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TECHNICAL REPORT

colour inside

Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety

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CONTENTS

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PHOTOBIOLOGICAL SAFETY OF LAMPS AND LAMP SYSTEMS –

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FOREWORD

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IEC 62471-2, which is a technical report, has been prepared by Technical Committee 76: Optical radiation safety and laser equipment

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
76/396/DTR	76/410/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of 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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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

INTRODUCTION

Optical radiation hazards from all types of lamps or other broadband light sources are assessed by the application of IEC 62471:2006 (Edition 1), *Photobiological safety of lamps and lamp systems*. IEC 62471 covers LEDs as well as incandescent, low and high pressure gas-discharge, arc and other lamps. It also covers electrically-powered optical radiation sources that are not lamps. The standard provides a risk group classification system for all lamps and lamp systems, and the measurement conditions are well developed. IEC 62471 does not include manufacturing or user safety requirements that may be required as a result of a lamp or lamp system being assigned to a particular risk group. The safety requirements for lamp systems necessarily vary and are best dealt with in vertical standards. This Part 2 provides the basis for safety requirements dependent upon risk group classification and examples thereof. The assigned risk group of a product may be used to assist with risk assessments, e.g. for occupational exposure in workplaces. National requirements may exist for the assessment of products or occupational exposure.

NOTE 1 There are some instances where the IEC 60825 laser product standards may be useful for a nearly "point" source, as in an LED fibre source or a superluminescent diode (see 3.16).

NOTE 2 IEC 62471 is currently being revised and will be published as IEC 62471-1.

PHOTOBIOLOGICAL SAFETY OF LAMPS AND LAMP SYSTEMS –

Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety

1 Scope

This technical report provides the basis for optical radiation safety requirements of non-laser products, serving as a guide for development of safety requirements in vertical product standards and assisting lamp system manufacturers in the interpretation of safety information provided by the lamp manufacturers.

This report provides guidance on:

- requirements for optical radiation safety assessment;
- allocation of safety measures;
- labelling of products.

This technical report does not address safety requirements of intentional exposure to optical radiation from sun tanning equipment, ophthalmic instruments or other medical/cosmetic devices whose specific safety issues are addressed through appropriate standards.

2 Normative references

The following referenced documents are indispensable for the application 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 62471, *Photobiological safety of lamps and lamp systems*

IEC 60825 (all parts), *Safety of laser products*

IEC 60050-845, *International Electrotechnical Vocabulary – Chapter 845: Lighting*

IEC 60417, *Graphical symbols for use on equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 62471 and the following additional terms and definitions apply.

3.1
controlled access location
location where an engineering and/or administrative control measure is established to restrict access except to authorised personnel with appropriate safety training

3.2
exposure hazard value
EHV
value defined as follows:

$$EHV\,(distance, exposure\ \ time) = \frac{Exposure\ level\ (distance, exposure\ time)}{Exposure\ limit\ value}$$

The EHV is greater than 1 when the exposure level (3.3) exceeds the exposure limit value (3.4)

3.3
exposure level
EL
level of exposure from a source at a location in space for a stated duration

3.4
exposure limit value
ELV
maximum level of exposure of optical radiation to the eye or skin that is not expected to result in adverse biological effects. These ELVs are used to determine hazard distances in respect to foreseeable photobiological effects

3.5
hazard distance
HD
distance from the source at which the EL equals the appropriate exposure limit value (ELV)

3.6
intended viewing
deliberate act of an individual to either look at a source of optical radiation or at a virtual source, such as a reflection

3.7
intended use
usage of a product, process or service in accordance with specifications, instructions and information provided by the manufacturer or supplier

3.8
lamp
electrically powered device emitting optical radiation in the wavelength range between 200 nm and 3 000 nm, with the exception of laser radiation

3.9
lamp system
electrically operated product incorporating a lamp or lamps, including fixtures and incorporated electrical or electronic components, generally as intended by the manufacturer to be used (for illumination purposes - luminaire)

NOTE 1 Lamp systems may include diffusers, enclosures and/or beam modifying optics.

NOTE 2 For the purpose of this technical report, a lamp system may incorporate a lamp that does not serve as the primary function of the product, e.g. an indicator lamp or an illumination lamp inside a refrigerator.

3.10
modifying optics
optical components, such as filters, lenses and reflectors, which change the characteristics of the optical radiation from a lamp when incorporated into a lamp system

3.11
non-laser optical radiation
incoherent optical radiation generated by a process other than stimulated emission

3.12
restricted access location
location which is normally inaccessible by the general public, including workers, visitors and residents in the immediate vicinity, by means of engineering or administrative control measures but is accessible to authorised personnel that may not have specific safety training

3.13
small source
source or apparent source with an angular subtense smaller than the angle of acceptance γ that should be applied according to a risk assessment or classification.

NOTE This may result in the spatially averaged radiance (3.15) of a source or apparent source being averaged over a larger area than would be applied for the source radiance (3.14).

3.14
source radiance
radiance of the emitting element of the source (see IEV 845-01-34). However, the applicable acceptance angle should not be smaller than 1,7 mrad

Symbol: L

NOTE It is defined to differentiate from spatially averaged radiance (3.15).

3.15
spatially averaged radiance
radiance spatially averaged over a given angle of acceptance to account for physiological factors such as eye-movements (sometimes referred to as "physiological radiance"). The spatially average radiance may be lower than the source radiance (see 3.14)

Symbol: L_{sa}

3.16
superluminescent diode
edge-emitting semiconductor light source based on superluminescence. It combines the high power and brightness of laser diodes with the low coherence of conventional light-emitting diodes. Its emission band is 20 nm to 100 nm wide

3.17
unintentional viewing
condition when eye exposure to optical radiation is not intended

3.18
unintentional skin exposure
condition when skin exposure to optical radiation is not intended

3.19
viewer-related risk
risk for intended or unintended viewers of a source under application-specific realistic conditions

NOTE In order to be independent of the use condition, the risk group classification of lamps and lamp systems is based on worst case assumptions of exposure duration, pupil size and viewing distance. However, the emission of lamps is often divergent and when a lamp is integrated into a product, depending on product design and its application, these assessment conditions may become inappropriate. In this case, the product may be assessed at the minimum distance and maximum exposure duration representative for the application-specific conditions of foreseeable access.

4 Risk groups applied for optical radiation safety assessments

4.1 Basis for optical radiation safety classification

IEC 62471 provides the method to determine the risk group of any lamp or any product incorporating a lamp. The risk groups in IEC 62471 indicate the degree of risk from potential optical radiation hazards and minimise the need for further measurements. The risk groups were developed based upon decades of lamp use experience and the analysis of accidental injuries related to optical radiation emission (where injuries were, generally, quite rare except from ultraviolet-emitting lamps or arc lamps). There are four basic risk groups:

- Exempt Group (RG 0), where no optical hazard is considered reasonably foreseeable, even for continuous, unrestricted use. Typical examples are most frosted incandescent lamps and fluorescent lamps used in domestic applications;
- Risk Group 1 (RG 1) products are safe for most use applications, except for very prolonged exposures where direct ocular exposures may be expected. An example of a Risk Group 1 product is a domestic battery operated torch (flashlight);
- Risk Group 2 (RG 2) products generally do not pose a realistic optical hazard if aversion responses limit the exposure duration or where lengthy exposures are unrealistic;
- Risk Group 3 (RG 3) products pose a potential hazard even for momentary exposures, and system safety requirements are generally essential.

IEC 62471 does not provide manufacturing requirements and control measures. These issues should be addressed in application-specific vertical standards (see 4.3.3). However, in order to provide a consistent approach across products, the (non-normative) labelling requirements are outlined in this technical report (see 5.4).

4.2 Assessment criteria

The standard measurement conditions consider the emission spectrum and, depending on the type of hazard, either irradiance or spatially averaged radiance to determine risk to the eye and/or the skin. The measurement conditions are related to potentially hazardous viewing conditions and take into consideration physiological factors of the eye, such as accommodation, pupil size, the aversion responses and eye movements (saccades).

IEC 62471 distinguishes between lamps intended for general lighting service (GLS) and lamps intended for use in other applications such as for germicidal use, heating, signalling, data transfer or others. Assessment and measurement conditions are different for these two groups:

- GLS - the hazard values should be quoted as irradiance or spatially averaged radiance values at a distance which produces an illuminance of 500 lux;
- other applications – the hazard values should be determined at a distance of 200 mm from the source.

Different application groups define a range of operational, maintenance and servicing conditions. If the assessment applied to different application groups in a vertical standard justifies it, the measurement conditions in IEC 62471 can be modified for specific application groups.

4.3 Application-related issues

4.3.1 Near-infrared sources

The limits set for the infrared (IR) spectral region were originally intended for applications of large IR-radiators with a significant amount of IR-A and IR-B radiation. The limits protect the cornea or lens of the eye against long-term thermal effects (e.g. cataract). Thus, the limits should be applied where the application is likely to result in chronic and lengthy exposures of

the eye for periods greater than 1 000 s and the daily averaged irradiance is expected to be at least 100 $W \cdot m^{-2}$. The primary objective is to minimise heating of the lens and cornea.

4.3.2 "Point sources"

There may be a small number of applications where an incoherent optical radiation source appears as a nearly monochromatic "point" source and should be considered within a laser safety standard framework. Generally, this will only apply to: superluminescent diodes (SLDs) (see 3.16), which resemble "point sources"; and LEDs which are employed in optical fibre communications, where the fibre source also resembles a very small, or "point" source. The user is referred to IEC 60825-1 for SLDs and to IEC 60825-2 for optical fibre communication systems.

4.3.3 Application-related vertical standards

The requirements in vertical standards may:

– limit the source risk group that can be used in a given application;
– require specific performance features based upon the risk group specifications; or
– specify application-specific control measures.

Basic guidance, based on the likelihood of direct source viewing, is provided in Clause 6. Vertical standards should be guided by the principle that it is not necessary to reduce optical radiation exposure to as low as reasonably achievable. However, as a general guideline, needless emissions that would produce unnecessary human exposure should be minimised. The hierarchy of applicable safety measures should follow the internationally accepted priority ranking of manufacturer safety measures. That is, engineering controls (e.g., filters, shielding, etc) are the highest priority, followed by administrative measures (such as warnings and labels, see 5.4) and then personal protective equipment as the last resort. Details should be provided in application-specific vertical standards.

5 Guidelines for lamp and lamp system manufacturers on how to apply IEC 62471

5.1 Limit values

5.1.1 General

It should be noted that the risk group classification system of IEC 62471 is primarily applied to lamps. However, in terms of product safety, the lamp system manufacturer has responsibility for assessing the final lamp system product. Because of different technical tasks and needs, manufacturers of lamp systems or luminaires might have limited capabilities for tests and measurements and they commonly rely on the lamp/LED data provided by the lamp/LED manufacturer. Therefore, guidance is provided on how and when lamp system manufacturers may rely on data provided by the lamp manufacturer.

There are many types of lamps for which the intended applications are known. For instance, for conventional light sources, the modifications of the safety-related optical features of the incorporated lamp by the lamp system manufacturer are generally not significant. In most cases there is a single conventional lamp type (light bulb) used for a luminaire and the lamp system manufacturer only adds a fixture and a power supply. In these cases, the lamp data are usually directly transferable to the lamp system. The assessment and risk group classification of the lamp can be used by the lamp system manufacturer for classification of the lamp system. However, other types of lamps may need detailed consideration.

The limit values of the safety standard are provided in two different quantities, which require separate consideration.

5.1.2 Limits provided in irradiance/radiant exposure

In the spectral ranges 200 nm to 400 nm and 1 400 nm to 3 000 nm where the emission limits in IEC 62471 are provided in irradiance or radiant exposure, the measurements of a single lamp can not simply be transferred directly to a lamp system but require an analysis of the optical additivity to determine the system risk group.

When a lamp is employed with additional integrated or attached modifying or projection optics, this lamp system should be considered as a different product and the lamp system manufacturer should provide the new risk group safety classification.

NOTE Additional optics primarily modify the irradiance of a source (i.e. may have a significant impact where the classification is based on irradiance or radiant exposure-criteria), whereas the radiance may remain unchanged (i.e. less impact where the classification is based on radiance-criteria).

5.1.3 Limits provided in (time integrated) radiance

In cases where the emission limits in IEC 62471 are provided in terms of spatially averaged radiance or time-integrated spatially averaged radiance, the principle of conservation of radiance may be used with caution. That is, if a lamp or single LED emits below the radiance level specified (per risk group), the final lamp system or LED-array also can not exceed the accessible emission limits. IEC 62471 requires measurements of spatially averaged radiance (3.15) values with the consequence that the relationship between the field of view and the source area, as it was used for the characterisation of a single component, may be changed by the integration of the single lamp or LED into luminaries (arrays) or with the attachment of beam-shaping optics.

Under specific conditions (see 5.2.2), the assessment of a single lamp/LED is directly transferable to the lamp system or luminaire. The risk group will remain the same, or may be reduced (e.g., by filters, etc.).

NOTE Since additional optics primarily modify (increase) the irradiance of a source rather than the radiance, an evaluation should verify that the most restrictive classification criterion of the lamp system has not been changed (from radiance to irradiance criterion).

5.2 Guidelines for lamp/LED manufacturers

5.2.1 General

The primary purpose of lamp risk-group classification by the lamp or LED manufacturer is to inform the user or final-product manufacturer of potential hazards that may need to be addressed in the safety design of the final product. Therefore, when a lamp is placed in Risk Groups 1, 2 or 3, it is important for the user to be informed of which potential hazards may require controls. If the manufacturer provides the EHV or HD for the lamp (see 5.3.4), the determination of appropriate controls can be simplified.

5.2.2 Measurement conditions

In the range 200 nm to 400 nm or 1 400 nm to 3 000 nm where the limits in IEC 62471 are provided in irradiance or radiant exposure, the measurements should be performed according to IEC 62471.

In cases where the limits in IEC 62471 are provided in spatially averaged radiance or time-integrated radiance, the source radiance (according to 3.14) data should be determined (LEDs: operating under maximum operating conditions, such as maximum current) according to IEC 62471. The angle of acceptance should be 1,7 mrad in any case.

NOTE These values should be compared with the risk group-specific limit values (rather than apply different angles of acceptance). Under these conditions it can be assured that the risk group allocation of the component in any case is directly transferable and useful to the characterisation of the final lamp system.