BRITISH STANDARD

BS 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

The European Standard EN 14255-1:2005 has the status of a British Standard

ICS 17.240

British Standards

National foreword

This British Standard is the official English language version of EN 14255-1:2005.

The UK participation in its preparation was entrusted by Technical Committee CPL/34, Lamps and related equipment, to Subcommittee CPL/34/10, Light and lighting, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 21 April 2005

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 32, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 45888 1

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14255-1

March 2005

ICS 17.240

English version

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

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

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

This European Standard was approved by CEN on 3 February 2005.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Ref. No. EN 14255-1:2005: E

Contents

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:

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

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):

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

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

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

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:

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

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

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

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

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

Or calculated from the ultraviolet hazard irradiance E_s by:

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

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.

Table 2 - Suitable methods for the measurement of UV-exposure at workplaces in dependence of the measurement aim and the exposure conditions (see Annex D)

Measurement aim and/or exposure condition	Methods for measuring H_s (180 nm to 400 nm)						Methods for measuring H (315 nm to 400 nm)						Methods for measuring E (315 nm to 400 nm)			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Constant radiation intensity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Radiation intensity varying in time	X	X		X	X	X	X	X		X	X	X	X	X		X
Direct measurement of ultraviolet hazard radiant exposure H_s (180 nm to 400 nm)				X	X	X										
Direct measurement of radiant exposure H (315 nm to 400 nm)										X	X	X				
Direct measurement of irradiance E (315 nm to 400 nm)							X						X	X		X
Direct personal measurement of radiant exposure H					X	X					X	X				
Direct personal measurement of irradiance E (315 nm to 400 nm)																X
Measurement with highly accurate spectral weighting		X	X					X	X					X	X	
X Suitable																

7.4 Requirements for the measurement methods

7.4.1 General

When having selected a measurement method it shall be checked if the method meets the necessary requirements. The basic check can usually be done by using the information provided together with the radiation measurement device. When the performance of the method depends on the way of implementation the check shall be done when the method is implemented.

The measurement methods (consisting of the device(s) used, the implementation and the evaluation) shall fulfil the requirements specified in 7.4.2 to 7.4.11.

7.4.2 Uncertainty

- The uncertainty shall not exceed 30 % for measurements where the results are to be compared with exposure limit values.
- The uncertainty shall not exceed 50 % for survey measurements.

- The uncertainty of a measurement method shall be determined in accordance with ENV 13005.
- If exposure duration measurements are part of the selected method, the resulting combined uncertainty shall fulfil these requirements.

7.4.3 Measurement sensitivity range

The measurement sensitivity ranges shall cover the range between 1/10 and 2 times the applied limit value(s).

NOTE 1 If ICNIRP recommendations are applied the corresponding measurement sensitivity ranges are:

a) E_s (180 nm to 400 nm): 0,1 mW/m² to 60 W/m²

b) E (315 nm to 400 nm): 35 mW/m² to 20 kW/m²

c) H_s (180 nm to 400 nm): 3 J/m² to 60J/m²

d) H (315 nm to 400 nm): 1 kJ/m² to 20 kJ/m²

e) Spectral irradiance: Spectroradiometer to measure either the irradiance E or radiant exposure H. Their sensitivity ranges are given by the wavelength-integrated values as required before.

NOTE 2 In order to cover the whole range the use of more than one measurement device is permissible.

7.4.4 Spectral sensitivity of the detector system

The spectral sensitivity of the measurement system shall be known.

NOTE For actinic radiometers which spectral sensitivity is declared to fit the ultraviolet hazard weighting function $s(\lambda)$ this information can be used to calculate the degree of matching $s(\lambda)$.

7.4.5 Active detector area, aperture and field of view

The detector area shall be sufficiently large so that the radiation flux density incident on the input optics exceeds the lower detection limit. 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 may be limited by using an aperture. The active detector area is small enough if repeated measurements with a smaller active area do not change the result.

7.4.6 Cosine angular response

The angular response within ± 60° viewing angle shall be within ± 5 % of cosine function.

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

7.4.7 Averaging time

Response time of the detector: For time-varying radiation flux densities the detector response time shall be short enough to allow the variation in time to be resolved according to the set of limit values applied.

Measurement time: According to the set of limit values applied measurements shall either include the complete exposure duration, or, if the flux density is constant or varies in a regular fashion, a measurement time shall be selected which is representative of the complete exposure duration.

7.4.8 Environmental conditions

All environmental conditions which might effect the measurement shall be regarded like temperature, humidity, dust, electromagnetic fields. Under the environmental conditions present during the measurement the uncertainty requirements shall be met.

7.4.9 Calibration

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

7.4.10 Wavelengths range

Integral measurement systems shall be sensitive across the whole wavelengths range as specified in 7.2 for the quantity to be measured but shall not be sensitive outside this range.

7.4.11 Scanning steps, bandwidth resolution and stray light

When a spectroradiometer is used the bandwidth and the scanning steps shall match the spectral emission characteristics of the source(s). The bandwidth shall be an integer multiple of the scanning steps.

NOTE For survey measurements scanning steps of ≤ 5 nm may be sufficient, for more accurate measurements scanning steps of ≤ 1 nm may be necessary.

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

7.5 Implementation

7.5.1 General

The exposure measurement shall be carried out regarding the following aspects.

7.5.2 Precautions

Before an UV-exposure measurement is carried out care of personal radiation protection shall be taken. The level of the UV-radiation intensity shall roughly be determined either by a survey measurement or by information provided with the radiation source. If necessary protective measures shall be applied in order to protect the people who are carrying out the exposure measurement.

NOTE Other potential hazards in the workplace may also have to be taken into account.

7.5.3 Measurement geometry

The work task analysis shows all activities where persons are exposed to ultraviolet radiation. For all these activities the irradiance or radiant exposure shall be measured at typical positions and in typical orientations towards the source(s) of the eyes, hands or other exposed parts of the body. The measurements shall be carried out in a way that guaranties that the results are representative for the personal exposure.

NOTE It may be sufficient to position a static detector at a typical exposure position and aim it into the direction of the highest flux density. However it may be that the radiation level depends on work activities. In this case either the detector of a measurement system can be kept near the exposed part of the body during the work or dosemeters can be placed at representative positions on the body.

7.5.4 Duration of measurement

The duration of measurements shall be according to the set of limit values applied. If no specific requirements are given, the following requirements shall apply.

In the case of a constant radiance/irradiance the duration of measurement is not specified, but it shall be long enough to make an accurate measurement.

In case of a regularly varying radiance/irradiance the duration of measurement shall cover a sufficient number of periods in order to obtain a representative average result (e.g. 10 periods).

In case of randomly varying radiance/irradiance the duration of measurement shall be long enough to obtain a representative average result (e.g. 1 shift).

7.5.5 Exposure duration measurement

If radiant exposure levels are to be determined from irradiance data the duration of the persons´ exposure shall also be determined.

NOTE 1 The work task analysis may provide sufficient data for this.

NOTE 2 The uncertainty of radiant exposure levels which are determined from irradiance data is directly effected by accuracy and precision of exposure duration measurements or estimations.

7.6 Expression of results

The measurement results shall be calculated and stated in the quantities and units in which the exposure limit values are set (see 3.1 and 7.2).

The uncertainties of the measurement results shall also be calculated and stated.

Where persons change locations or activity(ies) during a shift the total radiant exposure shall be calculated by:

$$H\ (shift) = \sum_{\substack{all \\ activities}} H(activity) \qquad (8)$$

NOTE It may be necessary to carry out this calculation separately for different parts of the body.

8 Assessment of the exposure

8.1 General

For the assessment of the exposure the procedure specified in 8.2 – 8.4 shall be carried out.

8.2 Comparison with limit value

The result of the measurement shall be compared with the applicable exposure limit value. The uncertainty of the measurement result shall also be taken into account.

8.3 Statement

It shall be demonstrated that the exposure limit value has been met or has not been met.

NOTE In general, a comparison of the measured radiation exposure with the applicable exposure limit value(s) allows an assessment of a personal workplace exposure to optical radiation. The aim is to get an unambiguous result telling us whether a limit value is "observed" or "exceeded". If the existing measurement uncertainty does not allow for a clear result, the measurement should be repeated with a higher precision (maybe after the implementation of protective measures).

8.4 Additional information

In addition all activities and factors which contribute to the UV-exposure of the observed person(s) shall be stated.

NOTE For people with enhanced photosensitivity special considerations may be necessary.

9 Decision about protective measures

If the exposure limit value is exceeded national regulations may require the application of protective measures.

NOTE 1 Examples of protective measures are given in Annex E.

NOTE 2 Even if the exposure limit value is not exceeded it may be reasonable to apply protective measures in order to reduce the personal exposure.

10 Repetition of measurement and assessment

Decision as to the necessity and frequency of repetitive measurements shall be made once the measurement result is available. This decision shall be reviewed if essential exposure or assessment conditions are changed.

NOTE The result of a measurement reflects the exposure situation at the time the measurement was made. Work and exposure situations being subject to change, it may be necessary to repeat the measurement and assessment if:

- the radiation source has changed (e.g. if an other UV-lamp has been installed or if the source is operated under different operating conditions);
- the work has changed;
- the exposure duration has changed;
- protective measures have been applied, discontinued or changed;
- a long period of time has elapsed since the last measurement and assessment so that the results may no longer be valid;
- a different set of exposure limit values is to be applied.

11 Report

11.1 Short report

A short report as result of a preliminary review (see Clause 5) shall contain at least the following information:

- data on which the preliminary review is based including the origin;
- basis of the assessment, e. g. the limit values applied;
- risk assessment based on the data;

- result of the preliminary review (see Clause 5):
  a) the limit values are not exceeded,
  b) the limit values are exceeded,
  c) no sufficient data available, an exposure measurement is necessary;
- proposal for improving the exposure situation and safety at work if necessary;
- date of the preliminary review;
- date of the report.

NOTE Additional information may be provided as: Details of the workplace, the exposed people, the person carrying out the preliminary review, the signature, etc..

11.2 Full report

For each exposure measurement and assessment a detailed report shall be written. The report shall contain at least:

- the result of the preliminary review,
- target of the measurement,
- work task analysis,
- measurement equipment (type and identification) and method used,
- photographs and/or schematic drawings of the workplace, the exposure situations and the measurement locations,
- basis of the assessment, e.g. the limit values applied,
- results of the measurement and assessment,
- analysis of uncertainty,
- proposals for improving the exposure situation and safety at work if necessary,
- proposals for the repetition of the measurement and assessment,
- date of measurement and assessment.

NOTE Additional information may be provided as: Details of the workplace, the exposed people, the measurement operator, the signature, etc..

Annex A
(informative)

Flowchart of procedure

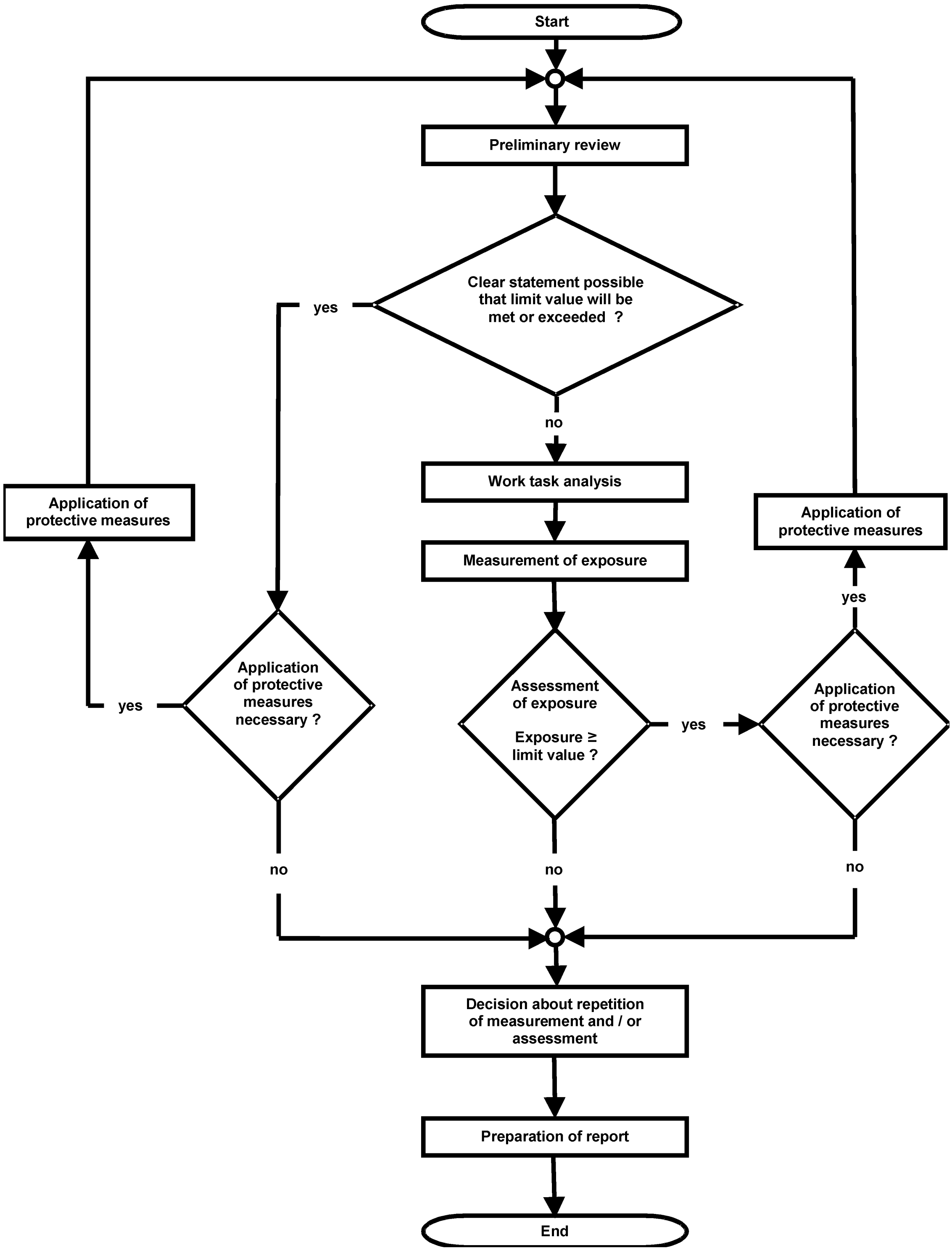

Figure A.1 – Flowchart of procedure

Annex B
(informative)

Tables (examples) for work task analysis

Table B.1 — Basic information

<table>
<tr><th>Nr.</th><th colspan="6">Information</th></tr>
<tr><td>1</td><td colspan="6">Date:</td></tr>
<tr><td>2</td><td colspan="6">Designation of workplace:</td></tr>
<tr><td>3</td><td colspan="6">Work procedure:</td></tr>
<tr><td>4</td><td colspan="6">Function of the exposed person:</td></tr>
<tr><td>5</td><td colspan="6">Any reported health effects possibly induced by UV-radiation:</td></tr>
<tr><td>6</td><td colspan="6">Personal protective equipment (incl. type designation and technical specification) and clothes used by the exposed person</td></tr>
<tr><td>6.1</td><td colspan="6">Eyes:</td></tr>
<tr><td>6.2</td><td colspan="6">Face:</td></tr>
<tr><td>6.3</td><td colspan="6">Hands:</td></tr>
<tr><td>6.4</td><td colspan="6">Other parts of the body:</td></tr>
<tr><td>7</td><td colspan="6">Factors which might increase:
Individual photosensitivity (e.g. skin type, medication, known diseases, cosmetics, etc.)
Collective photosensitivity (e.g. chemicals used within the workplace)</td></tr>
<tr><td>8</td><td colspan="6">Wavelength-range of the radiation: UV-A UV-B UV-C other</td></tr>
<tr><td>9</td><td colspan="3">Duration of a work shift:</td><td colspan="3">Number of work shifts per year:</td></tr>
<tr><td>10</td><td colspan="6">Number of radiation sources to be considered:</td></tr>
<tr><td>11</td><td colspan="6">Description of the radiation sources:</td></tr>
<tr><td></td><td>Name</td><td>Type</td><td>Identification (e.g. serial number)</td><td>Spectrum-information</td><td>Constancy/ Variation of spectrum with time</td><td>Constancy/ Variation of irradiance with time</td></tr>
<tr><td>11.1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11.2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11.3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11.4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td colspan="6">Hazards and limit values to be considered:</td></tr>
<tr><td>13</td><td colspan="6">Description of the locations during a working shift</td></tr>
<tr><td></td><td>Location Nr.</td><td colspan="2">Description of the location</td><td colspan="2">Time spent at this location</td><td>Exposed to radiation source Nr. 11.x</td></tr>
<tr><td>13.1</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>13.2</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>13.3</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>13.4</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
</table>

Table B.2 — Detailed information concerning activities at a single location

Work activities at location Nr. (see 13.x in Table B.1):												
Additional information about the work procedure:												
Working activity					Distance to the radiation source (more than one source can apply)				Source number 11.x in Table B.1	Protective measures used (see 6 in Table B.1)	Photo/ drawing Nr.	Remarks
Nr.	Description	Duration	Exposure duration	Frequency each shift	Eyes	Face	Hands	Other exposed parts				

Annex C
(informative)

Commonly used radiation measurement devices

For measurements of irradiance or radiant exposures the following devices can be used:

- Spectroradiometer with scanning monochromator

When using such an instrument the different wavelengths of the radiation are scanned step by step within minutes. The result of the measurement is a spectrum, which can be used to carry out calculations of weighted and unweighted irradiances and radiant exposures according to 3.2. Reliable results can only be obtained when the radiation intensity is constant during the time of scanning.

- Spectroradiometer with array detector

When using this instrument all the different wavelengths are instantly (within seconds/milliseconds) measured, no mechanical scanning movement is needed. Two different forms of instruments can be distinguished:

a) 1-dimensional detector array.

   The measured spectrum is projected onto a row of detectors (e.g. a photodiode array) using a grating.

b) 2-dimensional detector array.

   This form of instrument offers highly improved straylight rejection compared to 1-dimensional detector arrays. The measured spectrum is divided into a set of subspectra which are (geometrically separated) projected onto a 2-dimensional array of detectors (e.g. a camera chip) using an Echelle grating and a crossdispersion order sorter [16]

The result of the measurement is a spectrum of the radiation which can be used to carry out calculations of weighted and unweighted irradiances and radiant exposures according to 3.2. Reliable results can be obtained whether the radiation intensity is constant or varying during the measurement, provided such measurements fall within the response time of the instrument.

- Radiometer with constant spectral sensitivity

With this instrument the radiation is measured over the entire wavelength range with the same sensitivity at each wavelength. The result of the measurement is an integrated value over the entire wavelength range. The borders of the wavelength range may either be given by the instrument or may be chosen by using optical filters. So e.g. the irradiance E for UV-A (315 nm to 400 nm) can immediately be determined with a single measurement. Some types of radiometers allow a time integrated measurement, so that the radiant exposure H can be obtained in addition. The detector of the radiometer can either be static mounted or can be kept at the desired measurement point.

- Radiometer with spectral sensitivity according to a specified weighting function

With this instrument the radiation is measured in the wavelength range with a specified spectral weighting function $s(\lambda)$ according to 3.1. The result of the measurement is an ultraviolet hazard value. So e.g. the ultraviolet hazard irradiance E_s for UV-A/B/C (180 nm to 400 nm) can be measured with a single measurement. Some types of radiometers allow a time integrated measurement, so that the radiant exposure H_s can be obtained in addition. The detector of the radiometer can either be static mounted or can be kept at the desired measurement point.

- Passive personal dosemeter

With this instrument the radiation can be measured on exposed parts of the body. After the measurement an additional evaluation is necessary to get the result. The result is a radiant exposure dose which is integrated over the entire measurement time. The spectral sensitivity of the dosemeters can either be constant or can be in accordance with $s(\lambda)$ of 3.1. So H (UV-A) or H_s (UV-A/B/C) are determined.

- Active personal dosemeter

With this instrument the radiation can be measured on exposed parts of the body. The spectral sensitivity of the dosemeters can either be constant or can be in accordance with $s(\lambda)$ of 3.1. The result of the measurement can either be displayed on the dosemeter or transferred to a computer. The result of the measurement is the course in time of the irradiance E or of the ultraviolet hazard irradiance E_s. Also the time integrated values for H (UV-A) or for H_s (UV-A/B/C) can be obtained.

- Devices to distinguish between wavelength ranges

In order to exclude response of radiation outside the intended bandwidth of the applied instrument, optical filters (longpass, shortpass or bandpass) may be inserted between the measured source and the detector. If compliance with 7.4 cannot be demonstrated, the application of such means should be restricted to gathering qualitative spectral information only.

Spectroradiometric subtraction methods (e.g. to reduce straylight) are allowed provided compliance with cause 7.4 can be demonstrated.

Diagnostic tools such as photoluminescent indicator cards may be applied to gather qualitative spectral or geometrical information (e.g. checking whether radiation within the according stimulus bandwidth is present; or tracking down radiation leakages).

Annex D
(informative)

Methods for the measurement of UV-exposures

D.1 General

Subsequently different methods for the measurement of UV-exposures are listed. The methods are determined by the

- quantity or quantities which are measured;
- measurement devices used;
- wavelength band of the measurement;
- calibration of the radiation measurement device;
- way of performing the measurement (static/personal);
- measurement time;
- calculation of the result from the measured quantity or quantities.

Tables in Annex D are not intended to be exhaustive.

D.2 Methods A to F for the measurement of the ultraviolet hazard radiant exposure H_s (180 nm to 400 nm)

D.2.1 General

The ultraviolet hazard exposure H_s(180 nm to 400 nm) can be determined by using one of the following methods A to F.

D.2.2 Method A

1) Measurement of the ultraviolet hazard irradiance E_s in the wavelength-range from 180 nm to 400 nm using a static broad-band radiometer which is calibrated to measure the ultraviolet hazard irradiance E_s. The spectral sensitivity of the radiometer shall simulate the ultraviolet hazard weighting function $s(\lambda)$.

2) Measurement of the time of exposure duration Δt_{exp}.

3) Calculation of the ultraviolet hazard radiant exposure H_s by using Formula (7).

Table D.1 — Advantages and disadvantages of method A

Advantages	Disadvantages
• Direct reading of ultraviolet hazard irradiance effective E_s; • Relatively inexpensive; • Flexible use (portable, compact, may be battery powered, easy handling); • Rapid measurements (typical in the order of ms).	• Additional time measurement necessary; • Only static measurements. For the exposure determination of moving people several measurements are necessary; • In case of insufficient matching of the relative spectral sensor sensitivity to the ultraviolet hazard weighting function s(λ) the measurement uncertainty may be large.

D.2.3 Method B

1) Measurement of the spectral irradiance $E_\lambda(\lambda)$ in the wavelength-range from 180 nm to 400 nm using a static array spectroradiometer.

2) Measurement of the exposure duration Δt_{exp}.

3) Calculation of the ultraviolet hazard irradiance E_s for the wavelength-range from 180 nm to 400 nm by using the Formula (2).

4) Calculation of the ultraviolet hazard radiant exposure H_s by using Formula (7).

Table D.2 — Advantages and disadvantages of method B

Advantages	Disadvantages
• Fast measurement of spectral irradiance $E_\lambda(\lambda)$ for time varying and constant radiation intensities; • Allows measurement of average spectrum of time varying radiation intensities; • Compact systems are available; • Systems of low uncertainty are available.	• Additional time measurement necessary; • Only static measurements. For the exposure determination of moving people several measurements are necessary; • Simple systems may have a higher uncertainty; • Accurate systems are likely to be expensive and bulky.

D.2.4 Method C

1) Measurement of the spectral irradiance $E_\lambda(\lambda)$ in the wavelength-range from 180 nm to 400 nm using a static scanning spectroradiometer.

2) Measurement of the exposure duration Δt_{exp}.

3) Calculation of the ultraviolet hazard irradiance E_s for the wavelength-range from 180 nm to 400 nm by using the Formula (2).

4) Calculation of the ultraviolet hazard radiant exposure H_s by using Formula (7).

Table D.3 — Advantages and disadvantages of method C

Advantages	Disadvantages
• Accurate measurement of spectral irradiance $E_\lambda(\lambda)$ of constant radiation intensities; • Accurate calculation of the ultraviolet hazard irradiance E_s and the ultraviolet hazard radiant exposure H_s.	• Additional time measurement necessary; • Because of the long time of measurement and the sequential scanning of the wavelengths the method is in general not applicable for time varying radiation intensities; • Only static measurements. For the exposure determination of moving people several measurements are necessary.

D.2.5 Method D

Measurement of the ultraviolet hazard radiant exposure H_s in the wavelength-range from 180 nm to 400 nm using a static broad-band radiometer which is calibrated to measure the ultraviolet hazard radiant exposure H_s. The spectral sensitivity of the radiometer shall simulate the ultraviolet hazard weighting function $s(\lambda)$. The ultraviolet hazard radiant exposure H_s shall be measured throughout the exposure duration Δt_{exp}.

Table D.4 — Advantages and disadvantages of method D

Advantages	Disadvantages
• Direct reading of ultraviolet hazard radiant exposure H_s; • Flexible use (portable, compact, may be battery powered, easy handling); • Additional time measurement not necessary.	• Only static measurements. For the exposure determination of moving people several measurements are necessary; • In case of insufficient matching of the relative spectral sensor sensitivity to the ultraviolet hazard weighting function $s(\lambda)$ the measurement uncertainty may be large.

D.2.6 Method E

Measurement of the ultraviolet hazard radiant exposure H_s in the wavelength-range from 180 nm to 400 nm using a personal passive dosemeter which is calibrated to measure the ultraviolet hazard radiant exposure H_s. The spectral sensitivity of the dosemeter shall simulate the ultraviolet hazard weighting function $s(\lambda)$. The ultraviolet hazard radiant exposure H_s shall be measured throughout the exposure duration Δt_{exp}.

Table D.5 — Advantages and disadvantages of method E

Advantages	Disadvantages
• Representative measurement of personal ultraviolet hazard radiant exposure H_s; • Simple performance of the measurement; • Additional time measurement not necessary; • Exposure distribution across the body determinable.	• In case of insufficient matching of the relative spectral sensor sensitivity to the ultraviolet hazard weighting function $s(\lambda)$ the measurement uncertainty may be large; • Use of more than one dosemeter for the measurement necessary; • Time for the evaluation of the dosemeters is needed. The result will be obtained after the measurement; • Expensive if measurements are repeated.

D.2.7 Method F

Measurement of the ultraviolet hazard radiant exposure H_s in the wavelength-range from 180 nm to 400 nm using a personal active dosemeter which is calibrated to measure the ultraviolet hazard radiant exposure H_s The spectral sensitivity of the dosemeter shall simulate the ultraviolet hazard weighting function $s(\lambda)$. The ultraviolet hazard radiant exposure H_s shall be measured throughout the exposure duration Δt_{exp}.

Table D.6 — Advantages and disadvantages of method F

Advantages	Disadvantages
• Representative measurement of personal ultraviolet hazard radiant exposure H_s; • Simple performance of measurement; • Additional time measurement not necessary; • Exposure distribution across the body determinable.	• In case of insufficient matching of the relative spectral sensor sensitivity to the ultraviolet hazard weighting function $s(\lambda)$ the measurement uncertainty may be large; • Use of more than one dosemeter for the measurement necessary.

D.3 Methods G to L for the measurement of the radiant exposure *H* (315 nm to 400 nm)

D.3.1 General

The radiant exposure *H* (315 nm to 400 nm) can be determined by using one of the following methods G to L.

D.3.2 Method G

1) Measurement of the irradiance *E* in the wavelength-range from 315 nm to 400 nm using a static broad-band radiometer which is calibrated to measure the irradiance *E*. The sensitivity of the

radiometer shall be constant in the wavelength-range from 315 nm to 400 nm. The meter should not be sensitive in thewavelength-range less than 315 nm and more than 400 nm.

2) Measurement of the exposure duration Δt_{exp}.

3) Calculation of the radiant exposure H by using Formula (5).

Table D.7 — Advantages and disadvantages of method G

Advantages	Disadvantages
• Relatively inexpensive; • Flexible use (portable, compact, may be battery powered, easy handling); • Rapid measurements (typical in the order of ms).	• Additional time measurement necessary; • Only static measurements. For the exposure determination of moving people several measurements are necessary.

D.3.3 Method H

1) Measurement of the spectral irradiance $E_\lambda(\lambda)$ in the wavelength-range from 315 nm to 400 nm using a static array spectroradiometer,

2) Measurement of the exposure duration Δt_{exp},

3) Calculation of the irradiance E for the wavelength-range from 315 nm to 400 nm by using the Formula (1),

4) Calculation of the radiant exposure H by using Formula (5).

Table D.8 — Advantages and disadvantages of method H

Advantages	Disadvantages
• Fast measurement of spectral irradiance $E_\lambda(\lambda)$ for time varying and constant radiation intensities; • Allows measurement of average spectrum of time varying radiation exposure; • Compact systems are available; • Systems of low uncertainty are available.	• Additional time measurement necessary; • Only static measurements. For the exposure determination of moving people several measurements are necessary; • Compact systems are likely to be expensive. Less expensive systems may have lower sensitivity and higher uncertainty.

D.3.4 Method I

1) Measurement of the spectral irradiance $E_\lambda(\lambda)$ in the wavelength-range from 315 nm to 400 nm using a static scanning spectroradiometer;

2) Measurement of the exposure duration Δt_{exp}.

3) Calculation of the irradiance E for the wavelength-range from 315 nm to 400 nm by using the Formula (1).

4) Calculation of the radiant exposure *H* by using Formula (5).

Table D.9 — Advantages and disadvantages of method I

Advantages	Disadvantages
• Accurate measurement of spectral irradiance $E_\lambda(\lambda)$ of constant radiation intensities; • Accurate determination of the irradiance *E* and the radiance *H*.	• Additional time measurement necessary; • Only static measurements. For the exposure determination of moving people several measurements are necessary; • Because of the long time of measurement and the sequential scanning of the wavelengths the method is in general not applicable for time varying radiation intensities.

D.3.5 Method J

Measurement of the radiant exposure *H* in the wavelength-range from 315 nm to 400 nm using a static broad-band radiometer which is calibrated to measure the radiant exposure *H*. The spectral sensitivity of the radiometer shall be constant in the wavelength-range from 315 nm to 400 nm and zero outside. The radiant exposure *H* shall be measured throughout the exposure duration Δt_{exp}.

Table D.10 — Advantages and disadvantages of method J

Advantages	Disadvantages
• Direct reading of radiant exposure *H*; • Flexible use (portable, compact, may be battery powered, easy handling); • Additional time measurement not necessary.	• Only static measurements. For the exposure determination of moving people several measurements are necessary; • The uncertainty of the measurement may increase if the requirement for the spectral sensitivity is not met.

D.3.6 Method K

Measurement of the radiant exposure *H* in the wavelength range from 315 nm to 400 nm using a personal **passive** dosemeter which is calibrated to measure the radiant exposure *H*. The spectral sensitivity of the dosemeter shall be constant in the wavelength-range from 315 nm to 400 nm and zero outside. The radiant exposure *H* shall be measured throughout the exposure duration Δt_{exp}.

Table D.11 — Advantages and disadvantages of method K

Advantages	Disadvantages
• Representative measurement of personal radiant exposure *H*; • Simple performance of measurement; • Additional time measurement not necessary; • Exposure distribution across the body determinable.	• The uncertainty of the measurement may increase if the requirement for the spectral sensitivity is not met; • Use of more than one dosemeter for assessment; • Time for the evaluation of the dosemeters is needed. The result will be obtained after the measurement; • Expensive if measurements are repeated.

D.3.7 Method L

Measurement of the radiant exposure *H* in the wavelength-range from 315 nm to 400 nm using a personal **active** dosemeter which is calibrated to measure the radiant exposure *H.* The spectral sensitivity of the dosemeter shall be constant in the wavelength-range from 315 nm to 400 nm and zero outside. The radiant exposure *H* shall be measured throughout the exposure duration $\Delta t_{exp.}$.

Table D.12 — Advantages and disadvantages of method L

Advantages	Disadvantages
• Representative measurement of personal radiant exposure *H*; • Simple execution of measurement; • Additional time measurement not necessary; • Exposure distribution across the body determinable.	• The uncertainty of the measurement may increase if the requirement for the spectral sensitivity is not met; • Use of more than one dosemeter for assessment.

D.4 Methods M to P for the measurement of the irradiance *E* (315 nm to 400 nm)

D.4.1 General

The irradiance *E* (315 nm – 400 nm) can be determined by using the following methods M to P.

D.4.2 Method M

Measurement of the irradiance *E* in the wavelength-range from 315 nm to 400 nm using a static broad-band radiometer which is calibrated to measure the irradiance *E*. The spectral sensitivity of the radiometer shall be constant in the wavelength-range from 315 nm to 400 nm and zero outside.

Table D.13 — Advantages and disadvantages of method M

Advantages	Disadvantages
• Direct reading of irradiance *E*; • Relatively inexpensive; • Flexible use (portable, compact, may be battery powered, easy handling); • Rapid measurements (typical in the order of ms).	• Only static measurements. For the exposure determination of moving people several measurements are necessary; • The uncertainty of the measurement may increase if the requirement for the spectral sensitivity is not met.

D.4.3 Method N

1) Measurement of the spectral irradiance $E_\lambda(\lambda)$ in the wavelength-range from 315 nm to 400 nm using a static array spectroradiometer which is calibrated to measure the spectral irradiance $E_\lambda(\lambda)$.

2) Calculation of the irradiance *E* for the wavelength-range from 315 nm to 400 nm by using the Formula (1).

Table D.14 — Advantages and disadvantages of method N

Advantages	Disadvantages
• Fast measurement of spectral irradiance $E_\lambda(\lambda)$ for time varying and constant radiation intensities; • Allows measurement of average spectrum of time varying sources; • Compact systems are available; • Systems of low uncertainty are available.	• Only static measurements. For the exposure determination of moving people several measurements are necessary; • Compact systems are likely to be expensive. Less expensive systems may have higher uncertainty.

D.4.4 Method O

1) Measurement of the ultraviolet hazard irradiance $E_\lambda(\lambda)$ in the wavelength-range from 315 nm to 400 nm using a static scanning spectroradiometer which is calibrated to measure the spectral irradiance $E_\lambda(\lambda)$.

2) Calculation of the irradiance *E* for the wavelength-range from 315 nm to 400 nm by using the Formula (1).

Table D.15 — Advantages and disadvantages of method O

Advantages	Disadvantages
• Accurate measurement of spectral irradiance $E_\lambda(\lambda)$ of constant radiation intensities; • Accurate calculation of the irradiance *E*.	• Only static measurements. For the exposure determination of moving people several measurements are necessary; • Because of the long time of measurement and the sequential scanning of the wavelengths the method is in general not applicable for time varying radiation intensities.

D.4.5 Method P

Measurement of the irradiance *E* in the wavelength-range from 315 nm to 400 nm using a personal active dosemeter with integrated data logger which is calibrated to measure the irradiance *E.* The spectral sensitivity of the dosemeter shall be constant in the wavelength-range from 315 nm to 400 nm and zero outside. The irradiance *E* shall be measured throughout the exposure duration $\Delta t_{exp.}$

Table D.16 — Advantages and disadvantages of method P

Advantages	Disadvantages
• Determination of the variation of the irradiance *E* in time possible; • Representative measurement of personal irradiance *E*; • Simple execution of measurement; • Exposure distribution across the body determinable; • Additional calculation of the personal radiant exposure *H* possible.	• The uncertainty of the measurement may increase if the requirement for the spectral sensitivity is not met; • Use of more than one dosemeter for assessment may be necessary.

Annex E
(informative)

Examples of protective measures

Avoidance of exposure

- Choice of alternative technique without UV-source(s), if feasible

Technical measures

- Shielding to avoid the emission of UV-radiation
- Suitable filters to reduce the emission of UV-radiation
- Positioning of the radiation source so that no UV-radiation is directed towards persons or parts of the body

Organizational measures

- Minimization of exposure duration
- Enlarging the distance between sources and persons
- Placement of suitable warning signs
- Instruction of persons in the hazards of ultraviolet radiation and in the use of suitable protective measures

Personal protective measures and equipment

- Suitable glasses and filters for the protection of the eyes (e.g. EN 166 [7] and EN 170 [8])
- Suitable clothing and gloves for the protection of the skin
- Application of sunscreen with an appropriate protection factor

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