



Annex to Paper HSC/04/75

**COUNCIL OF  
THE EUROPEAN UNION**

**Brussels, 18 June 2004**

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**NOTE**

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from : the Presidency

to : Social Questions Working Party

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No. Cion props. : 5059/93 SOC 88 - COM (92) 560 final

8392/94 SOC 209 - COM (94) 284 final SYN 449

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**Subject : Amended proposal for a Directive of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (optical radiation)**

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Delegations will find attached a text of the optical radiation element of the above-mentioned amended proposal, presented by the Irish Presidency with a view to the meeting of the Social Questions Working Party on 29 June 2004.

**Draft proposal for a**

**DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on  
the minimum health and safety requirements regarding the exposure of workers to  
the risks arising from physical agents (optical radiation) ([19]th 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<sup>1</sup>, presented after consultation with the Advisory Committee on Safety, Hygiene and Health Protection at Work,

Having regard to the Opinion of the Economic and Social Committee<sup>2</sup>,

Having consulted the Committee of the Regions,

Acting in accordance with the procedure laid down in Article 251 of the Treaty<sup>3</sup>,

Whereas:

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<sup>1</sup> OJ C 77, 18.3.1993, p. 12 and OJ C 230, 19.8.1994, p. 3.

<sup>2</sup> OJ C 249, 13.9.1993, p. 28.

<sup>3</sup> 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), common position of the Council of .....(not yet published in the OJ) and Decision of the European Parliament of ..... (not yet published in the Official Journal).

- (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 undertakings.
- (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<sup>4</sup>, 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) On 25 June 2002, the European Parliament and the Council adopted Directive 2002/44/EC<sup>5</sup> 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<sup>6</sup>). Subsequently, on 6 February 2003, the European Parliament and the Council adopted Directive 2003/10/EC<sup>7</sup> 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). Thereafter, on 29th April 2004, the European Parliament and the Council adopted Directive 2004/40/EC<sup>8</sup> 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).

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<sup>4</sup> OJ C 260, 15.10.1990, p.167

<sup>5</sup> OJ L 177, 6.7.2002, p.13

<sup>6</sup> OJ L 183, 29.6.1989, p.1

<sup>7</sup> OJ L 42, 15.2.2003, p.38

<sup>8</sup> OJ L .....

- (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) 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 should not serve to justify any regression in relation to the situation which already prevails in each Member State.
- (6) A system of protection against the hazards of optical radiation must limit itself to a definition, free of excessive detail, of the objectives to be attained, the principles to be observed and the fundamental values to be applied, in order to enable Member States to apply the minimum requirements in an equivalent manner.
- (7) The level of exposure to optical radiation can be more effectively reduced by incorporating preventive measures into the design of work stations 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 the 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 <sup>9</sup>, collective protection measures have priority over individual protection measures.
- (8) 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.

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<sup>9</sup> OJ L 183, 29.6.1989, p.1

- (9) Since this Directive is an individual directive within the meaning of Article 16(1) 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<sup>10</sup>, the latter Directive therefore applies to the exposure of workers to optical radiation, without prejudice to more stringent and/or specific provisions contained in this Directive.
- (10) This Directive constitutes a practical step towards creating the social dimension of the internal market.
- (11) 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<sup>11</sup>.
- (12) 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. However, since the application of exposure limit values and engineering controls are not deemed appropriate in the case of exposure to natural sources of optical radiation, preventive measures, including information and training for workers, are critical in the assessment of risk and the reduction of solar exposure risks,

HAVE ADOPTED THIS DIRECTIVE:

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<sup>10</sup> OJ L 183, 29.6.1989, p.1

<sup>11</sup> OJ L 184, 17.7.1999, p.23

## SECTION I

### GENERAL PROVISIONS

#### Article 1

##### **Aim and scope**

1. This Directive, which is the [19] th. individual Directive within the meaning of Article 16(1) 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 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 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

##### **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 (UVR)*: optical radiation of wavelength range between 100 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 (IRR)*: optical radiation of wavelength range between 780 nm and 1 mm. The infrared region is divided into IR-A (780 -1400 nm), IR-B (1400-3000 nm) and IR-C (3000 nm -1 mm);
- b) *laser radiation*: optical radiation comprising light amplification by stimulated emission of radiation;
  - c) *non-coherent radiation*: any optical radiation other than laser radiation and including that from LEDs (light emitting diodes) ;
  - d) *exposure limit values (ELVs)*: 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;
  - e) *irradiance*: the radiant power incident on an element of the surface expressed in  $\text{W.m}^{-2}$ ;
  - f) *radiant exposure*: the time integral of the irradiance expressed in  $\text{J.m}^{-2}$ ;
  - g) *radiance*: the brightness of a source expressed in  $\text{W.m}^{-2}.\text{sr}^{-1}$ .

### Article 3

#### **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 1.
2. The exposure limit values for laser radiation are as set out in Annex 2.

## SECTION II

### OBLIGATIONS OF EMPLOYERS

#### Article 4

##### **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 source 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 CENELEC in respect of laser radiation and the recommendations of CIE 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 and also take account of data provided by the manufacturers of the equipment where it is covered by a relevant Community Directive.
2. 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 natural sources of optical radiation, shall make an assessment of the risk to health so that the measures needed to minimize these risks can be identified and put into effect. The methodology applied in the assessment shall reflect the advice and guidance of international health advisory authorities expert in this field.
3. The assessment, measurement and/or calculations referred to in Article 4(1) and the assessment referred to in Article 4(2) shall be planned and carried out by competent services or persons at suitable intervals, taking particular account of the provisions of Article 7 and

Article 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 assessments, including that obtained from the measurement and/or calculations of the level of exposure referred to in Article 4(1) shall be preserved in a suitable form so as to permit consultation at a later stage.

4. 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, duration and type of exposure, including exposure to natural 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 at particular risk;
  - d) any indirect effects;
  - e) the existence of replacement equipment designed to reduce the levels of exposure to optical radiation;
  - f) appropriate information obtained from health surveillance, including published information, as far as possible;
  - g) multiple sources of exposure to optical radiation;
  - h) a classification applied to a laser as defined in accordance with EN 60825-1 and, in relation to any artificial source likely to cause damage similar to that of a laser of class 3B or 4, or any similar classification;
  - i) information provided by the manufacturers of optical radiation sources and associated work equipment in accordance with the relevant Community Directives.

5. 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 when the results of health surveillance show it to be necessary.

#### Article 5

#### **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 optical radiation shall be eliminated or reduced to a minimum.

The reduction of risks arising from exposure to 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 has indicated a possible risk then the employer shall devise and implement an action plan comprising technical and/or organisational measures. In the case of workers exposed to artificial sources of optical radiation, the measures should prevent exposures exceeding the exposure limit values. In the case of workers exposed to natural sources of optical radiation, the exposure risk should be reduced to a minimum. Both cases should take into account in particular:
  - a) other working methods that reduce risk from optical radiation;
  - b) where appropriate, 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 work station systems;
  - e) the design and layout of workplaces and work stations;
  - f) the limitation of the duration and intensity of the exposure;
  - g) the availability of adequate personal protective equipment: in so far as exposure of the skin is concerned, clothing may be considered personal protective equipment as far as it meets the protection objectives;
  - h) where appropriate, the guidelines and advice published by WHO, ICNIRP, Euroskin and ILO.
3. On the basis of the risk assessment carried out in accordance with Article 4, workplaces where workers could be exposed to artificial sources of optical radiation exceeding the exposure limit values shall be indicated by appropriate signs in accordance with Directive 92/58/EEC<sup>12</sup> 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). The areas in question shall be identified, and access to them limited where this is practical and where there is a risk that the exposure limit values could be exceeded.

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<sup>12</sup> OJ L 245, 26.8.1992, p.23

4. 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 amend the protection and prevention measures accordingly in order to prevent them being exceeded again. In any event, workers shall not be exposed above the exposure limit values.
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 at particular risk.

#### Article 6

#### **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 the risks from 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(1) 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 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

### **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**

### **MISCELLANEOUS PROVISIONS**

#### Article 8

### **Health surveillance**

1. Without prejudice to Article 14 of Directive 89/391/EEC, Member States shall adopt provisions to ensure the appropriate health surveillance of workers with reference to the outcome of the risk assessment provided for in Article 4(1) of this Directive where it indicates a risk to their health. Those provisions, including the requirements specified for health records and their availability, shall be introduced in accordance with national law and/or practice.

2. 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 any 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 individual worker shall, at his request, have access to the health records relating to him personally.

3. 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-care professional to be the result of exposure to optical radiation at work:
  - (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 from 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-care 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, including the possibility of assigning the worker to alternative work where there is no risk of exposure exceeding the appropriate ELV, 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 care professional or the competent authority may propose that the exposed persons undergo a medical examination.

#### Article 9

#### **Sanctions**

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

#### Article 10

#### **Technical amendments**

1. Any modifications of the exposure limit values set out in the Annexes shall be adopted by the Council and the European Parliament in accordance with the procedure laid down in Article 137(2) of the Treaty.
2. Amendments to the Annexes of a strictly technical nature in line with:
  - a) the adoption of Directives in the field of technical harmonisation and standardisation with regard to the design, building, manufacture or construction of work equipment and/or workplaces;

- b) technical progress, changes in the most relevant harmonised European standards or international specifications, and new scientific findings concerning occupational exposure to optical radiation,

shall be adopted in accordance with the regulatory procedure laid down in Article 11(2).

#### Article 11

#### **Committee**

1. The Commission shall be assisted by the Committee referred to in Article 17 of Directive 89/391/EEC.
2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period referred to in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its rules of procedure.

### **SECTION IV**

#### **FINAL PROVISIONS**

#### Article 12

#### **Reports**

Every five years, Member States shall provide a report to the Commission on the practical implementation of this Directive, indicating the point of view of the social partners.

Every five years the Commission shall inform the European Parliament, the Council, the European Economic and Social Committee and the Advisory Committee on Safety and Health Protection at Work of the contents of these reports, of its assessment of developments in the field in question and of any action that may be warranted in the light of new scientific knowledge.

### Article 13

#### **Transposition**

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by [...] at the latest. They shall forthwith communicate to the Commission the text of those provisions and a correlation table between those provisions and this Directive.

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 provisions of national law which they adopt or have already adopted in the field covered by this Directive.

### Article 14

#### **Entry into force**

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

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4 years after the entry into force of this Directive.

Article 15

**Addressees**

This Directive is addressed to the Member States.

Done at ,

For the European Parliament

For the Council

The President

The President

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The exposure limit values referred to in Annex 1 are sourced from the exposure limit values used by the International Commission on Non-Ionising Radiation Protection (ICNIRP).

ANNEX 1						
Exposure Limit Values						
non-coherent optical radiation, other than that emitted by natural sources of optical radiation						
Wavelength (nm)	Radiation	Organ	Hazard	ELV Table No	Spectral Weighting Table No.	ELV Summary
180-315	UVB and UVC	Eye	Photokeratitis Cataracts	1.0	1.0	30 J/m <sup>2</sup> weighted over 8 hours
180-400	UVR	Skin	Erythema Cancer	1.0	1.0	30 J/m <sup>2</sup> weighted over 8 hours
315-400	UVA	Eye	Lens damage retinal injury	1.0	-	10 <sup>4</sup> J/m <sup>2</sup> unweighted over 8 hours
300-700	Blue-light	Eye	Photoretinitis	1.1	1.2	a) 1MJ/m <sup>2</sup> sr weighted for exposures ≤10 <sup>4</sup> sec.  b) 100W/m <sup>2</sup> sr weighted for exposures ≤ 10 <sup>4</sup> sec.
380-1400	Visible & IRA (with visual stimulus)	Eye	Retinal burn	1.3	1.4	ELV is a function of viewing angle, exposure time and weighted for frequency (W/m <sup>2</sup> sr)
780-1400	IRA (heat lamps & similar)	Eye	Retinal burn	1.6	1.4	ELV is a function of subtense angle for exposures ≥ 10 sec. (W/m <sup>2</sup> sr)
780-3000	IRA & IRB	Eye	Thermal injury to cornea & cataracts in the lens	1.5	-	a) ELV is a function of exposure time for exposures <1000 sec. (W/m <sup>2</sup> ) b) 100W/m <sup>2</sup> for exposure ≥ 1000 sec.
380-3000	Visible, IRA & IRB	Skin	Burn	1.7	-	ELV is a function of exposure time for exposures less than 10 sec. (W/m <sup>2</sup> )

**Table 1.0**

Wavelength <sup>a</sup> (nm)	EL (J m <sup>-2</sup> )	EL (mJ cm <sup>-2</sup> )	Relative Spectral Effectiveness SA	Wavelength <sup>a</sup> (nm)	EL (J m <sup>-2</sup> )	EL (mJ cm <sup>-2</sup> )	Relative Spectral Effectiveness SA
180	2,500	250	0.012	310	2,000	200	0.015
190	1,600	160	0.019	313 <sup>b</sup>	5,000	500	0.006
200	1,000	100	0.030	315	1.0 x 10 <sup>4</sup>	1.0 x 10 <sup>3</sup>	0.003
205	590	59	0.051	316	1.3 x 10 <sup>4</sup>	1.3 x 10 <sup>3</sup>	0.0024
210	400	40	0.075	317	1.5 x 10 <sup>4</sup>	1.5 x 10 <sup>3</sup>	0.0020
215	320	32	0.095	318	1.9 x 10 <sup>4</sup>	1.9 x 10 <sup>3</sup>	0.0016
220	250	25	0.120	319	2.5 x 10 <sup>4</sup>	2.5 x 10 <sup>3</sup>	0.0012
225	200	20	0.150	320	2.9 x 10 <sup>4</sup>	2.9 x 10 <sup>3</sup>	0.0010
230	160	16	0.190	322	4.5 x 10 <sup>4</sup>	4.5 x 10 <sup>3</sup>	0.00067
235	130	13	0.240	323	5.6 x 10 <sup>4</sup>	5.6 x 10 <sup>3</sup>	0.00054
240	100	20	0.300	325	6.0 x 10 <sup>4</sup>	6.0 x 10 <sup>3</sup>	0.00050
245	83	8.3	0.360	328	6.8 x 10 <sup>4</sup>	6.8 x 10 <sup>3</sup>	0.00044
250	70	7.0	0.430	330	7.3 x 10 <sup>4</sup>	7.3 x 10 <sup>3</sup>	0.00041
254 <sup>b</sup>	60	6.0	0.500	333	8.1 x 10 <sup>4</sup>	8.1 x 10 <sup>3</sup>	0.00037
255	58	5.8	0.520	335	8.8 x 10 <sup>4</sup>	8.8 x 10 <sup>3</sup>	0.00034
260	46	4.6	0.650	340	1.1 x 10 <sup>5</sup>	1.1 x 10 <sup>4</sup>	0.00028
265	37	3.7	0.810	345	1.3 x 10 <sup>5</sup>	1.3 x 10 <sup>4</sup>	0.00024
270	30	3.0	1.000	350	1.5 x 10 <sup>5</sup>	1.5 x 10 <sup>4</sup>	0.00020
275	31	3.1	0.960	355	1.9 x 10 <sup>5</sup>	1.9 x 10 <sup>4</sup>	0.00016
280 <sup>b</sup>	34	3.4	0.880	360	2.3 x 10 <sup>5</sup>	2.3 x 10 <sup>4</sup>	0.00013
285	39	3.9	0.770	365 <sup>b</sup>	2.7 x 10 <sup>5</sup>	2.7 x 10 <sup>4</sup>	0.00011
290	47	4.7	0.640	370	3.2 x 10 <sup>5</sup>	3.2 x 10 <sup>4</sup>	0.000093
295	56	5.6	0.540	375	3.9 x 10 <sup>5</sup>	3.9 x 10 <sup>4</sup>	0.000077
297 <sup>b</sup>	65	6.5	0.460	380	4.7 x 10 <sup>5</sup>	4.7 x 10 <sup>4</sup>	0.000064
300	100	10	0.300	385	5.7 x 10 <sup>5</sup>	5.7 x 10 <sup>4</sup>	0.000053
303 <sup>b</sup>	250	25	0.120	390	6.8 x 10 <sup>5</sup>	6.8 x 10 <sup>4</sup>	0.000044
305	500	50	0.060	395	8.3 x 10 <sup>5</sup>	8.3 x 10 <sup>4</sup>	0.000036
308	1,200	120	0.026	400	1.0 x 10 <sup>6</sup>	1.0 x 10 <sup>5</sup>	0.000030

<sup>a</sup> Wavelengths chosen are representative; other values should be interpolated at intermediate wavelengths.

<sup>b</sup> Emission lines of a mercury discharge spectrum.

**Table 1.1**

**Blue Light Photochemical Retinal Hazard**

**Exposure Limit Values**, spectrally weighted and integrated over wavelengths 300 – 700nm

Exposure Time (seconds)	Viewing Angle <0.011 rad	Viewing Angle ≥0.011 rad
≤10,000	$E_B.t = 100J.m^{-2}$	$L_B.t = 1MJ.m^{-2}.sr^{-1}$
>10,000	$E_B = 0.01W.m^{-2}$	$L_B = 100W.m^{-2}.sr^{-1}$

Where:

- $E_B$  is effective (spectrally weighted) irradiance  
(units :  $W.m^{-2}$ )
- $L_B$  is effective (spectrally weighted) radiance  
(units :  $W.m^{-2}.sr^{-1}$ )
- $t$  is exposure time (units : seconds)  
and spectral weightings are as set out in Table 1.2

**Table 1.2****Spectral Weighting – Blue – Light**

<b>Blue-light<sup>a</sup> Hazard Function B(<math>\lambda</math>)</b>	<b>Wavelength (nm)</b>
0.01	300
0.01	305
0.01	310
0.01	315
0.01	320
0.01	325
0.01	330
0.01	335
0.01	340
0.01	345
0.01	350
0.01	355
0.01	360
0.01	365
0.01	370
0.01	375
0.01	380
0.013	385
0.025	390
0.05	395
0.100	400
0.200	405
0.400	410
0.800	415
0.900	420
0.950	425
0.980	430
1.000	435
1.000	440
0.970	445
0.940	450
0.900	455
0.800	460
0.700	465
0.620	470
0.550	475
0.450	480
0.400	485
0.220	490
0.160	495
0.100	500
0.079	505
0.063	510
0.050	515
0.040	520
0.032	525
0.025	530
0.020	535
0.016	540
0.013	545
0.010	550
0.008	555
0.006	560
0.005	565
0.004	570
0.003	575
0.002	580
0.001	590
0.001	595
0.001	600-700

a – The UV extension of B( $\lambda$ ) at wavelength below 380nm are provided for the evaluation of light sources that may contain UV.

**Table 1.3**

**Retinal Thermal hazard**

**Exposure Limit Values**, spectrally weighted and integrated over wavelengths 380 – 1400nm units of radiance ( $\text{kW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$ )

Exposure Time t	Viewing Angle $\alpha$		
	<0.0017 rad	0.0017 – 0.1 rad	>0.1 rad
<10 $\mu\text{s}$	523,000	889/ $\alpha$	8,890
10 $\mu\text{s}$ – 10sec	29,400/ $t^{0.25}$	50/ $\alpha^{0.25}$	500/ $t^{0.25}$
>10sec	16,500	28.1/ $\alpha$	281

Where:

- $\alpha$  is viewing (subtense) angle in radians
- t is exposure time in seconds, and spectral weightings are as set out in Table 1.4

**Table 1.4****Spectral Weighting – Retinal Burn**

Retinal Thermal Hazard Function R (λ)	Wavelength (nm)
0.1	380
0.13	385
0.25	390
0.5	395
1.0	400
2.0	405
4.0	410
8.0	415
9.0	420
9.5	425
9.8	430
10.0	435
10.0	440
9.7	445
9.4	450
9.0	450
8.0	455
7.0	460
6.2	465
5.5	470
4.5	475
4.0	480
2.2	485
1.6	490
1.0	495
1.0	500
1.0	505
1.0	510
1.0	515
1.0	520
1.0	525
1.0	530
1.0	535
1.0	540
1.0	545
1.0	550
1.0	555
1.0	560
1.0	565
1.0	570
1.0	575
1.0	580
1.0	590
1.0	595
1.0	600-700
$10^{[(700-\lambda)/500]}$	700-1,050
0.2	1,050-1,150
$0.2 \times 10^{0.02[(1.1500-\lambda)]}$	1,150-1,200
0.02	1,200-1,400

**Table 1.5**

**Infra Red Hazards to the Eye: Cornea and Lens**

**Exposure Limit Values** , to avoid thermal injury to the cornea and possible delayed effects on the lens (cataractogenesis) in units of irradiance ( $\text{kW.m}^{-2}$ ) over wavelengths 780-3000nm.

Exposure Time (seconds)	Ambient Temperature		
	0 °C	10 °C	> 10 °C
≤ 1000	$72 t^{-3/4}$	$54 t^{-3/4}$	$18 t^{-3/4}$
> 1000	0.4	0.3	0.1

Where:

· t is exposure time in seconds

**Table 1.6**

**Infra Red Hazards to the Eye: Retina**

**Exposure Limit Values**, spectrally weighted for infrared heat lamps or similar sources that provide no strong visual stimulus, in units of radiance ( $\text{kW}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$ ) integrated over wavelengths 780 – 1400 nm.

Exposure Time (seconds)	Viewing Angle $\alpha$		
	<0.011 rad	0.011 – 0.1 rad	>0.1 rad
< 10	Table 1.3 applies for $t < 10$ sec...		
$\geq 10$	545	$6/\alpha$	60

Where:

- $\alpha$  is viewing (subtense) angle in radians, and spectral weightings are as set out in Table 1.4

**Table 1.7**

**Visible and Infra Red Thermal Injury to the Skin**

**Exposure Limit Values**, for visible and infrared source in the frequency range 380-3000nm to protect the skin from thermal injury in units of radiant exposure ( $J.m^{-2}$ ).

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Exposure Time (secs)	Radiant Exposure ( $J.m^{-2}$ )
$\leq 10$	$20,000t^{1/4}$
$>10$	see note

---

where:

- t is exposure time in seconds

**Note:** No limit is provided for longer exposure duration. Such exposures are dominated by concerns of heat stress and are outside the scope of an optical radiation Directive.

The exposure limit values referred to in Annex 2 are sourced from the exposure limit values used by the International Commission on Non-Ionising Radiation Protection (ICNIRP).

<b>ANNEX 2</b>					
<b>Exposure Limit Values</b>					
<b>laser radiation</b>					
<b>Wavelength (nm)</b>	<b>Radiation</b>	<b>Organ</b>	<b>Hazard</b>	<b>ELV Table No.</b>	<b>ELV Summary</b>
180-400	UVR	Eye	Photochemical	2.1	ELVs range from 30J/m <sup>2</sup> at lowest wavelength to 10kJ/m <sup>2</sup> at the highest
180-400	UVR	Eye	Thermal	2.1	ELV is a function of exposure time (kJ/m <sup>2</sup> )
180-400	UVR	Skin	Erythema	2.1	ELVs are the same as those for the eye (photochemical hazard)
400-700	Visible	Eye	Retinal Injury	2.2	ELV for exposures ≤10 sec. (J/m <sup>2</sup> )
400-600	Visible	Eye	Photochemical	2.2	ELV for exposures ≥10 sec. and different subtense angles
400-700	Visible	Eye	Thermal	2.2	ELV for exposures ≥ 10 sec and different subtense angles
400-700	Visible	Skin	Erythema	2.5	ELV is a function of exposure time.
700-1400	IRA	Eye	Thermal	2.3	ELVs are a function of exposure time and subtense angle.
700-1400	IRA	Skin	Erythema	2.5	ELV is a function of exposure time.
1400-2600	IRB	Eye	Thermal	2.4	ELV is a function of exposure time for exposures ≤ 10 sec.
2600 – 1mm	IRC	Eye	Thermal	2.4	ELV is a function of exposure time for exposures ≤ 10 sec.
1400 – 1mm	IRB IRC	Eye	Thermal	2.4	ELV is 1000W/m <sup>2</sup> for exposures ≥ 10 sec.
1400 – 1mm	IRB IRC	Skin	Erythema	2.5	ELV is the same as that for the eye for the same exposure period

**Table 2.1**

Wavelength $\lambda$ (nm)	Exposure duration $t$ (s)	Exposure limit EL (J/cm <sup>2</sup> or W/cm <sup>2</sup> )	Exposure limit EL (J/m <sup>2</sup> or W/m <sup>2</sup> )	Restrictions
<b>Ultraviolet</b>				
<i>Dual limits for 180–600 nm ultraviolet laser exposures at <math>t &gt; 1</math> ns:</i>				
Photochemical				
180 to 302	1 ns to 30 ks	3 mJ/cm <sup>2</sup>	30 J/m <sup>2</sup>	Aperture sizes: 1 mm for $t < 0.3$ s 1.5 $t^{0.375}$ mm for 0.3 s $< t < 10$ s 3.5 mm for $t > 10$ s
303	1 ns to 30 ks	4 mJ/cm <sup>2</sup>	40 J/m <sup>2</sup>	
304	1 ns to 30 ks	6 mJ/cm <sup>2</sup>	60 J/m <sup>2</sup>	
305	1 ns to 30 ks	10 mJ/cm <sup>2</sup>	100 J/m <sup>2</sup>	
306	1 ns to 30 ks	16 mJ/cm <sup>2</sup>	160 J/m <sup>2</sup>	
307	1 ns to 30 ks	25 mJ/cm <sup>2</sup>	250 J/m <sup>2</sup>	
308	1 ns to 30 ks	40 mJ/cm <sup>2</sup>	400 J/m <sup>2</sup>	
309	1 ns to 30 ks	63 mJ/cm <sup>2</sup>	630 J/m <sup>2</sup>	
310	1 ns to 30 ks	0.1 J/cm <sup>2</sup>	1.0 kJ/m <sup>2</sup>	
311	1 ns to 30 ks	0.16 J/cm <sup>2</sup>	1.6 kJ/m <sup>2</sup>	
312	1 ns to 30 ks	0.25 J/cm <sup>2</sup>	2.5 kJ/m <sup>2</sup>	
313	1 ns to 30 ks	0.40 J/cm <sup>2</sup>	4 kJ/m <sup>2</sup>	
314	1 ns to 30 ks	0.63 J/cm <sup>2</sup>	6.3 kJ/m <sup>2</sup>	
315 to 400	10 s to 30 ks	1.0 J/cm <sup>2</sup>	10 kJ/m <sup>2</sup>	
Thermal				
180 to 400	1 ns to 10 s	0.56 $t^{0.25}$ J/cm <sup>2</sup>	5.6 $t^{0.25}$ kJ/m <sup>2</sup>	

**Table 2.2**

<b>Visible</b>				
400 to 700	100 fs to 10 ps	0.015 $C_E$ $\mu$ J/cm <sup>2</sup>	0.15 $C_E$ mJ/m <sup>2</sup>	(all for 7-mm limiting aperture)
400 to 700	10 ps to 1 ns	2.7 $C_E t^{0.75}$ J/cm <sup>2</sup>	27 $C_E t^{0.75}$ kJ/m <sup>2</sup>	
400 to 700	1 ns to 18 $\mu$ s	0.5 $C_E$ $\mu$ J/cm <sup>2</sup>	5 $C_E$ mJ/m <sup>2</sup>	
400 to 700	18 $\mu$ s to 10 s	1.8 $C_E t^{0.75}$ mJ/cm <sup>2</sup>	18 $C_E t^{0.75}$ J/m <sup>2</sup>	
<i>Dual limits for 400–600 nm visible laser exposures at <math>t &gt; 10</math> s</i>				
Photochemical <sup>a</sup>				
400 to 600	10 s to 100 s	10 $C_B$ mJ/cm <sup>2</sup>	100 $C_B$ J/m <sup>2</sup>	for $\alpha < 11$ mrad ( $\gamma = 11$ mrad <sup>a</sup> )
400 to 600	100 s to 30 ks	0.1 $C_B$ mW/cm <sup>2</sup>	1 $C_B$ W/m <sup>2</sup>	for $\alpha < 11$ mrad
400 to 600	100 s to 10 ks	0.1 $C_B$ mW/cm <sup>2</sup>	1 $C_B$ W/m <sup>2</sup>	for $\alpha > 11$ mrad ( $\gamma = 1.1 t^{0.5}$ mrad)
400 to 600	10 ks to 30 ks	10 $C_B$ mW/(cm <sup>2</sup> sr)	100 $C_B$ W/(m <sup>2</sup> sr)	(See Note <sup>a</sup> )
Thermal <sup>a</sup>				
400 to 700	10 s to 30 ks	1.0 mW/cm <sup>2</sup>	10 W/m <sup>2</sup>	for $\alpha < 1.5$ mrad
400 to 700	10 s to $T_2$ s	1.8 $C_E t^{0.75}$ mJ/cm <sup>2</sup>	18 $C_E t^{0.75}$ J/m <sup>2</sup>	for $\alpha > 1.5$ mrad
400 to 700	$T_2$ s to 30 ks	1.8 $C_E T_2^{-0.25}$ mW/cm <sup>2</sup>	18 $C_E T_2^{-0.25}$ W/m <sup>2</sup>	for $\alpha > 1.5$ mrad

**Table 2.3**

<b>Near Infrared, IR-A</b>					
700 to 1,050	100 fs to 10 ps	0.015 $C_A C_E$ $\mu$ J/cm <sup>2</sup>	0.15 $C_A C_E$ mJ/m <sup>2</sup>	7 mm limiting aperture	
700 to 1,050	10 ps to 1 ns	2.7 $C_A C_E t^{0.75}$ $\mu$ J/cm <sup>2</sup>	27 $C_A C_E t^{0.75}$ mJ/m <sup>2</sup>		
700 to 1,050	1 ns to 18 $\mu$ s	0.5 $C_A C_E$ $\mu$ J/cm <sup>2</sup>	5 $C_A C_E$ mJ/m <sup>2</sup>		
700 to 1,050	18 $\mu$ s to 10 s	1.8 $C_A C_E t^{0.75}$ mJ/cm <sup>2</sup>	18 $C_A C_E t^{0.75}$ J/m <sup>2</sup>		
1,051 to 1,400	100 fs to 10 ps	0.15 $C_C C_E$ $\mu$ J/cm <sup>2</sup>	1.5 $C_C C_E$ mJ/m <sup>2</sup>		
1,051 to 1,400	10 ps to 1 ns	27 $C_C C_E t^{0.75}$ J/cm <sup>2</sup>	270 $C_C C_E t^{0.75}$ kJ/m <sup>2</sup>		
1,051 to 1,400	1 ns to 50 $\mu$ s	5 $C_C C_E$ $\mu$ J/cm <sup>2</sup>	50 $C_C C_E$ mJ/m <sup>2</sup>		
1,051 to 1,400	50 $\mu$ s to 10 s	9.0 $C_C C_E t^{0.75}$ mJ/cm <sup>2</sup>	90 $C_C C_E t^{0.75}$ J/m <sup>2</sup>		
700 to 1,400	10 s to 30 ks	1.0 $C_A C_C$ mW/cm <sup>2</sup>	10 $C_A C_C$ W/m <sup>2</sup>		for $\alpha < 1.5$ mrad
700 to 1,400	10 s to $T_2$ s	1.8 $C_A C_C C_E t^{0.75}$ mJ/cm <sup>2</sup>	18 $C_A C_C C_E t^{0.75}$ J/m <sup>2</sup>		for $\alpha > 1.5$ mrad
700 to 1,400	$T_2$ s to 30 ks	1.8 $C_A C_C C_E T_2^{-0.25}$ mW/cm <sup>2</sup>	18 $C_A C_C C_E T_2^{-0.25}$ W/m <sup>2</sup>		for $\alpha > 1.5$ mrad
			NTE <sup>b</sup> 100 mW/cm <sup>2</sup>		

**Table 2.4**

Far Infrared

1,400 to 1,500 nm	1 ns to 1 ms	0.1 J/cm <sup>2</sup>	1 kJ/m <sup>2</sup>	Aperture sizes: 1 mm for $t < 0.3$ s
1,400 to 1,500 nm	1 ms to 10 s	$0.56t^{0.25}$ J/cm <sup>2</sup>	$5.6t^{0.25}$ kJ/m <sup>2</sup>	
1,500 to 1,800 nm	1 ns to 10 s	1.0 J/cm <sup>2</sup>	10 kJ/m <sup>2</sup>	1.5 $t^{0.375}$ mm for
1,801 to 2,600 nm	1 ns to 1 ms	0.1 J/cm <sup>2</sup>	1 kJ/m <sup>2</sup>	0.3 s < $t < 10$ s
1,801 to 2,600 nm	1 ms to 10 s	$0.56t^{0.25}$ J/cm <sup>2</sup>	$5.6t^{0.25}$ kJ/m <sup>2</sup>	3.5 mm for $t > 10$ s
2,601 nm to 1 mm	1 ns to 100 ns	10 mJ/cm <sup>2</sup>	100 J/m <sup>2</sup>	
2,601 nm to 1 mm	100 ns to 10 s	$0.56t^{0.25}$ J/cm <sup>2</sup>	$56t^{0.25}$ kJ/m <sup>2</sup>	
1,400 nm to 1 mm	10 s to 30 ks	100 mW/cm <sup>2</sup>	1 kW/m <sup>2</sup>	

<sup>a</sup> For small sources subtending an angle of 1.5 mrad or less, the visible dual limit ELs from 400 nm to 600 nm, for times greater than 10 s, reduce to the thermal limits for times less than  $T_1$  and to photochemical limits for longer times.  $T_1 = 10$  s for  $\lambda < 450$  nm;  $T_1 = 10 \times 10^{0.02(\lambda - 450)}$  for  $450 \text{ nm} < \lambda < 500$  nm; and  $T_1 = 100$  s for  $\lambda > 500$  nm. The photochemical retinal hazard limit may also be expressed as an integrated radiance  $L = 100 C_B J/(\text{cm}^2 \text{ sr})$ ;  $T_2$  see Table 5.

<sup>b</sup> NTE = Not to exceed; see Table 5 for definitions of constants.

**Table 2.5**

Wavelength range (nm)	Exposure duration	Exposure limit (EL) <sup>a</sup>	Comments
400–1,400 nm	1 ns < $t < 1$ s	No Change in limit values, except to eliminate the increased value of $\alpha_{\min}$ for $t > 0.7$ s. <sup>b</sup>	Original limits well established as thermal damage mechanism. However, eye movement research required a change. <sup>b</sup>
400–600 nm	1 s < $t < 100$ s	H = $10 C_B$ mJ/cm <sup>2</sup> where FOV $\gamma = 11$ mrad, (i.e., $\Omega = 10^{-4}$ sr), and equivalent to: L = $100 C_B J/(\text{cm}^2 \text{ sr})$ where FOV $\gamma = 11$ mrad.	Photochemical: Assumes FOV $\gamma = 11$ mrad which is over-conservative for $t > 100$ s; therefore, a new proposal for meas. FOV $\gamma = 1.1 \sqrt{t}$ mrad for $t > 100$ s ( $\Omega = t \mu\text{sr}$ )
	100 s < $t < 10^4$ s	E = $0.1 C_B$ mW/cm <sup>2</sup> (i.e., L = $100 C_B J/(\text{cm}^2 \text{ sr})$ for meas. FOV $\gamma = 1.1 \sqrt{t}$ (mrad, important when $\alpha > 11$ mrad).	First dual limit to protect against photochemical injury (i.e., photoreinitis).
400–600 nm	1 s < $t < T_2$ s	H = $1.8 t^{0.75} C_E$ mJ/cm <sup>2</sup>	Based only upon thermal effects. Second dual limit to protect against retinal thermal injury.
	$T_2$ s < $t < 30$ ks	E = $1.8 C_E T_2^{-0.25}$ mW/cm <sup>2</sup> for $\alpha > 1.5$ mrad	
600–1,400 nm	1 s < $t < T_2$	H = $1.8 C_A C_E C_C t^{0.75}$ mJ/cm <sup>2</sup>	Original limits over-stated large-image thermal damage mechanisms, and eye movements not adequately addressed for CW exposures.
	$T_2 < t < 30$ ks	E = $1.0 C_A C_C$ mW/cm <sup>2</sup> for $\alpha < 1.5$ mrad E = $1.8 C_A C_C C_E T_2^{-0.25}$ mW/cm <sup>2</sup> for $\alpha > 1.5$ mrad	

<sup>a</sup>  $C_B = 1.0$  for  $\lambda < 450$  nm (referred to as the new  $C_3$  in IEC terminology);  $C_B = 10^{0.02(\lambda - 450)}$  for  $\lambda > 450$  nm; and  $T_2 = 10[10^{(\alpha - 1.5)/98.5}]$  limited to  $T_2 = 10$  s for  $\alpha < 1.5$  mrad and 100 s if  $\alpha > 100$  mrad;  $C_A = 1.0$  for  $\lambda < 700$  nm;  $C_A = 10^{0.002(\lambda - 700)}$  for  $700 \text{ nm} < \lambda < 1,050$  nm;  $C_A = 5.0$  for  $1,050 < \lambda < 1,400$  nm; and  $C_C = 1.0$  for  $\lambda < 1,150$  nm;  $C_C = 10^{0.018(\lambda - 1,150)}$  for  $1,150 < \lambda < 1,200$  nm;  $C_C = 8.0$  for  $1,200 \text{ nm} < \lambda < 1,400$  nm;  $C_E = \alpha/\alpha_{\min}$  where  $\lambda$  is expressed in nm and  $\alpha$  is expressed in milliradians (mrad).

<sup>b</sup>  $\alpha_{\min}$  now is 1.5 mrad for all thermal retinal hazard ELs.