Directive 2006/25/EC of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) (19th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

DIRECTIVE 2006/25/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 5 April 2006

on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) (19th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 137(2) thereof,

Having regard to the proposal from the Commission[(1)], presented after consultation with the Advisory Committee on Safety and Health at Work,

Having regard to the opinion of the European Economic and Social Committee[(2)],

After consulting the Committee of the Regions,

Acting in accordance with the procedure laid down in Article 251 of the Treaty[(3)], in the light of the joint text approved by the Conciliation Committee on 31 January 2006,

Whereas:

(1) Under the Treaty the Council may, by means of directives, adopt minimum requirements for encouraging improvements, especially in the working environment, to guarantee a better level of protection of the health and safety of workers. Such directives are to avoid imposing administrative, financial and legal constraints in a way which would hold back the creation and development of small and medium-sized enterprises (SMEs).

(2) The communication from the Commission concerning its action programme relating to the implementation of the Community Charter of the Fundamental Social Rights of Workers provides for the introduction of minimum health and safety requirements regarding the exposure of workers to the risks caused by physical agents. In September 1990 the European Parliament adopted a Resolution concerning this action programme[(4)], inviting the Commission in particular to draw up a specific directive on the risks caused by noise, vibration and any other physical agents at the workplace.

(3) As a first step, the European Parliament and the Council adopted Directive 2002/44/EC of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (16th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)[(5)]. Next, on 6 February 2003 the European Parliament and the Council adopted Directive 2003/10/EC

on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (17th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)[6]. Thereafter, on 29 April 2004, the European Parliament and the Council adopted Directive 2004/40/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)[7].

(4) It is now considered necessary to introduce measures protecting workers from the risks associated with optical radiation, owing to its effects on the health and safety of workers, in particular damage to the eyes and to the skin. These measures are intended not only to ensure the health and safety of each worker on an individual basis, but also to create a minimum basis of protection for all Community workers, in order to avoid possible distortions of competition.

(5) One of the aims of this Directive is the timely detection of adverse health effects resulting from exposure to optical radiation.

(6) This Directive lays down minimum requirements, thus giving Member States the option of maintaining or adopting more stringent provisions for the protection of workers, in particular the fixing of lower exposure limit values. The implementation of this Directive must not serve to justify any deterioration in the situation which already prevails in each Member State.

(7) A system of protection against the hazards of optical radiation should limit itself to a definition, free of excessive detail, of the objectives to be attained, the principles to be observed and the basic values to be applied, in order to enable Member States to apply the minimum requirements in an equivalent manner.

(8) The level of exposure to optical radiation can be more effectively reduced by incorporating preventive measures into the design of workstations and by selecting work equipment, procedures and methods so as to give priority to reducing the risks at source. Provisions relating to work equipment and methods thus contribute to the protection of the workers involved. In accordance with the general principles of prevention as laid down in Article 6(2) of Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work[8], collective protection measures have priority over individual protection measures.

(9) Employers should make adjustments in the light of technical progress and scientific knowledge regarding risks related to exposure to optical radiation, with a view to improving the safety and health protection of workers.

(10) Since this Directive is an individual directive within the meaning of Article 16(1) of Directive 89/391/EEC, that Directive applies to the exposure of workers to optical radiation, without prejudice to more stringent and/or specific provisions contained in this Directive.

(11) This Directive constitutes a practical step towards creating the social dimension of the internal market.

(12) A complementary approach that both promotes the principle of better regulation and ensures a high level of protection can be achieved where the products made by the manufacturers of optical radiation sources and associated equipment comply with harmonised standards devised to protect the health and safety of users from the hazards inherent in such products; accordingly, it is not necessary for employers to repeat the measurements or calculations already undertaken by the manufacturer to determine compliance with the essential safety requirements of such equipment as specified in the applicable Community Directives, provided that the equipment has been properly and regularly maintained.

(13) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission[(9)].

(14) Adherence to the exposure limit values should provide a high level of protection as regards the health effects that may result from exposure to optical radiation.

(15) The Commission should draw up a practical guide to help employers, in particular managers of SMEs, better to understand the technical provisions of this Directive. The Commission should strive to complete this guide as quickly as possible so as to facilitate adoption by the Member States of the measures necessary to implement this Directive.

(16) In accordance with paragraph 34 of the Interinstitutional Agreement on better law-making[(10)], Member States are encouraged to draw up, for themselves and in the interests of the Community, their own tables illustrating, as far as possible, the correlation between this Directive and the transposition measures, and to make them public,

HAVE ADOPTED THIS DIRECTIVE:

SECTION I U.K.

GENERAL PROVISIONS

Article 1 *U.K.*

Aim and scope

1 This Directive, which is the 19th individual Directive within the meaning of Article 16(l) of Directive 89/391/EEC, lays down minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to artificial optical radiation during their work.

2 This Directive refers to the risk to the health and safety of workers due to adverse effects caused by exposure to artificial optical radiation to the eyes and to the skin.

3 Directive 89/391/EEC shall apply fully to the whole area referred to in paragraph 1, without prejudice to more stringent and/or more specific provisions contained in this Directive.

Article 2 U.K.

Definitions

For the purposes of this Directive, the following definitions shall apply:

(a) optical radiation: any electromagnetic radiation in the wavelength range between 100 nm and 1 mm. The spectrum of optical radiation is divided into ultraviolet radiation, visible radiation and infrared radiation:

(i) ultraviolet radiation: optical radiation of wavelength range between 100 nm and 400 nm. The ultraviolet region is divided into UVA (315-400 nm), UVB (280-315 nm) and UVC (100-280 nm);

(ii) visible radiation: optical radiation of wavelength range between 380 nm and 780 nm;

(iii) infrared radiation: optical radiation of wavelength range between 780 nm and 1 mm. The infrared region is divided into IRA (780-1 400 nm), IRB (1 400-3 000 nm) and IRC (3 000 nm-1 mm);

(b) laser (light amplification by stimulated emission of radiation): any device which can be made to produce or amplify electromagnetic radiation in the optical radiation wavelength range primarily by the process of controlled stimulated emission;

(c) laser radiation: optical radiation from a laser;

(d) non-coherent radiation: any optical radiation other than laser radiation;

(e) exposure limit values: limits on exposure to optical radiation which are based directly on established health effects and biological considerations. Compliance with these limits will ensure that workers exposed to artificial sources of optical radiation are protected against all known adverse health effects;

(f) irradiance (E) or power density: the radiant power incident per unit area upon a surface expressed in watts per square metre (W m^{-2});

(g) radiant exposure (H): the time integral of the irradiance, expressed in joules per square metre (J m^{-2});

(h) radiance (L): the radiant flux or power output per unit solid angle per unit area, expressed in watts per square metre per steradian (W m^{-2} sr^{-1});

(i) level: the combination of irradiance, radiant exposure and radiance to which a worker is exposed.

Article 3 U.K.

Exposure limit values

1 The exposure limit values for non-coherent radiation, other than that emitted by natural sources of optical radiation, are as set out in Annex I.

2 The exposure limit values for laser radiation are as set out in Annex II.

SECTION II U.K.

OBLIGATIONS OF EMPLOYERS

Article 4 *U.K.*

Determination of exposure and assessment of risks

1 In carrying out the obligations laid down in Articles 6(3) and 9(1) of Directive 89/391/EEC, the employer, in the case of workers exposed to artificial sources of optical radiation, shall assess and, if necessary, measure and/or calculate the levels of exposure to optical radiation to which workers are likely to be exposed so that the measures needed to restrict exposure to the applicable limits can be identified and put into effect. The methodology applied in assessment, measurement and/or calculations shall follow the standards of the International Electrotechnical Commission (IEC) in respect of laser radiation and the recommendations of the International Commission on Illumination (CIE) and the European Committee for Standardisation (CEN) in respect of non-coherent radiation. In exposure situations which are not covered by these standards and recommendations, and until appropriate EU standards or recommendations become available, assessment, measurement and/or calculations shall be carried out using available national or international science-based guidelines. In both exposure situations, the assessment may take account of data provided by the manufacturers of the equipment when it is covered by relevant Community Directives.

2 The assessment, measurement and/or calculations referred to in paragraph 1 shall be planned and carried out by competent services or persons at suitable intervals, taking particular account of the provisions of Articles 7 and 11 of Directive 89/391/EEC concerning the necessary competent services or persons and the consultation and participation of workers. The data obtained from the assessment, including those obtained from the measurement and/or calculation of the level of exposure referred to in paragraph 1 shall be preserved in a suitable form so as to permit their consultation at a later stage.

3 Pursuant to Article 6(3) of Directive 89/391/EEC, the employer shall give particular attention, when carrying out the risk assessment, to the following:

a the level, wavelength range and duration of exposure to artificial sources of optical radiation;

b the exposure limit values referred to in Article 3 of this Directive;

c any effects concerning the health and safety of workers belonging to particularly sensitive risk groups;

d any possible effects on workers' health and safety resulting from workplace interactions between optical radiation and photosensitising chemical substances;

e any indirect effects such as temporary blinding, explosion or fire;

f the existence of replacement equipment designed to reduce the levels of exposure to artificial optical radiation;

g appropriate information obtained from health surveillance, including published information, as far as possible;

h multiple sources of exposure to artificial optical radiation;

i a classification applied to a laser as defined in accordance with the relevant IEC standard and, in relation to any artificial source likely to cause damage similar to that of a laser of class 3B or 4, any similar classification;

j information provided by the manufacturers of optical radiation sources and associated work equipment in accordance with the relevant Community Directives.

4 The employer shall be in possession of an assessment of the risk in accordance with Article 9(1)(a) of Directive 89/391/EEC and shall identify which measures must be taken in accordance with Articles 5 and 6 of this Directive. The risk assessment shall be recorded on a suitable medium, according to national law and practice; it may include a justification by the employer that the nature and extent of the risks related to optical radiation make a further, detailed risk assessment unnecessary. The risk assessment shall be updated on a regular basis, particularly if there have been significant changes which could render it out of date, or if the results of health surveillance show it to be necessary.

Article 5 U.K.

Provisions aimed at avoiding or reducing risks

1 Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to artificial optical radiation shall be eliminated or reduced to a minimum.

The reduction of risks arising from exposure to artificial optical radiation shall be based on the general principles of prevention set out in Directive 89/391/EEC.

2 Where the risk assessment carried out in accordance with Article 4(1) for workers exposed to artificial sources of optical radiation indicates any possibility that the exposure limit values may be exceeded, the employer shall devise and implement an action plan comprising technical and/or organisational measures designed to prevent the exposure exceeding the limit values, taking into account in particular:

a other working methods that reduce the risk from optical radiation;

b the choice of equipment emitting less optical radiation, taking account of the work to be done;

c technical measures to reduce the emission of optical radiation including, where necessary, the use of interlocks, shielding or similar health protection mechanisms;

d appropriate maintenance programmes for work equipment, workplaces and workstation systems;

e the design and layout of workplaces and workstations;

f limitation of the duration and level of the exposure;

g the availability of appropriate personal protective equipment;

h the instructions of the manufacturer of the equipment where it is covered by relevant Community Directives.

3 On the basis of the risk assessment carried out in accordance with Article 4, workplaces where workers could be exposed to levels of optical radiation from artificial sources exceeding the exposure limit values shall be indicated by appropriate signs in accordance with Council Directive 92/58/EEC of 24 June 1992 on the minimum requirements for the provision of safety and/or health signs at work (9th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)[11]. The areas in question shall be identified, and access to them limited where this is technically possible and where there is a risk that the exposure limit values could be exceeded.

4 Workers shall not be exposed above the exposure limit values. In any event, if, despite the measures taken by the employer to comply with this Directive in respect of artificial sources of optical radiation, the exposure limit values are exceeded, the employer shall take immediate action to reduce exposure below the exposure limit values. The employer shall identify the

reasons why the exposure limit values have been exceeded and shall adapt the protection and prevention measures accordingly in order to prevent them being exceeded again.

5 Pursuant to Article 15 of Directive 89/391/EEC, the employer shall adapt the measures referred to in this Article to the requirements of workers belonging to particularly sensitive risk groups.

Article 6 U.K.

Worker information and training

Without prejudice to Articles 10 and 12 of Directive 89/391/EEC, the employer shall ensure that workers who are exposed to risks from artificial optical radiation at work and/or their representatives receive any necessary information and training relating to the outcome of the risk assessment provided for in Article 4 of this Directive, concerning in particular:

(a) measures taken to implement this Directive;

(b) the exposure limit values and the associated potential risks;

(c) the results of the assessment, measurement and/or calculations of the levels of exposure to artificial optical radiation carried out in accordance with Article 4 of this Directive together with an explanation of their significance and potential risks;

(d) how to detect adverse health effects of exposure and how to report them;

(e) the circumstances in which workers are entitled to health surveillance;

(f) safe working practices to minimise risks from exposure;

(g) proper use of appropriate personal protective equipment.

Article 7 U.K.

Consultation and participation of workers

Consultation and participation of workers and/or of their representatives shall take place in accordance with Article 11 of Directive 89/391/EEC on the matters covered by this Directive.

SECTION III U.K.

MISCELLANEOUS PROVISIONS

Article 8 U.K.

Health surveillance

1 With the objectives of the prevention and timely detection of any adverse health effects, as well as the prevention of any long-term health risks and any risk of chronic diseases, resulting from exposure to optical radiation, Member States shall adopt provisions to ensure appropriate health surveillance of workers pursuant to Article 14 of Directive 89/391/EEC.

2 Member States shall ensure that health surveillance is carried out by a doctor, an occupational health professional or a medical authority responsible for health surveillance in accordance with national law and practice.

3 Member States shall establish arrangements to ensure that, for each worker who undergoes health surveillance in accordance with paragraph 1, individual health records are made and kept up to date. Health records shall contain a summary of the results of the health surveillance carried out. They shall be kept in a suitable form so as to permit consultation at a later date, taking into account any confidentiality. Copies of the appropriate records shall be supplied to the competent authority on request, taking into account any confidentiality. The employer shall take appropriate measures to ensure that the doctor, the occupational health professional or the medical authority responsible for the health surveillance, as determined by Member States as appropriate, has access to the results of the risk assessment referred to in Article 4 where such results may be relevant to the health surveillance. Individual workers shall, at their request, have access to their own personal health records.

4 In any event, where exposure above the limit values is detected, a medical examination shall be made available to the worker(s) concerned in accordance with national law and practice. This medical examination shall also be carried out where, as a result of health surveillance, a worker is found to have an identifiable disease or adverse health effect which is considered by a doctor or occupational health professional to be the result of exposure to artificial optical radiation at work. In both cases, when limit values are exceeded or adverse health effects (including diseases) are identified:

a the worker shall be informed by the doctor or other suitably qualified person of the result which relates to him personally. He shall, in particular, receive information and advice regarding any health surveillance which he should undergo following the end of exposure;

b the employer shall be informed of any significant findings of the health surveillance, taking into account any medical confidentiality;

c the employer shall:

— review the risk assessment carried out pursuant to Article 4,

— review the measures provided for to eliminate or reduce risks pursuant to Article 5,

— take into account the advice of the occupational health professional or other suitably qualified person or the competent authority in implementing any measure required to eliminate or reduce risk in accordance with Article 5, and

— arrange continued health surveillance and provide for a review of the health status of any other worker who has been similarly exposed. In such cases, the competent doctor or occupational health professional or the competent authority may propose that the exposed persons undergo a medical examination.

Article 9 U.K.

Penalties

Member States shall provide for adequate penalties to be applicable in the event of infringement of the national legislation adopted pursuant to this Directive. These penalties must be effective, proportionate and dissuasive.

[F1 Article 10 U.K.

Amendment of the Annexes

The Commission is empowered to adopt delegated acts in accordance with Article 10a to make strictly technical amendments to the Annexes, in order to take account of technical harmonisation and standardisation with regard to the design, building, manufacture or construction of work equipment or workplaces, technical progress, changes in harmonised European standards or international specifications and new scientific findings concerning occupational exposure to optical radiation. Those amendments shall not result in a modification of the exposure limit values set out in the Annexes.

Where, in duly justified and exceptional cases involving imminent, direct and serious risks to workers' and other persons' physical health and safety, imperative grounds of urgency require action in a very short timeframe, the procedure provided for in Article 10b shall apply to delegated acts adopted pursuant to this Article.**]**

Textual Amendments

F1 Substituted by Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance).

[F2 Article 10a U.K.

Exercise of the delegation

1 The power to adopt delegated acts is conferred on the Commission subject to the conditions laid down in this Article.

2 The power to adopt delegated acts referred to in Article 10 shall be conferred on the Commission for a period of five years from 26 July 2019. The Commission shall draw up a report in respect of the delegation of power not later than nine months before the end of the five-year period. The delegation of power shall be tacitly extended for periods of an identical duration, unless the European Parliament or the Council opposes such extension not later than three months before the end of each period.

3 The delegation of power referred to in Article 10 may be revoked at any time by the European Parliament or by the Council. A decision to revoke shall put an end to the delegation of the power specified in that decision. It shall take effect the day following the publication of the decision in the *Official Journal of the European Union* or at a later date specified therein. It shall not affect the validity of any delegated acts already in force.

4 Before adopting a delegated act, the Commission shall consult experts designated by each Member State in accordance with the principles laid down in the Interinstitutional Agreement of 13 April 2016 on Better Law-Making[(12)].

5 As soon as it adopts a delegated act, the Commission shall notify it simultaneously to the European Parliament and to the Council.

6 A delegated act adopted pursuant to Article 10 shall enter into force only if no objection has been expressed either by the European Parliament or the Council within a period of two months of notification of that act to the European Parliament and the Council or if, before the expiry of that period, the European Parliament and the Council have both informed the Commission that they will not object. That period shall be extended by two months at the initiative of the European Parliament or of the Council.

Textual Amendments

F2 Inserted by Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance).

Article 10b U.K.

Urgency procedure

1 Delegated acts adopted under this Article shall enter into force without delay and shall apply as long as no objection is expressed in accordance with paragraph 2. The notification of a delegated act to the European Parliament and the Council shall state the reasons for the use of the urgency procedure.

2 Either the European Parliament or the Council may object to a delegated act in accordance with the procedure referred to in Article 10a(6). In such a case, the Commission shall repeal the act immediately following the notification of the decision to object by the European Parliament or by the Council.**]**

Textual Amendments

F2 Inserted by Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance).

[F3 Article 11 U.K.

[[F3 Committee]

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Textual Amendments

F3 Deleted by Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance).

SECTION IV U.K.

FINAL PROVISIONS

F4 Article 12 U.K.

[F4 Reports]

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Textual Amendments

F4 Deleted by Directive 2007/30/EC of the European Parliament and of the Council of 20 June 2007 amending Council Directive 89/391/EEC, its individual Directives and Council Directives 83/477/EEC, 91/383/EEC, 92/29/EEC and 94/33/EC with a view to simplifying and rationalising the reports on practical implementation (Text with EEA relevance).

Article 13 U.K.

Practical guide

In order to facilitate implementation of this Directive the Commission shall draw up a practical guide to the provisions of Articles 4 and 5 and Annexes I and II.

Article 14 U.K.

Transposition

1 Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 27 April 2010. They shall forthwith inform the Commission thereof.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by Member States.

2 Member States shall communicate to the Commission the text of the provisions of national law which they adopt or have already adopted in the field covered by this Directive.

I F5 Article 14a U.K.

1 Without prejudice to the general principles of protection and prevention in the area of health and safety of workers, France may, until 31 December 2017, derogate from the application of the provisions necessary to comply with this Directive in Mayotte as an outermost region within the meaning of Article 349 of the Treaty on the Functioning of the European Union (hereinafter 'Mayotte'), provided that such application requires specific technical facilities that are not available in Mayotte.

The first subparagraph does not apply to the obligations set out in Article 5(1) of this Directive, or to the provisions of this Directive which reflect the general principles laid down in Directive 89/391/EEC.

2 All derogations from this Directive resulting from the application of measures existing on 1 January 2014 or from the adoption of new measures shall be preceded by a consultation with the social partners in accordance with national law and practice. Such derogations shall be applied under conditions which, taking into account the particular circumstances prevailing in Mayotte, guarantee that the resulting risks for workers are reduced to a minimum and that the workers concerned benefit from reinforced health surveillance.

3 The national derogating measures shall be reviewed every year, after consultation with the social partners, and shall be withdrawn as soon as the circumstances justifying them no longer subsist.**]**

Textual Amendments

F5 Inserted by Council Directive 2013/64/EU of 17 December 2013 amending Council Directives 91/271/EEC and 1999/74/EC, and Directives 2000/60/EC, 2006/7/EC, 2006/25/EC and 2011/24/EU of the European Parliament and of the Council, following the amendment of the status of Mayotte with regard to the European Union.

Article 15 U.K.

Entry into force

This Directive shall enter into force on the day of its publication in the *Official Journal of the European Union*.

Article 16 U.K.

Addressees

This Directive is addressed to the Member States.

ANNEX I U.K.

Non-coherent optical radiation

The biophysically relevant exposure values to optical radiation can be determined with the formulae below. The formulae to be used depend on the range of radiation emitted by the source and the results should be compared with the corresponding exposure limit values indicated in Table 1.1. More than one exposure value and corresponding exposure limit can be relevant for a given source of optical radiation.

Numbering (a) to (o) refers to corresponding rows of Table 1.1.

(a)	$H_{\mathrm{eff}} = \int_0^t \int_{\lambda=180\ \mathrm{nm}}^{\lambda=400\ \mathrm{nm}} E_\lambda(\lambda,t) \times S(\lambda) \times \mathrm{d}\lambda \times \mathrm{d}t$	(H_{eff} is only relevant in the range 180 to 400 nm)
(b)	$H_{\mathrm{UVA}} = \int_0^t \int_{\lambda=315\ \mathrm{nm}}^{\lambda=400\ \mathrm{nm}} E_\lambda(\lambda,t) \times \mathrm{d}\lambda \times \mathrm{d}t$	(H_{UVA} is only relevant in the range 315 to 400 nm)
(c), (d)	$L_B = \int_{\lambda=300\ \mathrm{nm}}^{\lambda=700\ \mathrm{nm}} L_\lambda(\lambda) \times B(\lambda) \times \mathrm{d}\lambda$	(L_B is only relevant in the range 300 to 700 nm)
(e), (f)	$E_B = \int_{\lambda=300\ \mathrm{nm}}^{\lambda=700\ \mathrm{nm}} E_\lambda(\lambda) \times B(\lambda) \times \mathrm{d}\lambda$	(E_B is only relevant in the range 300 to 700 nm)
(g) to (l)	$L_R = \int_{\lambda_1}^{\lambda_2} L_\lambda(\lambda) \times R(\lambda) \times \mathrm{d}\lambda$	(See Table 1.1 for appropriate values of λ_1 and λ_2)
(m), (n)	$E_{\mathrm{IR}} = \int_{\lambda=780\ \mathrm{nm}}^{\lambda=3000\ \mathrm{nm}} E_\lambda(\lambda) \times \mathrm{d}\lambda$	(E_{IR} is only relevant in the range 780 to 3 000 nm)
(o)	$H_{\mathrm{skin}} = \int_0^t \int_{\lambda=380\ \mathrm{nm}}^{\lambda=3000\ \mathrm{nm}} E_\lambda(\lambda,t) \times \mathrm{d}\lambda \times \mathrm{d}t$	(H_{skin} is only relevant in the range 380 to 3 000 nm)

For the purposes of this Directive, the formulae above can be replaced by the following expressions and the use of discrete values as set out in the following tables:

(a)	$E_{\mathrm{eff}} = \sum_{\lambda=180\ \mathrm{nm}}^{\lambda=400\ \mathrm{nm}} E_\lambda \times S(\lambda) \times \Delta\lambda$	and $H_{\mathrm{eff}} = E_{\mathrm{eff}} \times \Delta t$
(b)	$E_{\mathrm{UVA}} = \sum_{\lambda=315\ \mathrm{nm}}^{\lambda=400\ \mathrm{nm}} E_\lambda \times \Delta\lambda$	and $H_{\mathrm{UVA}} = E_{\mathrm{UVA}} \times \Delta t$
(c), (d)	$L_B = \sum_{\lambda=300\ \mathrm{nm}}^{\lambda=700\ \mathrm{nm}} L_\lambda \times B(\lambda) \times \Delta\lambda$	
(e), (f)	$E_B = \sum_{\lambda=300\ \mathrm{nm}}^{\lambda=700\ \mathrm{nm}} E_\lambda \times B(\lambda) \times \Delta\lambda$	
(g) to (l)	$L_R = \sum_{\lambda_1}^{\lambda_2} L_\lambda \times R(\lambda) \times \Delta\lambda$	(See Table 1.1 for appropriate values of λ_1 and λ_2)
(m), (n)	$E_{\mathrm{IR}} = \sum_{\lambda=780\ \mathrm{nm}}^{\lambda=3000\ \mathrm{nm}} E_\lambda \times \Delta\lambda$	
(o)	$E_{\mathrm{skin}} = \sum_{\lambda=380\ \mathrm{nm}}^{\lambda=3000\ \mathrm{nm}} E_\lambda \times \Delta\lambda$	and $H_{\mathrm{skin}} = E_{\mathrm{skin}} \times \Delta t$

Notes:

$E\lambda(\lambda,t)$, $E\lambda$	*spectral irradiance or spectral power density*: the radiant power incident per unit area upon a surface, expressed in watts per square metre per nanometre [W m^{-2} nm^{-1}]; values of $E\lambda(\lambda, t)$ and E_λ come from measurements or may be provided by the manufacturer of the equipment;
E_{eff}	*effective irradiance (UV range)*: calculated irradiance within the UV wavelength range 180 to 400 nm spectrally weighted by $S(\lambda)$, expressed in watts per square metre [W m^{-2}];
H	*radiant exposure*: the time integral of the irradiance, expressed in joules per square metre [J m^{-2}];
H_{eff}	*effective radiant exposure*: radiant exposure spectrally weighted by $S(\lambda)$, expressed in joules per square metre [J m^{-2}];
E_{UVA}	*total irradiance (UVA)*: calculated irradiance within the UVA wavelength range 315 to 400 nm, expressed in watts per square metre [W m^{-2}];
H_{UVA}	*radiant exposure*: the time and wavelength integral or sum of the irradiance within the UVA wavelength range 315 to 400 nm, expressed in joules per square metre [J m^{-2}];
$S(\lambda)$	*spectral weighting* taking into account the wavelength dependence of the health effects of UV radiation on eye and skin, (Table 1.2) [dimensionless];
t, Δt	*time, duration of the exposure*, expressed in seconds [s];
λ	*wavelength*, expressed in nanometres [nm];
$\Delta\lambda$	*bandwidth*, expressed in nanometres [nm], of the calculation or measurement intervals;
$L\lambda(\lambda)$, L_λ	*spectral radiance of the source* expressed in watts per square metre per steradian per nanometre [W m^{-2} sr^{-1} nm^{-1}];
$R(\lambda)$	*spectral weighting* taking into account the wavelength dependence of the thermal injury caused to the eye by visible and IRA radiation (Table 1.3) [dimensionless];
L_R	*effective radiance*(*thermal injury*): calculated radiance spectrally weighted by $R(\lambda)$ expressed in watts per square metre per steradian [W m^{-2} sr^{-1}];
$B(\lambda)$	*spectral weighting* taking into account the wavelength dependence of the photochemical injury caused to the eye by blue light radiation (Table 1.3) [dimensionless];
L_B	*effective radiance*(*blue light*): calculated radiance spectrally weighted by $B(\lambda)$, expressed in watts per square metre per steradian [W m^{-2} sr^{-1}];
E_B	*effective irradiance (blue light)*: calculated irradiance spectrally weighted by $B(\lambda)$ expressed in watts per square metre [W m^{-2}];
E_{IR}	*total irradiance (thermal injury)*: calculated irradiance within the infrared wavelength range 780 nm to 3 000 nm expressed in watts per square metre [W m^{-2}];
E_{skin}	*total irradiance (visible, IRA and IRB)*: calculated irradiance within the visible and infrared wavelength range 380 nm to 3 000 nm, expressed in watts per square metre [W m^{-2}];
H_{skin}	*radiant exposure*: the time and wavelength integral or sum of the irradiance within the visible and infrared wavelength range 380 to 3 000 nm, expressed in joules per square metre (J m^{-2});

α — *angular subtense*: the angle subtended by an apparent source, as viewed at a point in space, expressed in milliradians (mrad). Apparent source is the real or virtual object that forms the smallest possible retinal image.

TABLE 1.1

Exposure limit values for non-coherent optical radiation

Index	Wavelength nm	Exposure limit value	Units	Comment	Part of the body	Hazard
a.	180-400 (UVA, UVB and UVC)	H_{eff} = 30 Daily value 8 hours	[J m^{-2}]		eye: cornea, conjunctiva, lens; skin	photokeratitis, conjunctivitis, cataractogenesis, erythema, elastosis, skin cancer
b.	315-400 (UVA)	$H_{UVA} = 10^4$ Daily value 8 hours	[J m^{-2}]		eye lens	cataractogenesis
c.	300-700 (Blue light) *see note 1*	$L_B = \frac{10^6}{t}$ for t ≤ 10 000 s	L_B :[W m^{-2} sr^{-1}] t: [seconds]	for α ≥ 11 mrad	eye retina	photoretinitis
d.	300-700 (Blue light) *see note 1*	L_B = 100 for t > 10 000 s	[W m^{-2} sr^{-1}]			
e.	300-700 (Blue light) *see note 1*	$E_B = \frac{100}{t}$ for t ≤ 10 000 s	E_B: [W m^{-2}] t: [seconds]	for α < 11 mrad *see note 2*		
f.	300-700 (Blue light) *see note 1*	E_B = 0,01 t >10 000 s	[W m^{-2}]			
g.	380-1 400 (Visible and IRA)	$L_R = \frac{2{,}8\times10^7}{C_\alpha}$ for t >10 s	[W m^{-2} sr^{-1}]	C_α = 1,7 for α ≤ 1,7 mrad C_α = α for 1,7 ≤ α ≤ 100 mrad C_α = 100 for	eye retina	retinal burn
h.	380-1 400 (Visible and IRA)	$L_R = \frac{5\times10^7}{C_\alpha t^{0{,}35}}$ for 10 μs ≤ t ≤ 10 s	L_R:[W m^{-2} sr^{-1}] t: [seconds]			

Note 1: The range of 300 to 700 nm covers parts of UVB, all UVA and most of visible radiation; however, the associated hazard is commonly referred to as '*blue light*' hazard. Blue light strictly speaking covers only the range of approximately 400 to 490 nm.

Note 2: For steady fixation of very small sources with an angular subtense < 11 mrad, L_B can be converted to E_B. This normally applies only for ophthalmic instruments or a stabilized eye during anaesthesia. The maximum 'stare time' is found by: $t_{max} = 100/E_B$ with E_B expressed in W m^{-2}. Due to eye movements during normal visual tasks this does not exceed 100 s.

i.	380-1 400 (Visible and IRA)	$L_R = \frac{8,89\times10^8}{C_\alpha}$ for t <10 μs	[W m^{-2} sr^{-1}]	α > 100 mrad λ_1= 380; λ_2= 1 400		
j.	780-1 400 (IRA)	$L_R = \frac{6\times10^6}{C_\alpha}$ for t > 10 s	[W m^{-2} sr^{-1}]	C_α = 11 for α ≤ 11 mrad C_α = α for 11≤ α ≤ 100 mrad C_α = 100 for α > 100 mrad (measurement field-of-view: 11 mrad) λ_1= 780; λ_2= 1 400	eye retina	retinal burn
k.	780-1 400 (IRA)	$L_R = \frac{5\times10^7}{C_\alpha t^{0,25}}$ for 10 μs ≤ t ≤ 10 s	L_R: [W m^{-2} sr^{-1}] t: [seconds]			
l.	780-1 400 (IRA)	$L_R = \frac{8,89\times10^8}{C_\alpha}$ for t < 10 μs	[W m^{-2} sr^{-1}]			
m.	780-3 000 (IRA and IRB)	E_{IR} = 18 000 $t^{-0,75}$ for t ≤ 1 000 s	E: [W m^{-2}] t: [seconds]		eye: cornea, lens	corneal burn cataractogenesis
n.	780-3 000 (IRA and IRB)	E_{IR} = 100 for t > 1 000 s	[W m^{-2}]			
o.	380-3 000 (Visible, IRA and IRB)	H_{skin} = 20 000 $t^{0,25}$ for t < 10 s	H: [J m^{-2}] t: [seconds]		skin	burn

Note 1: The range of 300 to 700 nm covers parts of UVB, all UVA and most of visible radiation; however, the associated hazard is commonly referred to as '*blue light*' hazard. Blue light strictly speaking covers only the range of approximately 400 to 490 nm.

Note 2: For steady fixation of very small sources with an angular subtense < 11 mrad, L_B can be converted to E_B. This normally applies only for ophthalmic instruments or a stabilized eye during anaesthesia. The maximum 'stare time' is found by: $t_{max} = 100/E_B$ with E_B expressed in W m^{-2}. Due to eye movements during normal visual tasks this does not exceed 100 s.

TABLE 1.2

S (λ) [dimensionless], 180 nm to 400 nm

λ in nm	**S (λ)**	**λ in nm**	**S (λ)**	**λ in nm**	**S (λ)**	**λ in nm**	**S (λ)**	**λ in nm**	**S (λ)**
180	0,012	228	0,1737	276	0,9434	324	0,00052	372	0,000086
181	0,0126	229	0,1819	277	0,9272	325	0,0005	373	0,000083

182	0,0132	230	0,19	278	0,9112	326	0,000479	374	0,00008
183	0,0138	231	0,1995	279	0,8954	327	0,000459	375	0,000077
184	0,0144	232	0,2089	280	0,88	328	0,00044	376	0,000074
185	0,0151	233	0,2188	281	0,8568	329	0,000425	377	0,000072
186	0,0158	234	0,2292	282	0,8342	330	0,00041	378	0,000069
187	0,0166	235	0,24	283	0,8122	331	0,000396	379	0,000066
188	0,0173	236	0,251	284	0,7908	332	0,000383	380	0,000064
189	0,0181	237	0,2624	285	0,77	333	0,00037	381	0,000062
190	0,019	238	0,2744	286	0,742	334	0,000355	382	0,000059
191	0,0199	239	0,2869	287	0,7151	335	0,00034	383	0,000057
192	0,0208	240	0,3	288	0,6891	336	0,000327	384	0,000055
193	0,0218	241	0,3111	289	0,6641	337	0,000315	385	0,000053
194	0,0228	242	0,3227	290	0,64	338	0,000303	386	0,000051
195	0,0239	243	0,3347	291	0,6186	339	0,000291	387	0,000049
196	0,025	244	0,3471	292	0,598	340	0,00028	388	0,000047
197	0,0262	245	0,36	293	0,578	341	0,000271	389	0,000046
198	0,0274	246	0,373	294	0,5587	342	0,000263	390	0,000044
199	0,0287	247	0,3865	295	0,54	343	0,000255	391	0,000042
200	0,03	248	0,4005	296	0,4984	344	0,000248	392	0,000041
201	0,0334	249	0,415	297	0,46	345	0,00024	393	0,000039
202	0,0371	250	0,43	298	0,3989	346	0,000231	394	0,000037
203	0,0412	251	0,4465	299	0,3459	347	0,000223	395	0,000036
204	0,0459	252	0,4637	300	0,3	348	0,000215	396	0,000035
205	0,051	253	0,4815	301	0,221	349	0,000207	397	0,000033
206	0,0551	254	0,5	302	0,1629	350	0,0002	398	0,000032
207	0,0595	255	0,52	303	0,12	351	0,000191	399	0,000031
208	0,0643	256	0,5437	304	0,0849	352	0,000183	400	0,00003
209	0,0694	257	0,5685	305	0,06	353	0,000175		
210	0,075	258	0,5945	306	0,0454	354	0,000167		
211	0,0786	259	0,6216	307	0,0344	355	0,00016		
212	0,0824	260	0,65	308	0,026	356	0,000153		
213	0,0864	261	0,6792	309	0,0197	357	0,000147		
214	0,0906	262	0,7098	310	0,015	358	0,000141		
215	0,095	263	0,7417	311	0,0111	359	0,000136		

216	0,0995	264	0,7751	312	0,0081	360	0,00013		
217	0,1043	265	0,81	313	0,006	361	0,000126		
218	0,1093	266	0,8449	314	0,0042	362	0,000122		
219	0,1145	267	0,8812	315	0,003	363	0,000118		
220	0,12	268	0,9192	316	0,0024	364	0,000114		
221	0,1257	269	0,9587	317	0,002	365	0,00011		
222	0,1316	270	1,0	318	0,0016	366	0,000106		
223	0,1378	271	0,9919	319	0,0012	367	0,000103		
224	0,1444	272	0,9838	320	0,001	368	0,000099		
225	0,15	273	0,9758	321	0,000819	369	0,000096		
226	0,1583	274	0,9679	322	0,00067	370	0,000093		
227	0,1658	275	0,96	323	0,00054	371	0,00009		

TABLE 1.3

B (λ), R (λ) [dimensionless], 380 nm to 1 400 nm

λ in nm	**B (λ)**	**R (λ)**
$300 \leq \lambda < 380$	0,01	—
380	0,01	0,1
385	0,013	0,13
390	0,025	0,25
395	0,05	0,5
400	0,1	1
405	0,2	2
410	0,4	4
415	0,8	8
420	0,9	9
425	0,95	9,5
430	0,98	9,8
435	1	10
440	1	10
445	0,97	9,7
450	0,94	9,4
455	0,9	9
460	0,8	8
465	0,7	7

470	0,62	6,2
475	0,55	5,5
480	0,45	4,5
485	0,32	3,2
490	0,22	2,2
495	0,16	1,6
500	0,1	1
$500 < \lambda \leq 600$	$10^{0,02 \cdot (450 - \lambda)}$	1
$600 < \lambda \leq 700$	0,001	1
$700 < \lambda \leq 1\ 050$	—	$10^{0,002 \cdot (700 - \lambda)}$
$1\ 050 < \lambda \leq 1\ 150$	—	0,2
$1\ 150 < \lambda \leq 1\ 200$	—	$0,2 \cdot 10^{0,02 \cdot (1\ 150 - \lambda)}$
$1\ 200 < \lambda \leq 1\ 400$	—	0,02

ANNEX II U.K.

Laser optical radiation

The biophysically relevant exposure values to optical radiation can be determined with the formulae below. The formulae to be used depend on the wavelength and duration of radiation emitted by the source and the results should be compared with the corresponding exposure limit values indicated in the Tables 2.2 to 2.4. More than one exposure value and corresponding exposure limit can be relevant for a given source of laser optical radiation.

Coefficients used as calculation tools within the Tables 2.2 to 2.4 are listed in Table 2.5 and corrections for repetitive exposure are listed in Table 2.6.

$$E = \frac{dP}{dA}\left[\mathrm{W\ m^{-2}}\right]$$

$$H = \int_0^t E(t) \times dt\left[\mathrm{J\ m^{-2}}\right]$$

Notes:

dP	*power* expressed in watt [W];
dA	*surface* expressed in square metres [m^2];
E (t), E	*irradiance or power density*: the radiant power incident per unit area upon a surface, generally expressed in watts per square metre [W m^{-2}]. Values of E(t), E come from measurements or may be provided by the manufacturer of the equipment;
H	*radiant exposure*: the time integral of the irradiance, expressed in joules per square metre [J m^{-2}];
t	*time, duration of the exposure*, expressed in seconds [s];
λ	*wavelength*, expressed in nanometres [nm];

γ	*limiting cone angle of* measurement *field-of-view* expressed in milliradians [mrad];
γ_m	*measurement field of view* expressed in milliradians [mrad];
α	*angular subtense of a source* expressed in milliradians [mrad];
	limiting aperture: the circular area over which irradiance and radiant exposure are *averaged*;
G	*integrated radiance*: the integral of the radiance over a given exposure time expressed as radiant energy per unit area of a radiating surface per unit solid angle of emission, in joules per square metre per steradian [J m^{-2} sr^{-1}].

Table 2.1 Radiation hazards U.K.

Wavelength [nm]λ	**Radiation range**	**Affected organ**	**Hazard**	**Exposure limit value table**
180 to 400	UV	eye	photochemical damage and thermal damage	2.2, 2.3
180 to 400	UV	skin	erythema	2.4
400 to 700	visible	eye	retinal damage	2.2
400 to 600	visible	eye	photochemical damage	2.3
400 to 700	visible	skin	thermal damage	2.4
700 to 1 400	IRA	eye	thermal damage	2.2, 2.3
700 to 1 400	IRA	skin	thermal damage	2.4
1 400 to 2 600	IRB	eye	thermal damage	2.2
2 600 to 10^6	IRC	eye	thermal damage	2.2
1 400 to 10^6	IRB, IRC	eye	thermal damage	2.3
1 400 to 10^6	IRB, IRC	skin	thermal damage	2.4

Table 2.2 Exposure limit values for laser exposure to the eye — Short exposure duration < 10 s U.K.

Wavelength [a] [nm]		Aperture	Duration [s]						
			10^{-13} - 10^{-11}	10^{-11} - 10^{-9}	10^{-9} - 10^{-7}	10^{-7} - $1{,}8 \cdot 10^{-5}$	$1{,}8 \cdot 10^{-5}$ - $5 \cdot 10^{-5}$	$5 \cdot 10^{-5}$ - 10^{-3}	10^{-3} – 10^{1}
UVC	180 - 280	1 mm for t<0,3 s; $1{,}5 \cdot t^{0{,}375}$ for 0,3<t<10 s	$E = 3 \cdot 10^{10}$ [W m^{-2}] See note [c]		$H = 30$ [J m^{-2}]				
UVB	280 - 302				$H = 40$ [J m^{-2}];	if $t < 2{,}6 \cdot 10^{-9}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	303				$H = 60$ [J m^{-2}];	if $t < 1{,}3 \cdot 10^{-8}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	304				$H = 100$ [J m^{-2}];	if $t < 1{,}0 \cdot 10^{-7}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	305				$H = 160$ [J m^{-2}];	if $t < 6{,}7 \cdot 10^{-7}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	306				$H = 250$ [J m^{-2}];	if $t < 4{,}0 \cdot 10^{-6}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	307				$H = 400$ [J m^{-2}];	if $t < 2{,}6 \cdot 10^{-5}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	308				$H = 630$ [J m^{-2}];	if $t < 1{,}6 \cdot 10^{-4}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	309				$H = 10^{3}$ [J m^{-2}];	if $t < 1{,}0 \cdot 10^{-3}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	310				$H = 1{,}6 \cdot 10^{3}$ [J m^{-2}];	if $t < 6{,}7 \cdot 10^{-3}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	311				$H = 2{,}5 \cdot 10^{3}$ [J m^{-2}];	if $t < 4{,}0 \cdot 10^{-2}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	312				$H = 4{,}0 \cdot 10^{3}$ [J m^{-2}];	if $t < 2{,}6 \cdot 10^{-1}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	313				$H = 6{,}3 \cdot 10^{3}$ [J m^{-2}];	if $t < 1{,}6 \cdot 10^{0}$ then $H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}] see note [d]			
	314								
UVA	315 - 400				$H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}]				
Visible& IRA	400 - 700	7 mm	$H = 1{,}5 \cdot 10^{-4}\, C_E$ [J m^{-2}]	$H = 2{,}7 \cdot 10^{4}\, t^{0{,}75}\, C_E$ [J m^{-2}]	$H = 5 \cdot 10^{-3}\, C_E$ [J m^{-2}]		$H = 18\ t^{0{,}75}\, C_E$ [J m^{-2}]		
	700 - 1 050		$H = 1{,}5 \cdot 10^{-4}\, C_A\, C_E$ [J m^{-2}]	$H = 2{,}7 \cdot 10^{4}\, t^{0{,}75}\, C_A\, C_E$ [J m^{-2}]	$H = 5 \cdot 10^{-3}\, C_A\, C_E$ [J m^{-2}]		$H = 18\ t^{0{,}75}\, C_A\, C_E$ [J m^{-2}]		
	1 050- 1 400		$H = 1{,}5 \cdot 10^{-3}\, C_C\, C_E$ [J m^{-2}]	$H = 2{,}7 \cdot 10^{5}\, t^{0{,}75}\, C_C\, C_E$ [J m^{-2}]	$H = 5 \cdot 10^{-2}\, C_C\, C_E$ [J m^{-2}]			$H = 90\ t^{0{,}75}\, C_C\, C_E$ [J m^{-2}]	
IRB & IRC	1 400 - 1 500	See note [b]	$E = 10^{12}$ [W m^{-2}] See note [c]		$H = 10^{3}$ [J m^{-2}]			$H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}]	
	1 500 - 1 800		$E = 10^{13}$ [W m^{-2}] See note [c]		$H = 10^{4}$ [J m^{-2}]				
	1 800 - 2 600		$E = 10^{12}$ [W m^{-2}] See note [c]		$H = 10^{3}$ [J m^{-2}]			$H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}]	
	2 600 - 10^{6}		$E = 10^{11}$ [W m^{-2}] See note [c]		H=100 [J m^{-2}]	$H = 5{,}6 \cdot 10^{3}\, t^{0{,}25}$ [J m^{-2}]			

a If the wavelength of the laser is covered by two limits, then the more restrictive applies.
b When $1\,400 \le \lambda < 10^{5}$ nm : aperture diameter = 1 mm for $t \le 0{,}3$ s and $1{,}5\, t^{0{,}375}$ mm for $0{,}3\ s < t < 10$ s; when $10^{5} \le \lambda < 10^{6}$ nm : aperture diameter = 11 mm.
c Due to lack of data at these pulse lengths, ICNIRP recommends the use of the 1 ns irradiance limits.
d The table states values for single laser pulses. In case of multiple laser pulses, then the laser pulse durations of pulses falling within an interval T_{min} (listed in table 2.6) must be added up and the resulting time value must be filled in for t in the formula: $5{,}6\ 10^{3}\ t^{0{,}25}$.

Table 2.3 Exposure limit values for laser exposure to the eye — Long exposure duration ≥ 10 s U.K.

Wavelength [a] [nm]		Aperture	Duration [s]		
			10^{1} - 10^{2}	10^{2} - 10^{4}	10^{4} - $3 \cdot 10^{4}$
UVC	180 - 280	3,5 mm	$H = 30$ [J m^{-2}]		
UVB	280 - 302		$H = 40$ [J m^{-2}]		
	303		$H = 60$ [J m^{-2}]		
	304		$H = 100$ [J m^{-2}]		
	305		$H = 160$ [J m^{-2}]		
	306		$H = 250$ [J m^{-2}]		
	307		$H = 400$ [J m^{-2}]		
	308		$H = 630$ [J m^{-2}]		
	309		$H = 1{,}0 \cdot 10^{3}$ [J m^{-2}]		
	310		$H = 1{,}6 \cdot 10^{3}$ [J m^{-2}]		
	311		$H = 2{,}5 \cdot 10^{3}$ [J m^{-2}]		
	312		$H = 4{,}0 \cdot 10^{3}$ [J m^{-2}]		
	313		$H = 6{,}3 \cdot 10^{3}$ [J m^{-2}]		
	314				
UVA	315 - 400		$H = 10^{4}$ [J m^{-2}]		
Visible 400 – 700	400 - 600 Photochemical [b] Retinal damage	7 mm	$H = 100\ C_B$ [J m^{-2}] ($\gamma = 11$ mrad) [d]	$E = 1\ C_B$ [W m^{-2}]: ($\gamma = 1{,}1\ t^{0{,}5}$ mrad) [d]	$E = 1\ C_B$ [W m^{-2}] ($\gamma = 110$ mrad) [d]
	400 - 700 Thermal [b] Retinal damage		if $\alpha < 1{,}5$ mrad then $E = 10$ [W m^{-2}] if $\alpha > 1{,}5$ mrad and $t \le T_2$ then $H = 18\ C_B\, t^{0{,}75}$ [J m^{-2}] if $\alpha > 1{,}5$ mrad and $t > T_2$ then $E = 18\ C_B\, T_2^{-0{,}25}$ [W m^{-2}]		
IRA	700 - 1 400	7 mm	if $\alpha < 1{,}5$ mrad then $E = 10\ C_A\, C_C$ [W m^{-2}] if $\alpha > 1{,}5$ mrad and $t \le T_2$ then $H = 18\ C_A\, C_C\, C_E\, t^{0{,}75}$ [J m^{-2}] if $\alpha > 1{,}5$ mrad and $t > T_2$ then $E = 18\ C_A\, C_C\, C_E\, T_2^{0{,}25}$ [W m^{-2}] (not to exceed 1 000 W m^{-2})		
IRB & IRC	1 400 - 10^{6}	See [c]	$E = 1\,000$ [W m^{-2}]		

a If the wavelength or another condition of the laser is covered by two limits, then the more restrictive applies.
b For small sources subtending an angle of 1,5 mrad or less, the visible dual limits E from 400 nm to 600 nm reduce to the thermal limits for $10\ s \le t < T_1$ and to photochemical limits for longer times. For T_1 and T_2 see Table 2.5. The photochemical retinal hazard limit may also be expressed as a time integrated radiance $G = 10^{6}\, C_B$ [J m^{-2} sr^{-1}] for $t > 10$s up to $t = 10\,000$ s and $L = 100\, C_B$[W m^{-2} sr^{-1}] for $t > 10\,000$ s. For the measurement of G and L_{γ_m} must be used as averaging field of view. The official border between visible and infrared is 780 nm as defined by the CIE. The column with wavelength band names is only meant to provide better overview for the user. (The notation G is used by CEN; the notation L_s is used by CIE; the notation L_γ is used by IEC and CENELEC.)
c For wavelength $1\,400 - 10^{5}$ nm : aperture diameter = 3,5 mm; for wavelength $10^{5} - 10^{6}$ nm: aperture Diameter = 11 mm.
d For measurement of the exposure value the consideration of γ is defined as follows: If α (angular subtense of a source) > γ (limiting cone angle, indicated in brackets in the corresponding column) then the measurement field of view γ_m should be the given value of γ. (If a larger measurement field of view is used, then the hazard would be overestimated).
If α < γ then the measurement field of view γ_m must be large enough to fully enclose the source but is otherwise not limited and may be larger than γ.

Table 2.4 Exposure limit values for laser exposure of skin U.K.

Wavelength [a] [nm]		Aperture	Duration [s]					
			$< 10^{-9}$	10^{-9} - 10^{-7}	10^{-7} - 10^{-3}	10^{-3} – 10^{1}	10^{1} - 10^{3}	10^{3} - $3 \cdot 10^{4}$
UV (A, B, C)	180-400	3. 5mm	$E = 3 \cdot 10^{10}$ [W m^{-2}]	Same as eye exposure limits				
Visible and IRA	400-700	3. 5mm	$E = 2 \cdot 10^{11}$ [W m^{-2}]	$H = 200\ C_A$	$H = 1{,}1 \cdot 10^{4}\ C_A\ t^{0{,}25}$ [J m^{-2}]		$E = 2 \cdot 10^{3}\ C_A$ [W m^{-2}]	
	700 -1 400		$E = 2 \cdot 10^{11}\ C_A$ [W m^{-2}]	[J m^{-2}]				
IRB and IRC	1 400-1 500		$E = 10^{12}$ [W m^{-2}]	Same as eye exposure limits				
	1 500-1 800		$E = 10^{13}$ [W m^{-2}]					
	1 800-2 600		$E = 10^{12}$ [W m^{-2}]					
	2 600-10^{6}		$E = 10^{11}$ [W m^{-2}]					

a If the wavelength or another condition of the laser is covered by two limits, then the more restrictive applies.

Table 2.5 Applied correction factors and other calculation parameters U.K.

Parameter as listed in ICNIRP	Valid spectral range (nm)	Value
C_A	$\lambda < 700$	$C_A = 1{,}0$
	700 — 1 050	$C_A = 10^{\,0{,}002(\lambda - 700)}$
	1 050 — 1 400	$C_A = 5{,}0$
C_B	400 — 450	$C_B = 1{,}0$
	450 — 700	$C_B = 10^{\,0{,}02(\lambda - 450)}$
C_C	700 — 1 150	$C_C = 1{,}0$
	1 150 — 1 200	$C_C = 10^{\,0{,}018(\lambda - 1\,150)}$
	1 200 — 1 400	$C_C = 8{,}0$
T_1	$\lambda < 450$	$T_1 = 10$ s
	450 — 500	$T_1 = 10 \cdot [10^{\,0{,}02\,(\lambda - 450)}]$ s
	$\lambda > 500$	$T_1 = 100$ s

Parameter as listed in ICNIRP	Valid for biological effect	Value
α_{min}	all thermal effects	$\alpha_{min} = 1{,}5$ mrad

Parameter as listed in ICNIRP	Valid angular range (mrad)	Value
C_E	$\alpha < \alpha_{min}$	$C_E = 1{,}0$
	$\alpha_{min} < \alpha < 100$	$C_E = \alpha/\alpha_{min}$
	$\alpha > 100$	$C_E = \alpha^2/(\alpha_{min} \cdot \alpha_{max})$ mrad with $\alpha_{max} = 100$ mrad
T_2	$\alpha < 1{,}5$	$T_2 = 10$ s

	$1{,}5 < \alpha < 100$	$T_2 = 10 \cdot [10^{(\alpha - 1{,}5) / 98{,}5}]$ s
	$\alpha > 100$	$T_2 = 100$ s

Parameter as listed in ICNIRP	Valid exposure time range (s)	Value
γ	$t \leq 100$	$\gamma = 11$ [mrad]
	$100 < t < 10^4$	$\gamma = 1{,}1\ t^{0,5}$ [mrad]
	$t > 10^4$	$\gamma = 110$ [mrad]

Table 2.6 Correction for repetitive exposure U.K.

Each of the following three general rules should be applied to all repetitive exposures as occur from repetitively pulsed or scanning laser systems:

1. The exposure from any single pulse in a train of pulses shall not exceed the exposure limit value for a single pulse of that pulse duration.

2. The exposure from any group of pulses (or sub-group of pulses in a train) delivered in time t shall not exceed the exposure limit value for time t.

3. The exposure from any single pulse within a group of pulses shall not exceed the single-pulse exposure limit value multiplied by a cumulative-thermal correction factor $C_p=N^{-0,25}$, where N is the number of pulses. This rule applies only to exposure limits to protect against thermal injury, where all pulses delivered in less than T_{min} are treated as a single pulse.

Parameter	Valid spectral range (nm)	Value
T_{min}	$315 < \lambda \leq 400$	$T_{min} = 10^{-9}$ s (= 1 ns)
	$400 < \lambda \leq 1\,050$	$T_{min} = 18 \cdot 10^{-6}$ s (= 18 μs)
	$1\,050 < \lambda \leq 1\,400$	$T_{min} = 50 \cdot 10^{-6}$ s (= 50 μs)
	$1\,400 < \lambda \leq 1\,500$	$T_{min} = 10^{-3}$ s (= 1 ms)
	$1\,500 < \lambda \leq 1\,800$	$T_{min} = 10$ s
	$1\,800 < \lambda \leq 2\,600$	$T_{min} = 10^{-3}$ s (= 1 ms)
	$2\,600 < \lambda \leq 10^6$	$T_{min} = 10^{-7}$ s (= 100 ns)

(**1**) OJ C 77, 18.3.1993, p. 12 and OJ C 230, 19.8.1994, p. 3.

(**2**) OJ C 249, 13.9.1993, p. 28.

(**3**) Opinion of the European Parliament of 20 April 1994 (OJ C 128, 9.5.1994, p. 146) confirmed on 16 September 1999 (OJ C 54, 25.2.2000, p. 75), Council Common Position of 18 April 2005 (OJ C 172 E , 12.7.2005, p. 26) and Position of the European Parliament of 16 November 2005 (not yet published in the Official Journal), European Parliament Legislative Resolution of 14 February 2006 (not yet published in the Official Journal) and Decision of the Council of 23 February 2006.

(**4**) OJ C 260, 15.10.1990, p. 167.

(**5**) OJ L 177, 6.7.2002, p. 13.

(**6**) OJ L 42, 15.2.2003, p. 38.

(**7**) OJ L 159, 30.4.2004, p. 1. Directive as corrected in OJ L 184, 24.5.2004, p. 1.

(**8**) OJ L 183, 29.6.1989, p. 1. Directive as amended by Regulation (EC) No 1882/2003 of the European Parliament and of the Council (OJ L 284, 31.10.2003, p. 1).

(**9**) OJ L 184, 17.7.1999, p. 23.

(**10**) OJ C 321, 31.12.2003, p. 1.

(**11**) OJ L 245, 26.8.1992, p. 23.

(**12**) **[**[F2]OJ L 123, 12.5.2016, p. 1.**]**

Textual Amendments

F2 Inserted by Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance).