SLOVENSKI STANDARD
SIST EN 14255-1:2005

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Merjenje in ugotavljanje izpostavljenosti oseb inkoherentnemu optičnemu sevanju na delovnem mestu – 1. del: Ultravijolično sevanje »umetnih« svetlobnih virov

Measurement and assessment of personal exposures to incoherent optical radiation - Part 1: Ultraviolet radiation emitted by artificial sources in the workplace

Messung und Beurteilung von personenbezogenen Expositionen gegenüber inkohärenter optischer Strahlung - Teil 1: Von künstlichen Quellen am Arbeitsplatz emittierte ultraviolette Strahlung

Mesurage et évaluation de l'exposition des personnes aux rayonnements optiques incohérents - Partie 1: Rayonnements ultraviolets émis par des sources artificielles sur les lieux de travail

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Foreword

This document (EN 14255-1:2005) has been prepared by Technical Committee CEN/TC 169 “Light and lighting”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.

This document includes a Bibliography.

EN 14255 *Measurement and assessment of personal exposures to incoherent optical radiation* is published in four parts:

— *Part 1 (this part): Ultraviolet radiation emitted by artificial sources in the workplace*

— *Part 2: Visible and infrared radiation emitted by artificial sources in the workplace (in preparation)*

— *Part 3: UV-Radiation — Natural sources (in preparation)*

— *Part 4: Terminology and quantities used in UV-, visible and IR-exposure measurements (in preparation)*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

People may be exposed to ultraviolet (UV) radiation in the workplace. The most important natural source for such UV-radiation is the sun. There are also artificial UV-radiation sources, where UV-radiation is intentionally emitted to achieve the purpose of the source's application (e.g. UV-lamps for drying of printing colours, UV-lamps for testing of material, lamps for UV-disinfection, UV-phototherapy of patients and solaria devices, etc.) or where UV-radiation is unintentionally produced (such as welding arcs, some types of lamps, etc.). Time spent near these artificial sources may result in significant UV-exposure.

When people are irradiated by UV-radiation, injuries may occur. The eyes and the skin may be damaged by short term UV-irradiation of high intensity. Typical injuries are photoconjunctivitis and photokeratitis of the eye and UV-erythema of the skin. Minor doses of UV-radiation may induce or aggravate some diseases like porphyria or lupus erythematosis or may trigger phototoxic and photoallergic reactions. But additionally, long term UV-irradiation may result in damage to the eyes and skin, such as cataracts, skin aging and skin cancer. In order to avoid short term injuries and reduce additional risks from long term UV-exposures national regulations and international recommendations require restriction of UV-exposures in the workplace. To achieve this, it is necessary to determine the level of UV-exposure and assess its gravity.

The determination of the level of UV-exposure can be done by measurement of the UV-exposure of the people likely to be exposed. Determination of the severity of an UV-exposure is normally done by comparison of the determined UV-exposure level with the required or recommended limit value. When the UV-exposure level complies with the limit value no further action is necessary. When the limit value is exceeded protective measures have to be applied in order to decrease the UV-exposure. As the exposure situation in the workplace may change, it may be necessary to repeat the determination and assessment of UV-exposure at a later time.

UV radiation exposure measurements are often costly and time consuming. So it is reasonable to avoid measurements if possible, i. e. if the personal UV radiation exposure can be estimated and either exceeds the limit values by far or is far below the limit values. In some cases, the manufacturer may have classified a device according to International Standards such as EN 12198 and CIE S009. Knowledge of the classification of all potential sources of UV may allow a sufficiently precise assessment of hazard to be made without further measurement. Another approach could be to use known spectral data of sources in combination with calculation software in order to estimate exposure level [6]. UV- exposure measurements are only necessary if it cannot be estimated in advance whether the limit values will be exceeded or not. So as a first step of the assessment procedure it is useful to carry out a preliminary review including an exposure estimation.

This document does not specify UV-exposure limit values. UV-exposure limit values are set in national regulations or provided by international organizations, such as the International Commission for Non-ionizing Radiation Protection (ICNIRP) [1-3]. This document specifies the procedures for measurement and assessment of UV-exposures in the workplace. As the results of measurement and assessment of UV-exposure depend on the method of implementation, it is important to carry out measurements and assessments in a standardised way.

1 Scope

This document specifies procedures for the measurement and assessment of personal exposures to ultraviolet (UV) radiation emitted by artificial sources, where adverse effects can not readily be excluded.

NOTE 1 Adverse effects will usually not occur in exposures caused by commonly used artificial lighting. However, exposures to very strong light sources or light sources with extended spectra may cause a health risk nevertheless.

This document applies to UV-exposures in indoor and outdoor workplaces. It does not apply to UV-exposures in leisure time.

This document does not apply to UV-exposure caused by the sun.

NOTE 2 Part 3 of this standard will deal with UV-exposure caused by the sun.

This document does not specify UV-exposure limit values. It supports the application of limit values set by national regulations or international recommendations.

This document applies to UV-exposures by artificial incoherent sources, which emit spectral lines as well as continuous spectra. This document does not apply to coherent radiation sources.

NOTE 3 Coherent optical radiation sources are covered by standards for lasers, like EN 60825-1 etc..

This document applies to UV-exposures in the wavelength band 180 nm to 400 nm.

This document does not apply to radiation exposures which concern the retina.

NOTE 4 Part 2 of this standard will address these effects.

This document does not apply to radiation emissions of products.

NOTE 5 For radiation emissions of products other standards apply, such as: EN 60335-2-27 (IEC 60335-2-27) for sunbeds, EN 60335-2-59 (IEC 60335-2-59) for insect killers and EN 12198 for radiation emissions of machinery.

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.

ENV 13005, *Guide to the expression of uncertainty in measurement.*

CIE 17.4:1987, *International lighting vocabulary — Chapter 845: lighting*.

3 Terms and definitions

3.1
Quantities, symbols and units

For the purposes of this document the terms and definitions given in CIE 17.4:1987 and the following apply. (see Table 1)

Table 1 — Symbols

Symbol	Quantity	Unit
λ	Wavelength	nm
E	Irradiance	W/m²
$E_\lambda(\lambda)$	Spectral irradiance	W/(m²·nm)
E_s	Ultraviolet hazard irradiance	W/m²
H	Radiant exposure	J/m²
$H_\lambda(\lambda)$	Spectral radiant exposure	J/(m²·nm)
H_s	Ultraviolet hazard radiant exposure	J/m²
Δt_{exp}	Exposure duration	s
$s(\lambda)$	Ultraviolet hazard weighting function	—

NOTE 1 CIE is the International Commission on Illumination (abbreviated as CIE from its French title)

Values for the spectral weighting function $s(\lambda)$ are to be taken from the set of limit values applied.

NOTE 2 E.g. if $s(\lambda)$ is chosen to correspond to the ICNIRP relative spectral effectiveness S_λ [1-3], the ultraviolet hazard irradiance E_s will correspond to the ICNIRP effective irradiance E_{eff} and the ultraviolet hazard radiant exposure H_s will correspond to the ICNIRP effective radiant exposure H_{eff} (see 6.2).

3.2
Relationships between quantities

3.2.1
irradiance *E*

calculated from the spectral irradiance $E_\lambda(\lambda)$ by:

$$E = \int_{\lambda_1}^{\lambda_2} E_\lambda(\lambda) d\lambda \qquad (1)$$

3.2.2
ultraviolet hazard irradiance E_s

wavelength integrated product of the spectral irradiance $E_\lambda(\lambda)$ and the ultraviolet hazard weighting function s(λ):

$$E_s = \int_{\lambda_1}^{\lambda_2} E_\lambda(\lambda) \cdot s(\lambda) \mathrm{d}\lambda \qquad (2)$$

3.2.3
spectral radiant exposure $H_\lambda(\lambda)$

integral of the spectral irradiance $E_\lambda(\lambda)$ with respect to exposure duration t_{exp}:

$$H_\lambda(\lambda) = \int_{\Delta t_{exp}} E_\lambda(\lambda)\mathrm{d}t \tag{3}$$

3.2.4
radiant exposure *H*
either calculated from the integral of the spectral radiant exposures $H_\lambda(\lambda)$ with respect to the wavelength range:

$$H = \int_{\lambda_1}^{\lambda_2} H_\lambda(\lambda)\,d\lambda \tag{4}$$

Or calculated from the integral of the irradiance *E* with respect to exposure duration Δt_{exp}:

$$H = \int_{\Delta t_{exp}} E(t)\mathrm{d}t \tag{5}$$

3.2.5
ultraviolet hazard radiant exposure H_s
either calculated from the spectral radiant exposure $H_\lambda(\lambda)$ by:

$$H_s = \int_{\lambda_1}^{\lambda_2} H_\lambda(\lambda)\cdot s(\lambda)\mathrm{d}\lambda \tag{6}$$

Or calculated from the ultraviolet hazard irradiance E_s by:

$$H_s = \int_{\Delta t_{exp}} E_s(\mathrm{t})\mathrm{d}t \tag{7}$$

4 General procedure

In order to measure and assess the UV-exposure in the workplace the following steps shall be carried out:

a) Preliminary Review

b) Work task analysis

c) Measurement of the UV-exposure

d) Assessment of the UV-exposure

e) Decision about protective measures

f) Decision about a repetition of the UV-exposure measurement and assessment

g) Preparation of a report

Details of these procedures are specified in Clauses 5 to 11.

NOTE 1 A flow chart showing the procedural steps is given in Annex A (informative).

NOTE 2 In some cases it is not necessary to carry out all of these steps, see Clause 5.

5 Preliminary Review

The preliminary review is required to determine whether or not a detailed hazard assessment based on measurements is necessary. All available information about the radiation source and the possible personal UV-exposure shall be gathered. It shall then be decided if an exposure measurement is necessary or if a statement can be made without a measurement that the exposure limit values are met or are exceeded.

NOTE If UV irradiances are known to be either insignificant or extreme, a precise assessment may be unnecessary. Where all sources have emission characteristics which can be described as trivial, or where occupancy is minimal, it may be impossible for a person to exceed the chosen exposure limits. Conversely, where emissions are significant and/or occupancy is high, it may be obvious that the limits will be exceeded and that some form of protective measures (see Clause 9) will be required. Useful information towards the preliminary review might be found from several origins:

- A device may have been classified according to standards such as EN 12198 [11 – 13] and CIE S009 [5]. Knowledge of the classification of all potential sources of UV- radiation may allow a sufficiently precise assessment of hazard to be made without further measurement.
- If sufficient UV radiation emission data are available for a device it may be possible to estimate the personal UV exposure.
- If data like spectrum (e.g. derived from the source temperature), geometry and exposure duration are available calculation of the personal exposure may be performed (e.g. by computer software [6]).

If a clear statement can be made that the personal UV-exposure is insignificant and that the exposure limit values will be met, no further action is necessary and Clauses 6 to 9 need not be applied.

If a clear statement can be made that the UV exposure limit value(s) will be exceeded, Clause 9 shall be applied. After the application of protective measures the assessment procedure shall be repeated starting with the preliminary review in Clause 5.

If it can not clearly be estimated in advance whether the limit value(s) will be met or exceeded the procedures specified in Clauses 6 to 11 shall be carried out.

If the gathered data show a potential exposure in the visible and infrared range, the corresponding hazard shall be assessed according to EN 14255-2.

A short report according to 11.1 shall be prepared. If measurements are carried out the short report may be presented as part of the full report according to 11.2.

6 Work task analysis

For the determination of ultraviolet radiant exposure in the workplace a detailed work task analysis shall be carried out. All activities during which persons may be exposed to ultraviolet radiation shall be considered. For each of these activities the exposure situation shall be carefully analysed. This analysis shall include determining:

- the number, position(s) and types (e.g. wavelength, geometry) of radiation sources to be considered;
- radiation which is reflected or scattered on walls, equipment, materials etc.
- the spectrum of the radiation to which persons are exposed;
- the spectrum can be determined by:
  - — measuring the spectrum in the position where persons are exposed
  - — information on the emission spectrum of the radiation source provided by the source's manufacturer or directly measured close to the source, if the spectrum at the position where persons are exposed is identical to the spectrum emitted by the radiation source.

NOTE The spectrum may be altered by scattering, reflection and absorption between the radiation source and the exposed persons.

- the constancy or the variation of the spectrum and/or the irradiance/radiance with time;
- the distance between the exposed person and the radiation source(s);
- changes in the location of the exposed person during the work shift (respective during the entire duration of exposure);
- the time(s) spent by persons at different locations in relation to the radiation source and the duration(s) of exposure at these locations;
- which potential health effects are to be taken into account (damage to the eyes, skin, short- and long-term effects, wave length ranges);
- which limit values are to be considered;
- enhanced photosensitivity, individual or collective, caused by:
  - — pathological predisposition or induced by use of medical drugs or cosmetics;
  - — chemical(s) present in the workplace environment;
- type and specifications of technical protective measures, if applied;
- whether personal protective equipment is used or not and, if so, which type and technical specifications;
- number of working shifts with UV-exposure per year.

For each of these activities information shall be complete enough to allow the exposure during a shift length to be determined. It is useful to record all the information about the exposure in Tables as shown in Annex B (informative).

7 Measurement of the exposure

7.1 Planning

The measurement shall be planned taking into account the measurement aim (survey measurement or measurement for comparison with limit values) and the exposure conditions. It is important to define which measuring methods will be used and how the measurement will be conducted. The following points shall be taken into account:

- quantities which are to be determined (see 7.2);
- radiation spectrum:
  - a) UV-A, UV-B, UV-C
  - b) continuous or line-spectrum;
- variation of the spectrum with time: constant or varying;
- variation of irradiance with time: constant or varying;
- level of exposure;
- the measuring range of the measurement device shall be adapted to the level of the exposure;

- places of staying and movement of the people whose exposures are to be measured (see 6);
- selection of a suitable measurement method (see 7.3);
- check if the necessary requirements for the measurement methods are met (see 7.4);
- personal radiation protection (see 7.5.2).

7.2 Quantities to be determined

The radiometric quantities to be measured shall be selected with reference to the quantities in which the limit values are specified. For the spectral region λ = 180 nm to 400 nm exposure limit values are recommended by international organizations, such as ICNIRP, or set by national authorities.

NOTE E.g. ICNIRP [1-3] recommends to determine the quantities:

- effective radiant exposure H_{eff} for λ = 180 nm to 400 nm
- radiant exposure H for λ = 315 nm to 400 nm
- irradiance E for λ = 315 nm to 400 nm

7.3 Selection of method

A complete method for the measurement of UV-exposure consists of the measurement device or devices used, the implementation and the evaluation of the results. In Annex C commonly used radiation measurement devices are described. In some methods not only radiation measurement devices but also time measuring systems are used.

When selecting a measurement method account shall be taken of the measurement aim, the exposure conditions and the radiation characteristics.

NOTE 1 Depending on the quantity to be determined various measurement methods are available. These methods and their advantages and disadvantages are described in Annex D (informative). In some situations it will be necessary to apply more than one method.

NOTE 2 In Table 2 methods are presented which are presently suitable for the measurement of UV-exposure depending on the measurement aim and the exposure conditions.