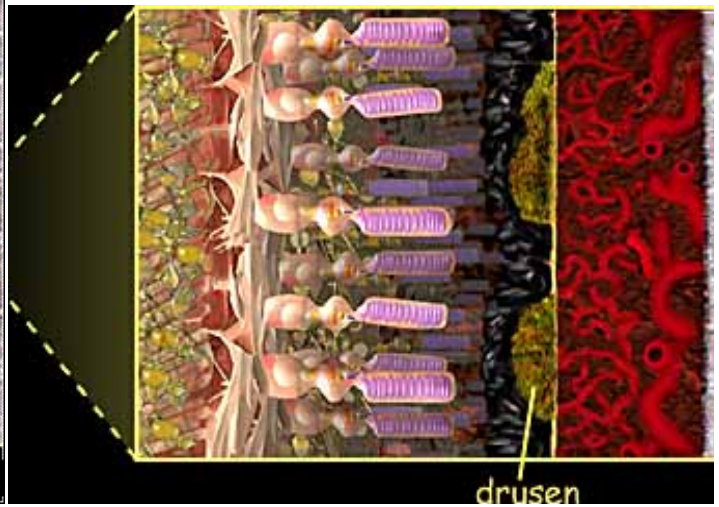
A2E (2-[2,6-dimethyl-8-(2,6,6-trimethyl-1-cyclohexen-1-yl)-1E,3E,5E,7E-octatetraenyl]-1-(2-hydroxyethyl)-4-[4-methyl-6-(2,6,6-trimethyl-1-cyclohexen-1-yl)-1E,3E,5E-hexatrienyl]-pyridinium) is a blue-absorbing molecular constituent of human ocular lipofuscin and contributes to the golden-yellow emission of this pigment




macula


drusen


photoreceptors
RPE
choroid


drusen

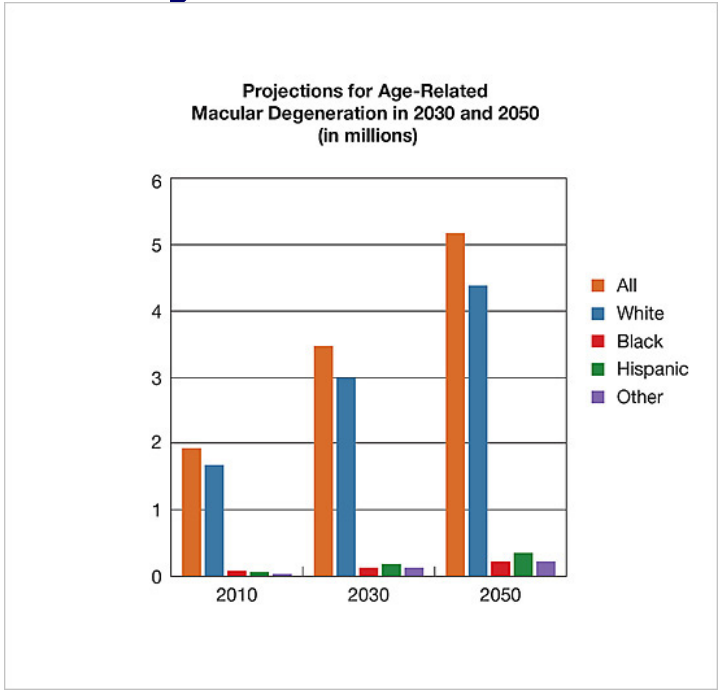
Bursts of blue light are thought to contribute to age-related macular degeneration at the individual level

Is sunlight exposure a risk factor for age-related macular degeneration? A systematic review and meta-analysis

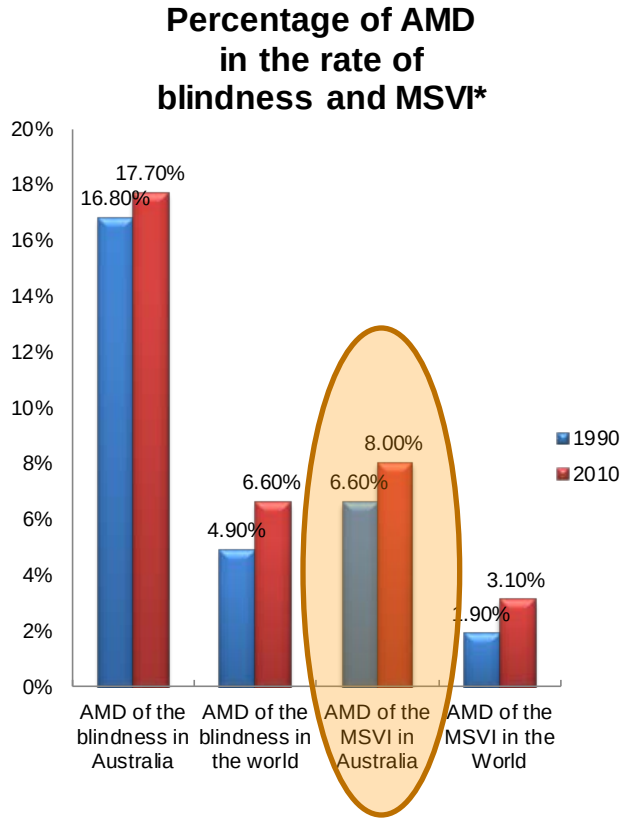
Conclusion: The epidemiological literature published to date indicates that individuals with more sunlight exposure are at a significantly increased risk of AMD.

Sui G-Y, et al. Br J Ophthalmol 2013;97:389–394

AMD is already an (increasing) problem at the population level, probably due to an ageing population



https://nei.nih.gov/eyedata/amd



* MSVI: Moderate and Severe Vision Impairment

(Data by Rupert B, et al 2014)

>60,000 Australians with AMD in 2009

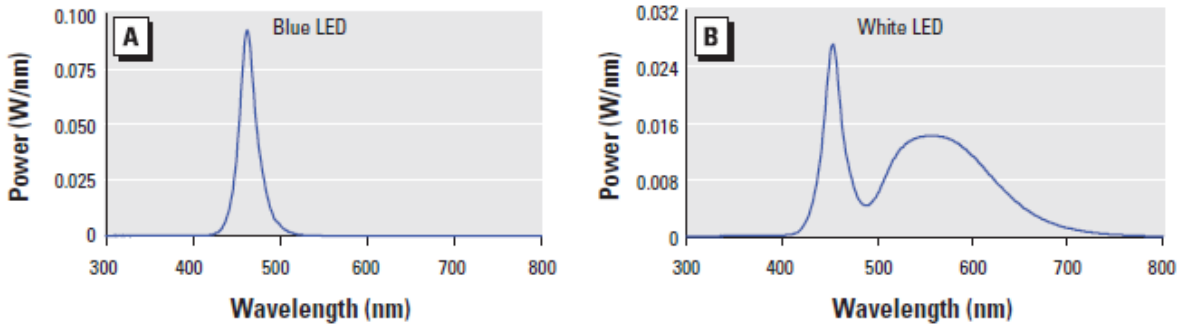
From 1990 - 2010
an increase from 6.6 to 8% in moderate and severe vision impairment attributable to AMD

Will it increase in the future?

White Light–Emitting Diodes (LEDs) at Domestic Lighting Levels and Retinal Injury in a Rat Model

Yu-Man Shang,[1] Gen-Shuh Wang,[1] David Sliney,[2] Chang-Hao Yang,[3,4] and Li-Ling Lee[5]

Environmental Health Perspectives • VOLUME 122 | NUMBER 3 | March 2014



Spectrum power distributions

CONCLUSION: Our results raise questions about adverse effects on the retina from chronic exposure to LED light compared with other light sources that have less blue light. Thus, we suggest a precautionary approach with regard to the use of blue-rich "white" LEDs for general lighting.

Is this an occupational health problem?

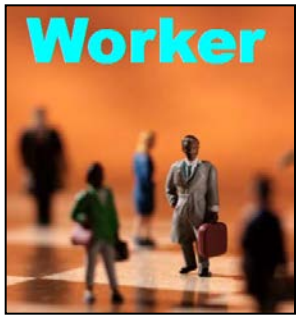
In the Chesapeake Bay Waterman Study, which analyzed **fishermen exposed to bright light reflected off the water** every day, **blue light exposure was found to increase the risk of age-related macular degeneration** (AMD).

This conclusion, while suggestive, is not definitive, since it is **difficult to quantify light exposure.**

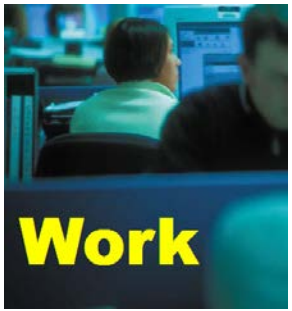
West et al, Arch Ophthalmol, 1989, 107: 875-9

Blue light issues (from ACGIH TLV booklet 2016)

Source type	Arc Sources	Discharge Lamps	Fluorescent Lamps and LEDs
	Arc welding; Arc lamps; Xenon arc searchlights		White-light and “black-light” fluorescent lamps; Visible or UV-A LEDs
	likely	**likely**	**possible**



Older workforce – less resistance to oxidative stress in visual system



Some jobs have intense blue light sources in the visual field. Generally more exposure to blue-rich white light?

Greater variety of bright light sources

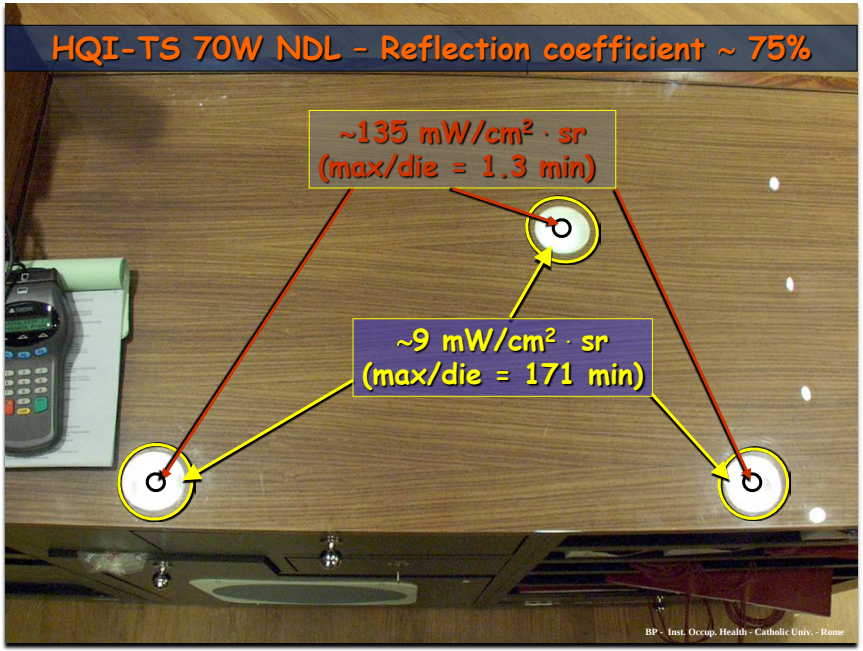
www.spaceneedsanalysis.com


Office Supplies
Furniture
Cleaning & Cleaning
BP - Inst. Public Health - Catholic Univ. - Rome

A professional photographer

Two lamps HMI da 2500 W – CCT ≈ 5150 K
One Xenon flash lamp – CCT ~ 5500 °K (flash duration = 0,001 s)

Metal halide lamps for shop lighting




≈ 15°
"FOVEAL RISK"

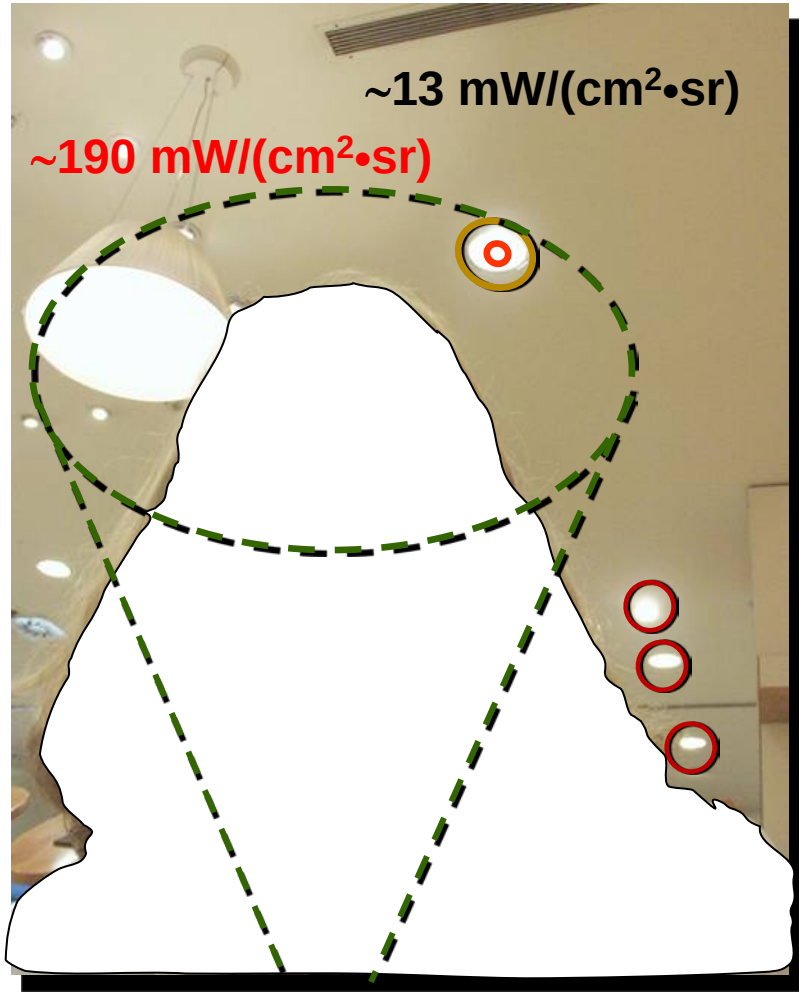
SHOP ASSISTANT

FOVEAL

PROJECTION:

THE METAL HALIDE

LAMP IS INCLUDED



HQI-TS 70W NDL

Max/die = 0.9 min

Max/die = 128 min

Infant Phototherapy Equipment

“main radiation spectrum in the range between 400 nm and 550 nm for reducing the concentration of bilirubin in the body of infants.”

Pinto at al, Journal of Occupational and Environmental Hygiene, 12: 603–610 (2015)

Cree LED guidance 2015

CREE

TECHNICAL ARTICLE

CLD-AP34 REV 15

Eye Safety With LED Components

Regardless of LED color, Cree advises users to not look directly at any operating LED component.
Further, Cree recommends that any manufacturer that is incorporating Cree® LED components into its lighting products make an assessment of how these components could create a light exposure risk to its employees during the manufacturing process.

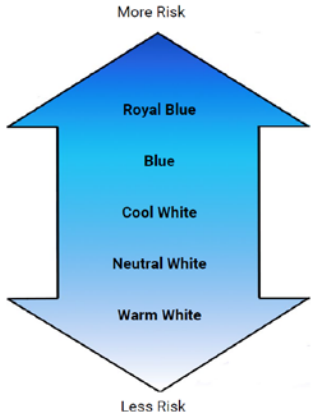


Figure 2: Risk decreases from royal blue to warm white at constant electrical conditions

http://www.cree.com/~/media/Files/Cree/LED%20Components%20and%20Modules/XLamp/XLamp%20Application%20Notes/XLamp_EyeSafety.pdf

Issues

- **Although there is good animal evidence for acute risks, there is a shortage of evidence for longer term risks.**
- **This has been acknowledgd by all researchers since the 1960s.**

Read this to mean

Absence of evidence is not evidence of absence

- **There have been few robust exposure studies internationally, and essentially all of these could be classified as screening studies based on acute risk criteria.**
- **No Australian studies, and no real guidance for practical risk assessment.**

Take home messages

- **Metal Halide, Mercury Vapor, Xenon Arc and Sodium Vapour lamps can result in blue weighted radiance levels exceeding the TLVs promulgated by ICNIRP and ACGIH.**
- **In some occupational contexts these kinds of lamps are in the line of vision (Occupational Visual Field), exceeding the TLV after only a few minutes of exposure.**
- **Since this adverse agent is poorly considered by OHS professionals, neither Risk Assessment nor Health Surveillance measures are properly implemented on a regular basis.**
- **Some literature *suggests* that subacute effects may be mitigated by (post-exposure) antioxidant treatment.**

Time for some regulation?

legislation.gov.uk

Back to full view

The Control of Artificial Optical Radiation at Work Regulations 2010

Assessment of the risk of adverse health effects to the eyes or skin created by exposure to artificial optical radiation at the workplace

3.—(1) Where—

(a) the employer carries out work which could expose any of its employees to levels of artificial optical radiation that could create a reasonably foreseeable risk of adverse health effects to the eyes or skin of the employee; and

(b) that employer has not implemented any measures to either eliminate or, where this is not reasonably practicable, reduce to as low a level as is reasonably practicable, that risk based on the general principles of prevention set out in Schedule 1 to the 1999 Regulations,

the employer must make a suitable and sufficient assessment of that risk for the purpose of identifying the measures it needs to take to meet the requirements of these Regulations.

(2) The employer must as part of that risk assessment assess, and if necessary, measure or calculate, the levels of artificial optical radiation to which employees are likely to be exposed.

(3) In carrying out the assessment, measurement or calculation, the employer must follow the following standards or recommendations—

(a) for laser radiation, the standards of the IEC; or

(b) for non-coherent radiation, the standards of the IEC and the recommendations of the CIE and the CEN.

(4) In exposure situations which are not covered by those standards or recommendations, the assessment, measurement or calculation must follow national or international science-based guidelines.

(5) The assessment must also include consideration of—

(a) the level, wavelength and duration of exposure;

(b) the exposure limit values;

(c) the effects of exposure on employees or groups of employees whose health is at particular risk from exposure;

(d) any possible effects on the health and safety of employees resulting from interactions between artificial optical radiation and photosensitising chemical substances;

(e) any indirect effects of exposure on the health and safety of employees such as temporary blinding, explosion or fire;

(f) the availability of alternative equipment designed to reduce levels of exposure;

(g) appropriate information obtained from health surveillance, including where possible published information;

(h) multiple sources of exposure;

(i) any class 3B or 4 laser that is classified in accordance with the relevant IEC standard that is in use by the employer and any artificial optical radiation source that is capable of presenting the same level of hazard; and

(j) information provided by the manufacturers of artificial optical radiation sources and associated work equipment in accordance with the relevant European Union Directives.

(6) The risk assessment must be reviewed regularly if—

(a) there is reason to suspect that it is no longer valid; or

(b) there has been a significant change in the work to which the assessment relates.

(7) The employer must record—

(a) the significant findings of the risk assessment as soon as is practicable after it is made or changed; and

(b) the measures which have been taken and which the employer intends to take to meet the requirements of regulation 4 and 5.

(8) In paragraphs (3) and (4)—

(a) a reference to standards or recommendations is a reference to standards or recommendations as revised or re-issued from time to time;

(b) "CEN" means the European Committee for Standardisation;

(c) "CIE" means the International Commission for Illumination; and

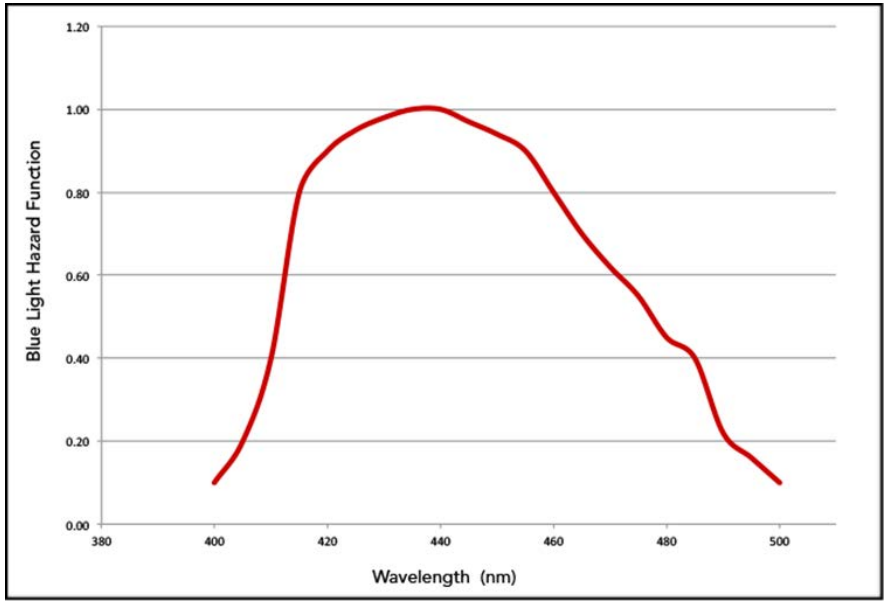
(d) "IEC" means the International Electrotechnical Commission.

(9) In paragraph (5)(a) "level" means the combination of irradiance, radiant exposure and radiance to which an employee is exposed.

Comparison of hazards: blue light and noise

	Blue Light	Noise
Age-related background (cumulative) effects	Yes (age-related macula degeneration)	Yes (age-related hearing loss)
Frequency dependence	Yes – highly dependent (Blue light hazard function)	Not thought to be important in audible frequency range
Energy dependence	Yes – damage increases with total energy. Threshold for irreversible damage about 100J/cm^2 (looking at sun for 1 minute)	Yes – damage increases with total energy Threshold for irreversible damage about 100 J/cm^2? (160 dB for 100 sec)
Sensory organ response protective mechanism	Yes – aversion response, pupil restriction, closing of eye lids	No
Directionality of the hazard	Highly directional, due to the anatomy of the eye	Partially directional, depending on frequency and distance from the noise source

Blue Light Hazard Function



The photochemical damage to the retina is very wavelength-specific.

The risk is related to the radiance (brightness) of the light source as well as the size of the image of the source that is projected onto the retina.