

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Safety of laser products –
Part 12: Safety of free space optical communication systems used for
transmission of information

Sécurité des appareils à laser –
Partie 12: Sécurité des systèmes de communication optiques en espace libre
utilisés pour la transmission d'informations



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SAFETY OF LASER PRODUCTS –

Part 12: Safety of free space optical communication systems used for transmission of information

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International Standard IEC 60825-12 has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment.

This second edition cancels and replaces the first edition published in 2004. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) LEDs have been removed from the scope.
- b) Normative references have been changed to refer the latest edition of the standards.
- c) A description of the Condition 2 measurement and determination method for access level has been added.

The text of this standard is based on the following documents:

FDIS	Report on voting
76/616/FDIS	76/617/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The list of all parts of the IEC 60825 series, published under the general title *Safety of laser products*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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SAFETY OF LASER PRODUCTS –

Part 12: Safety of free space optical communication systems used for transmission of information

1 Scope

This part of IEC 60825 provides requirements and specific guidance for the manufacture and safe use of laser products and systems used for point-to-point or point-to-multipoint free space optical data transmission in the wavelength range from 180 nm to 1 mm. This document only addresses the open beam portion of the system. If portions of the equipment or system incorporate optical fibre that extends from the confinements of the enclosure(s), the manufacturing and safety requirements in IEC 60825-2 apply to those portions only. This document does not apply to systems designed for the purposes of transmitting optical power for applications such as material processing or medical treatment. This document also does not apply to the use of systems in explosive atmospheres (see IEC 60079-0).

Light-emitting diodes (LEDs) employed by free space optical communication systems (FSOCSs), used for the purpose of free space optical data transmission, do not fall into the scope of this document. This document covers lasers employed by FSOCSs used for the purpose of free space optical data transmission.

This document:

- provides information to protect people from potentially hazardous optical radiation produced by FSOCSs by specifying engineering controls and requirements, administrative controls and work practices according to the degree of the hazard; and
- specifies requirements for manufacturing, installation, service and operating organizations in order to establish procedures and provide written information so that proper precautions can be adopted.

Because of the nature of FSOCSs, also known as optical wireless or free-air information transmission systems, care is taken in their manufacture as well as their installation, operation, maintenance and service to assure the safe deployment and use of these systems. This document places the responsibility for certain product safety requirements, as well as requirements for providing appropriate information on how to use these systems safely, on the manufacturer of the system and/or transmitters. It places the responsibility for the safe deployment and use of these systems on the installer and/or operating organization. It places the responsibility for adherence to safety instructions during installation and service operations on the installation and service organizations as appropriate, and during operation and maintenance functions on the operating organization. It is recognized that the user of this document may fall into one or more of the categories of manufacturer, installer, service organization and/or operating organization as mentioned above.

This document does not apply to a laser product if classification by the manufacturer according to IEC 60825-1 shows that the emission level does not exceed the accessible emission limit (AEL) of Class 1 under all conditions of operation, maintenance, service and reasonably foreseeable failure.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

access level

potential hazard at any accessible position associated with a free space optical communication system (FSOCS) installation

Note 1 to entry: The access level is based on the level of optical radiation which could become accessible in reasonably foreseeable circumstances, e.g. walking into an open beam path. It is closely related to the laser classification procedure in IEC 60825-1.

Note 2 to entry: Practically speaking, it takes two or more seconds to fully align an optical aid with a beam (which might occur in an unrestricted location), and this delay is incorporated into the method for determining access level.

3.2

access level 1

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits (AEL) of Class 1 for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 1 laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

3.3

access level 1M

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits (AEL) of Class 1M for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 1M laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

Note 2 to entry: If the applicable limit of access level 1M is larger than the limit of 3R and less than the limit of 3B, access level 1M is allocated.

3.4

access level 2

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of Class 2 for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 2 laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

3.5

access level 2M

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of Class 2M for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 2M laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

Note 2 to entry: If the applicable limit of access level 2M is larger than the limit of 3R and less than the limit of 3B, access level 2M is allocated.

3.6

access level 3R

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of Class 3R for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 3R laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

Note 2 to entry: If the applicable limit of access level 1M or 2M is larger than the limit of 3R and less than the limit of 3B, access level 1M or 2M is allocated.

3.7

access level 3B

level for which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of Class 3B for the applicable wavelengths and emission duration will not occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 3B laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

3.8

access level 4

level for which, under reasonably foreseeable circumstances, it is possible that human access to laser radiation in excess of the accessible emission limits of Class 3B for the applicable wavelengths and emission duration could occur

Note 1 to entry: The level of radiation is measured with the conditions for Class 4 laser products (see IEC 60825-1), but with Condition 2 and C₇ being as defined in 4.2.3 of this document (IEC 60825-12).

3.9

automatic power reduction

APR

feature of a transmitter of an FSOCS, provided by the system equipment manufacturer, by which the accessible power in the nominal hazard zone (NHZ) or extended nominal hazard zone (ENHZ) is reduced to a specified value within a specified time

Note 1 to entry: The term “automatic power reduction” (APR) used in this document encompasses the following terms used in recommendations of the International Telecommunication Union ITU:

- automatic laser shutdown (ALS);
- automatic power reduction (APR);
- automatic power shutdown (APSD).

Note 2 to entry: The accessible power in the NHZ or ENHZ is reduced to a specified value within a specified time, whenever there is an event which could result in human exposure to optical radiation above the maximum permissible exposure (MPE), e.g. by a person entering the NHZ or ENHZ, as applicable. In an FSOCS, this feature may be used by the transmitter manufacturer to determine the classification.

3.10

beacon

optical source whose function is to aid in pointing or alignment of an optical system

3.11

end-to-end system

FSOCS that is comprised of at least one transmitter, one receiver, and any peripheral hardware necessary for the effective transfer of data along the transmission path from one position in space to another

3.12**extended nominal hazard zone****ENHZ**

volume within which, when optical aids are used, the level of the direct, reflected or scattered radiation exceeds the applicable maximum permissible exposure (MPE) (under measurement conditions indicated in IEC 60825-1)

Note 1 to entry: Exposure levels outside the boundary of the ENHZ are below the applicable MPE when optical aids are used.

Note 2 to entry: This volume is determined prior to activation of any IPS or APR systems unless the APR is used for classification under the conditions of 4.5 of this document.

3.13**free space optical communication system****FSOCS**

installed, portable, or temporarily mounted, through-the-air system typically used, intended or promoted for voice, data or multimedia communications and/or control purposes via the use of modulated optical radiation produced by a laser

Note 1 to entry: "Free space" means indoor and outdoor optical wireless applications with both non-directed and directed transmission.

Note 2 to entry: Emitting and detecting assemblies may or may not be separated.

Note 3 to entry: Refer to the conditions within Clause 1, by which Class 1 FSOCS products are exempt from all requirements of this document.

3.14**FSOCS transmitter****transmitter**

optical transmitter emitting radiation through the air and used in an FSOCS

3.15**installation organization****installer**

organization or individual who is responsible for the installation of an FSOCS

3.16**installation protection system****IPS**

feature of an installation site, provided by the installer or operating organization, that has two functions: (1) it detects human entry into the accessible volume of either the NHZ for restricted or controlled locations or the ENHZ for an unrestricted location, and (2) once such entry is detected, causes reduction of the accessible power of the laser to a specified level within a specified time

3.17**interlock**

means either of preventing access to a hazardous location until the hazard is removed, or of automatically removing the hazardous condition when access is gained

3.18**location**

position or site occupied or available for occupancy

Note 1 to entry: Other standards may use the same terms for location types (3.19 to 3.22) with somewhat different definitions.

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3.19**location of inaccessible space**
inaccessible space

volume where a person cannot normally be located, i.e. the space that has a horizontal spacing more than 2,5 m from any unrestricted location and is both greater than 6 m above a surface in any unrestricted location, and more than 3 m above a surface in any restricted location

Note 1 to entry: Inaccessible space may be entered by, for example, aircraft.

Note 2 to entry: All open space that is neither an unrestricted, restricted nor controlled location.

3.20**location with controlled access**
controlled location

location where an engineering or administrative control measure is present to make it inaccessible except to authorized personnel with appropriate laser safety training

3.21**location with restricted access**
restricted location

location that is normally inaccessible to the general public (including workers, visitors, and residents in the immediate vicinity) by means of any administrative or engineering control measure but that is accessible to authorized personnel (e.g. maintenance or service personnel including window cleaners in exterior locations) who may not have laser safety training

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3.22**location with unrestricted access**
unrestricted location

location where access to the transmission/receiver equipment and open beam is not limited (accessible to the general public)

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3.23**manufacturer**

organization or individual who makes or assembles optical devices and other components for the construction or modification of an FSOCS

3.24**nominal hazard zone**
NHZ

volume within which the level of the direct, reflected or scattered radiation exceeds the applicable maximum permissible exposure (MPE) (under measurement conditions indicated in IEC 60825-1)

Note 1 to entry: Exposure levels outside the boundary of the NHZ are below the applicable MPE.

Note 2 to entry: This volume is determined prior to activation of any IPS or APR systems unless the APR is used for classification under the conditions of 4.5 of this document.

3.25**operating organization**
operator

organization or individual who is responsible for the operation and maintenance of an FSOCS

3.26**optically-aided viewing**

use of optical aids (for example, binoculars or magnifiers) to view an emitting source from within the emitted beam

Note 1 to entry: It is possible that telescopic optics, including binoculars, could increase the hazard to the eye by intrabeam viewing of a collimated beam when viewed at a distance.

3.27

removable laser system

laser system that can be removed from its protective housing and operated by simply plugging into electrical mains or a battery

3.28

primary beam

beam that transmits the modulated data signal

3.29

reasonably foreseeable event

event (or condition) that is credible and whose likelihood of occurrence (or existence) cannot be disregarded

3.30

service organization

organization or individual who is responsible for the service of an FSOCS

3.31

special tool

tool that is not readily available at retail consumer hardware stores

Note 1 to entry: Typical tools in this category are intended for use with tamper-resistant fasteners.

3.32

spillover

beam radiant energy that propagates past the receiving terminal

3.33

optically unaided without optical aids

without using magnifiers or other optical aids, as with the naked eye

Note 1 to entry: Prescription eyeglasses and contact lenses are not considered optical aids.

4 Requirements

4.1 General remarks

For FSOCSs employing lasers for the purpose of free space optical data transmission, all classification shall be made in accordance with IEC 60825-1.

If an FSOCS incorporates a removable laser system, that removable laser system shall comply with the applicable requirements of IEC 60825-1.

FSOCSs have limitations imposed by this document that are dependent on the location type(s) in which they are installed. Product classification and access level restrictions by location type are summarized in Table 1.

In each location where emission is transmitted, crosses or is received, respective exposure conditions shall be individually evaluated. Furthermore, potentially occupied locations along the beam path, within the NHZ or ENHZ, shall also be evaluated for acceptable access levels (Table 1) and for appropriate controls applied. Locations traversed by partial reflections from windows within the beam path shall also be evaluated if the emission could exceed access level 1 or 2. At a given location, the installation and operational constraints applied from 4.4

shall be determined by whichever is the more hazardous: the transmitted or the received optical radiation.

In the case of a location that receives access level 1 or 2 radiation but uses a Class 1M transmitter in the opposite direction, these combined conditions are acceptable for restricted locations but not for an unrestricted location unless the transmission equipment is installed as described in 4.4.2.2 to reduce the transmitter access level to 1 or 2.

For links with spillover beyond the receiver, but within the ENHZ that is of access level 1M or 2M, the spillover (and any accessible radiation otherwise outside of the receiver path, e.g. in front of it) shall be contained within a restricted or controlled location, an unrestricted location compliant with 4.4.2.2, or inaccessible space.

For Class 3B and Class 4 transmitters in controlled locations, the entire beam path that potentially passes through other location types, including inaccessible space, shall comply with the access level restrictions of Table 1. This may be satisfied in some applications by continually monitoring the entire NHZ to ensure rapid automatic power reduction in the event of human interception of the beam path. Any spillover beyond the receiver, (and any accessible radiation otherwise outside of the receiver path – e.g. in front of it), within the NHZ, shall also be contained in a controlled location or inaccessible space. Any additional spillover within the ENHZ shall be contained within a restricted or controlled location, an unrestricted location compliant with 4.4.2.2, or inaccessible space.

Table 1 – Restrictions for product classes and access levels

Location type	Permissible product classes and installation conditions	Permissible access levels
Unrestricted	Class 1 or 2 – No conditions Class 1M or 2M – See 4.4.2.2 Class 3R – See 4.4.2.3	1 or 2
Restricted	Class 1, 2, 1M or 2M – No conditions Class 3R – See 4.4.3.2	1, 2, 1M or 2M
Controlled	Class 1, 2, 1M, 2M, or 3R – No conditions Class 3B or 4 – See 4.4.4.2	1, 2, 1M, 2M, or 3R 3B or 4 – See 4.4.3.1
Inaccessible space	1, 2, 1M, 2M or 3R	1, 2, 1M, 2M or 3R

The operating organization has the ultimate responsibility for the installation, maintenance, service and safe use of the end-to-end system including engineering and administrative controls. This includes, especially

- identification of the location type at all portions of the entire transmission path, including beam spillover outside the receiver collection area and partial reflections from intermediate windows, where people may have access;
- ensuring that the product classification, access level requirements, and installation conditions from Table 1 are satisfied for those location types;
- ensuring that installation, maintenance and service are performed only by organizations with the capability of satisfying the requirements of 4.4.

Requirements for transmitter manufacturers, installers and service organizations are also included in this document.

IEC 60825-1 and IEC 60825-2 shall apply for classification and hazard level evaluations of FSOCSs employing lasers intended for transmission of data over fibre optic cable.

4.2 Determination of access level

4.2.1 General

Determination of access levels is the ultimate responsibility of the operating organization. However, they may be determined by the maintenance, installation or service organization. The methods for determining compliance with an access level are the same as those described for classification in IEC 60825-1 except for the following.

- a) The access level within a designated location shall be determined at any position relative to an FSOCS transmitter where the access level is maximized, and could depend on intermediate system elements such as windows.
- b) The access level may depend on the activation of an IPS or APR system.
- c) If an IPS or APR system is monitoring the location in question, during the 2 s immediately following any human interception, the accessible emission shall not exceed the MPE. Otherwise, the same method used for classification is also used for determination of access level. For viewing conditions without optical aids refer to the tables of MPEs in IEC 60825-1.

NOTE Rationale for 2 s: Because of the difficulty of a person with binoculars or other optical aid to fully align with the beam, it is not reasonably foreseeable that a person could intercept the beam's full power within 2 s. During the 2-s period following exposure, no part of the body would be exposed above the optically unaided MPE for access levels of 1, 2, 1M, 2M or 3R.

Verification testing of access levels shall be carried out under reasonably foreseeable single fault conditions to ensure that the APR and/or IPS, if used, is operating properly. In circumstances where it is difficult to carry out direct measurements, an assessment of the access level based on calculations may be acceptable. Faults which result in the emission of radiation in excess of the applicable AEL for a limited period only and for which it is not reasonably foreseeable that human access to the radiation will occur before the product is taken out of service or adjusted down below the AEL, need not be considered.

<https://standards.iteh.ai/catalog/standards/sist/b1d865a5-f375-49c5-93f6-e699f016af04/iec-60825-12-2019>

4.2.2 The use of Condition 2

4.2.2.1 General

The access level is determined by the measurement of the optical radiation that could become accessible following any reasonably foreseeable event during operation and maintenance.

All three conditions shall be tested. Condition 1 and Condition 3 shall be tested according to IEC 60825-1.

For all wavelengths, Condition 2 measurements to establish access levels shall be made with a 7 mm aperture at a distance of 70 mm from the end of the FSOCS transmitter (this simulates a $\times 7$ magnifier).

In addition to the above, and for all wavelengths, the total emission from the FSOCS transmitter for access level 3B systems shall not exceed the AEL of Class 3B.

In circumstances where it is difficult to carry out direct measurements, an assessment of access level based on calculations is acceptable.

For an FSOCS with automatic power reduction, the access level will be determined by the accessible emission (pulse or continuous wave) after the time interval of 2 s. Additionally the MPE requirement in 4.3 shall be satisfied.