

Safety of laser products —

Part 1: Equipment classification and requirements

ICS 13.280; 31.260

National foreword

This British Standard is the UK implementation of EN 60825-1:2007. It is identical to IEC 60825-1:2007, incorporating corrigendum August 2008. Together with BS EN 62471:2008, it supersedes BS EN 60825-1:1994 which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum August 2008 is indicated in the text by **AC1** **AC1**.

The UK participation in its preparation was entrusted to Technical Committee EPL/76, Optical radiation safety and laser equipment.

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

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

Compliance with a British Standard cannot confer immunity from legal obligations.

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**Safety of laser products -
Part 1: Equipment classification and requirements
(IEC 60825-1:2007)**

Sécurité des appareils à laser -
Partie 1: Classification des matériels
et exigences
(CEI 60825-1:2007)

Sicherheit von Lasereinrichtungen -
Teil 1: Klassifizierung von Anlagen
und Anforderungen
(IEC 60825-1:2007)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 76/338/CDV, future edition 2 of IEC 60825-1, prepared by IEC TC 76, Optical radiation safety and laser equipment, was submitted to the IEC-CENELEC parallel Unique Acceptance Procedure and was approved by CENELEC as EN 60825-1 on 2007-09-01.

This European Standard partially supersedes EN 60825-1:1994 (+ corrigendum February 1995) + A1:2002 + A2:2001 (+ corrigendum April 2004).

The user's guide has been removed from this part of the EN 60825 series and is now a separate document (Part 14). Light emitting diodes (LEDs) have been removed from the scope of this part of EN 60825, but may still be included in other parts.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2008-06-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2010-09-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60825-1:2007 was approved by CENELEC as a European Standard without any modification.

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SAFETY OF LASER PRODUCTS –

Part 1: Equipment classification and requirements

1 Scope and object

IEC 60825-1 is applicable to safety of laser products emitting laser radiation in the wavelength range 180 nm to 1 mm.

A laser product may consist of a single laser with or without a separate power supply or may incorporate one or more lasers in a complex optical, electrical, or mechanical system. Typically, laser products are used for demonstration of physical and optical phenomena, materials processing, data reading and storage, transmission and display of information, etc. Such systems have found use in industry, business, entertainment, research, education, medicine and consumer products.

Laser products that are sold to other manufacturers for use as components of any system for subsequent sale are not subject to IEC 60825-1, since the final product will itself be subject to this standard. However, if the laser system within the laser product is operable when removed from the equipment, the requirements of this Part 1 apply to the removable unit.

NOTE 1 Operable equipment does not require a tool to prepare for operation.

Any laser product is exempt from all further requirements of this Part 1 if classification by the manufacturer of that product according to Clauses 3, 8 and 9 shows that the emission level does not exceed the AEL (accessible emission limit) of Class 1 under all conditions of operation, maintenance, service and failure.

NOTE 2 The above exemption is to ensure that inherently safe laser products are not unnecessarily subject to the standard.

In addition to the hazards resulting from laser radiation, laser equipment may also give rise to other hazards such as fire and electric shock.

NOTE 3 However, the classification and other requirements of this standard are intended to address only the laser radiation hazards to the eyes and skin. Other hazards are not included within its scope.

This Part 1 describes the minimum requirements. Compliance with this Part 1 may not be sufficient to achieve the required level of product safety. Laser products must conform to the applicable performance and testing requirements of the applicable product safety standards.

NOTE 4 Other standards may contain additional requirements. Consideration should also be given to the intended application and user group. For example, a class 3B or class 4 laser product may not be suitable for use as a consumer product.

Where a laser system forms a part of equipment which is subject to another IEC product safety standard (e.g. for medical equipment (IEC 60601-2-22), IT equipment (IEC 60950), audio and video equipment (IEC 60065), equipment for use in hazardous atmospheres (IEC 60079), or electric toys (IEC 62115)), this Part 1 will apply in accordance with the provisions of IEC Guide 104¹⁾ for hazards resulting from laser radiation. If no product safety standard is applicable, then IEC 61010-1 applies.

In previous editions, LEDs were included in the scope of IEC 60825-1, and they may be still included in other parts of the IEC 60825 series. However, with the development of lamp safety standards, optical radiation safety of LEDs in general can be more appropriately addressed by lamp safety standards. The removal of LEDs from the scope of this Part 1 does not preclude other standards from including LEDs whenever they refer to lasers. CIE S009 may be applied to determine the risk group class of an LED or product incorporating one or more LEDs.

The MPE (maximum permissible exposure) values of this Part 1 were developed for laser radiation and do not apply to collateral radiation. However, if a concern exists that accessible collateral radiation might be hazardous, the laser MPE values may be applied to conservatively evaluate this potential hazard.

The MPE values are not applicable to intentional human exposure to laser radiation for the purpose of medical or cosmetic/aesthetic treatment.

NOTE 5 Annexes A to H have been included for purposes of general guidance and to illustrate many typical cases. However, the annexes are not regarded as definitive or exhaustive and reference should always be made to the appropriate clause(s) in the normative part of this document.

The objectives of this part of IEC 60825 are the following:

- to introduce a system of classification of lasers and laser products according to their degree of optical radiation hazard in order to aid hazard evaluation and to aid the determination of user control measures;
- to establish requirements for the manufacturer to supply information so that proper precautions can be adopted;
- to ensure, through labels and instructions, adequate warning to individuals of hazards associated with accessible radiation from laser products;
- to reduce the possibility of injury by minimizing unnecessary accessible radiation and to give improved control of the laser radiation hazards through protective features.

¹⁾ IEC Guide 104:1997, *The preparation of safety publications and the use of basic safety publications and group safety publications*

2 Normative references

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

IEC 60050-845:1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

IEC 60601-2-22, *Medical electrical equipment – Part 2: Particular requirements for the safety of diagnostic and therapeutic laser equipment*

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

3 Terms and definitions

For the purposes of this document, the definitions of IEC 60050-845 as well as the following apply.

NOTE For convenience here, the definitions have been arranged in English alphabetical order. Departures from IEC 60050-845 are intentional and are indicated. In such cases, reference is made, between brackets, to the definition of Part 845 of IEC 60050, with the mention “modified”.

3.1

access panel

part of the protective housing or enclosure which provides access to laser radiation when removed or displaced

3.2

accessible emission

level of radiation determined at a position and with aperture stops (when the AEL is given in units of Watts or Joules) or limiting apertures (when the AEL is given in units of $W \cdot m^{-2}$ or $J \cdot m^{-2}$) as described in Clause 9

The accessible emission is determined where human access is considered, as specified in Definition 3.37. The accessible emission is compared with the accessible emission limit (Definition 3.3) in order to determine the class of the laser product. In the body of the standard, whenever the term “emission level” is used, it is to be understood as accessible emission.

NOTE When the beam diameter is larger than the aperture stop, the accessible emission when given in units of Watts or Joules is less than the total emitted power or energy of the laser product. When the beam diameter is smaller than the diameter of the limiting aperture, the accessible emission when given in units of $W \cdot m^{-2}$ or $J \cdot m^{-2}$, i.e. as irradiance or radiant exposure averaged over the limiting aperture, is smaller than the actual irradiance or radiant exposure of the beam. See also aperture stop (3.9) and limiting aperture (3.52).

3.3

accessible emission limit

AEL

the maximum accessible emission permitted within a particular class

NOTE Wherever the text refers to “emission level not exceeding the AEL” or similar wording, it is implicit that the accessible emission is determined following the measurement criteria specified in Clause 9.

3.4

administrative control

safety measures of a non-engineering type such as: key supervision, safety training of personnel, warning notices, count-down procedures, and range safety controls

3.5

alpha min

$\alpha_{\min}$

see angular subtense and minimum angular subtense (see 3.7 and 3.58)

3.6

angle of acceptance

plane angle within which a detector will respond to optical radiation, usually measured in radians

This angle of acceptance may be controlled by apertures or optical elements in front of the detector (see Figure 3 and 4). The angle of acceptance is also sometimes referred to as the field of view.

Symbol: γ

3.7

angular subtense of the apparent source

α

angle subtended by an apparent source as viewed from a point in space, as shown in Figure 3

NOTE 1 The location and angular subtense of the apparent source depends on the viewing position in the beam (see 3.11).

NOTE 2 The angular subtense of an apparent source is applicable in this Part 1 only in the wavelength range from 400 nm to 1 400 nm, the retinal hazard region.

NOTE 3 The angular subtense of the source should not be confused with the divergence of the beam. The angular subtense of the source can not be larger than the divergence of the beam but it is usually smaller than the divergence of the beam.

3.8

aperture

any opening in the protective housing or other enclosure of a laser product through which laser radiation is emitted, thereby allowing human access to such radiation

See also limiting aperture (3.52).

3.9

aperture stop

opening serving to define the area over which radiation is measured

3.10

apparent source

for a given evaluation location of the retinal hazard, the real or virtual object that forms the smallest possible retinal image (considering the accommodation range of the human eye)

NOTE 1 The accommodation range of the eye is assumed to be variable from 100 mm to infinity. The location of the apparent source for a given viewing position in the beam is that location to which the eye accommodates to produce the most hazardous retinal irradiance condition.

NOTE 2 This definition is used to determine, for a given evaluation position, the location of the apparent origin of laser radiation in the wavelength range of 400 nm to 1 400 nm. In the limit of vanishing divergence, i.e. in the case of a well collimated beam, the location of the apparent source goes to infinity.

3.11**beam**

laser radiation that may be characterized by direction, divergence, diameter or scan specifications

Scattered radiation from a non-specular reflection is not considered to be a beam.

3.12**beam attenuator**

device which reduces the laser radiation to or below a specified level

3.13**beam diameter****beam width**

the beam diameter d_u at a position in space is the diameter of the smallest circle which contains u % of the total laser power (or energy)

For the purpose of this standard d_{63} is used.

NOTE 1 In the case of a Gaussian beam, d_{63} corresponds to the point where the irradiance (radiant exposure) falls to 1/e of its central peak value.

NOTE 2 The second moment diameter definition (as defined in ISO 11146-1) is not used for beam profiles with central high irradiance peaks and a low level background, such as produced by unstable resonators in the far field: the power that passes through an aperture can be significantly underestimated when using the 2nd moment and calculating the power with the assumption of a Gaussian beam profile.

3.14**beam divergence**

far field plane angle of the cone defined by the beam diameter

If the beam diameters (see 3.13) at two points separated by a distance r are d_{63} and d'_{63} the divergence is given by:

$$\varphi = 2 \arctan \left(\frac{d'_{63} - d_{63}}{2r} \right)$$

SI unit: radian

NOTE The second moment divergence definition (ISO 11146-1) is not used for beam profiles with central high irradiance peaks and a low level background, such as produced by unstable resonators in the far field or beam profiles that show diffraction patterns caused by apertures.

3.15**beam expander**

combination of optical elements which will increase the diameter of a laser beam

3.16**beam path component**

optical component which lies on a defined beam path (e.g. a beam steering mirror or a focusing lens)

3.17**beam stop**

device which terminates a laser beam path

3.18**Class 1 laser product**

any laser product which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations (see 8.2 and 8.3 e))

NOTE 1 See also the limitations of the classification scheme in Annex C.

NOTE 2 As tests for the determination of the classification of the product are limited to tests during operation, it may be the case for embedded laser products that, depending on the product, radiation above the AEL of Class 1 can become accessible during maintenance when interlocks of access panels are overridden.

3.19

Class 1M laser product

any laser product in the wavelength range from 302,5 nm to 4 000 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations (see 8.3e)), where the level of radiation is measured according to 9.2 g)

NOTE 1 See also the limitations of the Classification scheme in Annex C.

NOTE 2 Since the evaluation is with a smaller measurement aperture or at a greater distance from the apparent source than those used for Class 1 laser products, the output of a Class 1M laser product is therefore potentially hazardous when viewed using an optical instrument (see 8.2).

NOTE 3 As tests for the determination of the classification of the product are limited to tests during operation, it may be the case for embedded laser products that, depending on the product, radiation above the AEL of Class 1M can become accessible during maintenance when interlocks of access panels are overridden.

3.20

Class 2 laser product

any laser product in the wavelength range from 400 nm to 700 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations (see 8.2 and 8.3e))

NOTE 1 See also the limitations of the Classification scheme in Annex C.

NOTE 2 As tests for the determination of the classification of the product are limited to tests during operation, it may be the case for embedded laser products that, depending on the product, radiation above the AEL of Class 2 can become accessible during maintenance when interlocks of access panels are overridden.

3.21

Class 2M laser product

any laser product in the wavelength range from 400 nm to 700 nm which during operation does not permit human access to accessible laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations (see 8.3 e)), where the level of radiation is measured according to 9.2 h)

NOTE 1 See also the limitations of the Classification scheme in Annex C.

NOTE 2 Since the evaluation is with a smaller measurement aperture or at a greater distance from the apparent source than those used for Class 2 laser products, the output of a Class 2M product is therefore potentially hazardous when viewed using an optical instrument (see 8.2).

NOTE 3 As tests for the determination of the classification of the product are limited to tests during operation, it may be the case for embedded laser products that, depending on the product, radiation above the AEL of Class 2M can become accessible during maintenance when interlocks of access panels are overridden.

3.22

Class 3R and Class 3B laser products

any laser product which during operation permits human access to laser radiation in excess of the accessible emission limits of Class 1 and Class 2, as applicable, but which does not permit human access to laser radiation in excess of the accessible emission limits of Classes 3R and 3B (respectively) for any emission duration and wavelength (see 8.2)

NOTE 1 See also the limitations of the Classification scheme in Annex C.

NOTE 2 Class 1M and Class 2M products may have outputs above or below the AEL of Class 3R, depending on their optical characteristics.

3.23**Class 4 laser product**

any laser product which permits human access to laser radiation in excess of the accessible emission limits of Class 3B (see 8.2)

3.24**collateral radiation**

any electromagnetic radiation, within the wavelength range between 180 nm and 1 mm, except laser radiation, emitted by a laser product as a result of, or physically necessary for, the operation of a laser

3.25**collimated beam**

beam of radiation with very small angular divergence or convergence

3.26**continuous wave****CW**

in this Part 1, a laser operating with a continuous output for a duration equal to or greater than 0,25 s is regarded as a CW laser

3.27**defined beam path**

intended path of a laser beam within the laser product

3.28**demonstration laser product**

any laser product designed, manufactured, intended or promoted for purposes of demonstration, entertainment, advertising, display or artistic composition

The term "demonstration laser product" does not apply to laser products which are designed and intended for other applications, although they may be used for demonstrating those applications.

3.29**diffuse reflection**

change of the spatial distribution of a beam of radiation by scattering in many directions by a surface or medium

A perfect diffuser destroys all correlation between the directions of the incident and emergent radiation.

[IEV 845-04-47, modified]

3.30**embedded laser product**

in this Part 1, a laser product which, because of engineering features limiting the accessible emission, has been assigned a class number lower than the inherent capability of the laser incorporated

NOTE The laser which is incorporated in the embedded laser product is called the embedded laser.

3.31**emission duration**

temporal duration of a pulse, of a train or series of pulses, or of continuous operation, during which human access to laser radiation could occur as a result of operation, maintenance or servicing of a laser product

For a single pulse, this is the duration between the half-peak power point of the leading edge and the corresponding point on the trailing edge. For a train of pulses (or subsections of a train of pulses), this is the duration between the first half-peak power point of the leading pulse and the last half-peak power point of the trailing pulse.

3.32

errant laser radiation

laser radiation which deviates from a defined beam path

Such radiation includes unwanted reflections from beam path components and deviant radiation from misaligned or damaged components.

3.33

exposure duration

duration of a pulse, or series, or train of pulses or of continuous emission of laser radiation incident upon the human body

For a train of pulses, this is the duration between the first half-peak power point of the leading pulse and the last half-peak power point of the trailing pulse.

3.34

extended source viewing

viewing conditions whereby the apparent source at a distance of 100 mm or more subtends an angle at the eye greater than the minimum angular subtense ($\alpha_{\min}$)

Two extended source conditions are considered in this standard when considering retinal thermal injury hazards: intermediate source and large source. They are used to distinguish sources with angular subtenses of the apparent source, α , between $\alpha_{\min}$ and $\alpha_{\max}$ (intermediate sources), and greater than $\alpha_{\max}$ (large sources). (See also 3.80)

Examples are viewing of some diffused laser sources, diffuse reflections and of some laser diode arrays.

3.35

fail safe

design consideration in which failure of a component does not increase the hazard

In the failure mode the system is rendered inoperative or non-hazardous.

3.36

fail safe safety interlock

interlock which in the failure mode does not defeat the purpose of the interlock; for example, an interlock which is positively driven into the OFF position as soon as a hinged cover begins to open, or before a detachable cover is removed, and which is positively held in the OFF position until the hinged cover is closed or the detachable cover is locked in the closed position

3.37

human access

a) ability of the human body to meet laser radiation emitted by the laser product, i.e. radiation that can be intercepted outside of the protective housing, or

 b) ability of a cylindrical probe with a diameter of 100 mm and a length of 100 mm to intercept levels of radiation of Class 3B and below, or 

c) ability of a human hand or arm to intercept levels of radiation above the AEL of Class 3B,

- d) also, for levels of radiation within the housing that are equivalent to Class 3B or Class 4, ability of any part of the human body to meet hazardous laser radiation that can be reflected directly by any single introduced flat surface from the interior of the product through any opening in its protective housing

NOTE For laser products that provide walk-in access, it is necessary to consider radiation both inside and outside of the protective housing for the determination of human access. Human access inside the housing can be prevented by engineering controls such as automatic detection systems.

3.38

integrated radiance

integral of the radiance over a given exposure duration expressed as radiant energy per unit area of a radiating surface per unit solid angle of emission

(usually expressed in $\text{J}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$)

3.39

intrabeam viewing

all viewing conditions whereby the eye is exposed to the direct or specularly reflected laser beam in contrast to viewing of, for example, diffuse reflections

3.40

irradiance

quotient of the radiant flux $d\Phi$ incident on an element of a surface by the area dA of that element

$$E = \frac{d\Phi}{dA}$$

Symbol: E

SI unit: watt per square metre ($\text{W}\cdot\text{m}^{-2}$)

3.41

laser

any device which can be made to produce or amplify electromagnetic radiation in the wavelength range from 180 nm to 1 mm primarily by the process of controlled stimulated emission

[IEV 845-04-39, modified]

3.42

laser controlled area

area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards

3.43

laser energy source

any device intended for use in conjunction with a laser to supply energy for the excitation of electrons, ions or molecules

General energy sources such as electrical supply mains or batteries are not considered to constitute laser energy sources.

3.44

laser hazard area

see nominal ocular hazard area (3.61)

3.45

laser product

any product or assembly of components which constitutes, incorporates or is intended to incorporate a laser or laser system

3.46

laser radiation

all electromagnetic radiation emitted by a laser product between 180 nm and 1 mm which is produced as a result of stimulated emission

3.47

laser safety officer

one who is knowledgeable in the evaluation and control of laser hazards and has responsibility for oversight of the control of laser hazards

3.48

laser system

laser in combination with an appropriate laser energy source with or without additional incorporated components

3.49

light emitting diode

LED

any semiconductor p-n junction device which can be made to produce electromagnetic radiation by radiative recombination in the semiconductor in the wavelength range from 180 nm to 1 mm

(The optical radiation is produced primarily by the process of spontaneous emission, although some stimulated emission may be present.)

3.50

limiting angle of acceptance for evaluating retinal photochemical hazards

for evaluation of the retinal photochemical hazard, a limiting measurement angle of acceptance, γ_{ph} , is specified. The angle γ_{ph} is related to eye movements and is not dependent upon the angular subtense of the source. If the angular subtense of the source is larger than the specified limiting angle of acceptance γ_{ph} , the angle of acceptance γ is limited to γ_{ph} and the source is scanned for hotspots. If the measurement angle of acceptance γ is not limited to the specified level, the hazard may be over-estimated

NOTE If the angular subtense of the apparent source is smaller than the specified limiting angle of acceptance, the actual measurement angle of acceptance does not affect the measurement and does not have to be limited, i.e. a regular "open" angle of acceptance radiometer set-up can be used.

Symbol: γ_{ph}

3.51

limiting angle of acceptance for evaluating thermal hazards

the maximum angular subtense to be used for the evaluation of the retinal thermal hazard

The value of the angle of acceptance γ may vary between α_{min} and α_{max} (see 8.3 d); 9.3.2 b) 2)).

Symbol: γ_{th}

3.52

limiting aperture

circular area over which irradiance and radiant exposure are averaged

3.53**maintenance**

performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser product, which are to be performed by the user for the purpose of assuring the intended performance of the product

It does not include operation or service.

3.54**maximum angular subtense** **$\alpha_{\max}$**

value of angular subtense of the apparent source above which the MPEs and AELs are independent of the source size

NOTE $\alpha_{\max} = 100 \text{ mrad}$

3.55**maximum output**

maximum radiant power, and where applicable, the maximum radiant energy per pulse, of the total accessible laser radiation emitted in any direction by a laser product over the full range of operational capability at any time after manufacture

NOTE The maximum output is the maximum accessible emission that is used to determine the class of the laser product. Since the determination of the accessible emission includes, besides other conditions, considering single fault conditions (see 9.2), the maximum output may exceed the highest output during normal operation.

3.56**maximum permissible exposure****MPE**

level of laser radiation to which, under normal circumstances, persons may be exposed without suffering adverse effects

The MPE levels represent the maximum level to which the eye or skin can be exposed without consequential injury immediately or after a long time and are related to the wavelength of the laser radiation, the pulse duration or exposure duration, the tissue at risk and, for visible and near infra-red laser radiation in the range 400 nm to 1 400 nm, the size of the retinal image. Maximum permissible exposure levels are (in the existing state of knowledge) specified in Annex A.

3.57**medical laser product**

any laser product designed, manufactured, intended or promoted for purposes of *in vivo* diagnostic, surgical, or therapeutic laser irradiation of any part of the human body

3.58**minimum angular subtense** **$\alpha_{\min}$**

value of angular subtense of the apparent source above which a source is considered an extended source

MPEs and AELs are independent of the source size for angular subtenses less than $\alpha_{\min}$.

NOTE $\alpha_{\min} = 1,5 \text{ mrad}$

3.59**mode-locking**

regular mechanism or phenomenon, within the laser resonator, producing a train of very short (e.g. sub-nanosecond) pulses

While this may be a deliberate feature it can also occur spontaneously as "self-mode-locking". The resulting peak powers may be significantly greater than the mean power.

3.60

most restrictive position

position in the beam where the ratio of accessible emission over AEL is maximum

NOTE Both the accessible emission and the AEL may depend on the position of the evaluation in respect to the beam.

3.61

nominal ocular hazard area

NOHA

area within which the beam irradiance or radiant exposure exceeds the appropriate corneal maximum permissible exposure (MPE), including the possibility of accidental misdirection of the laser beam

If the NOHA includes the possibility of viewing through optical aids, this is termed the "extended NOHA".

3.62

nominal ocular hazard distance

NOHD

distance from the output aperture at which the beam irradiance or radiant exposure equals the appropriate corneal maximum permissible exposure (MPE)

If the NOHD includes the possibility of viewing through optical aids, this is termed the "extended NOHD (ENOHD)".

3.63

operation

performance of the laser product over the full range of its intended functions

It does not include maintenance or service.

3.64

photochemical hazard limit

either an MPE or AEL which was derived to protect persons against adverse photochemical effects

In the ultraviolet wavelength range, the photochemical hazard limit protects against adverse effects on the cornea and lens, while the retinal photochemical hazard limit, as defined in the wavelength range from 400 nm to 600 nm, protects against photoretinitis – a photochemical retinal injury from exposure to radiation.

3.65

protective enclosure

physical means for preventing human exposure to laser radiation, unless such access is necessary for the intended functions of the installation

3.66

protective housing

those portions of a laser product (including a product incorporating an embedded laser) which are designed to prevent human access to laser radiation in excess of the prescribed AEL (generally installed by a manufacturer)

3.67**pulse duration**

time increment measured between the half peak power points at the leading and trailing edges of a pulse

3.68**pulsed laser**

laser which delivers its energy in the form of a single pulse or a train of pulses

In this Part 1, the duration of a pulse is less than 0,25 s.

3.69**radiance**

quantity defined by the formula

$$L = \frac{d\Phi}{dA \cdot \cos\theta \cdot d\Omega}$$

where

$d\Phi$ is the radiant flux transmitted by an elementary beam passing through the given point and propagating in the solid angle $d\Omega$ containing the given direction;

dA is the area of a section of that beam containing the given point;

θ is the angle between the normal to that section and the direction of the beam

Symbol: L

SI unit: $\text{W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$

[IEV 845-01-34, modified]

NOTE This definition is a simplified version of IEV 845-01-34, sufficient for the purpose of this Part 1. In cases of doubt, the IEV definition should be followed.

3.70**radiant energy**

time integral of the radiant flux over a given duration Δt

$$Q = \int_{\Delta t} \Phi dt$$

[IEV 845-01-27]

Symbol: Q

SI unit: joule (J)

3.71**radiant exposure**

at a point on a surface, the radiant energy incident on an element of a surface divided by the area of that element

$$H = \frac{dQ}{dA} = \int E dt$$

Symbol: H

SI unit: joule per square metre ($\text{J} \cdot \text{m}^{-2}$)

3.72

radiant power radiant flux

power emitted, transferred, or received in the form of radiation

$$\Phi = \frac{dQ}{dt}$$

[IEV 845-01-24]

Symbol: Φ , P

SI unit: watt (W)

3.73

reflectance

ratio of the reflected radiant power to the incident radiant power in the given conditions

[IEV 845-04-58, modified]

Symbol: ρ

SI unit: 1

3.74

remote interlock connector

connector which permits the connection of external controls placed apart from other components of the laser product (see 4.4)

3.75

safety interlock

automatic device associated with each portion of the protective housing of a laser product to prevent human access to Class 3R, Class 3B or Class 4 laser radiation when that portion of the housing is removed, opened or displaced (see 4.3)

3.76

scanning laser radiation

laser radiation having a time-varying direction, origin or pattern of propagation with respect to a stationary frame of reference

3.77

service

performance of those procedures or adjustments described in the manufacturer's service instructions, which may affect any aspect of the product's performance

It does not include maintenance or operation.

3.78

service panel

access panel that is designed to be removed or displaced for service

3.79

single fault condition

any single fault that might occur in a product and the direct consequences of that fault

3.80

small source

source with an angular subtense α less than, or equal to, the minimum angular subtense $\alpha_{\min}$

3.81**specular reflection**

reflection from a surface that can be considered a beam (see 3.11), including reflections from mirrored surfaces

NOTE This definition is intended to recognise that some reflecting surfaces, such as parabolic reflectors, may increase the hazard from an incident beam, or at least leave it unchanged.

3.82**thermal hazard limit**

either an MPE or AEL which was derived to protect persons against adverse thermal effects, as opposed to photochemical injury

3.83**time base**

emission duration to be considered for classification of laser products (see 8.3 e))

3.84**tool**

denotes a screwdriver, hexagonal key or other object which may be used to operate a screw or similar fixing means

3.85**transmittance**

ratio of the transmitted radiant flux to the incident flux in the given conditions

[IEV 845-04-59, modified]

Symbol: τ

SI unit: 1

3.86**transmittance (optical) density**

logarithm to base ten of the reciprocal of the transmittance τ

[IEV 845-04-66]

$$D = -\log_{10} \tau$$

Symbol: D

3.87**visible radiation (light)**

any optical radiation capable of causing a visual sensation directly

[IEV 845-01-03]

NOTE In this Part 1, this is taken to mean electromagnetic radiation for which the wavelengths of the monochromatic components lie between 400 nm and 700 nm.

3.88**workpiece**

an object intended for processing by laser radiation

4 Engineering specifications

4.1 General remarks

Laser products require certain built-in safety features, depending on the class to which they have been assigned by the manufacturer. The requirements for these are given in 4.2 to 4.12. The manufacturer shall ensure that the personnel responsible for the classification of laser products and systems have received training to an appropriate level that allows them to understand the full implications of the classification scheme.

- **Modification**

If the modification of a previously classified laser product affects any aspects of the product's performance or intended functions within the scope of this standard, the person or organization performing any such modification is responsible for ensuring the reclassification and relabelling of the laser product.

4.2 Protective housing

4.2.1 General

Each laser product shall have a protective housing which, when in place, prevents human access to laser radiation (including errant laser radiation) in excess of the AEL for Class 1, except when human access is necessary for the performance of the function(s) of the product.

When the classification of a laser product is based on the prevention of human access to a level of energy that is equivalent to Class 4 (for instance, for laser processing machines), the protective housing must withstand exposures under reasonably foreseeable single fault conditions (see 9.1), without human intervention. If the protective housing is of a size that permits human entry, see 4.12.

Maintenance of Class 1, 1M, 2, 2M, or 3R laser products shall not permit human access to levels of laser radiation of Class 3B or Class 4. Maintenance of Class 3B laser products shall not permit human access to levels of laser radiation of Class 4.

4.2.2 Service

Any parts of the housing or enclosure of a laser product (including embedded laser products) that can be removed or displaced for service and which would allow access to laser radiation in excess of the AEL assigned and are not interlocked (see 4.3) shall be secured in such a way that removal or displacement of the parts requires the use of a tool or tools.

4.2.3 Removable laser system

If a laser system can be removed from its protective housing or enclosure and operated without modification, the laser system shall comply with the manufacturing requirements of Clauses 4 and 5 that are appropriate to its class.

4.3 Access panels and safety interlocks

4.3.1 A safety interlock shall be provided for access panels of protective housings when both of the following conditions are met:

- a) the access panel is intended to be removed or displaced during maintenance or operation, and
- b) the removal of the panel gives access to laser radiation levels designated by "X" in Table 1 below.

Table 1 below indicates (X) the applicability of a safety interlock.

Table 1 – Requirements for safety interlocking

Product class	Accessible emission during or after removal of access panel				
	1, 1M	2, 2M	3R	3B	4
1, 1M	–	–	X	X	X
2, 2M	–	–	X	X	X
3R	–	–	–	X	X
3B	–	–	–	X	X
4	–	–	–	X	X

Removal of the panel shall not result in emission through the opening in excess of the AEL for Class 1M or Class 2M, as applicable according to the wavelength.

When a safety interlock is required, the safety interlock shall prevent access to accessible emission levels above the applicable AEL in Table 1 when the panel is removed. Inadvertent resetting of the interlock shall not in itself restore emission values above the applicable AEL in Table 1. These interlocks shall conform to the requirements in the applicable IEC product safety standard (see Clause 1).

NOTE The requirements of 9.1 also apply to interlocks, i.e. interlocks need to be failsafe or redundant.

4.3.2 If a deliberate override mechanism is provided, the manufacturer shall also provide adequate instructions about safe methods of working. It shall not be possible to leave the override in operation when the access panel is returned to its normal position. The interlock shall be clearly associated with a label conforming to 5.9.2. Use of the override shall give rise to a distinct visible or audible warning whenever the laser is energized or capacitor banks are not fully discharged, whether or not the access panel is removed or displaced. Visible warnings shall be clearly visible through protective eyewear specifically designed or specified for the wavelength(s) of the accessible laser radiation.

4.4 Remote interlock connector

Each Class 3B and Class 4 laser system shall have a remote interlock connector. When the terminals of the connector are open-circuited, the accessible radiation shall not exceed the AEL for Class 1M or Class 2M as applicable.

4.5 Manual reset

Each Class 4 laser system shall incorporate a manual reset to enable resumption of accessible Class 4 laser radiation emission after interruption of emission caused by the use of the remote interlock connector or an interruption of longer than 5 s of electrical mains power.

NOTE Manufacturers may include a second interlock connector that does not require active action for starting emission, but it is not required for a product to have two connectors.

4.6 Key control

Each Class 3B and Class 4 laser system shall incorporate a key-operated master control. The key shall be removable and the laser radiation shall not be accessible when the key is removed.

NOTE In this Part 1 the term "key" includes any other control devices, such as magnetic cards, cipher combinations, computer passwords, etc.

4.7 Laser radiation emission warning

4.7.1 Each Class 3R laser system in the wavelength range below 400 nm and above 700 nm and each Class 3B and Class 4 laser system shall satisfy the following.

4.7.2 A warning device shall give an audible or visible signal when the laser system is switched on or if any capacitor banks of a pulsed laser are being charged or have not positively discharged. The warning device shall be fail-safe or redundant. Any visible warning device shall be clearly visible through protective eyewear specifically designed for the wavelength(s) of the emitted laser radiation. The visible warning device(s) shall be located so that viewing does not require exposure to laser radiation in excess of the AEL for Class 1M and 2M.

4.7.3 Each operational control and laser aperture that can be separated by 2 m or more from a radiation warning device shall itself be provided with a radiation warning device. The warning device shall be clearly visible or audible to the person in the vicinity of the operational control or laser aperture.

4.7.4 Where the laser emission may be distributed through more than one output aperture, then a visible warning device shall clearly indicate the output aperture or apertures through which laser emission can occur, in accordance with 4.7.2.

4.8 Beam stop or attenuator

Each Class 3B and Class 4 laser system shall incorporate one or more permanently attached means of attenuation (e. g., beam stop, attenuator, switch). The beam stop or attenuator shall be capable of preventing human access to laser radiation in excess of the AEL for Class 1M or Class 2M as applicable.

4.9 Controls

Each laser product shall have controls located so that adjustment and operation do not require exposure to laser radiation equivalent to Class 3R, Class 3B or Class 4.

4.10 Viewing optics

Any viewing optics, viewport or display screen incorporated in a laser product shall provide sufficient attenuation to prevent human access to laser radiation in excess of the AEL for Class 1M, and, for any shutter or variable attenuator incorporated in the viewing optics, viewport or display screen, a means shall be provided to:

- a) prevent human access to laser radiation in excess of the AEL for Class 1M when the shutter is opened or the attenuation varied;
- b) prevent opening of the shutter or variation of the attenuator when exposure to laser radiation in excess of the AEL for Class 1M is possible.

4.11 Scanning safeguard

Laser products intended to emit scanned radiation and classified on this basis, shall not, as a result of scan failure or of variation in either scan velocity or amplitude, permit human access to laser radiation in excess of the AEL for the assigned class, unless exposure of people is not reasonably foreseeable during the time interval between failure and when the scanning safeguard reduces emission to levels below the AEL of the class of the product (also see 9.1).

4.12 "Walk-in" access

If a protective housing is equipped with an access panel which provides "walk-in" access then:

- a) means shall be provided so that any person inside the housing can prevent activation of a laser hazard that is equivalent to Class 3B or Class 4;
- b) a warning device shall be situated so as to provide adequate warning of emission of laser radiation equivalent to Class 3R in the wavelength range below 400 nm and above 700 nm, or of laser radiation equivalent to Class 3B or Class 4 to any person who might be within the housing;
- c) where "walk-in" access during operation is intended or reasonably foreseeable, emission of laser radiation that is equivalent to Class 3B or Class 4 while someone is present inside the enclosure of a Class 1, Class 2, or Class 3R product shall be prevented by engineering means.

NOTE Methods to prevent human access to radiation when persons are inside the protective housing may include pressure sensitive floor mats, infrared detectors, etc.

4.13 Environmental conditions

The laser product shall meet the safety requirements defined in this standard under all expected operating conditions appropriate to the intended use of the product. Factors to be considered shall include:

- climatic conditions (e.g. temperature, relative humidity);
- vibration and shock.

If no provisions are made in the product safety standard, the relevant subclauses of IEC 61010-1 shall apply.

NOTE Requirements related to electromagnetic susceptibility are under consideration.

4.14 Protection against other hazards

4.14.1 Non-optical hazards

The requirements of the relevant product safety standard shall be fulfilled during operation and in the event of a single fault for the following:

- electrical hazards;
- excessive temperature;
- spread of fire from the equipment;
- sound and ultrasonics;
- harmful substances;
- explosion.

If no provisions are included in the product safety standard, the relevant subclauses of IEC 61010-1 shall apply.

NOTE Many countries have regulations for the control of harmful substances. Contact the appropriate national agency for these requirements.

4.14.2 Collateral radiation

The protective housing of laser products will normally protect against the hazards of collateral radiation (e.g. ultraviolet, visible, infrared radiation). However, if a concern exists that accessible collateral radiation might be hazardous, the laser MPE values may be applied to conservatively evaluate this hazard.

5 Labelling

5.1 General

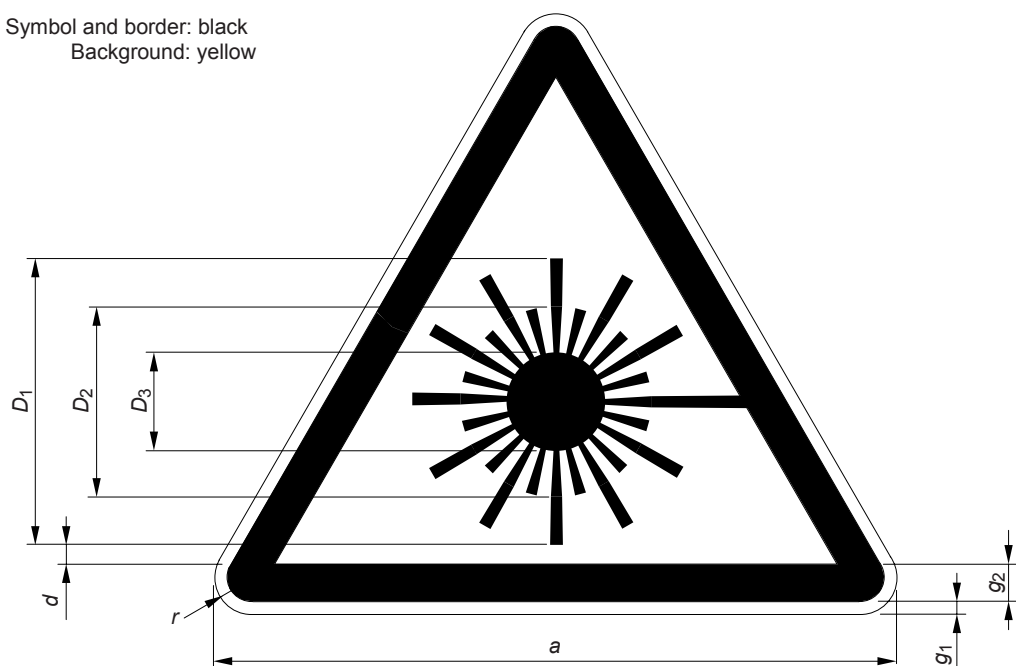
Each laser product shall carry label(s) in accordance with the requirements of the following clauses. The labels shall be durable, permanently affixed, legible, and clearly visible during operation, maintenance or service, according to their purpose. They shall be so positioned that they can be read without the necessity for human exposure to laser radiation in excess of the AEL for Class 1. Text borders and symbols shall be black on a yellow background except for Class 1, where this colour combination need not be used.

The wording of labels shown in Clause 5 is recommended but not mandatory. Other wording that conveys the same meaning may be substituted.

If the size or design of the product makes labelling impractical, the label shall be included with the user information or on the package.

NOTE Direct printing or engraving of equivalent labels on the laser product or panels is acceptable.

Symbol and border: black
Background: yellow



IEC 411/07

Dimensions in millimetres

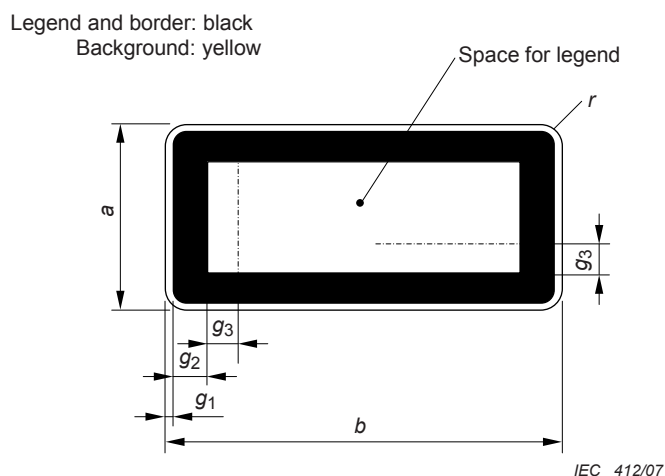
<i>a</i>	<i>g</i> ₁	<i>g</i> ₂	<i>r</i>	<i>D</i> ₁	<i>D</i> ₂	<i>D</i> ₃	<i>d</i>
25	0,5	1,5	1,25	10,5	7	3,5	0,5
50	1	3	2,5	21	14	7	1
100	2	6	5	42	28	14	2
150	3	9	7,5	63	42	21	3
200	4	12	10	84	56	28	4
400	8	24	20	168	112	56	8
600	12	36	30	252	168	84	12

The dimensions *D*₁, *D*₂, *D*₃, *g*₁ and *d* are recommended values.

NOTE 1 The relationship between the greatest distance *L* from which the label can be understood and the minimum area *A* of the label is given by: $A = L^2/2\ 000$, where *A* and *L* are expressed in square metres and metres respectively. This formula applies for distance *L* less than about 50 m.

NOTE 2 These dimensions are recommended values. As long as they are proportional to the values, the symbol and border may be of any legible size as required to suit the size of the laser product.

Figure 1 – Warning label – Hazard symbol



Dimensions in millimetres

$a \times b$	g_1	g_2	g_3	r	Minimum height of lettering
26 × 52	1	4	4	2	Lettering shall be of a size which renders it legible
52 × 105	1,6	5	5	3,2	
84 × 148	2	6	7,5	4	
100 × 250	2,5	8	12,5	5	
140 × 200	2,5	10	10	5	
140 × 250	2,5	10	12,5	5	
140 × 400	3	10	20	6	
200 × 250	3	12	12,5	6	
200 × 400	3	12	20	6	
250 × 400	4	15	25	8	
The dimension g_1 is recommended.					

NOTE 1 The relationship between the greatest distance L from which the label can be understood and the minimum area A of the label is given by: $A = L^2/2\,000$, where A and L are expressed in square metres and metres respectively. This formula applies for distance L less than about 50 m.

NOTE 2 These dimensions are recommended values. The label may be of any size necessary to contain the required lettering and border. The minimum width of each border dimension g_2 and g_3 must be 0,06 times the length of the shorter side of the label.

Figure 2 – Explanatory label

5.2 Class 1 and Class 1M

Except as permitted in Clause 1, each Class 1 laser product shall have affixed an explanatory label (Figure 2) bearing the words:

CLASS 1 LASER PRODUCT

Each Class 1M laser product shall have affixed an explanatory label (Figure 2) bearing the words:

LASER RADIATION
DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 1M LASER PRODUCT

Instead of the above labels, at the discretion of the manufacturer, the same statements may be included in the information for the user.

The type of optical instrument which could result in an increased hazard may be added in parenthesis after the word "instruments" on the Class 1M label. The added wording could in particular be "(BINOCULARS OR TELESCOPES)" for a laser product with a collimated, large-diameter beam, which is classified 1M because it fails condition 1 (see Clause 9), or "(MAGNIFIERS)" for a laser product which is classified 1M because it fails condition 2 (see Clause 9) (highly diverging beam).

Alternatively, the second line of the Class 1M label could read "DO NOT EXPOSE USERS OF BINOCULARS OR TELESCOPES"

If the accessible emission exceeds the AEL of Class 3B as determined with a 3,5 mm diameter aperture placed at the closest point of human access, an additional warning is to be given on a product label and in the information for the user:

SKIN EXPOSURE NEAR APERTURE MAY CAUSE BURNS

NOTE Only applies if condition 2 is used to determine the AEL.

5.3 Class 2 and Class 2M

Each Class 2 laser product shall have affixed a warning label (Figure 1) and an explanatory label (Figure 2) bearing the words:

LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT

Each Class 2M laser product shall have affixed a warning label (Figure 1) and an explanatory label (Figure 2) bearing the words:

LASER RADIATION
DO NOT STARE INTO THE BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT

The type of optical instrument which could result in an increased hazard may be added in parenthesis after the word "instruments". The added wording could in particular be "(BINOCULARS OR TELESCOPES)" for a laser product with a collimated, large-diameter beam which is classified 2M because it fails condition 1 (see Clause 9), or "(MAGNIFIERS)" for a laser product which is classified 2M because it fails condition 2 (see Clause 9) (highly diverging beam).

Alternatively, the second line of the Class 2M label could read "DO NOT EXPOSE USERS OF BINOCULARS OR TELESCOPES"

If the accessible emission exceeds the AEL of Class 3B as determined with a 3,5 mm diameter aperture placed at the closest point of human access, an additional warning is to be given on a product label and in the information for the user:

SKIN EXPOSURE NEAR APERTURE MAY CAUSE BURNS

NOTE Only applies if condition 2 is used to determine the AEL.

5.4 Class 3R

Each Class 3R laser product shall have affixed a warning label (Figure 1) and an explanatory label (Figure 2) bearing the words:

LASER RADIATION
AVOID DIRECT EYE EXPOSURE
CLASS 3R LASER PRODUCT

NOTE Labels using AVOID EXPOSURE TO BEAM in the second line would also be acceptable.

5.5 Class 3B

Each Class 3B laser product shall have affixed a warning label (Figure 1) and an explanatory label (Figure 2) bearing the words:

LASER RADIATION
AVOID EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

5.6 Class 4

Each Class 4 laser product shall have affixed a warning label (Figure 1) and an explanatory label (Figure 2) bearing the words:

LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

5.7 Aperture label

Each Class 3R, Class 3B and Class 4 laser product shall have affixed a label close to each aperture through which laser radiation in excess of the AEL for Class 1 or Class 2 is emitted. The label(s) shall bear the words:

LASER APERTURE

or

APERTURE FOR LASER RADIATION

or

AVOID EXPOSURE – LASER RADIATION IS
EMITTED FROM THIS APERTURE

5.8 Radiation output and standards information

The name and publication date of the standard to which the product was classified shall be included on the explanatory label or elsewhere in close proximity on the product. Each laser product, except those of Class 1, shall be described on the explanatory label (Figure 2) by a statement of the maximum output of laser radiation (see definition 3.55), the pulse duration (if appropriate) and the emitted wavelength(s). For Class 1 and Class 1M, instead of the labels on the product, the information may be contained in the information for the user.

5.9 Labels for access panels

5.9.1 Labels for panels

Each connection, each panel of a protective housing, and each access panel of a protective enclosure which, when removed or displaced permits human access to laser radiation in excess of the AEL for Class 1, shall have affixed labels bearing the words (for the case of an embedded Class 1M laser, the statement instead may be included in the information for the user):

a)

CAUTION – CLASS 1M LASER RADIATION WHEN OPEN
DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS

if the accessible radiation does not exceed the AEL for Class 1M where the level of radiation is measured according to 9.2 g) and 9.3;

b)

CAUTION – CLASS 2 LASER RADIATION WHEN OPEN
DO NOT STARE INTO THE BEAM

if the accessible radiation does not exceed the AEL for Class 2 where the level of radiation is measured according to 9.2 h) and 9.3;

c)

CAUTION – CLASS 2M LASER RADIATION WHEN OPEN
DO NOT STARE INTO THE BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS

if the accessible radiation does not exceed the AEL for Class 2M where the level of radiation is measured according to 9.2 h) and 9.3;

d)

CAUTION – CLASS 3R LASER RADIATION WHEN OPEN
AVOID DIRECT EYE EXPOSURE

if the accessible radiation does not exceed the AEL for Class 3R;

NOTE Labels using AVOID EXPOSURE TO THE BEAM in the second line would also be acceptable.

e)

CAUTION – CLASS 3B LASER RADIATION WHEN OPEN
AVOID EXPOSURE TO THE BEAM

if the accessible radiation does not exceed the AEL for Class 3B;

f)

CAUTION – CLASS 4 LASER RADIATION WHEN OPEN
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

if the accessible radiation exceeds the limits for Class 3B.

This information may be provided in more than one adjacent label on the product.