



LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

LIGHTINGEUROPE GUIDE
ON PHOTOBIOLOGICAL SAFETY
IN GENERAL LIGHTING PRODUCTS
FOR USE IN WORKING PLACES

Edition February 2013

1. Foreword

This LightingEurope Guide on photobiological safety in general lighting products for use in working places is intended to be used by luminaires designers.

With the introduction of the photobiological risk evaluation in working places required by Directive 2006/25/EC it became important for lighting equipment manufacturers to deliver radiation data and to assist the employers to evaluate the exposure and assessment of risk in working places. This demand of data has been evaluated in standardization committees leading to several considerations and modifications of standards to guarantee a high level of optical safety and to provide enough information for products which need attention at use.

Particular attention has been taken for **Blue light hazard** for which many concerns have been raised in the past in domestic areas and in working places. For this problem IEC has recently published **IEC/TR 62778** which introduces new concepts in measurements and assessment. In addition to the spectral measurements the TR introduces the possibility to evaluate Blue light hazard directly in applications avoiding expensive and complicated measurements.

2. Introduction

Optical radiation limit values required in directive 2006/25/EC are related to exposure time. On lighting products, unless the work or the task requires to stare at the light source, the viewing of the source is random and normally happens accidentally turning the eyes towards it. In the technical standards in progress in IEC (and in parallel in CENELEC) the following safety limits have been taken into account:

A lighting product is considered safe without the need to provide any warning or advise when it provides optical radiation within the following limits

- 2 mW/klm or 2 mW/(m² · klx) for actinic UV radiation. This corresponds to an irradiance of 0,001 W·m⁻² (RG 0 = exempt on the basis of IEC 62471 with evaluation at 500 lx). This limit corresponds to 8 h exposure time as in table 1.1 of directive 2006/25/EC.
- 10.000 W/(m²·sr) or 1 W/m² for blue light hazard corresponding to RG 1 of IEC 62471 and to 100 s exposure limit.
- 28000/α W/(m²·sr) or 6000/α W/(m²·sr) or 100 W/m² for IR radiation corresponding to RG 0 of IEC 62471 (exempt).

It should also be pointed out that the luminaire standard IEC 60598-1 already takes into account the possibility of having light sources that emit a level of UV greater than 2 mW/klm. In this case, the lamps are identified by the following symbol:



This symbol indicates that the lamp cannot be used in open luminaires without any glass protection. According to clause 4.24 of IEC 60598-1, the protective glass shall be designed so that the UV emission will not be excessive and the assessment is made by the standard being based on RG 0 of IEC 62471. It can therefore be stated that a luminaire in accordance with IEC 60598-1 already ensures a level of UV exposure corresponding to RG 0.

Standards under development are going to introduce, for most of the light sources, the above mentioned limits to ensure a safe use.

3. Limits and assessment in the technical standards of the light sources

3.1. Incandescent lamp and halogen lamp

A. IEC 60432-1: Tungsten filament lamps for domestic and similar general lighting purposes

Applicable to tungsten filament incandescent lamps for general lighting service having:

- rated wattage up to and including 200 W;
- rated voltage of 50 V to 250 V inclusive;
- bulbs of the A, B, C, G, M, P, PS, PAR or R shapes, or other bulb shapes where the lamps are intended to serve the same purpose as lamps with the foregoing bulb shapes;
- bulbs with all kinds of finishes;
- caps B15d, B22d, E12, E14, E17, E26, E26d, E26/50x39, E27 or E27/51x39.

In the Amendment 2: 2012 the following statement has been introduced into the annex K:

K.7 Photobiological safety

It is expected that luminaires using lamps covered by this part of the standard will not require further assessment for photobiological safety.

So, for products using this kind of lamp, any further risk assessment for photobiological safety (UV – blue – IR) is not necessary.

B. IEC 60432-2: Tungsten halogen lamps for domestic and similar general lighting purposes

It covers those tungsten halogen lamps that are used as direct replacements for conventional tungsten filament lamps as well as new tungsten halogen lamps which have no correspondence in IEC 60432-1. These tungsten halogen lamps have the following characteristics:

- rated wattage up to and including 250 W;
- rated voltage of 50 V to 250 V inclusive;
- caps B15d, B22d, E12, E14, E17, E26, E26d, E26/50x39, E27 or E27/51x39.

For this kind of lamp the UV limits are already below 2 mW/klm. In Amendment 2: 2012 the following statement has been introduced into the annex C:

C.4 Photobiological safety

It is expected that luminaires using lamps covered by this part of IEC 60432 will not require further assessment for photobiological safety.

So, for products using this kind of lamp any further risk assessment for photobiological safety (UV – blue – IR) is not necessary.

C. IEC 60432-3: Tungsten halogen lamps (non-vehicle)

Applicable to single capped and double capped tungsten halogen lamps, having rated voltages of up to 250 V, used for the following applications:

- projection (including cinematograph and still projection),

- photographic (including studio),
- floodlighting,
- special purpose,
- general purpose,
- stage lighting,

Also for self-shielded lamps the UV limits (2 mW/klm or 2 mW/(m²·klx)) was already required by the former editions. If not self shielded, an appropriate protective shielding is provided by the luminaire according IEC 60598-1. In Amendment 2: 2012 the following new statement has been introduced in annex C

C.13 Photobiological safety

It is expected that luminaires using lamps covered by this part of the standard will not require further assessment for photobiological safety marking if they are

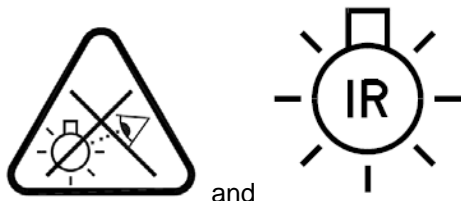
- a) floodlight lamps,
- b) general purpose capsule lamps, or
- c) general purpose reflector lamps.

However, luminaires using beam focusing optics should be assessed for blue light hazards in the same way as a reflector lamp.

So, for products using the lamps mentioned in this statement any further risk assessment for photobiological safety (UV – IR) is not necessary. For blue light hazard it is normally not necessary any further assessment except in case of luminaires using narrow beam focusing optics.

For other types of lamp the following new marking has been introduced under clause 2.2:

Projection lamps, photographic lamps, special purpose and stage lighting lamps shall be marked with the following symbol on the packaging or accompanying information.



For this kind of lamp, it is necessary to refer to the manufacturer documentation for risk assessment (only for IR).

3.2. Fluorescent lamps

A. IEC 60968: Self-ballasted lamps for general lighting services

Applicable to tubular fluorescent and other gas discharge lamps with integrated means for controlling starting and stable operation (self-ballasted lamps), intended for domestic and similar general lighting purposes, having:

- a rated wattage up to 60 W;
- a rated voltage of 100 V to 250 V;
- Edison screw or bayonet caps.

For the incoming next edition a new sub clause 2.10 with the UV limits (2 mW/klm) will be introduced while in the scope the following statement will be introduced:

“Blue light and infrared hazards are below the level which requires marking”.

So, for products using this kind of lamps it is not necessary any further risk assessment for photobiological safety (UV* – blue – IR).

**In case of exposure higher than 500 lx for more than 8 hours per day, assessment against UV may be necessary.*

B. IEC 61195: Double-capped fluorescent lamps

Applicable to double-capped fluorescent lamps for general lighting purposes of all groups having Fa6, Fa8, G5, G13, 2G13, R17d and W4.3x8.5d caps.

In the incoming Amendment 1, a new sub clause 2.11 with the UV limits (2 mW/klm) will be introduced while in the scope the following statement will be introduced:

“Blue light and infrared hazards are below the level which requires marking”.

So, for products using this kind of lamp, any further risk assessment for photobiological safety (UV* – blue – IR) is not necessary.

**In case of exposure higher than 500 lx for more than 8 hours per day, assessment against UV may be necessary.*

C. IEC 61199: Single-capped fluorescent lamps

Applicable to single-capped fluorescent lamps for general lighting purposes having the following caps: 2G7, 2GX7, GR8, 2G10, G10q, GR10q, GX10q, GY10q, 2G11, G23, GX23, G24, GX24 and GX32.

Limits for UV were already included in clause 4.11 (2 mW/klm) and in the incoming Amendment 1, the following statement will be introduced in the scope:

“Blue light and infrared hazards are below the level which requires marking”.

So, for products using this kind of lamp, any further risk assessment for photobiological safety (UV* – blue – IR) is not necessary.

**In case of exposure higher than 500 lx for more than 8 hours per day, assessment against UV may be necessary.*

3.3. High intensity discharge lamps

A. IEC 62035: Discharge lamps (excluding fluorescent lamps)

Applicable to low-pressure sodium vapour lamps and to high intensity discharge (HID) lamps, i.e. high-pressure mercury vapour lamps (including blended lamps), high-pressure sodium vapour lamps and metal halide lamps. It applies to single- and double-capped lamps.

In the incoming next edition the following new requirements will be included:

- **UV:** The UV limits for lamps remain unchanged, but the correspondence with the risk group classification in IEC 62471 will be clarified as follows:

Table 6 – Classification of risk groups

Risk group (RG)	Ultraviolet hazard efficacy of luminous radiation (mW/klm)
Exempt (RG0)	≤ 2
Low risk (RG1)	>2 and ≤ 6
Moderate Risk (RG2)	>6 and ≤ 60
High Risk (RG3)	>60

Luminaire standard (IEC 60598-1) requires already assessment to limit UV radiation as indicate in the introduction of this document.

- **Blue light hazard: for the assessment for blue light hazard, the following is required:**

Frosted, coated, low pressure sodium lamps and high pressure sodium lamps may be regarded as Low Risk (RG 1) for blue light hazard without measurement. No white light source within the scope of this standard is expected to come into the High Risk (RG 3) class.


Other lamps shall be assessed for blue light hazard according to IEC/TR 62778 (see clause 5 of this document for the assessment in this case) and if necessary marked with the symbol



- **IR:** HID lamps for general lighting are not expected to reach an IR level that requires marking.

So for this kind of lamp, IR does not require any additional assessment and UV is already covered by the standard as in the introduction.

With regard to blue light hazard if no symbol or mounting limitation are mentioned, no further evaluation is necessary. However, luminaires designed for the operation of lamps carrying the

symbol  particular requirements will be included in the next revision of IEC 60598-1(see clause 4 of this document)

3.4. LED

A. IEC 62031: LED modules for general lighting

Applicable to light-emitting diode (LED) modules:

- LED modules without integral control gear for operation under constant voltage, constant current or constant power;
- self-ballasted LED modules for use on d.c. supplies up to 250 V or a.c. supplies up to 1 000 V at 50 Hz or 60 Hz.

The incoming Amendment 2 is going to introduce the following requirements:

- **UV:** in clause 22.1 the limits for UV are going to be introduced: "The ultraviolet hazard efficacy of luminous radiation of a LED module shall not exceed 2 mW/klm. LED modules for general lighting not relying on the conversion of UV radiation are not expected to exceed the maximum allowed ultraviolet hazard efficacy of luminous radiation".
- **Blue light hazard:** LED shall be assessed for blue light hazard according to IEC/TR 62778 (see clause 5 of this document for the assessment in this case).
- **IR:** in clause 22.3 it will be indicated that LED modules for general lighting are not expected to reach a level of infrared radiation where marking or other safety measurements are required.

So for this kind of light source the only hazard that needs to be evaluated is the blue light hazard. Assessment shall be carried out according to the declaration of the manufacturer. If no threshold illuminance is mentioned, no further evaluation is necessary. However, luminaires designed for the operation of modules carrying the threshold illuminance indication, particular requirements will be included in the next revision of IEC 60598-1.

4. Limits and assessment in the luminaire

As already stated in the introduction, the UV safety risk is already covered by the existing standard IEC 60598-1 under clause 4.24 and annex P.

For blue light hazard, the incoming new edition of IEC 60598-1 will require how to assess the luminaire following the classification of IEC/TR 62778 (see clause 5 of this document). Luminaire with light source with RG 0 or RG 1 do not need to be marked. In all other cases, a distance where a boundary condition between RG 1 and RG 2 is reached, has to be calculated according to IEC/TR 62778 (see clause 5 of this document). If the distance is higher than 20 cm the following requirements are proposed:

- In case of fixed luminaire the manufacturer instruction sheet for installation will provide an advice as follows: "the luminaire should be positioned so that prolonged staring into the luminaire at a distance closed than X_m is not expected" (Where X_m is the distance between light source and the eye or the viewer). In addition if the light source is directly visible during maintenance the luminaire shall be provided with the symbol as below
- In case of portable and hand held luminaire it will be required the symbol as below



Symbol indicating: "Do not stare at the light source"

5. Blue light hazard: limits introduced in the technical standards for lighting products

To define the limits and criteria for the application of IEC 62471, regarding the evaluation blue light hazard, IEC TC 34 has recently published (June 2012) the IEC/TR 62778 "Application of IEC 62471 to light sources and luminaires for the assessment of blue light hazard."

5.1. Consideration and classification of lighting products

The application of the standard IEC 62471 for assessment of the blue light hazard, has generated in some cases, different interpretations in the evaluation of the test results. In particular, the following aspects were evaluated:

- The evaluation of the source at a distance which produces 500 lx is not always significant so that the distance between the eye of the observer and the source may be lower
- To evaluate all sources at a distance of 200 mm (as for sources not GLS) would lead to an overestimation of the phenomenon requiring limitations even where not required.
- It is necessary to define parameters in order to transfer data from the manufacturer of the light source to the luminaire manufacturer
- The products that fall within the risk group RG 2 are not considered dangerous even if warnings are required to use in order to avoid direct vision.

5.2. Assessment and classification of the light source for blue light hazard in accordance with IEC/TR 62778

The assessment carried out on the light source (lamp or module) is then transferable to the luminaire as follows:

- Light sources with risk group “RG 0 unlimited”: If the assessment on the light source carried out in accordance with the IEC/TR 62778 leads to a “RG 0 unlimited” for blue light hazard, each luminaire that incorporates one or more light sources of this kind, will have the same blue light hazard classification, regardless of the visual distance, optical lenses or reflector used in the luminaire.
- Light sources with risk group “RG 1 unlimited”: If the assessment on the light source carried out in accordance with the IEC/TR 62778 leads to a “RG 1 unlimited” for blue light hazard, each luminaire that incorporates one or more sources of this kind, will have the same blue light hazard classification or lower, regardless of the visual distance, optical lenses or reflector used in the luminaire.
- Sources with risk group in which the assessment leads to define a E_{thr} (threshold illuminance). If the assessment on the light source carried out in accordance with the IEC/TR 62778 leads to a threshold illuminance E_{thr} for blue light hazard, each device that incorporates one or more light sources will have the same E_{thr} which will form the basis for the calculation of the distance for a safe vision depending on the distribution curve of the luminaire.

5.3. Evaluation of light sources where radiometric measurements for blue light hazard are not available (only for white light source)

In IEC/TR 62778 considerations are made on the spectral distribution of the light sources. In particular a correlation has been found between the CCT of the sources and blue light hazard with the parameter $K_{B,v}$ (1).

(1) $K_{B,v}$ is defined as the quotient of the blue light hazard quantity to the corresponding photometric quantity.

Following the spectral analysis and the consideration made it is possible to find a photometric threshold corresponding to the threshold between RG 1 ($t_{max} > 100$ s) and RG 2 ($t_{max} < 100$ s) in the small source regime.

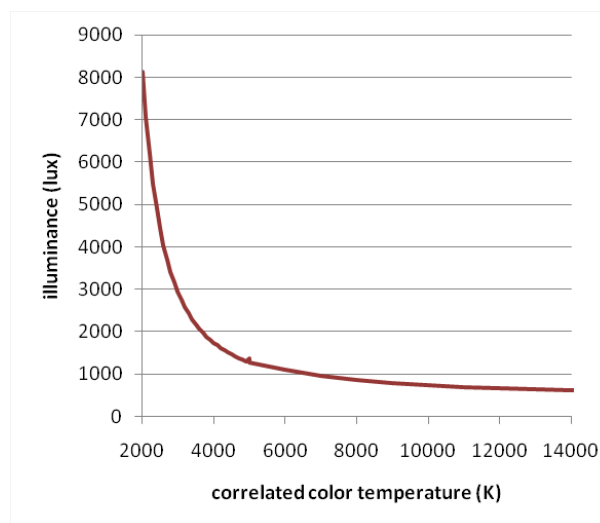


Figure 1: Estimate of the illuminance level where $EB = 1$ W/m^2 , border between RG 1 ($t_{max} > 100$ s) and RG 2 ($t_{max} < 100$ s) in the small source regime, as a function of CCT

On the basis of these considerations and taking into account a safety margin (corresponding to a factor of 2), it is possible to define levels of illuminance below which the source is certainly at RG 1 or less.




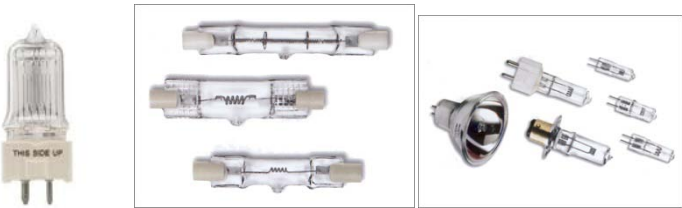
Important: It should be kept in mind that the evaluations of the illuminance level shall be made at the eyes position of the observer. This value is normally higher than the illuminance level of the lighting design calculated on the task area or on the floor. The illuminance to be considered shall be that provided by any single luminaire. Contribution on the same place (eye position) by other luminaires is disregarded. The plane on which illuminance E is determined is perpendicular to the direction of the light and the cosine of the angle α equals to 1. This represents the condition where the eye looks directly at the light source

Table 1 – Illuminance values giving risk group not greater than RG 1

Rated CCT (K)	Illuminance E (lx)
$CCT \leq 2\ 350$	4 000
$2\ 350 < CCT \leq 2\ 850$	1 850
$2\ 850 < CCT \leq 3\ 250$	1 450
$3\ 250 < CCT \leq 3\ 750$	1 100
$3\ 750 < CCT \leq 4\ 500$	850
$4\ 500 < CCT \leq 5\ 750$	650
$5\ 750 < CCT \leq 8\ 000$	500

It can therefore be concluded that, in applications where the illuminance level at eye position (easily measured with a lux meter) is lower than the values shown in Table 1, the radiation level for blue light hazard is lower than the limits of the RG 2 and therefore no further evaluations are necessary. It should however be again noted that the above table relates to the illumination achieved by a single luminaire or single element of a luminaire comprising multiple LED modules. This table is based on an extrapolation from the calculation of risk threshold of RG 1 - RG 2 with additional measuring tolerances allowed for. If any initial assessment shows a value above the threshold limit you should contact the supplier for actual data for the “blue light hazard” as this will have been measured and will accurately reflect any actual risk from the luminaire.

6. Summary

Type of light source	Picture	IR Infrared hazard	Blue Blue light hazard	UV UV hazard
Tungsten filament lamp IEC 60432-1		No risk	No risk	No risk
Tungsten halogen lamps for domestic and similar general lighting purposes IEC 60432-2		No risk	No risk	No risk
Tungsten halogen lamps (non-vehicle) IEC 60432-3		No risk	No risk	No risk (1)
Tungsten halogen lamps for special application IEC 60432-3		To be evaluated according to the manufacturer specifications	No risk (4)	No risk (1)

Type of light source	Picture	IR Infrared hazard	Blue Blue light hazard	UV UV hazard
Self-ballasted lamps for general lighting services IEC 60968		No risk	No risk	No risk
Double-capped fluorescent lamps IEC 61195		No risk	No risk	No risk
Single-capped fluorescent lamps IEC 61199		No risk	No risk	No risk
Low and high pressure sodium vapour lamp IEC 62035		No risk	No risk	No risk

Type of light source	Picture	IR Infrared hazard	Blue Blue light hazard	UV UV hazard
High pressure mercury and MH frosted coated lamps IEC 62035		No risk	No risk	No risk
Clear MH lamp IEC 62035		No risk	To be evaluated according to the manufacturer specifications (2)(3)	No risk (1)
LED Module IEC 62031		No risk	To be evaluated according to the manufacturer specifications (2)(3)	No risk

- (1) Non-self-shielded lamps may have an emission level higher than the RG 0, in this case the luminaire according to the IEC 60598-1 filters the content of UV down to RG 0
- (2) Products that have a risk group higher than 1, are accompanied by installation instructions and symbols. The standard will require a) symbols to don't stare at the light source or b) installation distances.
- (3) Risk assessment of blue light hazard can be made in accordance to the illuminance levels at the eye of the observer in application as indicated in 4.3 of this document
- (4) For blue light hazard it is normally not necessary any further assessment except in case of luminaires using narrow beam focusing optics.

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