INTERNATIONAL STANDARD

IEC 60825-1

Edition 1.2

2001-08

Edition 1:1993 consolidated with amendments 1:1997 and 2:2001

GROUP SAFETY PUBLICATION

Safety of laser products –

Part 1:
Equipment classification, requirements and user's guide

Sécurité des appareils à laser –

Partie 1:
Classification des matériels, prescriptions et guide de l'utilisateur

Reference number
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY OF LASER PRODUCTS –

Part 1: Equipment classification, requirements and user's guide

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60825-1 has been prepared by IEC technical committee 76: Laser equipment.

This consolidated version of IEC 60825-1 is based on the first edition (1993), its amendment 1 (1997) [documents 76/157/FDIS and 76/165/RVD] and amendment 2 (2001) [documents 76/220/FDIS and 76/223/RVD].

It bears the edition number 1.2.

A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2.

This part of IEC 60825 has the status of a Group Safety Publication, in accordance with IEC Guide 104*, for aspects of laser radiation pertaining to human safety.

It is also referred to as "part 1" in this publication.

Annexes A, B, C, D, E, F, G and H are given for information only.

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* IEC Guide 104:1984, *Guide to the drafting of safety standards, and the role of Committees with safety pilot functions and safety group functions.*

It gives guidance to IEC technical committees and to writers of specifications concerning the manner in which safety publications should be drafted.

This guide does not constitute a normative reference but reference to it is given for information only.

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of June 2002 have been included in this copy.

SAFETY OF LASER PRODUCTS –

Part 1: Equipment classification, requirements and user's guide

Section One – General

1 Scope and object

1.1 Scope

IEC 60825-1 is applicable to safety of laser products. For convenience it is divided into three separate sections: Section One (General) and the annexes; Section Two (Manufacturing requirements); and Section Three (User's guide*).

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 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 IEC 60825-1, since the final product will itself be subject to this standard.

Throughout this part 1 light emitting diodes (LED) are included whenever the word "laser" is used. See also annex G which describes information which should be provided by manufacturers of LEDs.

Any laser product or LED product is exempt from all further requirements of this part 1 if

– classification by the manufacturer according to clauses 3, 8 and 9 shows that the emission level does not exceed the AEL of Class 1 under all conditions of operation, maintenance, service and failure, and

– it does not contain an embedded laser or embedded LED.

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

This part 1 describes the minimum requirements.

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), this part 1 will apply in accordance with the provisions of IEC Guide 104**, for hazards resulting from laser radiation.

However, if the laser system is operable when removed from the equipment, all the requirements of this part 1 will apply to the removed unit.

If no product safety standard is applicable, then IEC 61010-1 shall apply.

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* Some countries have requirements which differ from Section Three of this part 1. Therefore, contact the appropriate national agency for these requirements.

** IEC Guide 104:1984, *Guide to the drafting of safety standards, and the role of Committees with safety pilot functions and safety group functions.*

It gives guidance to IEC technical committees and to writers of specifications concerning the manner in which safety publications should be drafted.

This guide does not constitute a normative reference but reference to it is given for information only.

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 risk.

The MPE values shall not be applicable to patient exposure to laser radiation for the purpose of medical treatment.

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

1.2 Object

1.2.1 To protect persons from laser radiation in the wavelength range 180 nm to 1 mm* by indicating safe working levels of laser radiation and by introducing a system of classification of lasers and laser products according to their degree of hazard.

1.2.2 To lay down requirements for both user and manufacturer to establish procedures and supply information so that proper precautions can be adopted.

1.2.3 To ensure adequate warning to individuals of hazards associated with accessible radiation from laser products through signs, labels and instructions.

1.2.4 To reduce the possibility of injury by minimizing unnecessary accessible radiation and to give improved control of the laser radiation hazards through protective features and provide safe usage of laser products by specifying user control measures.

1.2.5 To protect persons against other hazards resulting from the operation and use of laser products.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60825. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60825 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*
Amendment 1, 1997

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

IEC 60601-2-22:1995, *Medical electrical equipment – Part 2: Particular requirements for the safety of diagnostic and therapeutic laser equipment*

IEC 60825-2:2000, *Safety of laser products – Part 2: Safety of optical fibre communication systems*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*

IEC 61040:1990, *Power and energy measuring detectors, instruments and equipment for laser radiation*

ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units*

* In this part 1, the wavelength range λ_1 to λ_2 means $\lambda_1 \leq \lambda < \lambda_2$ (e.g. 180 nm to 1 mm means 180 nm $\leq \lambda <$ 1 mm).

3 Definitions*

For the purposes of this part of IEC 60825, 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 relation to one another;

c) defining a plane, level, elevation or straight line.

3.5
alpha min. (α_{min})
see angular subtense (3.7)

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 16). The angle of acceptance is also sometimes referred to as the field of view

Symbol: γ

NOTE Angle of acceptance for evaluating photochemical hazards. For evaluation of the photochemical hazard, a limiting measurement angle of acceptance, γ_p, is specified. The angle γ_p is biologically related to eye movements and is not dependent upon the angular subtense of the source. If the angular subtense of the source is smaller than the limiting angle of acceptance, the actual measurement angle of acceptance does not have to be limited. If the angular subtense of the source is larger than the specified limiting angle of acceptance, the angle of acceptance has to be limited and the source has to be scanned for hotspots. If the measurement angle of acceptance is not limited to the specified level, the hazard may be over-estimated.

Symbol: γ_p

* Arranged here for convenience in English alphabetical order. Departures from IEC 60050(845) are intentional and are indicated. Reference is made to the definition number in Chapter 845 of IEC 60050.

3.7
angular subtense (α)
angle subtended by an apparent source as viewed at a point in space. In this standard, for classification, the angular subtense is determined at a point not less than 100 mm from the apparent source (or at the exit window or lens of the product if the apparent source is located at a distance greater than 100 mm within the window or lens). (See also 3.53 and 3.57.) For an analysis of the maximum permissible exposure levels, the angular subtense shall be determined at the viewing distance from the apparent source but not less than 100 mm. This concept is also discussed in clause A.3 of annex A

NOTE 1 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 2 The angular subtense of the source should not be confused with the divergence of the beam.

3.8
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.

3.9
apparent source
the real or virtual object that forms the smallest possible retinal image

NOTE This definition is used to determine the location of the apparent origin of laser radiation in the wavelength range of 400 nm 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.

The concept of an apparent source is used in the extended wavelength region 302,5 nm to 4 000 nm since focusing by conventional lenses might be possible in that region.

3.10
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

3.11
beam attenuator
a device which reduces the laser radiation to or below a specified level

3.12
beam diameter (beam width)
the beam diameter d_u at a point 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 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.

3.13
beam divergence
the beam divergence is the far field plane angle of the cone defined by the beam diameter. If the beam diameters (see 3.10) 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

3.14
beam expander
a combination of optical elements which will increase the diameter of a laser beam

3.15
beam path component
an optical component which lies on a defined beam path (e.g. a beam steering mirror or a focusing lens)

3.16
beam stop
a device which terminates a laser beam path

3.17
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 durations (see 8.2 and 8.4e))

3.18
Class 1M laser product
any laser product in the wavelength range from 302,5 nm to 4 000 nm which does not permit human access to laser radiation in excess of the accessible emission limits of Class 1 for applicable wavelengths and emission durations (see 8.4e)), where the level of radiation is measured according to 9.2g), however, evaluated with smaller measurement apertures or at a greater distance from the apparent source than those used for Class 1 laser products. The output of a Class 1M product is therefore potentially hazardous when viewed using an optical instrument (see 8.2)

3.19
Class 2 laser product
any laser product which does not permit human access to laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations (see 8.2 and 8.4e))

3.20
Class 2M laser product
any laser product in the wavelength range from 400 nm to 700 nm which does not permit human access to laser radiation in excess of the accessible emission limits of Class 2 for applicable wavelengths and emission durations (see 8.4e)), where the level of radiation is measured according to 9.2h), however, evaluated with smaller measurement apertures 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

3.21
Class 3R and Class 3B laser products
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 3R and 3B (respectively) for any emission duration and wavelength (see 8.2)

3.22
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)