SIST

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Merjenje in ocenjevanje izpostavljenosti oseb inkoherentnemu optiļ nemu sevanju - 2. del: Vidno in infrardeļ e sevanje svetlobnih virov na delovnem mestu

Measurement and assessment of personal exposures to incoherent optical radiation - Part 2: Visible and infrared radiation emitted by artificial sources in the workplace

Messung und Beurteilung von personenbezogenen Expositionen gegenüber inkohärenter optischer Strahlung - Teil 2: Sichtbare und infrarote Strahlung künstlicher Quellen am Arbeitsplatz

Mesurage et évaluation de l'exposition des personnes aux rayonnements optiques incohérents - Partie 2 : Rayonnements visibles et infrarouges émis par des sources artificielles sur les lieux de travail

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Mesure et évaluation de l'exposition des personnes aux rayonnements optiques incohérents - Partie 2 : Rayonnements visibles et infrarouges émis par des sources artificielles sur les lieux de travail

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This European Standard was approved by CEN on 4 November 2005.

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Foreword

This European Standard (EN 14255-2:2005) 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of an identical text or by endorsement, at the latest by June 2006, and conflicting national standards shall be withdrawn at the latest by June 2006.

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

Part 1: Ultraviolet radiation emitted by artificial sources in the workplace.

Part 2 (this part): Visible and infrared radiation emitted by artificial sources in the workplace.

Part 3: UV-Radiation emitted by the sun (in preparation).

Part 4: Terminology and quantities used in UV-, visible and IR-exposure measurements.

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 adversely high levels of visible (VIS) and/or infrared (IR) radiation in the workplace. The most important natural source for such VIS/IR-radiation is the sun. There are also artificial VIS/IR-radiation sources, where VIS- and/or IR-radiation is either intentionally emitted to achieve the purpose of the source's application or is unintentionally emitted.

Visible optical radiation (VIS-radiation): Common applications for sources intentionally emitting visible optical radiation are: general lighting, signalling devices, initiation of industrial-, medical- or agricultural-photochemical processes and phototherapy of patients (e.g. hyperbilirubinemia- and bright light therapy, physiotherapy and photodynamic therapy). Some examples of sources where visible radiation is unintentionally emitted are: welding arcs, industrial furnaces and some types of UV-sources. When people are irradiated by intense VIS-radiation, injuries may occur. VIS-radiation can cause damage to the retina through thermal or photochemical mechanisms. Photosensitization of the skin to visible light, usually due to the action of certain drugs, plants, or other substances, may occur shortly after administration of the drug (phototoxic sensitivity), or may occur only after a latent period which can vary from days to months (photoallergic sensitivity, or photoallergy). VIS-radiation may also induce or aggravate some diseases like porphyria.

Infrared optical radiation (IR-radiation): Common applications for sources intentionally emitting infrared optical radiation are: radiative heaters, military nightsight devices, phototherapy of patients (e.g. physiotherapy and photodynamic therapy), industrial photochemical or photothermal processes. Some examples of sources, where infrared radiation is unintentionally emitted, are: welding arcs, some types of visible light sources (e.g. high power tungsten lamps) and industrial furnaces. When people are irradiated by intense IR-radiation, injuries may occur. The anterior structures of the eyes (cornea) and the skin may be damaged by short term IR-irradiation of high irradiance. Depending on the wavelength a certain fraction of IR radiation can also cause damage to the retina through thermal or photochemical mechanisms. But additionally, long term less intense IR-irradiation may also result in cumulative damage to the eyes and skin, such as cataracts and skin aging.

In order to avoid short term injuries and reduce additional risks from long term overexposure to VIS- and/or IR-radiation, national regulations and international recommendations require restriction of VIS/IR-exposure levels in the workplace. To achieve this, it is necessary to determine the level of VIS/IR-exposure and assess its gravity.

The determination of the level of VIS/IR-exposure can be done by measurement of the VIS/IR-exposure of the people likely to be exposed. Determination of the severity of a VIS/IR-exposure is normally done by comparison of the determined exposure level with the required or recommended limit value. When the 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 VIS/IR-exposure. As the exposure situation at the workplace may change, it may be necessary to repeat the determination and assessment of VIS/IR-exposure at a later time.

VIS/IR radiation exposure measurements are often costly and time consuming. So it is reasonable to avoid measurements if possible, i. e. if the personal VIS/IR 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 European and International Standards such as EN 12198 and CIE S009. Knowledge of the classification of all potential sources of VIS/IR 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 [5]. VIS/IR-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 European Standard does not specify VIS/IR-exposure limit values. VIS/IR-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]. This European Standard specifies the procedures for measurement and assessment of VIS/IR-exposures in the workplace. As the results of measurement and assessment of

VIS/IR-exposure depend on the method of implementation, it is important to carry out measurements and assessments in a standardised way.

1 Scope

This European Standard specifies procedures for the measurement and assessment of personal exposures to visible (VIS) and infrared (IR) radiation emitted by artificial sources, where adverse effects cannot be readily excluded.

NOTE 1 Adverse effects will normally not occur in exposures caused by normal lighting or room heating.

This European Standard applies to VIS- and IR- exposures in indoor and outdoor workplaces. It does not apply to VIS- and IR-exposures in leisure time.

This European Standard does not apply to VIS- and IR- exposures caused by the sun.

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

This European Standard does not specify VIS- and IR-exposure limit values. It supports the application of limit values set by national regulations or international recommendations.

This European Standard applies to VIS- and IR- exposures by artificial incoherent sources, which emit spectral lines as well as continuous spectra. This European Standard 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 European Standard applies to visible (VIS) and infrared (IR) radiation exposures in the wavelength band 380 nm to 3 µm. It also applies to radiation exposures that may present a blue-light hazard in the wavelength band 300 nm to 700 nm.

This European Standard does not apply to other effects of which the action spectra lie solely within the UV-region 180 nm to 400 nm.

NOTE 4 Part 1 of EN 14255 addresses these effects.

This European Standard does not apply to radiation emissions of products.

NOTE 5 For radiation emissions of products other standards apply, such as EN 12198 for radiation emissions of machinery, EN 60335-2-27 for household appliances for skin exposures to ultraviolet and infrared radiation and CIE S009 for the safety of lamps and lamp systems.

This European Standard does not apply to heat stress, i.e. long term heating of the humans body with strain of the cardiac/circular system caused by climatic environmental conditions including VIS/IR radiation.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. 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*

EN 14255-1, *Measurement and assessment of incoherent optical radiation — Part 1: Ultraviolet radiation by artificial UV-sources in the workplace*

CIE 17.4:1987, *International electrotechnical vocabulary, Chapter 845: lighting*

3 Terms and definitions

3.1 Quantities, symbols and units

Table 1 – Quantities, symbols and units

Symbol	Quantity	Unit
λ	wavelength	nm
$E_\lambda(\lambda)$	spectral irradiance	W/(m²·nm)
E	irradiance	W/m²
E_b	blue-light irradiance	W/m²
$H_\lambda(\lambda)$	spectral radiant exposure	J/(m²·nm)
H	radiant exposure	J/m²
H_b	blue-light radiant exposure	J/m²
$L_\lambda(\lambda)$	spectral radiance	W/(m²·nm·sr)
L	radiance	W/(m²·sr)
L_r	retinal thermal radiance	W/(m²·sr)
L_b	blue-light radiance	W/(m²·sr)
G	radiance dose	J/(m²·sr)
G_b	blue-light radiance dose	J/(m²·sr)
Δt_{exp}	exposure duration	s
$b(\lambda)$	blue-light hazard weighting function	-
$r(\lambda)$	retinal thermal hazard weighting function	-
D	actual source diameter	m
D_L	viewing source diameter	m
r	viewing distance	m
α	angular subtense	mrad
ϕ	viewing angle	° / mrad
γ	angle of acceptance	mrad

NOTE Values for the spectral weighting function like $b(\lambda)$ and $b(\lambda)$ can be taken from the set of limit values applied. E.g. if $b(\lambda)$ is chosen to correspond to the ICNIRP relative spectral effectiveness $B(\lambda)$ [1,3], the blue-light irradiance E_b will correspond to the ICNIRP blue-light hazard weighted irradiance E_B and the blue-light radiant exposure H_b will correspond to the ICNIRP blue-light hazard weighted radiant exposure H_B (see 7.2).

3.2 Definitions and relationships between quantities

For the purposes of this European Standard, the terms and definitions given in CIE 17.4:1987 and the following apply.

3.2.1
irradiance
E
is calculated from the spectral irradiance $E_\lambda(\lambda)$ by:

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

3.2.2
blue-light irradiance
$\boldsymbol{E_\mathrm{b}}$
integral of the product of the spectral irradiance $E_\lambda(\lambda)$ and the blue-light hazard weighting function $b(\lambda)$:

$$E_\mathrm{b} = \int_{\lambda_1}^{\lambda_2} E_\lambda(\lambda)b(\lambda)\mathrm{d}\lambda \tag{2}$$

3.2.3
spectral radiant exposure
$\boldsymbol{H_\lambda(\lambda)}$
integral of the spectral irradiance $E_\lambda(\lambda)$ with respect to the exposure duration Δt_exp:

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

3.2.4
radiant exposure
H
integral of the irradiance E with respect to the exposure duration Δt_exp:

$$H = \int_{\Delta t_\mathrm{exp}} E(t)\mathrm{d}t \tag{4}$$

The radiant exposure H is calculated from the integral of the spectral radiant exposure $H_\lambda(\lambda)$:

$$H = \int_{\lambda_1}^{\lambda_2} H_\lambda(\lambda)\mathrm{d}\lambda \tag{5}$$

3.2.5
blue-light radiant exposure
$\boldsymbol{H_\mathrm{b}}$
integral of the blue-light irradiance E_b with respect to the exposure duration Δt_exp:

$$H_\mathrm{b} = \int_{\Delta t_\mathrm{exp}} E_\mathrm{b}\mathrm{d}t \tag{6}$$

The blue-light radiant exposure H_b can also be calculated from the spectral radiant exposure $H_\lambda(\lambda)$ and the blue-light hazard weighting function $b(\lambda)$:

$$H_b = \int_{\lambda_1}^{\lambda_2} H_\lambda(\lambda) b(\lambda) \mathrm{d}\lambda \quad (7)$$

3.2.6
radiance
L
is calculated from the spectral radiance $L_\lambda(\lambda)$ by:

$$L = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) \mathrm{d}\lambda \quad (8)$$

3.2.7
retinal thermal radiance
$\boldsymbol{L_r}$
integral of the product of the spectral radiance $L_\lambda(\lambda)$ and the retinal thermal hazard weighting function $r(\lambda)$:

$$L_r = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) r(\lambda) \mathrm{d}\lambda \quad (9)$$

3.2.8
blue-light radiance
$\boldsymbol{L_b}$
integral of the product of the spectral radiance $L_\lambda(\lambda)$ and the blue-light hazard weighting function $b(\lambda)$:

$$L_b = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) b(\lambda) \mathrm{d}\lambda \quad (10)$$

3.2.9
radiance dose
G
integral of the radiance L with respect to the exposure duration Δt_{exp}:

$$G = \int_{\Delta t_{exp}} L \mathrm{d}t \quad (11)$$

3.2.10
blue-light radiance dose
$\boldsymbol{G_b}$
integral of the blue-light radiance L_b with respect to the exposure duration Δt_{exp}:

$$G_b = \int_{\Delta t_{exp}} L_b \mathrm{d}t \quad (12)$$

3.2.11
actual source diameter
D

— the circle diameter, if the source is circular;

— the arithmetic mean of the longest and shortest dimension, if the source is oblong

3.2.12
viewing source diameter
D_L
given by:

$$D_L = D\cos\varphi \qquad (13)$$

3.2.13
viewing distance
distance between the centre of the source and the eye respective the detector

3.2.14
angular subtense
α
given by:

$$\alpha = D_L / r \qquad (14)$$

3.2.15
viewing angle
ϕ
angle between the normal of the source and the line of sight

3.2.16
angle of acceptance
γ
largest angle between all directions in which a radiation detector is sensitive

4 General procedure

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

a) Preliminary review

b) Work task analysis

c) Measurement of the exposure

d) Assessment of the exposure

e) Decision about protective measures

f) Decision about a repetition of the 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 VIS/IR-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 VIS/IR 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 [10], [11], [12] and CIE S009 [3]. Knowledge of the classification of all potential sources of VIS/IR-radiation may allow a sufficiently precise assessment of hazard to be made without further measurement.

- If sufficient VIS/IR-radiation emission data are available for a device it may be possible to estimate the personal VIS/IR-exposure.

- If data like spectrum (e.g. derived from the source temperature), geometry and exposure time are available calculation of the personal exposure may be performed (e.g. by computer software [5]).

If a clear statement can be made that the personal VIS/IR-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 VIS/IR-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 cannot 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 UV- range, the corresponding hazard shall be assessed according to EN 14255-1.

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 visible and infrared radiation exposures in the workplace a detailed work task analysis shall be carried out. All activities during which persons may be exposed to VIS- and IR- radiation shall be considered. For each of these activities the exposure situation shall be carefully analysed. This analysis includes 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:

  a) by measuring the spectrum in the position where persons are exposed,

b) by calculation of the spectrum for a known temperature and emission coefficient of the source (black body radiation calculation),

NOTE 1 The spectrum may be altered by scattering, reflection and absorption between the radiation source and the exposed persons.

c) by 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 2 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 radiation flux density with time;
- the distance between the exposed person and the radiation source(s);
- the changes in the location of the exposed person during the work shift (respective during the entire time of exposure);
- the time(s) spent by persons at different locations in relation to the radiation source(s) and the time(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, wavelength ranges);
- which limit values are to be considered;
- whether personal protective equipment is used or not and, if so, which type and technical specifications;
- number of working shifts with VIS- and/or IR-exposures 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:
  - — UV, VIS, IR,
  - — continuous or line-spectrum;
- variation of the spectrum with time: constant or varying;
- variation of radiation flux density with time: constant or varying;