

Radiation safety of laser products, equipment classification, requirements and user's guide

The European Standard EN 60825 : 1991 has the status of a British Standard

Sécurité du rayonnement des appareils laser,
classification des matériels, prescriptions et
guide de l'utilisateur

Strahlungssicherheit von
Laser-Einrichtungen, Klassifizierung von
Anlagen, Anforderungen und
Benutzer-Richtlinien

Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

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Greece	Sweden
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**Corrigendum to BS EN 60825 : 1992****Radiation safety of laser products, equipment classification,
requirements and user's guide****Correction**

Page 26. Table I Accessible emission limits for Class I laser products**In the second column, headed ' $\leq 10^{-9}$ ' in row 8, the text should read ' 2×10^3 W'**

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National foreword

This British Standard has been prepared under the direction of the Electronic Equipment Standards Policy Committee and is the English language version of EN 60825 'Radiation safety of laser products, equipment classification, requirements and user's guide', published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by CENELEC from IEC 825 : 1984 as amended by Amendment No. 1 : 1990 published by the International Electrotechnical Commission (IEC).

This British Standard supersedes BS 7192 : 1989 which implemented CENELEC Harmonization Document HD 482 S1 and which is withdrawn.

Text amended by Amendment No. 1 : 1990 is indicated by two side lines in the margin. The CENELEC common modifications, which have been implemented at the appropriate places in the text, are indicated by a single side line in the margin. Parts of the original IEC text that have been modified by CENELEC have been quoted in national annex NA.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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English version

Radiation safety of laser products, equipment classification, requirements and user's guide

(IEC 825 : 1984 + A1 : 1990, modified)

Sécurité du rayonnement des appareils laser,
classification des matériels, prescriptions et
guide de l'utilisateur
(CEI 825 : 1984 + A1 : 1990, modifié)

Strahlungssicherheit von Laser-Einrichtungen,
Klassifizierung von Anlagen, Anforderungen
und Benutzer-Richtlinien
(IEC 825 : 1984 + A1 : 1990, modifiziert)

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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.

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

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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 proposal to endorse the International Standard IEC 825 : 1984 and its Amendment 1 : 1990 was submitted to the CENELEC members for unique acceptance in September 1989. The results were presented to the 64th Technical Board that referred them to the reporting secretariat SR 76 in order to prepare a proposal for common modifications. This proposal was submitted to the CENELEC members for a second vote in August 1990.

The reference documents, together with the common modifications prepared by CLC/SR 76, were approved by CENELEC as EN 60825 on 15 March 1991.

The following dates were fixed:

- latest date of publication
of an identical national
standard (dop) 1992-03-01
- latest date of withdrawal
of conflicting national
standards (dow) 1992-03-01

For products which have complied with the relevant national standard before 1992-03-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1997-03-01.

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative.

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RADIATION SAFETY OF LASER PRODUCTS, EQUIPMENT CLASSIFICATION, REQUIREMENTS AND USER'S GUIDE

SECTION ONE — GENERAL

1. Scope

This standard is applicable to radiation from laser products. For convenience, this standard has been divided into three separate sections: Section One (General) and the appendices (of interest of all concerned); Section Two (Manufacturing Requirements); and Section Three (User's Guide)¹⁾. The requirements for electrical safety are detailed in IEC 820 or other relevant IEC standards.

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 phenomenon; material processing; data reading and storage; transmission and display of information; etc. Such systems have found use in industry, business, entertainment, research, education and medicine. However, laser products which are sold to other manufacturers for use as components of any system for subsequent sale are not subject to this standard, since the final product will itself be subject to this standard.

The MPE (maximum permissible exposure) values of this standard were developed for laser radiation and do not apply to collateral radiation. The MPE values shall not be applicable to patient exposure to laser radiation for the purpose of medical treatment.

Note. — Appendices A to D have been included for purposes of general guidance and to illustrate many typical cases. However, the appendices must not be regarded as definitive or exhaustive and reference should always be made to the appropriate clause(s) in Sections One to Three.

2. Object

- 2.1 To protect persons from laser radiation in the wavelength range 180 nm to 1 mm²⁾ by indicating safe working levels of laser radiation and introducing a system of classification of lasers and laser products according to their degree of hazard.
- 2.2 To lay down requirements for both user and manufacturer to establish procedures and supply information so that proper precautions can be adopted.

¹⁾ Some countries have requirements which differ from this standard. Therefore, contact the appropriate national agency for these requirements.

²⁾ In this standard, the wavelength range λ_1 to λ_2 means $\lambda_1 < \lambda < \lambda_2$ (e.g. 180 nm to 1 mm means $180 \text{ nm} < \lambda < 1 \text{ mm}$).

- 2.3 To ensure adequate warning to individuals of hazards associated with accessible radiation from laser products through signs, labels and instructions.
- 2.4 To reduce the possibility of injury by minimizing unnecessary accessible radiation and to give improved control of the laser radiation through protective features and provide safe usage of laser products by specifying user control measures.

3. Definitions*

For the purposes of this standard, the following definitions apply.

3.1 Access panel

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

3.2 Accessible emission limit (AEL)

The maximum accessible emission level permitted within a particular class.

3.3 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.

3.4 Alignment laser product

The laser product designed, manufactured, intended or promoted for one or more of the following uses:

- a) determining and delineating the form, extent or position of a point, body or area by taking angular measurements,
- b) positioning or adjusting parts in proper relation to one another,
- c) defining a plane, level, elevation or straight line.

3.5 Alpha min. ($\alpha_{\min}$)

See *Limiting angular subtense*, Sub-clause 3.39.

3.6 Aperture, aperture stop

An aperture is 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. An aperture stop is an opening serving to define the area over which radiation is measured.

3.7 Apparent source

The real or virtual object that forms the smallest possible retinal image.

Note that this definition is used to determine the location of the apparent origin of laser radiation in the wavelength range 400 to 1 400 nm, with the assumption of the apparent source being located in the eye's range of accommodation (≥ 100 mm). In the limit of vanishing divergence, i.e. in the case of an ideally collimated beam, the location of the apparent source goes to infinity.

* Arranged here for convenience in English alphabetical order. Departures from IEC Publication 50(845) (1987): International Electrotechnical Vocabulary (IEV), Chapter 845: Lighting, are intentional and are indicated.

3.8 *Beam divergence (Gaussian beam)*

For purposes of hazard assessment it is the plane angle of the mean cone of rays which in any cross-section encloses 63% of the total beam power (or energy). The diameter of the circle in any cross-section is the beam diameter at that point. The circle is the separation of points where the power (or energy) intensity falls to $1/e$ of its central peak value. If the beam diameters are d_1 and d_2 metres at points x metres apart the beam divergence in radians is given by:

$$\frac{(d_2 - d_1)}{x}$$

3.9 *Beam expander*

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

3.10 *Class 1 laser product*

Any laser product which does not permit human access to laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission duration (see Sub-clause 9.2).

3.11 *Class 2 laser product*

Any laser product which:

- a) permits human access to laser radiation in excess of the accessible emission limits of Class 1, but not in excess of the accessible emission limits of Class 2 in the wavelength range from 400 nm to 700 nm;
- b) does not permit human access to laser radiation in excess of the accessible emission limits of Class 1 for any other wavelength (see Sub-clause 9.2).

3.12 *Class 3A and Class 3B laser product*

Any laser product which 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 3A and 3B (respectively) for any emission duration and wavelength (see Sub-clause 9.2).

3.13 *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 Sub-clause 9.2).

3.14 *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.

3.15 *Collimated beam*

A "parallel" beam of radiation with very small angular divergence or convergence.

3.16 *Continuous wave (CW)*

The output of a laser which is operated in a continuous rather than pulsed mode. In this standard, a laser operating with a continuous output for a period greater than 0.25 s is regarded as a CW laser.

3.17 *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.

3.18 *Diffuse reflection*

Change of the spatial distribution of a beam of radiation when it is scattered in many directions by a surface or medium. A perfect diffuser destroys all correlation between the directions of the incident and emergent radiation.

Note. — This definition is different from IEV 845-04-47.

3.19 *Embedded laser product*

In this standard a laser product which, because of engineering features limiting the accessible emissions, has been assigned a class number lower than the inherent capability of the laser incorporated.

3.20 *Emission duration*

The 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.

3.21 *Exposure time*

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

3.22 *Extended source viewing*

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

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

3.23 *Fail safe*

The 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.

3.24 *Fail safe safety interlock*

An 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.

3.25 *Human access*

Capability for a part of the human body to meet hazardous laser radiation either as emitted from an aperture, by redirection from within a housing to the outside by the use of a reflector or optical guide or by insertion of part of the body through an enclosure port into the interior of the laser system, or by a single failure mode of the laser equipment.

3.26 *Integrated radiance*

The integral of the radiance over a given exposure time expressed as radiant energy per unit area of a radiating surface per unit solid angle of emission (usually expressed in $\text{J} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$).

3.27 *Intrabeam viewing*

All viewing conditions whereby the eye is exposed to laser radiation, other than extended source viewing.

Examples are viewing of collimated beams and of point-type sources.

3.28 *Irradiance*

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

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

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

3.29 *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.

Note. — This definition is different from IEC 845-04-39.

3.30 *Laser controlled area*

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

3.31 *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 shall not be considered to constitute laser energy sources.

3.32 *Laser hazard area*

See *Nominal ocular hazard area* (Sub-clause 3.46).

3.33 *Laser fibre optic transmission system*

A system consisting of one or more laser transmitters and associated fibre optic cable.

3.34 *Laser product*

Any product or assembly of components which constitutes, incorporates or is intended to incorporate a laser or laser system, and which is not sold to another manufacturer for use as a component (or replacement for such component) of an electronic product.

3.35 *Laser radiation*

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

3.36 *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.

3.37 *Laser system*

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

3.38 *Levelling laser product*

See *Alignment laser product*, Sub-clause 3.4.

3.39 *Limiting angular subtense ($\alpha_{\min}$)*

The visual angle subtended by the apparent source (including diffuse reflections) at the eye of an observer which is used to differentiate between intrabeam and extended source viewing. See Figure 8, page 48, and Sub-clause 9.3e. This concept is discussed in Section B of Appendix A.

3.40 *Limiting aperture*

The circular area over which irradiance and radiant exposure shall be averaged.

3.41 *Maintenance*

The 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.

3.42 *Maximum output*

The 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.

3.43 *Maximum permissible exposure (MPE)*

That 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 radiation, the pulse duration or exposure time, the tissue at risk and, for visible and near infra-red 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 Clause 13. Appendix A gives examples of the calculations of MPE levels.

3.44 *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.

3.45 *Mode-locking*

A regular mechanism or phenomenon, within the laser resonator, producing a train of very short pulses. While this may be a deliberate feature it may also occur spontaneously as “self-mode-locking”. The resulting peak powers may be significantly greater than the mean power.

3.46 *Nominal ocular hazard area (NOHA)*

The 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”.

3.47 *Nominal ocular hazard distance (NOHD)*

The distance at which the beam irradiance or radiant exposure equals the appropriate corneal maximum permissible exposure (MPE). If the NOHD includes the possibility of optically-aided viewing, this is termed the “extended NOHD”.

3.48 *Operation*

The performance of the laser product over the full range of its intended functions. It does not include maintenance or service.

3.49 *Transmittance (optical) density*

Logarithm to base ten of the reciprocal of the transmittance (IEV 845-04-66).

Symbol: D

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

3.50 *Protective enclosure*

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

3.51 *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).

3.52 *Pulse duration*

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

3.53 Pulsed laser

A laser which delivers its energy in the form of a single pulse or a train of pulses. In this standard, the duration of a pulse is less than 0.25 s.

3.54 Radiance

The radiant power per unit area of a radiation surface per unit solid angle of emission.

Symbol: L

$$L = \frac{d^2\Phi}{d\Omega \cdot dA \cdot \cos \theta}$$

SI unit: watt per square metre per steradian ($\text{W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$)

Note. — This definition is a simplified version of IEV 845-01-34, sufficient for the purpose of this standard. In case of doubt the IEV definition should be followed.

3.55 Radiant energy

Time integral of the radiant flux over a given duration Δt (IEV 845-01-27):

Symbol: Q

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

SI unit: joule (J)

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

Symbol: H

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

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

3.57 Radiant flux; radiant power

Power emitted, transmitted or received in the form of radiation (IEV 845-01-24).

Symbol: Φ, P

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

SI unit: watt (W)

3.58 Reflectance

Ratio of the reflected radiant power to the incident radiant power in the given conditions (IEV 845-04-58).

Symbol: ρ

SI unit: 1

3.59 Remote interlock connector

A connector which permits the connection of external controls placed apart from other components of the laser product (see Sub-clause 4.4).

3.60 Safety interlock

An automatic device associated with the protective housing of a laser product to prevent human access to Class 3 or Class 4 laser radiation when that portion of the housing is removed.

3.61 Scanning laser radiation

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

3.62 Service

The 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.

3.63 Service connection

An access point in a laser fibre optic transmission system which is designed for service and requires a tool to disconnect.

3.64 Service panel

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

3.65 Specular reflection

A reflection from a surface which maintains correlation between incident and reflected beams of radiation, as with reflections from a mirror.

3.66 Surveying laser products

See *Alignment laser product*, Sub-clause 3.4.

3.67 Tool

Denotes a screwdriver, a coin or other object which may be used to operate a screw or similar fixing means.

3.68 Transmittance

Ratio of the transmitted radiant power to the incident radiant power in the given conditions (IEV 845-04-59).

Symbol: τ

SI unit: 1

3.69 Visible radiation: light

Any optical radiation capable of causing a visual sensation directly (IEV 845-01-03).

Note. — In this standard, this is taken to mean electromagnetic radiation for which the wavelengths of the monochromatic components lie between 400 nm and 700 nm.

SECTION TWO — MANUFACTURING REQUIREMENTS

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 Sub-clauses 4.2 to 4.10. The manufacturer shall ensure that the personnel responsible for the classification of laser products and systems have received training to an appropriate level which allows them to understand the full implications of the classification scheme.

4.1.1 Modification

If the modification of a previously classified laser product affects any aspect 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, apart from laser apertures, prevents human access to laser radiation in excess of Class 1.

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 Sub-clause 4.3) shall be secured in such a way that removal or displacement of the parts requires the use of tools.

4.2.3 Removable laser system

If an embedded laser product or a laser system can be removed from its protective housing or enclosure and operated without modification, the laser shall comply with the manufacturing requirements of Clauses 4 and 5 that are appropriate to its class, except for laser products which are sold to other manufacturers for use as components of any system for subsequent sale which are not subject to this standard, since the final product will itself be subject to this standard.

4.3 Access panels and safety interlocks

4.3.1 A safety interlock shall be provided for access panels of protective housings when all 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 human access to laser radiation from the embedded laser, and

c) the table below indicates (×) the necessity of a safety interlock.

Product class	Accessible emission during removal of access panel:					
	1	2	3A	3B*	3B**	4
1	—	—	—	×	×	×
2	—	—	—	×	×	×
3A	—	—	—	×	×	×
3B*	—	—	—	—	×	×
3B**	—	—	—	—	—	×
4	—	—	—	—	—	—

Note. — 3B* : Class 3B lasers with less than five times the AEL of Class 2 in the wavelength range of 400 to 700 nm.

3B** : Class 3B lasers excluding 3B*.

Removal of the panel shall not result in emission through the opening in excess of the AEL for Class 3A. The emission accessible through the opening, e.g. by insertion of a reflector, shall not exceed the limits of the class assigned. The safety interlock shall be of a design which prevents the removal of the panel until accessible emission values are below the AEL for the class assigned and inadvertent resetting of the interlock shall not in itself restore emission values above the AEL of the class assigned.

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 Sub-clause 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

Any laser product belonging to one of the following classes shall have a remote interlock connector: Class 4 and Class 3B, except for Class 3B with not more than five times the AEL of Class 2 in the wavelength range of 400 to 700 nm. When the terminals of the connector are open-circuited, the accessible radiation shall not exceed the AEL for Class 1, Class 2 and Class 3A.

4.5 Key control

Any laser product belonging to one of the following classes shall incorporate a key-operated master control: Class 4 and Class 3B, except for Class 3B with not more than five times the AEL of Class 2 in the wavelength range of 400 to 700 nm. The key shall be removable and laser radiation shall not be accessible when the key is removed. In this standard, the term "key" includes any other control devices, such as magnetic cards, cipher combinations, etc.

4.6 *Laser radiation emission warning*

Any laser product belonging to one of the following classes shall give an audible or visible warning when the energy source is activated or if capacitor banks of pulsed lasers are being charged or have not been positively discharged: Class 4 and Class 3B, except for Class 3B with not more than five times the AEL of Class 2 in the wavelength range of 400 to 700 nm. The warning device shall be of a fail-safe or redundant design. Any visible warning device shall be clearly visible through protective eye-wear specifically designed for the wavelength(s) of the emitted laser radiation. If the laser and its energy source are separately housed, and if they can be operated at a separation distance greater than 2 m, they shall each be provided with audible or visible warning devices. 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 1 and Class 2.

4.7 *Beam stop or attenuator*

Any laser product belonging to one of the following classes shall incorporate one or more permanently attached means of attenuation (beam stop or attenuator, other than laser energy source switch, mains connector or key control): Class 4 and Class 3B, except for Class 3B with not more than five times the AEL of Class 2 in the wavelength range of 400 to 700 nm. The beam stop or attenuator shall be capable of preventing human access to laser radiation in excess of the AEL for Class 1, Class 2 or Class 3A.

4.8 *Controls*

Each laser product shall have controls located so that adjustment and operation do not require exposure to laser radiation in excess of the AEL for Class 1 and Class 2.

4.9 *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 1, 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 1 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 1 is possible.

4.10 *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.

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 permanently fixed, 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.

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

5.2 Class 1

Each Class 1 laser product shall have affixed an explanatory label (Figure 15, page 56), bearing the words:

CLASS 1 LASER PRODUCT

5.3 Class 2

Each Class 2 laser product shall have affixed a warning label (Figure 14, page 55) and an explanatory label (Figure 15) bearing the words:

**LASER RADIATION
DO NOT STARE INTO BEAM
CLASS 2 LASER PRODUCT**

5.4 Class 3A

Each Class 3A laser product shall have affixed a warning label (Figure 14) and an explanatory label (Figure 15) bearing the words:

**LASER RADIATION
DO NOT STARE INTO BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 3A LASER PRODUCT**

5.5 Class 3B

Each Class 3B laser product shall have affixed a warning label (Figure 14) and an explanatory label (Figure 15) 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 14) and an explanatory label (Figure 15) 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 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

**AVOID EXPOSURE — LASER RADIATION IS
EMITTED FROM THIS APERTURE**

5.8 Radiation output and standards information

Each laser product (except those of Class 1) shall be described on the explanatory label (Figure 15) by statements of the maximum output of laser radiation, the pulse duration (if appropriate) and the emitted wavelength(s). 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.

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 a label bearing the words:

CAUTION — LASER RADIATION WHEN OPEN

In addition, this label shall bear the words:

- a) **DO NOT STARE INTO BEAM**
if the accessible radiation does not exceed the AEL for Class 2;
- b) **DO NOT STARE INTO BEAM OR
VIEW DIRECTLY WITH OPTICAL INSTRUMENTS**
if the accessible radiation does not exceed the AEL for Class 3A;
- c) **AVOID EXPOSURE TO BEAM**
if the accessible radiation does not exceed the AEL for Class 3B;
- d) **AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION**
if the accessible radiation exceeds the limits for Class 3B at any wavelength.

5.9.2 Labels for safety interlocked panels

Appropriate labels shall be clearly associated with each safety interlock which may be readily overridden and which would then permit human access to laser radiation in excess of the AEL of Class 1. Such labels shall be visible prior to and during interlock override and be in close proximity to the opening created by the removal of the protective housing and shall bear the words:

**CAUTION — LASER RADIATION WHEN OPEN
AND INTERLOCKS DEFEATED**

In addition, this label shall bear the words specified in Items a), b), c), and d) of Sub-clause 5.9.1.

5.10 *Warning for invisible laser radiation*

In many cases, the wording prescribed for explanatory labels includes the phrase “laser radiation”. If the output of the laser is outside the wavelength range 400 nm to 700 nm, this shall be modified to read “Invisible laser radiation”, or if the output is at wavelengths both inside and outside this wavelength range, to read “Visible and invisible laser radiation”.

5.11 *Warning for visible laser radiation*

The wording “laser radiation” on the explanatory labels may be modified to read “laser light” if the output of the laser is in the (visible) wavelength range of 400 to 700 nm.

6. Other informational requirements

6.1 *Information for the user*

Manufacturers of laser products shall provide (or see to the provision of) as an integral part of any user instruction or operation manual which is regularly supplied with the laser product:

- a) Adequate instructions for proper assembly, maintenance, and safe use including clear warnings concerning precautions to avoid possible exposure to hazardous laser radiation.
- b) A statement in appropriate units of beam divergence for collimated beams, pulse duration and maximum output, with the magnitudes of the cumulative measurement uncertainty and any expected increase in the measured quantities at any time after manufacture added to the values measured at the time of manufacture (duration of pulses resulting from unintentional mode-locking need not be specified; however, those conditions associated with the product known to result in unintentional mode-locking shall be specified).
- c) Legible reproductions (colour optional) of all required labels and hazard warnings to be affixed to the laser product or provided with the laser product. The corresponding position of each label affixed to the product shall be indicated or, if provided with the product, a statement that such labels could not be affixed to the product but were supplied with the product and a statement of the form and manner in which they were supplied shall be provided.
- d) A clear indication in the manual of all locations of laser apertures.
- e) A listing of controls, adjustments and procedures for operation and maintenance, including the warning “Caution—use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.”
- f) In the case of laser products that do not incorporate the laser energy source necessary for laser emission, a statement of the compatibility requirements for a laser energy source to ensure safety.

6.2 *Purchasing and servicing information*

Manufacturers of laser products shall provide or cause to be provided:

- a) In all catalogues, specification sheets and descriptive brochures pertaining to each laser product, a legible reproduction (colour optional) of the required classification labels (Sub-clauses 5.3 to 5.6) to be affixed.
- b) To servicing dealers and distributors, and to others upon request, adequate instructions for service adjustments and service procedures for each laser product model which includes clear warnings and precautions to be taken to avoid possible exposure to radiation and a schedule of maintenance necessary to keep the product in compliance; and, in all such service instructions a listing of those controls and procedures which could be utilized by persons other than the manufacturer or his agents to increase accessible emission levels of radiation, and a clear description of the location of displaceable portions of the protective housing which could allow access to laser radiation in excess of the accessible limits in Tables I, II, III and IV. The instructions shall include protective procedures for service personnel, and legible reproductions (colour optional) of required labels and hazard warnings.

7. **Additional requirements for specific laser products**

7.1 *Medical laser products*

Each medical laser product shall comply with all of the applicable requirements for laser products of its class. In addition, the manufacturers shall:

- a) For Class 3B or Class 4 laser products, incorporate in each medical laser product a means for the measurement of the level of that laser radiation intended for irradiation of the human body with an error in measurement of no more than $\pm 20\%$. Indication of the measurement shall be in SI units.
- b) Supply with each medical laser product instructions specifying a procedure and schedule for calibration of the measurement system.
- c) Provide a target-indicating device for Class 3B and Class 4 laser products.

7.2 *Laser fibre optic transmission system*

Laser systems which employ fibre optic transmission shall have cable service connections which require a tool for disconnection if the AEL for Class 1, Class 2 and Class 3A is exceeded when disconnected and if such cable connections form part of the protective housing.

Consideration should also be given to incorporating mechanical beam attenuators at connectors if service is anticipated in an unsupervised work area. A device suitable for the detection of any optical fibre link interruption should be included in Classes 4 and 3B. This device should immediately stop the laser emission and at the same time actuate an audible or visible warning.

8. Tests

8.1 General

Tests shall take into account all errors and statistical uncertainties in the measurement process and increases in emission and degradation in radiation safety with age.

Specific use requirements may impose additional tests.

Tests for each of the applicable requirements shall be made during operation, maintenance or service as appropriate under any single fault condition.

Equivalent tests or procedures are acceptable.

8.2 Measurements of laser radiation for determining classification

Measurement of laser radiation levels may be necessary to classify a laser product in accordance with Sub-clause 9.1. Measurements are unnecessary when the physical characteristics and limitations of the laser source place the laser product or laser installation clearly in a particular class.

Measurements shall be made under the following conditions:

- a) Under those conditions and procedures which maximize the accessible emission levels, including start-up, stabilized emission, and shut-down of the laser product.
- b) With all controls and adjustments listed in the operation, maintenance, and service instructions adjusted in combination to result in the maximum accessible level of radiation.
- c) At points in space to which human access is possible during operation for measurement of accessible emission levels, (e.g. if operation may require removal of portions of the protective housing and defeat of safety interlocks, measurements shall be made at points accessible in that product configuration).
- d) With the measuring instrument detector so positioned and so oriented with respect to the laser product as to result in the maximum detection of radiation by the instrument.
- e) For a laser product other than a laser system, with the laser coupled to that type of laser energy source which is specified as compatible by the laser product manufacturer and which produces the maximum emission of accessible radiation from the product.
- f) For values expressed in radiant power (W) or radiant energy (J), with a circular aperture stop of 50 mm diameter (to simulate the collection by an optical instrument of a stationary laser beam).
- g) For values expressed in irradiance ($\text{W} \cdot \text{m}^{-2}$) or radiant exposure ($\text{J} \cdot \text{m}^{-2}$) averaged over a circular stop according to the limiting apertures of table VI.