Table E.1 – Maximum radiance of a diffused source for Class 1

Wavelength nm	Radiance $W \cdot m^{-2} \cdot sr^{-1}$	Radiance $W \cdot cm^{-2} \cdot sr^{-1}$
430	*10 000*	*1,00*
450	*10 000*	*1,00*
460	*15 848*	*1,58*
465	*19 952*	*2,00*
470	*25 119*	*2,51*
480	*39 811*	*3,98*
505	48 316	4,83
520	48 316	4,83
555	48 316	4,83
565	48 316	4,83
595	48 316	4,83
610	48 316	4,83
625	48 316	4,83
645	48 316	4,83
660	48 316	4,83
660	48 316	4,83
700	48 316	4,83
750	60 826	6,08
800	76 576	7,66
850	96 403	9,64
900	121 365	12,14
950	152 789	15,28
1 000	192 350	19,24
1 050	241 580	24,16
1 100	241 580	24,16
1 150	241 580	24,16
Figures in italics indicate retinal photochemical hazard limits.		

E.3 Rationale

The radiance values are calculated using IEC/ICNIRP MPE levels. As MPEs are generally expressed in terms of radiant exposure ($J \cdot m^{-2}$) or irradiance ($W \cdot m^{-2}$), it is necessary to convert the MPE values to radiance ($W \cdot m^{-2} \cdot sr^{-1}$). The radiance values are then plotted as a function of wavelength.

For MPEs expressed as irradiance, the following method to calculate radiance was used. Radiance is defined as:

$$L = \frac{\mathrm{d}\,\Phi}{\mathrm{d}\Omega \cdot \mathrm{d}A \cdot \cos\theta} \tag{E.1}$$

where Φ is the radiant power, Ω is a unit of solid angle with the vertex at the measurement plane of the irradiance, and A is the area over which irradiance is defined. MPEs are frequently expressed in terms of irradiance, which is defined as

$$E = \frac{\mathrm{d}\Phi}{\mathrm{d}A} \tag{E.2}$$

Substituting Equation E.2 into Equation E.1 yields radiance as a function of irradiance:

$$L = \frac{\mathrm{d}E}{\mathrm{d}\Omega \cdot \cos\theta} \tag{E.3}$$

We need to find the solid angle Ω and viewing angle θ. Substituting the following equation for Ω:

$$\Omega = \frac{\pi\alpha^2}{4} \tag{E.4}$$

and assuming the worst-case viewing angle where θ = 0° (the viewer is looking directly into the beam), Equation E.3 reduces to

$$L = \frac{4E}{\pi\alpha^2} \tag{E.5}$$

For MPEs expressed as radiant exposure a slightly different method was used. Radiant exposure is defined as

$$H = \frac{\mathrm{d}Q}{\mathrm{d}A} \tag{E.6}$$

where Q is radiant energy expressed in Joules. Dividing by time yields

$$\frac{H}{\mathrm{d}t} = \frac{\mathrm{d}Q}{\mathrm{d}A \cdot \mathrm{d}t} \tag{E.7}$$

As radiant power is expressed as

$$\Phi = \frac{\mathrm{d}Q}{\mathrm{d}t} \tag{E.8}$$

Equation E.8 can be substituted into Equation E.7, yielding

$$\frac{H}{\mathrm{d}t} = \frac{\mathrm{d}\Phi}{\mathrm{d}A} \tag{E.9}$$

Returning to Equation E.1, we substitute equation E.9 to yield

$$L = \frac{\mathrm{d}H}{\mathrm{d}\Omega \cdot \mathrm{d}t \cdot \cos\theta} \tag{E.10}$$

Again substituting equation E.4 and assuming the worst-case scenario of θ = 0°, we obtain

$$L = \frac{4H}{\pi\alpha^2 t} \tag{E.11}$$

For the calculations, we assumed a worst-case scenario of a 100 mrad angular subtense for an exposure duration of 100 s. The results are listed in Table E.1 and plotted in Figure E.1.

Annex F
(informative)

Summary tables

Table F.1 summarizes the physical quantities referred to in this Part 1, and gives the unit (and the symbol for the unit) used for each of them. The definitions of the SI base units are taken from ISO 80000-1. The units and symbols are taken from IEC 60027-1. Table F.2 summarizes the manufacturer's requirements.

Table F.1 – Summary of the physical quantities used in this Part 1

Quantity	Name of unit	Unit symbol	Definition
Length	metre	m	The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second
	millimetre	mm	10^{-3} m
	micrometre	μm	10^{-6} m
	nanometre	nm	10^{-9} m
Area	square metre	m^2	1 m^2
Mass	kilogram	kg	The mass equal to the mass of the international prototype of the kilogram
Time	second	s	The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state caesium-133 atom
Frequency	hertz	Hz	The frequency of a periodic phenomenon equal to one cycle per second
Plane angle	radian	rad	The plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius
	milliradian	mrad	10^{-3} rad
Solid angle	steradian	sr	The solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere
Force	newton	N	1 $m \cdot kg \cdot s^{-2}$
Energy	joule	J	1 N·m
Radiant exposure	joule per square metre	$J \cdot m^{-2}$	1 $J \cdot m^{-2}$
Integrated radiance	joule per square metre per steradian	$J \cdot m^{-2} \cdot sr^{-1}$	1 $J \cdot m^{-2} \cdot sr^{-1}$
Power	watt	W	1 $J \cdot s^{-1}$
	milliwatt	mW	10^{-3} W
Irradiance	watt per square metre	$W \cdot m^{-2}$	1 $W \cdot m^{-2}$
Radiance	watt per square metre per steradian	$W \cdot m^{-2} \cdot sr^{-1}$	1 $W \cdot m^{-2} \cdot sr^{-1}$
NOTE For convenience, multiples and submultiples of units have been included where appropriate.			

Table F.2 – Summary of manufacturer's requirements *(1 of 2)*

Requirements subclause	Classification						
	Class 1*	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
Description of hazard class Annex C	Safe under reasonably foreseeable conditions	As for Class 1 except may be hazardous if user employs optics	Low power; eye protection normally afforded by aversion & active responses	As for Class 2 except may be more hazardous if user employs optics	Direct intrabeam viewing may be hazardous	Direct intrabeam viewing normally hazardous	High power; diffuse reflections may be hazardous
Protective housing 6.2		Required for each laser product; limits access necessary for performance of functions of the products					
Safety interlock in protective housing 6.3	Designed to prevent removal of the panel until accessible emission values are below that for Class 3R				Designed to prevent removal of the panel until accessible emission values are below that for Class 3B or 3R for some products		
Remote Interlock 6.4	Not required					Permits easy addition of external interlock in laser installation. Not required for some products in Class 3B	
Manual Reset 6.5	Not required						Requires manual reset if power interrupted or remote interlock is actuated
Key control 6.6	Not required					Laser inoperative when key is removed	
Emission warning device 6.7	Not required				Gives audible or visible warning when laser is switched on or if capacitor bank of pulsed laser is being charged. For Class 3R, only applies if invisible radiation is emitted		
Attenuator 6.8	Not required					Gives means to temporarily block beam	
Control locations 6.9	Not required				Controls so located that there is no danger of exposure to AEL above Classes 1 or 2 when adjustments are made		
Viewing optics 6.10	Not required	Emission from all viewing systems shall be below Class 1M AEL					
Scanning 6.11	Scan failure shall not cause product to exceed its classification						

Table F.2 *(2 of 2)*

Requirements subclause	Classification						
	Class 1	Class 1M	Class 2	Class 2M	Class 3R	Class 3B	Class 4
Class label 7.2 to 7.7	Required wording		Figures 3 and 4 and required wording				
Aperture label 7.8	Not required				Specified wording required		
Radiation output label 7.9	Not required	Required wording					
Standards information label 7.9	Required on product or in information to user		Required wording				
Service access label 7.10.1	Not required	Required as appropriate to the class of accessible radiation					
Override interlock label 7.10.2	Required under certain conditions as appropriate to the class of laser used						
Wavelength range label 7.10 and 7.12	Required for certain wavelength ranges						
Burn hazard label 7.13	Required wording when AE at closest point of human access (3.5mm aperture) exceeds AEL of Class 3B					Not applicable	
User information 8.1	Operation manuals shall contain instructions for safe use. Additional requirements apply for Class 1M and Class 2M						
Purchasing and service information 8.2	Promotion brochures shall specify product classification; service manuals shall contain safety information						
Medical products 9.2	Not required					For the safety of medical laser products, IEC 60601-2-22 may be applied.	

*NOTE This table is intended to provide a convenient summary of requirements. See text of this standard for complete requirements. Due to the specific concept of Class 1C, the requirements for Class 1C laser products are not included in this table; in this Part 1, mostly generic requirements are specified; product type specific requirements are defined in vertical standards.

Annex G
(informative)

Overview of associated parts of IEC 60825

The associated parts of IEC 60825 are intended for use in conjunction with the basic standard IEC 60825-1. Each part covers a defined scope and provides additional normative and informative guidance to enable the manufacturer and user to correctly classify and use the product in a safe manner by taking account of the particular conditions of use and competence/training of the operator/user. The information covered may include rationale, examples, clarification, methods, labelling, and any additional limits and requirements. See Table G.1.

Table G.1 – Overview of additional data in associated parts of IEC 60825

Part No.	Type	Description	Product designer	Product supplier	Product user	Safety critical component supplier	Test methods	Hazard assessment	Related standards
1	Standard	Equipment classification and requirements	Yes	Yes	Yes	Yes	Yes	Yes	
2	Standard	Safety of optical fibre communication systems (provides application notes and examples)	Yes	Yes	Yes	Yes	Yes	Yes	
3	Technical report	Guidance for laser displays and shows	No	No	Yes	No	No	Yes	
4	Standard	Laser guards (also addresses ability of high-power lasers to remove guard material)	Yes	Yes	Yes	Yes	Yes	Yes	
5	Technical report	Manufacturer's checklist for IEC 60825-1 (suitable for use in a safety report)	Yes	Yes	No	Yes	No	No	
6	Technical specification (withdrawn)								
7	Technical specification (withdrawn)								
8	Technical report	Guidelines for the safe use of medical laser equipment	No	No	Yes	No	No	No	IEC 60601-2-22
9	Technical report	Compilation of maximum permissible exposure to incoherent optical radiation (broadband sources)	No	No	Yes	No	Yes	Yes	IEC 62471
10	Technical report (withdrawn)								
12	Standard	Safety of free space optical communication systems used for transmission of information	Yes	Yes	Yes	Yes	Yes	Yes	
13	Technical report	Measurements for classification of laser products	Yes	Yes	Yes	Yes	Yes	Yes	
14	Technical report	A user's guide	No	Yes	Yes	No	No	Yes	
17	Technical report	Safety aspects for use of passive optical components and optical cables in high power optical fibre communication systems	No	Yes	Yes	Yes	Yes	Yes	

NOTE This table is intended to provide an indication of content – see text of the particular standard for complete requirements. Some parts listed above may be under discussion by working groups and may not be formally published.

Bibliography

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60065, *Audio, video and similar apparatus – Safety requirements*

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60079-0:2011, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60601-2-22, *Medical electrical equipment - Part 2-22: Particular requirements for basic safety and essential performance of surgical, cosmetic, therapeutic and diagnostic laser equipment*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

IEC/TR 60825-3, *Safety of laser products – Part 3: Guidance for laser displays and shows*

IEC 60825-4, *Safety of laser products – Part 4: Laser guards*

IEC/TR 60825-5, *Safety of laser products – Part 5: Manufacturer's checklist for IEC 60825-1*

IEC/TR 60825-8, *Safety of laser products – Part 8: Guidelines for the safe use of laser beams on humans*

IEC/TR 60825-9, *Safety of laser products – Part 9: Compilation of maximum permissible exposure to incoherent optical radiation*

IEC 60825-12, *Safety of laser products – Part 12: Safety of free space optical communication systems used for transmission of information*

IEC/TR 60825-13, *Safety of laser products – Part 13: Measurements for classification of laser products*

IEC/TR 60825-14, *Safety of laser products – Part 14: A user's guide*

IEC 60950 (all parts), *Information technology equipment – Safety*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 62115, *Electric toys – Safety*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC/ISO 11553 (all parts), *Safety of machinery — Laser processing machines*

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ISO 11146-1, *Lasers and laser-related equipment – Test methods for laser beam widths, divergence angles and beam propagation ratios – Part 1: Stigmatic and simple astigmatic beams*

ISO 12100, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13694, *Optics and optical instruments – Lasers and laser-related equipment – Test methods for laser beam power (energy) density distribution*

ISO 13849 (all parts), *Safety of machinery – Safety-related parts of control systems*

ISO 15004-2:2007, *Ophthalmic instruments – Fundamental requirements and test methods – Part 2: Light hazard protection*

ISO 80000-1, *Quantities and units – Part 1: General*

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