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BSI Standards Publication

Classification of non-electrical sources of incoherent optical radiation

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National foreword

This British Standard is the UK implementation of EN 16237:2013.

The UK participation in its preparation was entrusted to Technical Committee EL/1, Light and lighting applications.

This standard has limited application, as the main sources of incoherent optical radiation are either electrical or associated with machines, and hence beyond the scope of this standard, but are covered in:

EN 12198-1:2000+A1:2008;
EN 60825-1:2007;
EN 62471:2008.

It is the view of EL/1 that BS EN 16237:2013 does not cover solar radiation; however, solar radiation is not specifically excluded.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Date	Text affected
30 June 2013	Insertion of additional national foreword text

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16237

January 2013

ICS 17.180.20; 17.240

English Version

Classification of non-electrical sources of incoherent optical radiation

Classification des sources non électriques de rayonnement optique incohérent

Klassifizierung nicht elektrisch betriebener Quellen inkohärenter optischer Strahlung

This European Standard was approved by CEN on 1 December 2012.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 16237:2013) 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of an identical text or by endorsement, at the latest by July 2013, and conflicting national standards shall be withdrawn at the latest by July 2013.

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Introduction

Optical radiation consists of the spectral regions covered by ultraviolet, visible and infrared radiation. Sources of incoherent optical radiation are used both in workplaces and privately. The radiation may intentionally be applied to carry out a specific task or may occur unintentionally as a by-product. Some sources are powered electrically, others are powered non-electrically, e.g. by gas or other fuels. Examples for non-electrically powered sources are burners, furnaces, heaters, gas welding, thermal cutting, chemical torches, hot materials etc.

People staying near to or working in the vicinity of such sources may be exposed to optical radiation. Depending on the level of exposure, injuries may occur to the skin and/or to the eyes. In order to avoid such injuries, European [1] and national legislation require the determination of exposures and the assessment of the associated risks in workplaces. In addition, maximum allowed optical radiation exposure limit values are set by legislation. Workers must not exceed these exposure limit values. If necessary, exposure reduction measures have to be applied.

Optical radiation exposures can be determined by several procedures: measurements, calculations, derivations from source emission data, etc. Not all of these procedures are appropriate in every case. Exposure measurements can be made in accordance with EN 14255-1 and EN 14255-2, but are expensive and time consuming. Generally, it is preferable to carry out a risk assessment without expensive measurements, if possible. Calculations of exposures may be done with the aid of software such as Catrayon[1)] [3], but not in all cases. If quantitative emission data from the source are available, the user may in some cases estimate the possible exposure of people in the vicinity of the radiation source.

A simpler approach for risk assessment is the classification of the optical radiation emissions. If such an emission classification is available, the user may easily assess the risk from use of the source. Emission classifications are already provided by standards for laser devices (EN 60825-1) [8] and for machinery (EN 12198-1) [7] as well as for lamps and lamp systems (EN 62471) [9]. This present standard provides a specific emission classification for non-electrically powered optical radiation sources.

The classification in this standard is intended to be user-friendly. The emission classes depend on the duration Δt_{max} beyond which the exposure limit values of the European directive on artificial optical radiation 2006/25/EC [1] may be exceeded. By comparing the actual exposure duration occurring at the workplace with Δt_{max}, the user can easily estimate if the exposure limit values may or may not be exceeded. Therefore, for a classified source, a risk assessment as required by Directive 2006/25/EC can easily be carried out.

The measurement of the optical radiation emission for the classification of the source is always carried out at a standard distance and at greater distances if that is where emission is at the maximum. Therefore, this classification represents the worst case exposure. This is appropriate if people are likely to be in the vicinity. However, sources are often operated in such a way that people will be further away than the worst-case location. For these applications, a classification shall be made not only for the worst case, but in addition for normal use conditions. The source classification measurements shall then be made for several distances around the source including the normal operating distance(s). As a result, emission classes are produced depending on the distance or even iso-emission-class lines around the source. The user is then able to estimate more easily the maximum possible exposure under normal use conditions and also under worst case conditions.

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1) Catrayon is an example of a suitable software available commercially. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN or CENELEC of this product.

There is a limitation of the concept of risk assessment with classified sources. A risk assessment can only be carried out if the classified source contributes predominantly to the optical radiation exposure of people. If there are several optical radiation sources that significantly contribute to the exposure, the risk assessment has to be carried out in a different way, e.g. by measurement of the exposure and comparison with the exposure limit values. In many cases however, one source will be predominant and an easy risk assessment can be carried out using the emission classification. Therefore, emission classification of a source forms a practical approach.

1 Scope

This European Standard provides a scheme for the classification of artificial non-electrical sources of incoherent optical radiation with regard to their radiation emissions. It helps users of the sources to easily carry out a risk assessment when people can be exposed to radiation from the sources.

This standard applies for sources emitting optical radiation in the wavelength between 180 nm and 3 000 nm.

This standard does not apply for electrically powered sources.

This standard does not apply for machinery, for laser devices and for lamps and lamp systems.

NOTE A classification for machinery is given in EN 12198-1 [7], a classification for laser devices is given in EN 60825-1 [8] and a classification for lamps and lamp systems is given in EN 62471 [9].

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14255-1:2005, *Measurement and assessment of personal exposures to incoherent optical radiation — Part 1: Ultraviolet radiation emitted by artificial sources in the workplace*

EN 14255-2:2005, *Measurement and assessment of personal exposures to incoherent optical radiation — Part 2: Visible and infrared radiation emitted by artificial sources in the workplace*

EN 14255-4:2006, *Measurement and assessment of personal exposures to incoherent optical radiation — Part 4: Terminology and quantities used in UV-, visible and IR-exposure measurements*

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14255-4:2006 and the following apply.

3.1
emission class
characteristic of an optical source which reflects the level of optical radiation emission at a specified distance

Note 1 to entry: Emission classes in this standard are correlated to maximum exposure durations Δt_{max} according to Tables 2, 3, 4 and 5.

3.2
maximum exposure duration
Δt_{max}
time duration up to which a person being exposed to optical radiation does not exceed the exposure limit values

Note 1 to entry: Exposure limit values associated with Δt_{max} in this standard are taken from the European Directive on artificial optical radiation 2006/25/EC [1].

3.3
irradiance
E
quotient of the radiant power incident on an element of a surface by the area of that element

Note 1 to entry: See also CIE 17.4 [5].

Note 2 to entry: The irradiance E may be defined for a specified wavelength-band, e.g. 315 nm to 400 nm (UV-A), 380 nm to 3 000 nm (visible and IR-A and IR-B), 780 nm to 3 000 nm (IR-A and IR-B).

3.4
ultraviolet hazard irradiance
E_s
irradiance spectrally weighted with the ultraviolet hazard weighting function $s(\lambda)$, given by:

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

[SOURCE: EN 14255-4]

Note 1 to entry: Values for the function $s(\lambda)$ are specified in EU directive 2006/25/EC in the wavelength range 180 nm to 400 nm.

3.5
retinal thermal radiance
L_r
radiance spectrally weighted with the retinal thermal hazard weighting function $r(\lambda)$, given by:

$$L_r = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) r(\lambda) \mathrm{d}\lambda \tag{2}$$

[SOURCE: EN 14255-4]

Note 1 to entry: The retinal thermal radiance can be defined in specific wavelength bands e.g. 380 nm to 1 400 nm and 780 nm to 1 400 nm. See Table 4.

3.6
blue-light radiance
L_b
radiance spectrally weighted with the blue-light hazard weighting function $b(\lambda)$, given by:

$$L_b = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) b(\lambda) \mathrm{d}\lambda \tag{3}$$

[SOURCE: EN 14255-4]

Note 1 to entry: Values for the function $b(\lambda)$ are specified in EU directive 2006/25/EC in the wavelength range 300 nm to 700 nm.

3.7
blue-light irradiance
E_b
irradiance spectrally weighted with the blue-light hazard weighting function $b(\lambda)$, given by:

$$E_b = \int_{\lambda_1}^{\lambda_2} E_\lambda(\lambda) b(\lambda) \mathrm{d}\lambda \tag{4}$$

[SOURCE: EN 14255-4]

Note 1 to entry: Values for the function $b(\lambda)$ are specified in EU directive 2006/25/EC in the wavelength range 300 nm to 700 nm

3.8
optical radiation
electromagnetic radiation in the wavelength range between 100 nm and 1 mm

3.9
incoherent optical radiation
optical radiation with no constant phase-relationship between any two points in space and time

Note 1 to entry: In practice, this means optical radiation other than laser radiation.

3.10
angular subtense of the source
α
plane angle in radians under which a source is seen from the point of observation, given by:

$$\alpha = D / r \tag{5 a}$$

where

D diameter of the source

r distance between source and point of observation

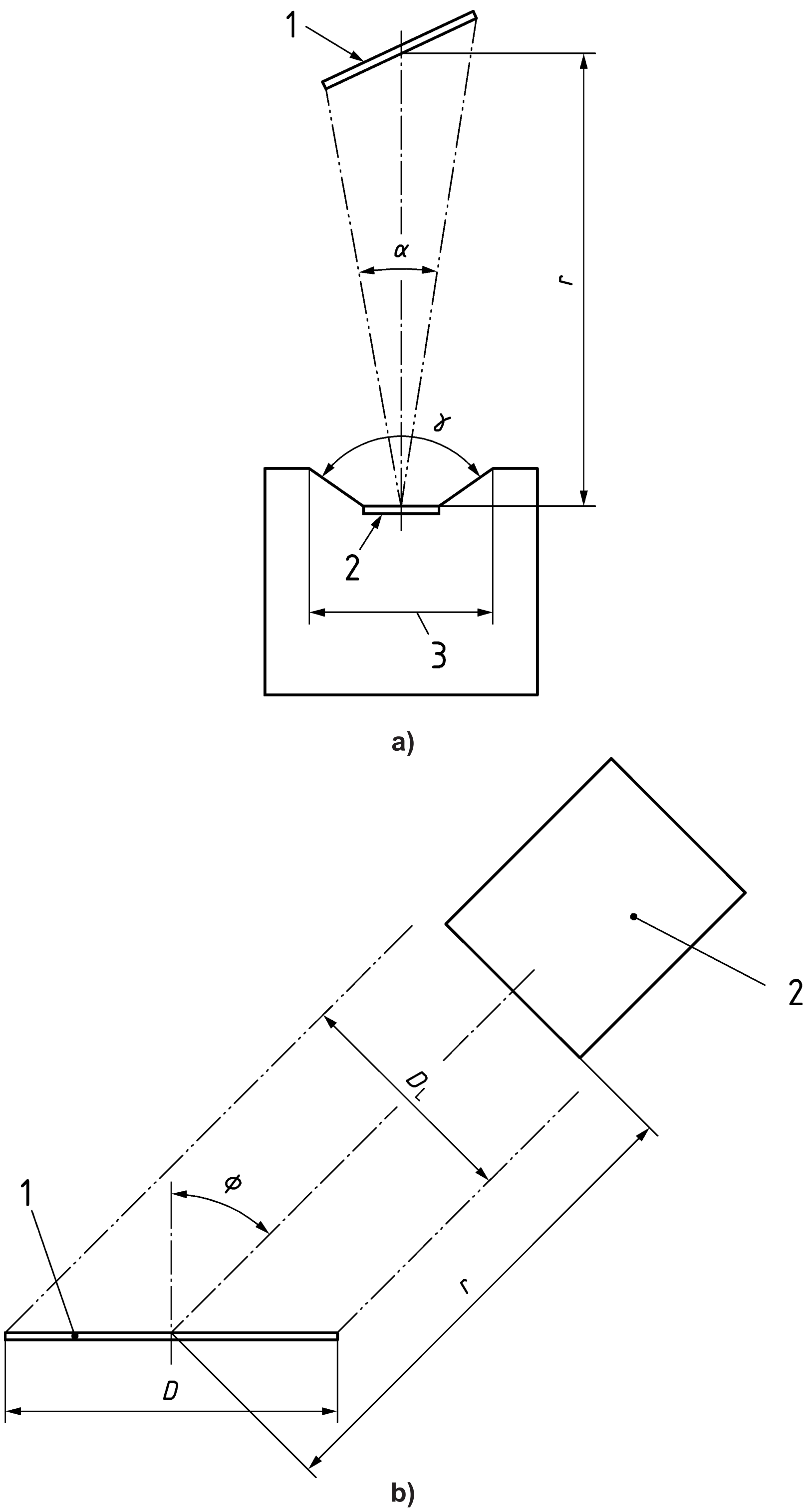
If the surface of the source is not perpendicular to the line of sight, the diameter of the source D is replaced by the viewing source diameter D_L. In this case, the angular subtense of the source α is given by:

$$\alpha = D_L / r \tag{5 b}$$

where

D_L viewing source diameter (see EN 14255-4)

r distance between source and point of observation



Key

1 source
2 detector
3 aperture
α angular subtense of the source
D diameter of the source
r distance between source and point of observation
γ angle of acceptance
ϕ viewing angle
D_L viewing source diameter (see EN 14255-4)

Figure 1 — Angle of acceptance γ of the detector and angular subtense α of the source (simplified drawings)

3.11
source diameter
D
diameter of the circle, if the source is circular,

or

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

[SOURCE: EN 14255-4]

3.12
angle of acceptance
γ
largest plane angle between all directions in which a radiation detector is sensitive

Note 1 to entry: In practical applications the angle of acceptance is determined by both the choice of an aperture and the distance between this aperture and the detector (see Figure 1a).

Note 2 to entry: The angle of acceptance γ is a property of a radiation detector. It should not be confused with the angular subtense α, which is a property of the radiation source.

[SOURCE: EN 14255-4]

4 Classification

4.1 General

The radiation emissions of the source shall be determined by measurement or reliable estimation. Measurements shall be done according to Clause 5. Subsequently the source shall be assigned a class between 0 and 6, based upon the measured or reliably estimated emissions, according to the classification scheme in 4.2.

The classification shall be done for each wavelength band (ultraviolet, visible and infrared) and for all quantities specified in Tables 1 to 5. In wavelength bands where the emissions are reliably known to be insignificant, the source can be assigned to Class 0. The highest emission class of all quantities in all wavelength bands shall then be assigned to the source. Emission measurements for the classification of the source shall be carried out at points specified in 5.4.3. Hence the emission class finally assigned to the source represents the worst case when people may be exposed to the source.

If the assigned emission class is greater than 0, it shall be provided in the information for use of the source and marked on the source.

If during normal use of the source people stay farther than the distance for which the standard worst-case classification is done (see 5.4.3.1), then classifications shall also be done for the distance(s) of the normal use (see 5.4.3.2). The emissions in different normal use conditions shall then be determined and iso-emission-class lines around the source shall be provided (see 5.4.3.2).

NOTE Under some unusual conditions of use (such as servicing, maintenance or repair) the classification might no longer be valid.

4.2 Emission classes

4.2.1 General

Emission classes are specified in Tables 2 to 5 depending on the optical radiation emission levels with respect to the following quantities:

— ultraviolet hazard irradiance E_s (180 nm to 400 nm);

— irradiance E (315 nm to 400 nm);

— blue-light radiance L_b (300 nm to 700 nm);

— blue-light irradiance E_b (300 nm to 700 nm);

— retinal thermal radiance L_r (380 nm to 1 400 nm);

— retinal thermal radiance L_r (780 nm to 1 400 nm);

— irradiance E (780 nm to 3 000 nm);

— irradiance E (380 nm to 3 000 nm).

NOTE 1 The emission classes in Tables 2 to 5 are specified for emission levels which correlate to exposure durations Δt_{max} beyond which the exposure limit values of the European Directive on artificial optical radiation 2006/25/EC [1] may be exceeded.

NOTE 2 Measurement quantities are designated with different names in standards and in the EU-Directive 2006/25/EC. In Table 1, the quantity names used in EN 14255-1, EN 14255-2, EN 14255-4 and in this standard are listed together with the equivalent names used in EU-Directive 2006/25/EC. The wavelength ranges in which the quantities are applied are the same in the standards and the EU-Directive.

Table 1 — Names of measuring quantities in EN 14255-1, EN 14255-2, EN 14255-4 and this standard and equivalent names for the same quantities in EU-Directive 2006/25/EC

Name of quantity in EN 14255-1, EN 14255-2, EN 14255-4 and this standard		Name of quantity in EU-Directive 2006/25/EC	
E_s (180 nm to 400 nm)	ultraviolet hazard irradiance	E_{eff}	effective irradiance
E (315 nm to 400 nm)	irradiance	E_{UVA}	total irradiance (UVA)
L_b (300 nm to 700 nm)	blue light radiance	L_B	effective radiance (blue light)
E_b (300 nm to 700 nm)	blue light irradiance	E_B	effective irradiance (blue light)
L_r (380 nm to 1 400 nm)	retinal thermal radiance	L_R	effective radiance (thermal injury) (used in wavelength 380 nm to 1 400 nm)
L_r (780 nm to 1 400 nm)	retinal thermal radiance	L_R	effective radiance (thermal injury) (used in wavelength 780 nm to 1 400 nm)
E (780 nm to 3 000 nm)	irradiance	E_{IR}	total irradiance (thermal injury)
E (380 nm to 3 000 nm)	irradiance	E_{skin}	total irradiance (visible, IRA and IRB)

4.2.2 UV-emissions potentially causing eye and skin hazards

Emission classes with respect to UV-emissions potentially causing eye and skin hazards are specified in Table 2.

Table 2 — Source classification by radiation emissions with respect to ultraviolet hazard irradiance E_s (180 nm to 400 nm) and UV-A irradiance E (315 nm to 400 nm)

Emission class	Δt_{max}	E_s (180 nm to 400 nm) mW/m²	E (315 nm to 400 nm) W/m²
0	24 h	≤ 0,35	≤ 0,12
1	8 h	0,35 < E_s ≤ 1,0	0,12 < E ≤ 0,35
2	2,5 h	1,0 < E_s ≤ 3,3	0,35 < E ≤ 1,1
3	1 h	3,3 < E_s ≤ 8,3	1,1 < E ≤ 2,8
4	20 min	8,3 < E_s ≤ 25	2,8 < E ≤ 8,3
5	5 min	25 < E_s ≤ 100	8,3 < E ≤ 33
6	< 5 min	> 100	> 33

NOTE The term ultraviolet hazard irradiance E_s as defined in EN 14255-4 is equivalent to the term effective irradiance E_{eff} in the EU Directive 2006/25/EC [1]; irradiance E (315 nm to 400 nm) as defined in EN 14255-4 is equivalent to the term E_{UVA} in the EU Directive 2006/25/EC [1].

4.2.3 UV- and visible emissions potentially causing blue-light hazard

Emission classes with respect to UV- and visible emissions potentially causing blue-light hazard are specified in Table 3.

Table 3 — Source classification by radiation emissions with respect to blue-light radiance L_b (300 nm to 700 nm) and blue-light irradiance E_b (300 nm to 700 nm)

Emission class	Δt_{max}	L_b W/(m²sr)	E_b mW/m²
0	24 h	≤ 100	≤ 10
1	8 h	-	-
2	2,5 h	100 < L_b ≤ 111	10 < E_b ≤ 11
3	1 h	111 < L_b ≤ 278	11 < E_b ≤ 28
4	20 min	278 < L_b ≤ 833	28 < E_b ≤ 83
5	5 min	833 < L_b ≤ 3333	83 < E_b ≤ 333
6	< 5 min	> 3 333	> 333

NOTE 1 Blue-light radiance L_b is equivalent to effective radiance (blue light) L_B in the EU Directive 2006/25/EC [1]; blue-light irradiance E_b is equivalent to effective irradiance (blue light) E_B in the EU Directive 2006/25/EC [1].

NOTE 2 For classification regarding blue-light radiance and irradiance there is no emission class 1.

NOTE 3 The classification in column E_b is only relevant to intended fixated viewing of small sources with an angular subtense α less than 11 mrad.

4.2.4 Visible and IR-emissions potentially causing retinal thermal hazard

Emission classes with respect to visible and IR-emissions potentially causing retinal thermal hazard are specified in Table 4.

Table 4 — Source classification by radiation emissions with respect to retinal thermal radiance L_r (380 nm to 1 400 nm) and L_r (780 nm to 1 400 nm)

Emission class	Δt_{max}	L_r (380 nm to 1400 nm) W/(m²sr)	L_r (780 nm to 1400 nm) W/(m²sr)
0	24 h	≤ 2,8 * $10^7/C_\alpha$	≤ 6 * $10^6/C_\alpha$
1	8 h	-	-
2	2,5 h	-	-
3	1 h	-	-
4	20 min	-	-
5	5 min	-	-
6	< 5 min	> 2,8 * $10^7/C_\alpha$	> 6 * $10^6/C_\alpha$
NOTE For classification regarding retinal thermal radiance there are no emission classes 1 to 5.			

In order to classify a source with respect to the retinal thermal radiance L_r (380 nm to 1 400 nm) not only L_r (380 nm to 1 400 nm) shall be measured but also the angular subtense α of the source. For sources with an angular subtense α less than or equal to 1,7 mrad, C_α shall be set to 1,7. For sources with an angular substance α between 1,7 mrad and 100 mrad, C_α is equal to α, but is dimensionless. For sources with an angular subtense α equal to or larger than 100 mrad, C_α shall be set to 100.

In order to classify a source with respect to the retinal thermal radiance L_r (780 nm to 1 400 nm) not only L_r (780 nm to 1 400 nm) shall be measured but also the angular subtense α of the source. For sources with an angular subtense α less than or equal to 11 mrad, C_α shall be set to 11. For sources with an angular substance α between 11 mrad and 100 mrad, C_α is equal to α, but is dimensionless. For sources with an angular subtense α equal to or larger than 100 mrad, C_α shall be set to 100.

4.2.5 Visible and IR-emissions potentially causing cornea and lens hazards and skin burning hazard

Emission classes with respect to visible and IR-emissions potentially causing cornea and lens hazards and skin burning hazard are specified in Table 5.

Table 5 — Source classification by radiation emissions with respect to irradiance E (780 nm to 3 000 nm) potentially causing cornea and lens hazards and irradiance E (380 nm to 3 000 nm) potentially causing skin burning hazard

Emission class	Δt_{max}	E (780 nm to 3 000 nm) W/m²	E (380 nm to 3 000 nm) W/m²
0	24 h	≤ 100	< 300
1	8 h	-	-
2	2,5 h	-	300 < E ≤ 580
3	1 h	-	580 < E ≤ 660
4	20 min	-	660 < E ≤ 690
5	5 min	100 < E ≤ 250	690 < E ≤ 1100
6	< 5 min	> 250	> 1100

NOTE 1 Irradiance E (780 nm to 3 000 nm) is equivalent to E_{IR} in the EU Directive 2006/25/EC [1]; irradiance E (380 nm to 3 000 nm) is equivalent to E_{skin} in the EU Directive 2006/25/EC [1].

NOTE 2 For classification regarding cornea and lens hazards, there are no emission classes 1 to 4 specified by the emission value E (780 nm to 3 000 nm).

NOTE 3 For classification regarding the skin burning hazard, there is no emission class 1 specified by the emission value E (380 nm to 3 000 nm).

NOTE 4 Values of E (380 nm to 3 000 nm) for the specification of emission classes are derived from a calculation model for pain sensation and standard specification for heat stress; see Annex B.

4.3 Additional information for class 6 emissions

If, for any quantity specified in 4.2, the determined emission value exceeds the upper reference value of class 5 then the value(s) shall be indicated.

NOTE This additional information supports carrying out risk assessments according to EU Directive 2006/25/EC.

4.4 Procedures for the classification for non-constant radiation emissions

4.4.1 UV-emissions potentially causing eye and skin hazards

For time varying UV emissions, the classification reference values specified in Table 2 apply as mean values averaged over the corresponding Δt_{max}. The measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

4.4.2 UV- and visible emissions potentially causing blue-light hazard

For time varying UV- and visible emissions, the classification reference values specified in Table 3 apply as mean values averaged over the corresponding Δt_{max}. The measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

4.4.3 Visible and IR-emissions potentially causing retinal thermal hazard

For time varying visible and IR-emissions, the classification reference values specified in Table 4 apply as maximum values within the corresponding Δt_{max}. The measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

4.4.4 Visible and IR-emissions potentially causing cornea and lens hazards and skin burning hazard

For time varying IR-emissions, the classification reference value for E (780 nm to 3 000 nm) specified in Table 5, potentially causing cornea and lens hazards, apply as maximum values within the corresponding Δt_{max}. The measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

For time varying visible and IR-emissions, the classification reference values for E (380 nm to 3 000 nm) specified in Table 5, potentially causing skin burning hazard, apply as maximum values within the corresponding Δt_{max}. The measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

5 Procedures for determining optical radiation emissions

5.1 General

In order to classify an optical radiation source, the optical radiation emissions around the source shall either be determined by reliable estimations, measurements or a combination of both techniques.

NOTE Estimations may be based on e.g. black body emission laws, inverse square law and software models like CATRAYON [3] or published emission data. Estimation is considered reliable if, in consideration of the estimation uncertainty, the resulting classification based on the estimation leads to an unambiguous result.

5.2 Physical quantities

The physical quantities to be determined are specified in 4.2.

5.3 Measurement methods

5.3.1 Selection of suitable methods

Suitable measurement methods and apparatus can be selected using 7.3 and Annexes C and D of EN 14255-1:2005 for UV-emissions as well as 7.3 and Annexes C and E of EN 14255-2:2005 for visible and IR-emissions. There are however some deviations: For measuring E_s only step 1 of method A or steps 1 and 3 of methods B and C in Annex D of EN 14255-1:2005 are applicable. For measuring E (380 nm to 3 000 nm) only step 1 of method X in E.9 of EN 14255-2:2005 is applicable.

NOTE Suitable measurement methods are given in Annex C.

5.3.2 Suitable apparatus

Surveys of commonly used radiation measurement devices are provided in Annex C of EN 14255-1:2005 and Annex C of EN 14255-2:2005. From these surveys, devices shall be taken which are capable to measure irradiance and radiance quantities according to 4.2.

5.3.3 Requirements

The measurement methods shall meet the requirements specified in 5.3.3.1 to 5.3.3.10.

NOTE These requirements are based on EN 14255-1:2005, 7.4 and EN 14255-2:2005, 7.4.

5.3.3.1 Uncertainty

The measurement uncertainty shall be such that the measured emissions may be unambiguously assigned to particular classes according to Tables 2 to 5. If due to measurement uncertainty the assignment of different classes is possible, the higher emission class shall be chosen.

The uncertainty shall be determined in accordance with ENV 13005.

5.3.3.2 Measurement dynamic range

For each quantity, the measurement dynamic range shall at least cover the range between the highest specified emission value of class 0 and the lowest specified emission value of class 6. If the worst-case emission class is 6, the method shall also be able to determine the actual emission value (see 4.3). The measurement uncertainty shall be taken into account when considering dynamic ranges.

NOTE In order to cover the whole range, more than one measurement method may be needed.

5.3.3.3 Spectral sensitivity of the detector system

The spectral sensitivity of the measurement system shall be known.

NOTE For broadband radiometers of which the spectral sensitivity is declared to fit the weighting function $s(\lambda)$, $b(\lambda)$ or $r(\lambda)$ this information can be used to calculate the degree of matching $s(\lambda)$, $b(\lambda)$ or $r(\lambda)$.

5.3.3.4 Active detector area, aperture and field of view

5.3.3.4.1 Measurement of irradiance

If the radiation field is inhomogeneous, the active detector area shall be sufficiently small so that any geometric variation in the flux density of radiation incident to the detector system is small.

NOTE If the detector area is too large, the active area can be limited by using an aperture and the measurement results corrected accordingly. The active detector area is small enough if repeated measurements with a smaller active area do not change the resulting class or, in case of class 6, do not change the resulting measurement values significantly.

5.3.3.4.2 Measurement of radiance

The detectors field of view (angle of acceptance γ) shall meet the specifications listed in Table E.1 of EN 14255-2:2005.

5.3.3.5 Cosine angular response

For irradiance and radiance measurements, the angular response within ± 60° of the central axis of the detector shall be within ± 5 % of cosine function.

The angular response should be determined including any optical elements located in the front of the detector.

5.3.3.6 Averaging time

For time-varying radiation flux densities, the detector response time shall be sufficient to allow the variation in time to be resolved.

The measurement duration shall either include the complete Δt_{max}, or, if the radiation flux density is constant or varies in a regular fashion, a measurement time shall be selected which is representative of the complete Δt_{max}.

Where classification is based on mean emission values (see Tables 2 and 3 as well as 4.4.1 and 4.4.2), the measurement time and duration shall be selected so that the result represents a mean value over the corresponding Δt_{max}.

Where classification is based on the maximum emission values (see Tables 4 and 5 as well as 4.4.3 and 4.4.4), the measurement time and duration shall be selected so that the result represents the maximum within the corresponding Δt_{max}.

5.3.3.7 Environmental conditions

All environmental conditions which might affect the measurement shall be considered, like temperature, humidity, dust, electromagnetic fields etc. Under the environmental conditions present at the place of measurement, the uncertainty requirement shall be met.

5.3.3.8 Calibration

Calibration shall be traceable to a national standards laboratory. Calibration intervals shall be selected with regard to the uncertainty requirement.

5.3.3.9 Wavelengths range

Broad band measurement systems shall be sensitive across the whole wavelength range as specified in 4.2.1 for the quantity to be measured but shall not be sensitive outside this range.

5.3.3.10 Spectral resolution, bandwidth and stray light

When a spectroradiometer is used, the spectral resolution shall match the spectral emission characteristics of the source. For a source having pronounced emission lines, the spectral resolution shall be sufficiently fine to resolve these lines.

When using a scanning spectroradiometer, the bandwidth shall be an integer multiple of the scanning steps.

When carrying out spectroradiometric measurements, care shall be taken to avoid influence of stray light.

5.4 Performing measurements

5.4.1 General

Measurements shall be performed in conditions such that there are no reflections or they can be neglected, so that the radiation emissions will not be overestimated. The area around the source shall be cleared of any objects not required for the source's operation and which might hinder the free propagation of the radiation(s) to be measured.

WARNING — Before carrying out measurements, rough estimates of the level of emission should be made to ensure that persons are not exposed to hazardous levels of radiation without adequate protection. This estimation should also prevent overloading of measurement equipment.

5.4.2 Operating conditions

During measurement, the operating conditions shall be representative of the highest emission of radiation during intended use of the source.

Simplified operating conditions may be used provided that the manufacturer's documentation has specified that these conditions are representative of the maximum radiation emissions.

5.4.3 Measurement points

5.4.3.1 Measurement points for the classification of the source

The basic measurements for the emission classification shall be carried out

— at 10 cm from the accessible surface of the source,

and

— if the maximum emission is located further than 10 cm away from the accessible surface of the source then an additional measurement shall be carried out at the point where the maximum emission is located.

5.4.3.2 Additional measurement points

If during normal use the distance between the source and people staying near to the source differs from the distances specified in 5.4.3.1 then measurements shall be carried out in addition at the point(s) where people stay in the vicinity of the source.

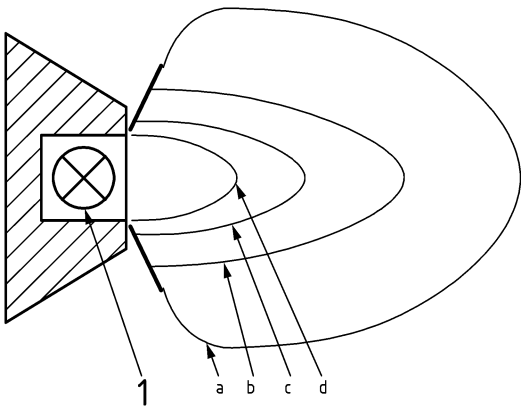
These additional measurements are not necessary for class 0 sources.

All measurement points shall be specified, so that they are uniquely identified.

Measurements may be supplemented by theoretical predictions.

Iso-emission class equivalent lines shall be determined around the source and presented in a figure or in a table, including the worst case and the normal use case.

NOTE An example for an iso-emission class equivalent lines figure is provided in Figure 2. The class numbers mentioned in Figure 2 have been arbitrarily chosen as examples.



Key

1 source

a) borderline between areas where the emission levels are equal to values corresponding to class 0 and class 1, i.e. on this line the emission levels are equal to the values specified for class 0 in Tables 2 to 5

b) borderline between areas where the emission levels are equal to values corresponding to class 1 and class 2, i.e. on this line the emission levels are equal to the values specified for class 1 in Tables 2 to 5

c) borderline between areas where the emission levels are equal to values corresponding to class 2 and class 3, i.e. on this line the emission levels are equal to the values specified for class 2 in Tables 2 to 5

d) borderline between areas where the emission levels are equal to values corresponding to class 3 and class 4, i.e. on this line the emission levels are equal to the values specified for class 3 in Tables 2 to 5

Figure 2 — Example of iso-emission–class equivalent lines figure

5.4.4 Measurement time and duration

The measurement time and duration shall be chosen in such a way that all the important characteristics of the radiation (constant or varying) and the measuring instrument and the operating conditions of the source are taken into consideration. When carrying out measurements for the classification according to 4.4.1 and 4.4.2, time and duration shall be selected with regard to any averaging period within Δt_{max}. When carrying out measurements for the classification according to 4.4.3 and 4.4.4, time and duration shall be selected to record the maximum value within the corresponding Δt_{max}.

In all cases where emissions are time varying, the measurement period shall be carefully selected such that Δt_{max} includes the maximum emission of which the source is capable.

5.4.5 Report of the measurements

The results of the measurement shall be recorded in a report, and be made available in the information for use.

This report shall give at least the following information:

— specification of the source (e.g. nature, type, serial number, purpose of use);

— date, time and place of measurement;

— characteristics of the radiation emission of the source;

— location of the points of measurements;

— measurement methods used (e.g. detailed descriptions or other references);

— operating conditions of source;

— characteristics of the measurement apparatus (including type, serial number and calibration data);

— results of measurements including uncertainty;

— class assigned to the source;

— any supplementary detailed theoretical prediction of emissions.

6 Marking

Sources classified to classes 1 to 6 shall be marked.

This marking consists of:

— a safety sign according to ISO 7010-W027 "Warning; optical radiation" indicating optical radiation emission;

— the emission class assigned to the source;

— the number of this standard: EN 16237;

— all types of emitted radiation (UV, IR, VIS).

Figure 3 gives an example of the marking.

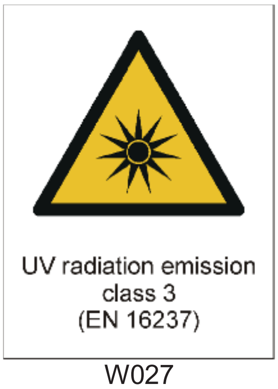


Figure 3 — Example of a safety sign indicating the type of optical radiation emission, the emission class according to this standard and the number of this standard

7 Information for use

The emission class allocated to the source shall be provided in the information for use of the source. In addition, warnings of high levels of optical radiation emissions shall be provided, if necessary. If the worst-case emission class of the source is 6 for any quantity specified in 4.2, the measured emission value shall be provided in addition.

Not only the worst-case emission class but also the results of the classification of all other wavelength bands and quantities shall be provided in the information for use.

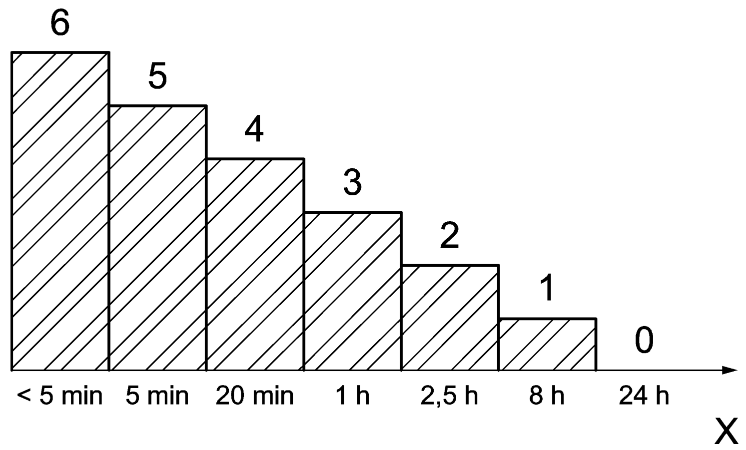
The information for use shall also provide information about the type of hazard (skin or eye), spectral range(s), distance dependence, warnings (if necessary).

Annex A
(informative)

Rationale for the radiation emission classification

A.1 Background for the emission class specifications

The classification of sources as specified in this standard is intended to offer a simple indication of potential hazard(s) for eyes and/or skin arising from optical radiation source emission(s). Figure A.1 shows the class steps in dependence on the maximum exposure duration up to which the exposure limit values are not exceeded.



Key
X maximum exposure duration Δt_{max}

The numbers above the columns represent the emission classes.

Figure A.1 — Correspondence between the emission class and the maximum exposure duration Δt_{max}

The scale is intuitive; a low class number represents a low level of emissions, and a high class number represents a high level of emissions. The class number corresponds inversely with the maximum exposure duration Δt_{max}. Hence, persons in proximity to a source for times not longer than the appropriate Δt_{max} for the classified source will not exceed the exposure limit values set by the European Directive 2006/25/EC. Therefore the source classification simplifies the risk assessment for workplaces and other exposure situations.

As different interaction mechanisms (photochemical and thermal) exist, which depend on the emitted wavelength band and tissue type, there are several quantities to be considered for the eyes as well as for the skin. The classification is to be done for each quantity. The highest emission class of all quantities in all wavelength bands has then to be assigned to the source. Therefore, this standard provides a method to summarise all possible hazards of the source in one class number. The measurements for the classification of the source have to be carried out at points near to the source and in addition at points with highest emission level, if the maximum occurs further away from the source (see 5.4.3.1). Hence, the emission class finally assigned to the source represents the worst case when people may be exposed to the radiation of the source.

Risk assessment focuses not only on the worst case but also on normal use. During practical use of optical sources, people often stay farther away from the sources than the closest measurement points specified for the classification. Therefore, the standard also requires emission measurements at greater distances and provision of iso-emission class equivalent lines around the source (see 5.4.3.2). This greatly eases the risk assessment in practical exposure situations.

A.2 Use of the source classification in a risk assessment

When workers can be exposed to radiation from strong optical radiation sources, risk assessments have to be carried out according to national regulations implementing the European Directive 2006/25/EC. A classification of an optical source based on the level of radiation emission can help to carry out such a risk assessment:

— If the emission class of the source is 1, staying near the source will not lead to a violation of any exposure limit values specified in Directive 2006/25/EC within exposure duration of 8 h. Therefore, there is no risk of getting hurt by optical radiation exposure caused by this source during a normal working shift. No additional optical radiation protection measures are necessary in general.

NOTE 1 Meeting the exposure limit values set in the EU Directive 2006/25/EC protects the majority of the population against injuries caused by optical radiation. However, there are individuals with enhanced light sensitivity who might be harmed even if they meet the exposure limit values. The concept of protection by exposure limit values is not applicable for these people.

— If the emission class of the source is 0, continuous exposure (24 h per day) to the source presents no risk of injuries for the vast majority of the population. Hence, there is no risk of getting hurt by optical radiation exposure caused by this source during a whole day. A source of emission class 0 is inherently safe with respect to the optical radiation emission and may be used without additional optical radiation protection measures anywhere (workplaces, home, public spaces, etc).

NOTE 2 There are no optical exposure limit values specified for the general public. The irradiance and radiance reference values for emission class 0 in Tables 2 to 5 are derived from the 8 h limit values set in Directive 2006/25/EC taking into account the longer exposure duration of 24 h. Meeting the reference values for class 0 emissions protects the vast majority of the population against injuries caused by optical radiation exposures. But there are individuals with enhanced light sensitivity who might be harmed even if they meet the reference values.

— If the emission class of the source is between 2 and 5, staying in proximity to the source will not lead to a violation of any exposure limit values, as specified in Directive 2006/25/EC, within the exposure duration corresponding to the class (2,5 h, 1 h, 20 min, 5 min) according to Tables 2 to 5. If it is known that the real daily exposure duration at a workplace does not exceed the exposure duration corresponding to the class of the source, the exposure limit values will not be exceeded. Hence, there is no risk of getting injured by the optical radiation of the source, and so a daily maximum permissible exposure time can be easily derived from the classification.

— The emission class assigned to the source according to this standard represents the worst case when people stay either very near to the source (10 cm) or in the place of the maximum radiation emission (see 5.4.3.1). In practical applications of optical radiation sources at workplaces and other sites, people will often be farther from the source; in such cases, the optical radiation exposure is not determined by the worst case emission but by the emission measured at the actual exposure location. Therefore, this standard also requires the determination of the emissions at points likely to be occupied by people during normal use of the source (see 5.4.3.2). Iso-emission-class equivalent lines are to be determined around the source (see Figure 2). These lines are very useful for a risk assessment. An iso-emission-class equivalent lines figure can be used to determine for how long different places around the source may be occupied without exceeding the exposure limit values.

EXAMPLE In places and areas which correspond to emission class 2, persons will not exceed the limit values within 2,5 h.

— A classified radiation source may be safely used provided that the actual exposure time does not exceed the maximum exposure duration corresponding to the emission class at the exposure location. When carrying out a risk assessment, it will not be necessary to measure the radiation emissions from the source. The user need only determine how long people are likely to stay at various places around the source. An iso-emission-class equivalent lines figure makes it easy for the user to assess whether or not exposure limit values might be exceeded.

— Exposure to a source of emission class 6 can lead to violation of the exposure limit values of EU Directive 2006/25/EC within less than 5 min. A risk assessment can also be carried out using the information required by this standard. In 4.3 it is required that the measured or estimated emission value(s) for quantities which fall into emission class 6 shall be indicated. By using these emission values and by determining the duration of exposure to the class 6 source, it is possible for the user to assess whether or not exposure limit values might be exceeded.

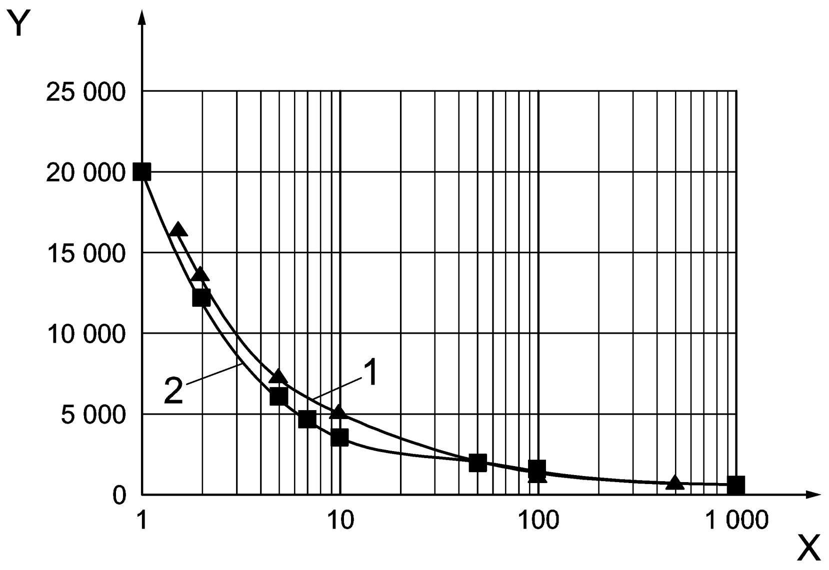
— Emission classification of optical radiation sources may simplify risk assessment provided that there is only one source of significant radiation emission responsible for exposure of people. If there are several sources, classification may help, but only as long as one of the sources is clearly dominant. In more complicated cases (e.g. moving sources, people moving between several sources, several operating modes with different emission classes, etc.), classification of the sources does not give sufficient information to ease risk assessment. In these cases, personal exposures need to be determined individually by measurement or reliable estimation.

Annex B
(informative)

Classification reference values related to skin burn hazards

For protection of the skin against the hazard of burning, the EU Directive 2006/25/EC [1] does not provide exposure limit values for exposure durations longer than 10 s. The limit values in the EU Directive have been adopted from the guidance documents of the International Commission on Non-ionising Radiation Protection (ICNIRP) [2]. ICNIRP has not provided optical radiation limit value recommendations against skin burning for exposure durations longer than 10 s. ICNIRP justifies this by the argument that no exposure durations longer than 10 s would occur due to avoidance behaviour. However, in practice, longer exposure durations occur at workplaces and so limit values for longer durations are needed. Bux and Siekmann created a model [4] that allows selecting appropriate limit values in the duration interval between 1 s and 1 000 s. It is based on the EU Directive limit values and on DIN 33403-3 [6]. DIN 33403-3:2001, Figure 5, provides values for pain sensation if the skin is heated by optical radiation. Between 1 s and 10 s the Bux/Siekmann model follows the EU Directive formula modified for the quantity irradiance: $E = 20\,000\ t^{-0,75}$ W/m². Between 10 s and 1 000 s the Bux/Siekmann model proposal is $E = 7\,700\ t^{-0,34}$ W/m². This formula connects to the EU Directive formula and fits the values of DIN 33403-3 between 50 s and 1 000 s very well. The model is shown in Figure B.1 (solid line with square data points).

The values in Table 5 of this standard for the emission classification with respect to E (380 nm to 3 000 nm) are derived using the Bux/Siekmann model up to Δt_{exp} = 20 min, i.e. for emission classes 4, 5 and 6. For longer exposure durations, the effect of heat stress of the whole body supersedes the pain sensation (see ICNIRP) [2]. Thus for classes 0 to 3, values for maximum tolerable body heat stress are taken into account. Thermal effects from an irradiance of 300 W/m² can be tolerated for 8 h and longer; see DIN 33403-3:2001, Figures 3 and 4. Hence, for classes 0 to 3 of Table 5, values have been taken from a linear interpolation between the Class 4 value and a value of 300 W/m².



Key

1 DIN 33403-3:2001 Figure 5
2 1 – 10 s EU Directive / 10 – 1 000 s Bux/Siekmann proposal
X exposure duration Δt_{exp} in s
Y irradiance E (380 nm to 3 000 nm) in W/m²

NOTE The lines show the time dependence of the limit values of the EU Directive 2006/25/EC (lower line, squares between 1 s and 10 s), the Bux/Siekmann model (lower line, squares between 10 s and 1 000 s) and recommendation according to DIN 33403-3 (line 1, triangles between 1,5 s and 1 000 s).

Figure B.1 — Time dependence of thermal injury to skin and pain sensation following optical radiation exposure.

Annex C
(informative)

Suitable methods for measurement of optical radiation emissions

For classification of an optical radiation source according to this standard, its radiation emissions have to be measured or reliably estimated. If measurements are carried out, suitable methods have to be selected. Table C.1 presents different methods for the measurement of optical radiation quantities E_s, E, L_b, E_b and L_r, as used for classification in 4.2 of this Standard. This list is not claimed to be exhaustive. All of the methods given below are described in EN 14255-1 and 14255-2.

Table C.1 provides guidance for the selection of suitable measurement methods depending on the quantity to be classified against (see 4.2). The methods are described in more detail, including descriptions of the advantages and disadvantages of each method, in EN 14255-1:2005, Annex D, and EN 14255-2:2005, Annex E.

Table C.1 — Survey of suitable measurement methods

Measurement for classification according to	Quantity to be measured	Wavelength range	Reference for measurement method	Radiometric methods	Spectroradiometric methods
4.2.2	E_s	180-400 nm	EN 14255-1:2005, Annex D	A (step 1 only)	B and C (steps 1 & 3 only)
	E	315-400 nm		M	N and O
4.2.3	L_b	300-700 nm	EN 14255-2:2005, Annex E	D (steps 1 – 4 only)	E and F (steps 1 – 5 only)
	E_b	300-700 nm		O (steps 1 – 3 & 6 only)	P and Q (steps 1 – 3, 6 & 7 only)
4.2.4	L_r	380-1 400 nm	EN 14255-2:2005, Annex E	A (steps 1 – 4 only)	B and C (steps 1 – 5 only)
	L_r	780-1 400 nm		U (steps 1 – 4 only)	V and W (steps 1 – 5 only)
4.2.5	E	380-3 000 nm	EN 14255-2:2005, Annex E	X (step 1 only)	Not usually measured using spectroradiometers
	E	780-3 000 nm		R (step 1 only)	S and T (steps 1 & 2 only)

Bibliography

[1] EU Directive 2006/25/EC, Minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation)

[2] ICNIRP: Guidelines on limits of exposure to broad-band incoherent optical radiation (0,38 µm to 3 µm), Health Physics Vol. 73, No. 3, pp. 539-554, 1997

[3] INRS: CatRayon; CD-Rom interactif pour l'évaluation des risques relatifs aux sources de rayonnement optique

[4] Limit values for protection of the skin from burns due to exposure to radiant heat. Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA), 2011 http://www.dguv.de/ifa/en/fac/strahl/pdf/empfehlung_IR_expgrenzwerte_engl.pdf

[5] CIE 17.4, *International lighting vocabulary*

[6] DIN 33403-3:2001, *Klima am Arbeitsplatz und in der Arbeitsumgebung — Teil 3: Beurteilung des Klimas im Warm- und Hitzebereich auf der Grundlage ausgewählter Klimasummenmaße (en: Climate at the workplace and its environments — Part 3: Assessment of the climate in the warm and hot working areas based on selected climate indices)*

[7] EN 12198-1, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 1: General principles*

[8] EN 60825-1, *Safety of laser products — Part 1: Equipment classification and requirements (IEC 60825-1)*

[9] EN 62471, *Photobiological safety of lamps and lamp systems (IEC 62471)*

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