Photobiological Safety of Lamps and Lamps Systems

Related Systems

- IDR300-PSL Photobiological Safety Spectroradiometer [www.bentham.co.uk/products/systems/source-characterisation/idr300-psl-photobiological-safety-spectroradiometer-109/]

A consideration of the potential hazards to the human body posed by exposure to optical radiation has, in the past, been limited to those known through experience to be the most dangerous, lasers and sources of ultraviolet (UV). The publication in 2006 of IEC 62471:2006 "Photobiological Safety of Lamps and Lamp Systems", heralded a new framework for the evaluation of the photobiological safety of non-laser electrically-powered products emitting light in the spectral region 200-3000nm.

Adopting the existing CIE S009/E-2002 guidelines to publish IEC62471:2006, the scope of this standard is to provide guidance for the evaluation of the photobiological safety of lamps and lamps systems, excluding lasers, emitting light in the spectral region 200-3000nm. A measurement methodology and exposure limit values (taken from ICNIRP data) are given in the consideration of the six hazards to the skin and eye for an exposure duration of up to eight hours, taken as a working day. No consideration is taken of the potential effects of long-term exposure, abnormal behaviour, nor abnormal photosensitivity.

Hazard	Wavelength Range (nm)	Skin*	Eye*
Actinic UV	200-400	Erythema Elastosis	Photokeratitis Cataractogenesis
Near UV	315-400	-	Cataractogenesis

Retinal Blue Light	300-700	-	Photoretinitis
Retinal Thermal	380-1400	-	Retinal burn
Infrared Radiation	780-3000	-	Corneal burn Cataractogenesis
Thermal	380-3000	Skin burn	-
*Principle Bioeffects			

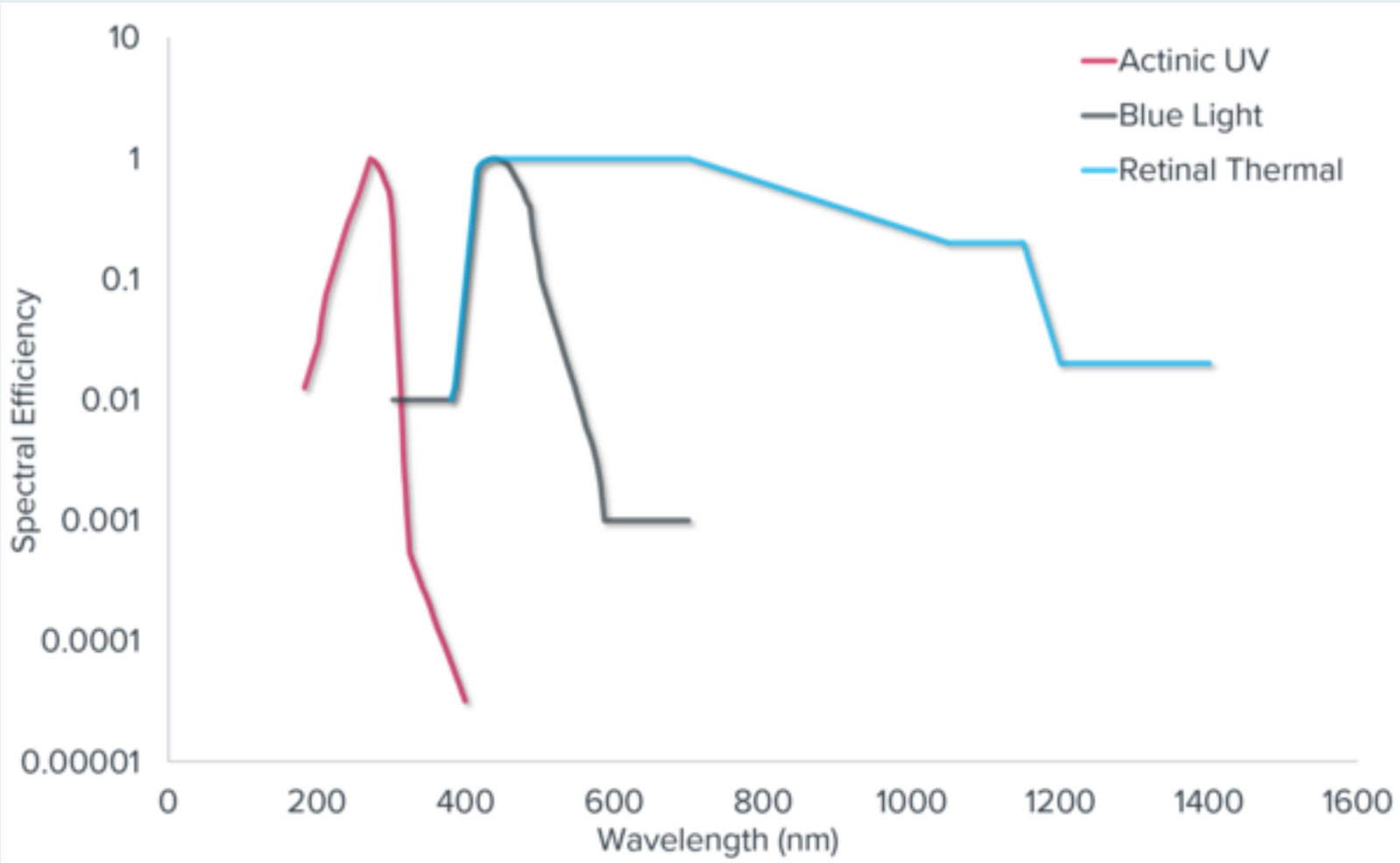
A four tier-classification structure, based on permissible exposure time before exceeding the EL of each hazard, is defined, ranging from “Exempt” to “Risk Group (RG)” 3. In the case of retinal hazards, the aversion response time of the eye is taken into account.

Risk Group	Philosophical Basis
Exempt	No photobiological hazard
RG1	No photobiological hazard under normal behavioural limitation
RG2	Does not pose a hazard due to aversion response to bright light or thermal discomfort
RG3	Hazardous even for momentary exposure

The evaluation consists of a complex series of measurements of spectral irradiance (200-3000nm) in consideration of hazards to the skin and front surfaces of the eye, and spectral radiance (300-1400nm) in consideration of hazards to the retina which is essentially protected outside this range due to the transmission characteristics of the lens. Measurements are performed in specific geometrical conditions which replicate biophysical phenomenon, such as the effect of eye movements on retinal irradiance.

Hazard	Wavelength Range (nm)	Spectral Weighting Function	Quantity Measured
Actinic UV	200-400	Actinic	Irradiance
Near UV	315-400	-	Irradiance
IR Radiation Eye	780-3000	-	Irradiance
Thermal Skin	380-3000	-	Irradiance
Blue Light Small Source	300-700	Blue Light	Irradiance
Blue Light	300-700	Blue Light	Radiance

Retinal Thermal	380-1400	Retinal Thermal	Radiance
Retinal Thermal Weak Visual	780-1400	Retinal Thermal	Radiance

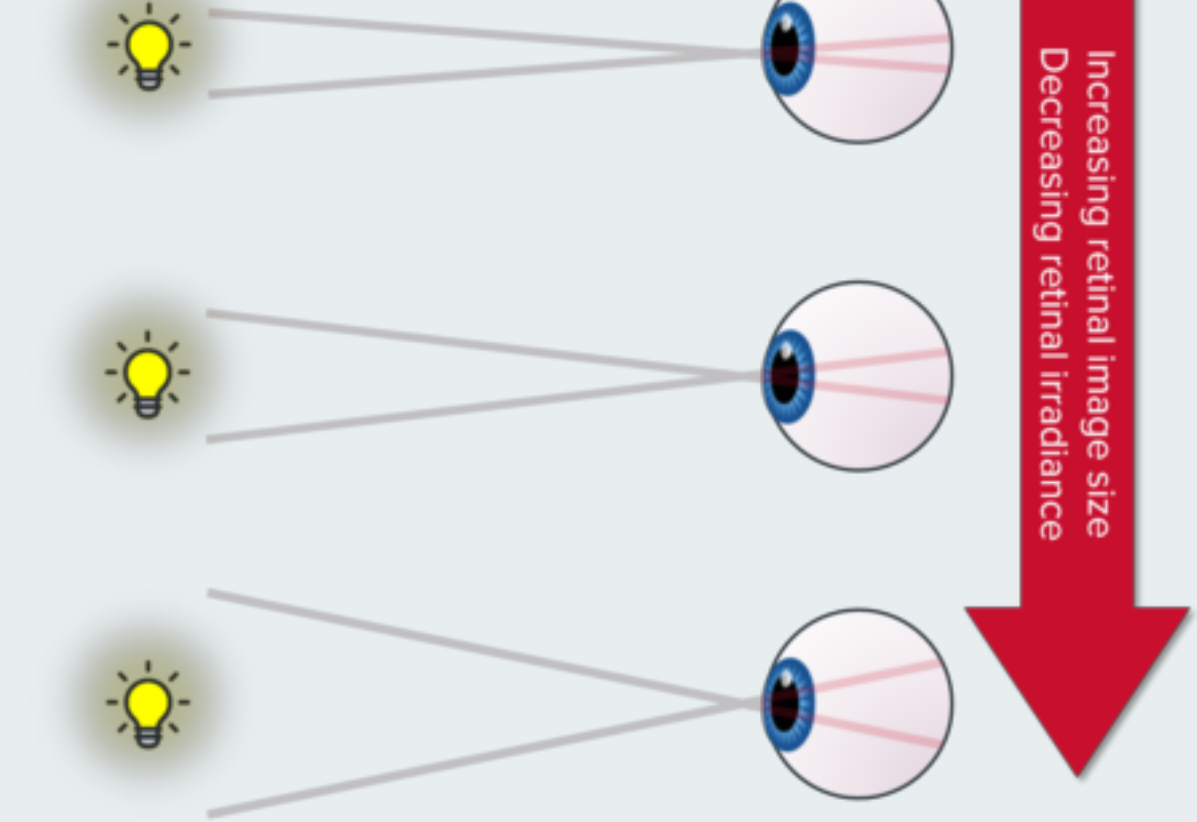


See our technical note on **The Measurement of Spectral Irrandiance** [www.bentham.co.uk/knowledge/tools-resources/technical-notes/measurement-of-spectral-irradiance-152/]

Whilst irradiance accounts for light arriving at a surface from the entire hemisphere above, due to its position with respect to the bridge and nose, the eye is shielded from wide-angle radiation. Within the scope of this standard, the measurement of irradiance in all but the case of the thermal skin hazard is performed over a 1.4 radian acceptance angle: light emitted from a source outside this acceptance angle need not be measured.

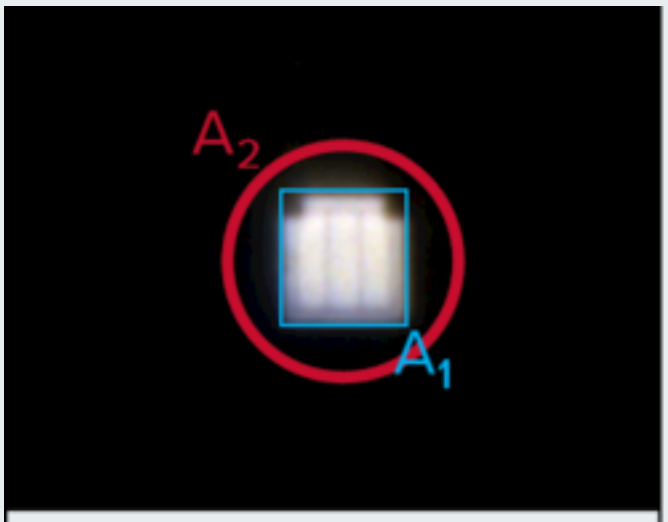
See our technical note on **The Measurement of Spectral Radiance** **[www.bentham.co.uk/knowledge/tools-resources/technical-notes/measurement-of-spectral-radiance-154/]**

In consideration of hazards to the retina, consideration is made of the eye movement to account for the impact on retinal irradiance.



For momentary viewing , the retinal image of a source subtends the same angle as does the source, the smallest image formed on the retina, according to IEC62471, having an angular extent of 1.7mrad, given the imperfect imaging performance of the eye. With increasing exposure time, due to eye movement (saccades) and task-determined movement, the retinal image is “smeared” over a larger area of the retina, resulting in a corresponding reduction in retinal irradiance. A time dependent function is defined to represent the spread of the retinal image, ranging from 1.7 to 100mrad, from 0.25s (aversion response time) to 10000s exposure.

In the context of the photobiological safety, the measurement of radiance is performed in a manner that reflects this phenomenon, the FOV of measurement being chosen to account for the light falling within a given area of the retina. The measurement FOV follows therefore the same time dependence, from 1.7 to 100mrad, regardless of the size of the source measured. The measured quantity is more accurately termed spatially averaged radiance. Where the FV extends beyond the angle subtended by the source, the result is an average of the true source radiance and the “dark” background. Furthermore, since the angular subtense of a source varies with distance, spatially averaged radiance varies with measurement distance.



The distance at which a source should be evaluated depends upon its intended application to permit consideration in a likely exposure scenario, taken broadly as general lighting service (GLS) and all other applications (non-GLS).

The present definition of GLS is ambiguous, but relates to finished products intended for illuminating spaces which emit “white” light. Evaluation should be reported, not necessarily measured, at a distance at which the source produces an illuminance of 500 lux, which distance may be less than a metre for household luminaires, but many metres for street lighting for example. Whilst irradiance measurements may be performed at a convenient distance and scaled to 500 lux, physiological radiance, dependant on the source subtense with respect to the applicable FOV, should be performed at the correct distance. The evaluation of photobiological safety in lighting applications has largely been replaced by an approach introduced by IEC TC 34.

See our applications page on **Photobiological Safety in Lighting Applications**
[www.bentham.co.uk/applications/application-search/photobiological-safety-in-lighting-applications-14/]

Non-GLS sources should be measured at a distance of 200mm from the (apparent) source, which distance represents the near point of the human eye: closer than 200mm, the retinal image is out of focus, resulting in lower retinal irradiance. Here, the concept of apparent source is important. Where a lens is used to collimate the output of an LED, a magnified virtual image is produced behind the chip. It is with respect to this apparent source that the 200mm measurement distance should be taken since it is this which the eye images.

Whilst the measurement at 200mm may represent a worst-case exposure condition for the retina, it is not the case for the skin and front surfaces of eye where the exposure distance may be closer. This latter eventuality has not yet been taken account of in this standard for which the primary concern is acute retinal damage.

Risk group dependent emission limit values can be computed from the ELVs and the risk group time basis are provided in terms of radiant flux for thermal hazards or energy (radiant flux times time) for photochemical hazards: a measured irradiance result can be directly compared with the former, and an exposure time obtained for the latter. This procedure does not apply to the measurement of radiance for which the FOV of measurement is time dependant.

A pass/ fail test is therefore applied to the retinal hazards based on measurements at FOVs corresponding to the minimum exposure times of the classification system in turn, starting from the exempt risk group. Where the resultant radiance exceeds the maximum permissible radiance for a given risk group, the next risk group is tested. The detailed evaluation of retinal hazards is rather more convoluted since source size and level of visual stimulus should be taken into account in determining which ELVs to apply.

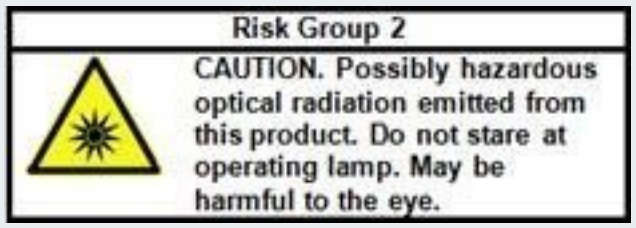
Classification

A outlined in part 1, a classification system, based on the minimum exposure time before the ELV is exceeded, is defined ranging from exempt (no risk) to risk group 3 (RG3) (high risk), from which may be determined the limit irradiance (radiance) of each risk group, and against which the measured irradiance (radiance) may be compared.

Labelling

IEC62471 is intended as a horizontal standard, and as such does not include manufacturing or user safety requirements that may be required as a result of a product being assigned to a particular risk group. Such safety requirements vary according to application, and should be dealt with in vertical,

product standards. IEC TR 62471-2, however, does provide some further guidance on the measurement and provides a recommendation of labelling for each hazard and risk group.



Photobiological Implementation of IEC62471 in Europe

In the European Union, CE marking demonstrates product safety by compliance with the relevant applicable EU directive, such as the low voltage directive (LVD), through application of European Norme (EN) standards harmonised to the directive under consideration. Whilst compliance with these EN standards is not mandatory, it does provide presumption of compliance with the essential health and safety requirements of the directive considered.

Optical radiation is specifically considered under the terms of the LVD, applicable to electrical products operating at voltages of 50-1000V AC, and to which EN62471:2008, the European adoption of IEC62471, is harmonised. From the 1st September 2011, evaluation of LEDs against the laser standard ceases to allow presumption of conformity with the essential health and safety requirements of the LVD.

From April 2010 the EU artificial optical radiation directive (AORD), 2006/25/EC, came into force, adopting exposure limits slightly different to those of IEC62471. For consistency, EN62471 adopts the exposure limits of the AORD and is the standard to be used to evaluate worker exposure to non-laser sources of optical radiation.

Relevant also to LEDs is the EU Toy Safety directive to which is harmonised EN62115 “Safety of electric toys”. Whilst this standard has in the past referenced the laser standard, EN60825 for the classification of LEDs, it is currently under review but it is expected that reference will be made to EN 62471 where measurements are required.

Finally where products are not covered by the LVD or toy directives, consideration should also be made of the general product safety directive to which few standards are specifically harmonised, yet for the evaluation of non-laser sources of light, EN62471 is the relevant EN standard.

Implementation of IEC62471 in ROW

Whilst many standardisation bodies around the world are considering the adoption of IEC62471, few have yet issued national standards let alone a legal framework to render testing mandatory. Of the activity seen, much is related to the lighting industry, for which a well-defined standardisation framework is in place and under active development to accommodate solid state lighting.

To the knowledge of the author, China is presently alone in having formally implemented a voluntary standard, GB/T 20145-2006, with Japan expected to publish JIS C 7550 in November 2011.

Whilst some countries, such as Australia and New Zealand, are currently working on the adoption of IEC62471 as a voluntary standard, some (Hong Kong, Republic of Korea) are presently content to reference IEC62471 on a voluntary basis, and others (Canada) are at the stage of considering implementation and potential regulations.

Finally, in the USA, where ANSI RP27.1 exists as a voluntary standard, there is currently no mandatory requirement for the evaluation of non-laser sources. Following a meeting in August 2011, however, of the standards technical panel of UL/ANSI 8750 “Light Emitting Diode (LED) Equipment for Use in Lighting Products”, a task group has been formed to consider the implementation of photobiological safety standards for those lighting products covered by this UL standard.

See our applications page on **The photobiological safety testing of image projectors (EN/IEC 62471-5)** [www.bentham.co.uk/applications/application-search/photobiological-safety-testing-of-image-projectors-6/]

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