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PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

colour inside

Position statement on germicidal UV-C irradiation UV-C safety guidelines

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC PAS 63313 has been processed by IEC technical committee 34: Lighting.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft	**Report on voting**
34/795/DPAS	34/812/RVDPAS

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

It is based on the Global Lighting Associations's *Position Statement on Germicidal UV-C Irradiation – UV-C Safety Guidelines*. The structure and editorial rules used in this publication reflect the practice of the organization which submitted it.

This PAS shall remain valid for an initial maximum period of 2 years starting from the publication date. The validity may be extended for a single period up to a maximum of 2 years, at the end of which it shall be published as another type of normative document, or shall be withdrawn.

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.

INTRODUCTION TO THE PAS

UV-C irradiation is a proven methodology for inactivating microorganisms (including viruses) in water, in air and on solid surfaces. UV-C devices, that intentionally generate effective UV-C radiation, are considered safe if they meet the electrical, thermal, mechanical, human exposure to electromagnetic fields (EMF) and photobiological safety requirements provided in international safety standards. Guidance on the effectiveness of UV-C irradiation is given in publications like CIE 155. Currently, a few UV-C devices are supported by dedicated product standards, like for air purifiers (IEC 60335-2-65, which also provides information on ozone limits). However, related to the present COVID-19 pandemic, many UV-C devices are entering the market for which no adequate product standards exist yet. IEC/TC 34 recognizes this standardization gap and will start working on the development of required product standards.

Pending the development and publication of comprehensive product safety standards, the Global Lighting Association (GLA) issued the GLA "UV-C Safety Guidelines" (May 2020) with safety measures and compliance criteria, these to be taken in conjunction with the requirements of IEC 62471:2006/CIE S 009:2002 (in the GLA document abbreviated to IEC 62471). In addition, the GLA "UV-C Safety Guidelines" include safety measures and compliance criteria to avoid excessive ozone exposure.

IEC/TC 34 considers the GLA "UV-C Safety Guidelines" as a good starting point for developing any missing IEC safety standard(s) for UV-C devices, although it is recognized that the GLA "UV-C Safety Guidelines" were considered as initial guidance and its contents are not complete. For example, the photobiological safety assessment is limited to the actinic hazard in the UV-C spectral region, referring to risk groups specified in IEC 62471:2006/CIE S 009:2002; additional radiation such as UV-B/A is not addressed. Furthermore, the effects of ozone production are only mentioned with limited guidance.

However, since the development and publication of a full IEC safety standard will take at least 2 to 3 years, it has been agreed to publish the GLA "UV-C safety guidelines" as an intermediate IEC Publicly Available Specification (PAS), to offer an IEC document that helps manufacturers introducing safe UV-C devices which tackle the present COVID-19 pandemic. The IEC PAS document is a copy of the existing GLA document. This approach was already offered for consideration to IEC/TC 34 members who concluded that there is indeed a need for publication of the GLA "UV-C Safety Guidelines" as an IEC PAS. This PAS will serve as an interim measure to fill gaps in the present standardization landscape, it is not intended to predetermine any future TC 34 responsibility in the field of germicidal UV radiation. Aspects of this PAS document might serve as a basis for future standard(s) in subsequent project(s) as advised by TC 34 Advisory Group 17 and for execution by IEC/TC 34 or any other standardization body, as appropriate.

POSITION STATEMENT ON GERMICIDAL UV-C IRRADIATION UV-C SAFETY GUIDELINES

Foreword to this guidance document

About the Global Lighting Association

The Global Lighting Association (GLA) is the voice of the lighting industry on a global basis. GLA shares information on political, scientific, business, social and environmental issues of relevance to the lighting industry and advocates the position of the global lighting industry to relevant stakeholders in the international sphere. See www.globallightingassociation.org.

UV-C and urgent need for safety guidelines

UV-C[1] irradiation is a proven germicidal methodology for inactivating bacteria and viruses in water, air and solid surfaces. For effective disinfection purposes, the UV-C energy of UV-C devices is much higher than normal sunlight. These high UV-C energies can be a hazard to exposed humans and materials if proper safety measures are not observed.

In this context, and in the midst of a global COVID-19 epidemic, GLA is concerned at the proliferation of UV-C disinfecting devices – particularly being sold on the internet – with dubious safety features and inadequate safety instructions.

There is an urgent need for comprehensive technical safety standards for UV-C devices. Standards are expected to be developed by the International Electrotechnical Commission (IEC), Underwriters Laboratories (UL) and other standards development organisations (SDOs), but will take many months before they are published. Pending development and publication of such standards, the Global Lighting Association has published this document as an intermediate measure to draw attention to safety issues associated with UV-C products and to provide guidance on their safe use.

1 Introduction

UV-C devices are considered safe if they meet the electrical, thermal, mechanical, human exposure to electromagnetic fields (EMF) and photobiological safety requirements provided in IEC and UL standards. Regional safety codes or policies may reference these standards and other regional safety requirements. An overview of applicable IEC and UL safety standards is given in Appendix A.

Additionally, special attention should be given to UV-C **irradiance** hazards [1] which can damage the human eye and cause severe sunburn-like reaction to the human skin. UV-C **irradiance** can damage materials. It can also produce ozone (O_3), a known human toxin. Ozone can be produced in air due to exposure to optical radiation at wavelengths below 240 nm.

The information in this document represents current UV-C safety knowledge. Pending publication of comprehensive safety standards by SDOs, this document provides safeguards to avoid human exposure to **irradiance** hazards (section 3) and to excessive ozone concentrations

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1 UV-C forms part of the ultraviolet (UV) spectrum and is defined within ISO standard ISO-21348 as having wavelengths between 100 – 280 nm. In practice, 100 nm – 200 nm wavelengths are strongly absorbed by atmospheric oxygen which means they can only be used effectively under vacuum conditions. (This is also the reason the scope of the IEC standard *Photobiological safety of lamps and lamp systems* starts at 200 nm). This document changed the lower boundary from 200 nm to 180 nm to include low-pressure mercury lamps.

(section 4). The associated information requirements and compliance criteria are given in section 5 and 6 respectively. Definitions of **bold-marked** terms are given in section 7.

The Global Lighting Association strongly recommends applying these guidelines during safety assessments of UV-C devices in conjunction with applicable IEC and/or UL standards and/or other regional safety requirements.

2 Scope of this guidance document

The safety advice in this document applies to UV-C sources and UV-C products which emit in the wavelength range of 180[2] nm to 280[3] nm.

Not within the scope are:

- devices having their own product safety standard, such as IEC 60335-2-109 applicable to UV-C water disinfection equipment and IEC 60335-2-65 applicable to UV-C air disinfection equipment
- application environments of UV-C devices
- products combining UV-C **irradiance** with chemicals and additives
- products that do not emit UV-C radiation such as UV-A, UV-B and near-UV devices
- requirements for performance and functional characteristics
- requirements for preventing material degradation and material damage

3 UV-C radiation safety requirements

Section 3.1 summarises UV-C safety requirements identified in the photobiological safety standard IEC 62471 [3]. It also alters the lower wavelength boundary from 200 nm to 180 nm to extend safety considerations to common 185 nm sources as outlined in the scope of this document. Section 3.2 supplements these requirements with quantification of the effective UV-C **irradiance** distribution. Section 3.3 describes the safeguards which should be taken to avoid human exposure to **irradiance** hazards.

3.1 Summary of UV-C safety requirements of photobiological safety standard IEC 62471

[Source: IEC 62471 modified to lower 180 nm wavelength boundary and limited to upper 280 nm wavelength boundary]

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2 The lower wavelength boundary of the UV-C wavelength range has been adjusted from 200 nm to 180 nm to include 185 nm low-pressure mercury lamps. The product safety requirements for this wavelength extension are derived from ICNIRP 2004 Guidelines [1].

3 There are also broadband UV-C devices with UV emission above 280 nm. These broadband UV-C devices have additional product safety requirements described in IEC 62471.

NOTE The product safety requirements for the wavelength extension are derived from ICNIRP 2004 Guidelines [1].

3.1.1 Effective UV-C irradiance

To determine the effective **irradiance** of broadband UV-C devices, the device **irradiance** should be weighted against the peak of the spectral effectiveness curve (270 nm) according to Equation 1.

$$E_{eff} = \sum_{180\ nm}^{280\ nm} E_\lambda \cdot S(\lambda) \cdot \Delta(\lambda) \qquad [Equation\ 1]$$

For monochromatic UV-C devices Equation 1 can be simplified to Equation 2.

$$E_{eff} = E_\lambda \cdot S(\lambda) \qquad [Equation\ 2]$$

where:

E_{eff} = effective **irradiance** at a distance d_1 from the UV-C device in μW/cm^2 or W/m^2 and weighted against a 270 nm source

E_λ = spectral device **irradiance** in μW/cm^2/nm or W/m^2/nm measured at a distance d_1 from the UV-C device

$S(\lambda)$ = relative spectral effectiveness as given in Table 1

$\Delta\lambda$ = bandwidth in nanometres of the calculation or measurement intervals

Table 1 – Spectral weighting S(λ)

UV-range	λ (nm)	S (λ)
UV-C	180	0.012
	185*	0.015
	200	0.03
	220	0.12
	222	0.13
	240	0.30
	254*	0.50
	260	0.65
	270	1.00
	280	0.88

NOTE 1 Values marked * are mercury lines.

NOTE 2 Wavelengths chosen are representative. Other values should be obtained by logarithmic interpolation at intermediate wavelengths.

NOTE 3 CIE 239:2020 TR Goniospectroradiometry of Optical Radiation Sources gives guidance on spectral distribution measurements for 200 nm-2500 nm. Effective UV-C spectral **irradiance** distribution acquisition needs spectroradiometers or detectors sensitive in the range of interest: 180 nm-280 nm. Below 200 nm, there are difficulties in measuring **irradiance** distributions in typical air conditions. A nitrogen environment may be required due to ozone blocking of the UV.

NOTE 4 Broadband UV-C devices that emit in the 280 nm to 400 nm range should be evaluated according to IEC 62471 as such devices have additional product safety requirements.

3.1.2 Effective irradiance at a distance d_2

The effective **irradiance** from a UV-C device can be determined at any distance d_2 by the inverse square law as given in Equation 3.

$$E_{eff\,@\,d_2} = \left(\frac{d_1}{d_2}\right)^2 \cdot E_{eff} \qquad [Equation\ 3]$$

where:

E_{eff} = effective irradiance at a distance d_1 from the UV-C device in μW/cm^2 or W/m^2 and weighted against a 270 nm source

$E_{eff@d_2}$ = effective irradiance at a distance d_2 from the UV-C device in μW/cm^2 or W/m^2 and weighted against a 270 nm source

For devices unable to be modelled by the inverse square law (such as collimated sources), the effective irradiance should be measured at all relevant distances.

3.1.3 Effective irradiance at a distance d_2 = 200 mm

The effective **irradiance** from UV-C devices should be determined in the direction where the highest **irradiance** occurs and at a fixed distance d_2 of 200 mm.

NOTE The distance d_2 of 200 mm derives from IEC 62471 [1] and should be used for all UV-C devices to make them comparable and to categorize them in the correct UV-C risk group

3.1.4 UV-C risk groups

The UV-C risk group of UV-C devices should be determined by $E_{eff@d_2\,=\,200mm}$ according to section 3.1.3, the exposure time (t) per 8 hours' time interval and the flow-chart of Figure 1.

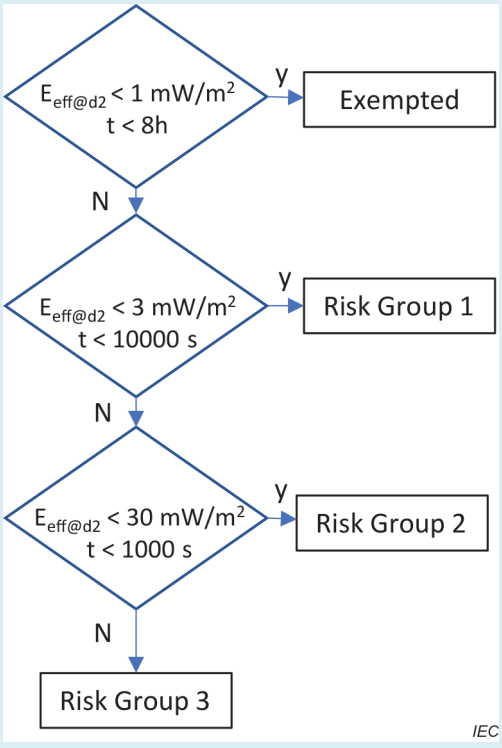

Figure 1 – UV-C Risk Groups (UV-C RGs)