IEC 62471-7

Edition 1.0 2023-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Photobiological safety of lamps and lamp systems – Part 7: Light sources and luminaires primarily emitting visible radiation

Sécurité photobiologique des lampes et des appareils utilisant des lampes – Partie 7: Sources de lumière et luminaires qui émettent principalement un rayonnement visible

IEC 62471-7:2023-02(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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PHOTOBIOLOGICAL SAFETY OF LAMPS AND LAMP SYSTEMS –

Part 7: Light sources and luminaires primarily emitting visible radiation

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 62471-7 has been prepared by IEC technical committee 34: Lighting. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
34/1004/FDIS	34/1011/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62471 series, published under the general title *Photobiological safety of lamps and lamp systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

The contents of the corrigendum 1 (2023-06) have been included in this copy.

INTRODUCTION

The wording "lamps and lamp systems" is used in the title of the IEC 62471 series. However, in the title of this Part 7, the wording "light sources and luminaires" is used. The reason for this is that due to the introduction of new LED technologies the characteristics of the light-generating components have changed. Therefore, the terms "electrical light source" and "luminaire" are nowadays used in TC 34 instead of "lamp" and "lamp system".

"Electric light source" is the generic term for products which produce light; the term "lamp" (light source with a lamp cap-holder system) is thereby included.

"Luminaire" is the basic term (see IEC 60050-845:2020, 845-30-001) for a product that includes all necessary accessories and describes a device that distributes, filters, or transforms the light produced from at least one source of optical radiation and which includes, except the sources themselves, all the parts necessary for fixing and protecting the sources and, where necessary, circuit auxiliaries together with the means for connecting them to the power supply.

When luminaires are designed and constructed in accordance with the requirements of this document, they are presumed to function safely under normal use and present no photobiological hazard. Conformity of luminaires can be verified by application of the assessment procedures described in this document.

The light sources can be interchangeable or an integral part of the luminaire. If the light source is an integral part of the luminaire, the luminaire can also be considered a light source system (corresponding to a lamp system).

Most electrical light sources and luminaires within the scope of this document will not present a photobiological hazard due to their spectra, their light distribution, the light levels, and the natural aversion responses – people do not usually stare into bright sources, for example. There remain, however, some light sources and luminaires, which have the potential to pose adverse health effects from the emitted optical radiation. Exposure limits for a range of photobiological hazards associated with broad-band optical radiation sources have been developed and published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

This document introduces a new assessment procedure to address the various lighting applications in which the intended purpose is the illumination of objects and scenes and in signalling applications. This new approach uses revised time bases (and emission limits) related to the intentional or unintentional direct viewing of the luminaire and assessment distances depending on application. These emission limits are based on the exposure limits of the ICNIRP.

In this document, a complete procedure is used to cover all photobiological hazards in the range of 200 nm to 3 000 nm as implemented in IEC 62471.

This procedure, based on a product- and application-related assessment, leads to a pass/fail result for a specific product in that given application.

PHOTOBIOLOGICAL SAFETY OF LAMPS AND LAMP SYSTEMS –

Part 7: Light sources and luminaires primarily emitting visible radiation

1 Scope

This part of IEC 62471 specifies an assessment of the photobiological safety of electrical light sources and luminaires in normal use as well as some basic product requirements. It applies to electrical light sources and luminaires that emit radiation predominantly in the visible spectral range (380 nm to 780 nm) and are used to illuminate spaces or objects or used for signalling.

Electrical light sources and luminaires designed for emitting radiation in the visible range can also emit radiation in the ultraviolet (UV) and infrared (IR) regions depending on the technology applied. This document, therefore, includes the blue light, thermal, UV, UV-A, IR and skin thermal hazards for the optical radiation over the wavelength range 200 nm to 3 000 nm.

Electrical light sources and luminaires that are designed to predominantly emit radiation outside the visible spectral range (380 nm to 780 nm) (e.g. UV sterilizers or industrial heaters) are not within the scope of this document.

Electrical light sources for illumination are considered to emit continuous light for photobiological safety assessment. This includes light sources with pulse width modulation (PWM).

This document can also be applied to the illumination function of multi-function luminaires which can simultaneously perform functions other than illumination. Other standards can be applied to the non-illumination function(s).

This document can also be applied to electric light sources and luminaires which emit visible light, when there is no limitation on the presence of people (e.g. horticulture).

This document can also be applied to laser products used for illumination and signalling when the conditions of IEC 60825-1:2014, 4.4 are met.

NOTE See IEC 60825-1:2014 for other requirements of laser products.

This document is intended to be referenced by product standards for the assessment of applicable photobiological safety aspects. Additional details for the photobiological safety assessment and data presentation are specified in the product standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845, *International Electrotechnical Vocabulary (IEV) – Part 845: Lighting,* available at http://www.electropedia.org

IEC 60598-1:2020, *Luminaires – Part 1: General requirements and tests*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

IEC 62471-5:2015, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62471, IEC 60050-845 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
blue light hazard
BLH
potential for a photochemically induced retinal injury (photic maculopathy) resulting from optical radiation exposure at wavelengths primarily between 400 nm and 500 nm

Note 1 to entry: This damage mechanism dominates over the thermal damage mechanism for exposure durations exceeding 10 s.

Note 2 to entry: The weighting function extends into the UV-A for persons without a normal UV-A absorbing lens.

[SOURCE: IEC 60050-845:2020, 845-26-055, modified – In Note 2 to entry "action spectrum" has been replaced with "weighting function".]

3.2
exposure limit
maximum level of exposure of a surface, usually the eye or skin, that is not expected to result in adverse biological effects

Note 1 to entry: Exposure limits for human safety of optical radiation, H_L, are normally recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

Note 2 to entry: Exposure limits are often based on irradiance (e.g. for the skin), but where relevant, can also be based on radiance (e.g. the blue light hazard of extended sources).

[SOURCE: IEC 60050-845:2020, 845-26-072]

3.3
emission limit
specified maximum emission level of a source of optical radiation that is not expected to result in adverse biological effect for a specific application

Note 1 to entry: Evaluation of sources to the emission limits can be based upon reasonably foreseeable conditions of time-weighted exposure. It incorporates both the concept of exposure duration and exposure distance and is derived from exposure limits.

[SOURCE: IEC 60050-161:1990, 161-03-12, modified – The domain has been deleted, the definition has been adapted in relation to optical radiation and the Note to entry has been added.]

3.4
field of view
FOV
solid angle as "seen" by the detector (acceptance angle), e.g. of a radiometer or spectroradiometer, out of which the detector receives radiation

Note 1 to entry: The field of view should not be confused with the angular subtense of the apparent source, α.

Note 2 to entry: A plane angle is sometimes used to describe a circular symmetric solid angle field of view.

Note 3 to entry: The field of view is expressed in steradian (sr).

[SOURCE: IEC 60050-845:2020, 845-25-077]

3.5
illuminance
E_v
density of incident luminous flux with respect to area at a point on a real or imaginary surface

$$E_\mathrm{v} = \frac{\mathrm{d}\Phi_\mathrm{v}}{\mathrm{d}A}$$

where Φ_v is luminous flux and A is the area on which the luminous flux is incident

Note 1 to entry: Illuminance can be derived from the spectral irradiance distribution by

$$E_\mathrm{v} = K_\mathrm{m} \int_0^\infty E_{\mathrm{e},\lambda}(\lambda) \cdot V(\lambda) \cdot \mathrm{d}(\lambda)$$

where K_m is maximum luminous efficacy, $E_{\mathrm{e},\lambda}(\lambda)$ is the spectral irradiance at wavelength λ and $V(\lambda)$ is spectral luminous efficiency.

Note 2 to entry: The corresponding radiometric quantity is "irradiance". The corresponding quantity for photons is "photon irradiance".

Note 3 to entry: The illuminance is expressed in lux ($\mathrm{lx} = \mathrm{lm} \cdot \mathrm{m}^{-2}$).

[SOURCE: IEC 60050-845:2020, 845-21-060]

3.6
infrared radiation
IRR
optical radiation for which the wavelengths are longer than those for visible radiation

Note 1 to entry: For infrared radiation, the range between 780 nm and 1 mm is commonly subdivided into:

IR-A: 780 nm to 1 400 nm, or 0,78 µm to 1,4 µm;

IR-B: 1,4 µm to 3,0 µm;

IR-C: 3 µm to 1 mm.

Note 2 to entry: A precise border between "visible radiation" and "infrared radiation" cannot be defined because visual sensation at wavelengths greater than 780 nm can be experienced.

Note 3 to entry: In some applications the infrared spectrum has also been divided into "near", "middle", and "far" infrared; however, the borders necessarily vary with the application.

[SOURCE: IEC 60050-845:2020, 845-21-004]

3.7
irradiance
density of incident radiant flux with respect to area at a point on a real or imaginary surface

$$E_e = \frac{d\Phi_e}{dA}$$

where Φ_e is radiant flux and A is the area on which the radiant flux is incident

Note 1 to entry: The corresponding photometric quantity is "illuminance". The corresponding quantity for photons is "photon irradiance".

Note 2 to entry: The irradiance is expressed in watt per square metre ($W \cdot m^{-2}$).

[SOURCE: IEC 60050-845:2020, 845-21-053]

3.8
electric light source
primary light source with the means for connecting to the power supply and usually designed to be incorporated into a luminaire

Note 1 to entry: In IEC standards, "light source” and "lamp" are commonly used with the same meaning.

Note 2 to entry: An electric light source can be an electric lamp, or LED module designed to be connected by terminals, connectors, or similar devices.

Note 3 to entry: For products that have the same physical characteristics as electric light sources for general lighting but that are built to emit optical radiation (IEV 845-21-002) mainly in the IR or UV spectrum, the term "IR lamp" or "UV lamp" is often used.

[SOURCE: IEC 60050-845:2020, 845-27-004, modified – In Note 1 to entry, "and "lamp" are" has been added and Note 3 to entry has been added.]

3.9
luminaire
apparatus which distributes, filters or transforms the light transmitted from at least one source of optical radiation and which includes, except the sources themselves, all the parts necessary for fixing and protecting the sources and, where necessary, circuit auxiliaries together with the means for connecting them to the power supply

[SOURCE: IEC 60050-845:2020, 845-30-001]

3.10
optical radiation
electromagnetic radiation at wavelengths between the region of transition to X-rays ($\lambda \approx 1$ nm) and the region of transition to radio waves ($\lambda \approx 1$ mm)

[SOURCE: IEC 60050-845:2020, 845-21-002]

3.11
radiance
L_{e}
L
density of radiant intensity with respect to projected area in a specified direction at a specified point on a real or imaginary surface, expressed by

$$L_{\mathrm{e}} = \frac{\mathrm{d}I_{\mathrm{e}}}{\mathrm{d}A} \cdot \frac{1}{\cos\alpha}$$

where I_{e} is radiant intensity, A is area, and α is the angle between the normal to the surface at the specified point and the specified direction

Note 1 to entry: In a practical sense, the definition of radiance can be thought of as dividing a real or imaginary surface into an infinite number of infinitesimally small surfaces which can be considered as point sources, each of which has a specific radiant intensity, I_{e}, in the specified direction. The radiance of the surface is then the integral of these radiance elements over the whole surface.

The equation in the definition can mathematically be interpreted as a derivative (i.e. a rate of change of radiant intensity with projected area) and could alternatively be rewritten in terms of the average radiant intensity $\overline{I}_{\mathrm{e}}$ as:

$$L_{\mathrm{e}} = \lim_{A \to 0} \cdot \frac{\overline{I}_{\mathrm{e}}}{A} \cdot \frac{1}{\cos\alpha}$$

Hence, radiance is often considered as a quotient of averaged quantities; the area, A, should be small enough that uncertainties due to variations in radiant intensity within that area are negligible, otherwise, the quotient $\overline{L}_{\mathrm{e}} = \frac{\overline{I}_{\mathrm{e}}}{A} \cdot \frac{1}{\cos\alpha}$ gives the average radiance and the specific measurement conditions have to be reported with the result.

Note 2 to entry: For a surface being irradiated, an equivalent formula in terms of irradiance, E_{e}, and solid angle, Ω, is

$L_{\mathrm{e}} = \frac{\mathrm{d}E_{\mathrm{e}}}{\mathrm{d}\Omega} \cdot \frac{1}{\cos\theta}$, where θ is the angle between the normal to the surface being irradiated and the direction of irradiation. This form is useful when the source has no surface (e.g. the sky, the plasma of a discharge).

Note 3 to entry: An equivalent formula is $L_{\mathrm{e}} = \frac{\mathrm{d}\Phi_{\mathrm{e}}}{\mathrm{d}G}$, where Φ_{e} is radiant flux and G is geometric extent.

Note 4 to entry: Radiant flux can be obtained by integrating radiance over projected area, $A \cdot \cos\alpha$, and solid angle, Ω:

$$\Phi_{\mathrm{e}} = \iint L_{\mathrm{e}} \cdot \cos\alpha \cdot \mathrm{d}A \cdot \mathrm{d}\Omega$$

Note 5 to entry: Since the optical extent, expressed by $G \cdot n^2$, where G is geometric extent and n is refractive index, is invariant, the quantity expressed by $L_{\mathrm{e}} \cdot n^{-2}$ is also invariant along the path of the beam if the losses by absorption, reflection and diffusion are taken as 0. That quantity is called "basic radiance".

Note 6 to entry: The equation in the definition can also be described as a function of radiant flux, Φ_{e}. In this case, it is mathematically interpreted as a second partial derivative of the radiant flux at a specified point (x, y) in space in a specified direction (ϑ, φ) with respect to projected area, $A \cdot \cos\alpha$, and solid angle, Ω,

$$L_{\mathrm{e}}(x, y, \vartheta, \varphi) = \frac{\partial^2 \Phi_{\mathrm{e}}(x, y, \vartheta, \varphi)}{\partial A(x, y) \cdot \cos\alpha \cdot \partial\Omega(\vartheta, \varphi)}$$

where α is the angle between the normal to that area at the specified point and the specified direction.

Note 7 to entry: The corresponding photometric quantity is "luminance". The corresponding quantity for photons is "photon radiance".

Note 8 to entry: The radiance is expressed in watts per square metre per steradian ($W \cdot m^{-2} \cdot sr^{-1}$).

[SOURCE: IEC 60050-845:2020, 845-21-049]

3.12
retina
membrane situated inside the back of the eye that is sensitive to light stimuli

Note 1 to entry: The retina contains photoreceptors and nerve cells that interconnect and transmit to the optic nerve the signals resulting from stimulation of the photoreceptors. The photoreceptors in the human retina are of three types: rods and cones, which are responsible for vision, and intrinsically photosensitive retinal ganglion cells (ipRGCs), which play a role in controlling circadian and neuro-endocrine systems.

[SOURCE: IEC 60050-845:2020, 845-22-001]

3.13
spectral irradiance
$E_{e,\lambda}$
E_{λ}
density of irradiance with respect to wavelength

Note 1 to entry: The spectral irradiance is expressed by

$$E_{e,\lambda} = \frac{dE_e(\lambda)}{d\lambda}$$

where $E_e(\lambda)$ is irradiance in terms of wavelength λ.

Note 2 to entry: The spectral irradiance is expressed in watt per square metre per nanometre ($W \cdot m^{-2} \cdot nm^{-1}$).

[SOURCE: IEC 60050-845:2020, 845-21-056, modified – Part of the definition has been included in Note 1 to entry.]

3.14
spectral radiance
L_{λ}
density of radiance with respect to wavelength

Note 1 to entry: The spectral radiance is expressed by

$$L_{e,\lambda} = \frac{dL_e(\lambda)}{d\lambda}$$

where $L_e(\lambda)$ is radiance in terms of wavelength λ.

Note 2 to entry: The spectral radiance is expressed in watt per square metre per nanometre per steradian ($W \cdot m^{-2} \cdot nm^{-1} \cdot sr^{-1}$).

[SOURCE: IEC 60050-845:2020, 845-21-052, modified – Part of the definition has been included in Note 1 to entry.]

3.15
ultraviolet radiation
UV radiation
UVR
optical radiation for which the wavelengths are shorter than those for visible radiation

Note 1 to entry: The range between 100 nm and 400 nm is commonly subdivided into:

UV-A: 315 nm to 400 nm;

UV-B: 280 nm to 315 nm;

UV-C: 100 nm to 280 nm.

Note 2 to entry: A precise border between "ultraviolet radiation" and "visible radiation" cannot be defined, because visual sensation at wavelengths shorter than 400 nm is noted for very bright sources.

Note 3 to entry: In some applications the ultraviolet spectrum has also been divided into "far," "vacuum," and "near" ultraviolet; however, the borders necessarily vary with the application (e.g. in meteorology, optical design, photochemistry, and thermal physics).

[SOURCE: IEC 60050-845:2020, 845-21-008]

3.16
visible radiation
optical radiation capable of causing a visual sensation directly

Note 1 to entry: There are no precise limits for the spectral range of visible radiation since they depend upon the amount of radiant flux reaching the retina and the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

[SOURCE: IEC 60050-845:2020, 845-21-003]

3.17
ultraviolet hazard efficacy of luminous radiation
$K_{\mathrm{S,v}}$
quotient of an ultraviolet hazard quantity to the corresponding photometric quantity

$$K_{\mathrm{S,v}} = \frac{E_{\mathrm{s}}}{E_{\mathrm{v}}}$$

where

E_{S} is the effective actinic irradiance in W · m^{-2} and

E_{v} is the illuminance in lx = lm · m^{-2}

EXAMPLE With E_{S} = 10^{-3} W · m^{-2} and E_{v} = 500 lx follows $K_{\mathrm{S,v}}$ = 2 · 10^{-6} W · lm^{-1} = 2 mW · klm^{-1}.

Note 1 to entry: Ultraviolet hazard efficacy of luminous radiation is expressed in watt per lumen (W · lm^{-1}), possibly with a metric prefix (here mW · klm^{-1}).

Note 2 to entry: The ultraviolet hazard efficacy of luminous radiation is obtained by weighting the spectral power distribution of the lamp or LED module with the UV hazard function $S_{\mathrm{UV}}(\lambda)$. Information about the relevant UV hazard function is given in IEC 62471:2006. It only relates to possible hazards regarding UV exposure of human beings. It does not deal with the possible influence of optical radiation on materials such as mechanical damage or discoloration.

[SOURCE: IEC 62031:2018, 3.1, modified – The equation with the corresponding explanations has been added.]