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Safety laser products - Part 2: Safety of optical fibre communication system (IEC 60825-2:2000)

Safety of laser products -- Part 2: Safety of optical fibre communication systems

Sicherheit von Lasereinrichtungen -- Teil 2: Sicherheit von Lichtwellenleiter-Kommunikationssystemen

Sécurité des appareils à laser -- Partie 2: Sécurité des systèmes de télécommunication par fibres optiques

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English version

Safety of laser products
Part 2: Safety of optical fibre communication systems
(IEC 60825-2:2000)

Sécurité des appareils à laser
Partie 2: Sécurité des systèmes de télécommunication par fibres optiques
(CEI 60825-2:2000)

Sicherheit von Lasereinrichtungen
Teil 2: Sicherheit von Lichtwellenleiter-Kommunikationssystemen
(IEC 60825-2:2000)

This European Standard was approved by CENELEC on 2000-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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 76/208/FDIS, future amendment to IEC 60825-2:1993, prepared by IEC TC 76, Optical radiation safety and laser equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 60825:1994 on 2000-04-01.

The text of this document, together with that of IEC 60825-2:1993 and its amendment 1:1997, was published by IEC as the second edition of IEC 60825-2 in May 2000. According to a decision of principle taken by the Technical Board of CENELEC, the approval of EN 60825-2:1994/A2 has been converted into the approval of a new EN 60825-2.

This European Standard supersedes EN 60825-2:1994 + corrigendum March 1994 + A1:1998.

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) 2001-03-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2003-04-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annexes B and ZA are normative and annexes A, C, D and E are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60825-2:2000 was approved by CENELEC as a European Standard without any modification.

In the official version, under "Bibliography", the following note has to be added for the standard indicated:

IEC 60812:1985 NOTE: Harmonized as HD 485 S1:1987 (not modified).

CONTENTS

SAFETY OF LASER PRODUCTS –

Part 2: Safety of optical fibre communication systems

1 Scope

This part 2 of IEC 60825 provides requirements and specific guidance for the safe use of optical fibre and/or control communication systems where optical power may be accessible at great distance from the optical source. It does not apply to optical fibre systems primarily designed to transmit optical power for applications such as material processing or medical treatment.

Throughout this part of IEC 60825, light emitting diodes (LEDs) are included whenever the word "laser" is used.

The objective of this part 2 of IEC 60825 is to:

- protect people from optical radiation resulting from optical fibre communication systems. This requires the introduction of engineering requirements and work practices according to the degree of hazard;
- lay down requirements for manufacturers and operating organizations in order to establish procedures and supply information so that proper precautions can be adopted;
- ensure adequate warning to individuals of the hazards associated with optical fibre communication systems through signs, labels and instructions;
- reduce the possibility of injury by minimizing unnecessary accessible radiation, give improved control of the optical radiation through protective features and provide safe usage of products by specifying user control measures.

Annex A gives a more detailed rationale for this part of IEC 60825.

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 60794-2:1989, *Optical fibre cables – Part 2: Product specifications*

IEC 60825-1:1993, *Safety of laser products – Part 1: Equipment classification, requirements and user's guide*

3 Definitions

For the purpose of this part of IEC 60825, the following definitions apply. They are in addition to those given in IEC 60825-1.

3.1
accessible location
any part within an optical fibre communication system at which, under reasonably foreseeable circumstances, human access to laser radiation is possible

3.2
automatic power reduction
feature of an optical fibre communication system by which the accessible power is reduced to a specified level within a specified time, whenever there is an event which could result in human exposure to radiation, e.g. a fibre cable break

3.3
enclosed system
system in which, during normal operation, the optical radiation is totally enclosed, e.g. by light-proof cabinets, components, total internal reflection or optical fibre cables and connectors

3.4
end-user
person/organization using the optical fibre communication system in the manner the system was designed to be used. The user cannot necessarily control the power generated and transmitted within the system

3.5
hazard level
potential hazard at any accessible location within an optical fibre communication system. It is based on the level of optical radiation which could become accessible in reasonably foreseeable circumstances, e.g. a fibre cable break. It is closely related to the laser classification procedure in IEC 60825-1

3.6
hazard level 1
hazard level 1 is allocated to any accessible location within an optical fibre communication system at 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

3.7
hazard level 2
hazard level 2 is allocated to any accessible location within an optical fibre communication system at 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

3.8
hazard level 3A
hazard level 3A is allocated to any accessible location within an optical fibre communication system at which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of class 3A for the applicable wavelengths and emission duration will not occur

3.9
hazard level $k \times$ 3A
in the wavelength range 400 nm to 4 000 nm, a hazard level $k \times$ 3A is allocated to any accessible location within an optical fibre communication system at which, under reasonably foreseeable circumstances, human access to laser radiation in excess of the accessible emission limits of hazard level $k \times$ 3A for the applicable wavelengths and emission duration will not occur. For purposes of the $k \times$ 3A hazard level evaluation, class 3A AEL table is used; the minimum measurement distance shall be increased to 250 mm from the apparent source and the time base used shall be 10 s, provided longer viewing durations are not reasonably foreseeable. For wavelengths greater than 1 400 mm, the radiant power limit shall be a factor of 10 greater than for class 1

NOTE The value of k is not a constant and need not be calculated (see annex A for rationale).

3.10
hazard level 3B
hazard level 3B is allocated to any accessible location within an optical fibre communication system at 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

3.11
hazard level 4
hazard level 4 is allocated to any accessible location within an optical fibre communication system at 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 may occur

3.12
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.)

3.13
local operator control
an optical communication system is under local operator control if the operating controls and the optical output may be directly monitored simultaneously by a single operator who has control over the potential human access to optical radiation

3.14
location with controlled access
location where access to the protective housing (enclosure) is controlled and is accessible only to authorized persons who have received adequate training in laser safety and the servicing of the system involved. Examples include optical cable ducts and switching centres

3.15
location with restricted access
location where access to the protective housing (enclosure) is restricted and not open to the public. Examples include industrial and commercial premises

3.16
location with unrestricted access
location where access to the protective housing (enclosure) is unrestricted. Examples include domestic premises and premises open to the public

3.17
manufacturer
organization/individual who assembles optical devices and other components in order to construct or modify an optical fibre communication system

3.18
operating organization
organization/individual who is responsible for the installation and/or operation of an optical fibre communication system

3.19
optical fibre communication system
engineered assembly for the generation, transference and reception of optical radiation arising from lasers, in which the transference is by means of optical fibre for communication and/or control purposes

3.20
reasonably foreseeable event
event the occurrence of which under given circumstances can be predicted fairly accurately, and the occurrence probability or frequency of which is not low or very low.

Examples of reasonably foreseeable events might include the following: component failure, fibre cable break, optical connector disconnection, operator error or inattention to safe working practices.

Reckless use or use for completely inappropriate purposes is not to be considered as a reasonably foreseeable event

3.21
protected cable
a cable in which the fibre or fibres are contained within a robust sheath which permits normal handling without breakage and/or exposure of the fibre ends. See also 4.1.2.2 and annex B

3.22
subassembly
any discrete unit of an optical fibre communication system which contains an optical emitter or optical amplifier

4 Manufacturing requirements

4.1 Engineering specifications

4.1.1 General remarks

Optical fibre communication systems require certain built-in safety features, depending on their hazard level. The manufacturer of the optical fibre communication system is responsible for the allocation of the hazard level and for compliance with the manufacturing requirements. These requirements are summarized in annex B.

Whenever alterations which may affect hazard levels are made to the optical fibre communication system, the person or organization performing such a modification shall reassess the hazard levels by carrying out tests and measurements, wherever appropriate, for ensuring compliance and, where the hazard level has changed, relabelling.

Manufacturers of ready-for-use optical fibre communication systems which are to be supplied to end-users are responsible for assessing the hazard levels of the optical system under all reasonably foreseeable circumstances and for compliance with the appropriate manufacturing and safety requirements.

Manufacturers of ready-for-use optical transmission subassemblies which are intended to be used only as part of an OFCS need not classify such equipment but are responsible for assessing the hazard levels of the optical system under all reasonably foreseeable circumstances and for the compliance with the appropriate manufacturing and safety requirements.

For other optical communication systems, the operating organization has the ultimate responsibility for the safety of the system. This includes especially:

– the identification of the location type at all subdivisions of the entire transmission path;
– the assessment of hazard level at any accessible location in the case of reasonably foreseeable events;
– assuring compliance with the manufacturing and safety requirements.

Optical fibre communication systems that also transmit electrical power shall meet the requirements of this standard in addition to any applicable electrical standard.

4.1.2 Cable design

The mechanical design of optical fibre cables shall be specified according to the hazard level and location (see clause D.3 for examples).

If such cables are not at a controlled location:

4.1.2.1 In all systems, the mechanical characteristics of the individual single or multiple fibre cable shall be not less than those required by IEC 60794-2.

4.1.2.2 Locations with hazard levels in excess of 3A shall have the above cable requirements with further and adequate mechanical protection.

4.1.3 Cable connectors

4.1.3.1 All systems operating in unrestricted locations in which cable connectors are accessible require the use of a tool for disconnection if hazard level 1 can be exceeded.

4.1.3.2 All systems operating in restricted locations in which cable connectors are accessible require the use of a tool for disconnection if hazard level 3A can be exceeded.

4.1.3.3 All systems operating in controlled locations in which cable connectors are accessible require the use of a tool for disconnection if hazard level $k \times$ 3A can be exceeded.

4.1.3.4 The positioning of the connector in a way that prevents human access to a higher hazard level is an acceptable feature to ensure that these requirements are met.

4.1.4 Automatic power reduction

Automatic power reduction may be used to control the hazard levels defined in 3.6 to 3.11.

4.2 Labelling

4.2.1 Optical fibre cables should carry appropriate markings to distinguish them from cables containing other services, e.g. electricity.

4.2.2 Sleeving, a tag or a tape shall be associated with each optical connector if the hazard level at the location is in excess of hazard level 1. The sleeving, tag or tape shall be coloured yellow, with the warning label according to figure 14 of IEC 60825-1 and the hazard level number incorporated in the explanatory label according to figure 15 of IEC 60825-1, both labels appropriately reduced in size.

4.2.3 Groups of connectors such as patch panels may be labelled as a group, with just a single clearly visible location hazard label rather than having each connector individually labelled. If a group of connectors is enclosed within a box, a label shall be clearly visible both before and after the access panel is opened, which may require the use of more than one label.

4.3 Provision of information

Manufacturers of ready-for-use optical fibre communication systems and manufacturers of ready-for-use subassemblies shall provide the operating organization with the following information, where applicable:

a) an adequate description of the engineering design features incorporated into the product to prevent access to hazardous levels of optical radiation;

b) adequate instructions for proper assembly, maintenance and safe use, including clear warnings concerning the precautions to be taken in order to avoid possible exposure to hazardous radiation;

c) a statement, in SI units, of the power propagating in the fibre at all locations in the system, together with the pulse duration and pulse repetition frequency, or the maximum modulation frequency. The cumulative measurement uncertainty and any expected variation in the measured quantities at any time after manufacture shall also be provided;

d) a statement of the range of operating wavelength(s) within the optical fibre communication system at the time of manufacture and under specified conditions as well as the range of emission wavelengths expected during normal operation at any time after manufacture;

e) the reaction time of any automatic power reduction system;

f) legible reproductions (in appropriate colours or in black and white) of all the labels and hazard warnings to be displayed at locations within an optical fibre communication system or subassembly, as appropriate;

g) a clear indication of all locations of apertures and fibre connectors;

h) a listing of controls, adjustments and procedures for operation and maintenance, including a warning, where appropriate;

i) advice on safe operating procedures, and warnings concerning known malpractices, malfunctions and hazardous failure modes. Where maintenance procedures are detailed, they shall, wherever possible, include explicit instructions on the safe procedures to be followed;

j) where installation or servicing requires that an automatic power reduction system is overridden, information to enable the operating organization to specify a safe system of work at such times, and a safe procedure for the reinstating and safe testing of the automatic power reduction system;

k) any other information relevant to the safe use of the optical fibre communication system or subassembly, as appropriate.

4.4 Assessment of hazard level

4.4.1 The hazard level is determined by the measurement of optical radiation accessible in any reasonably foreseeable event. The methods for the determination of compliance with the specified radiation limit values are the same as those described for classification in IEC 60825-1. Measurements need to be taken under the appropriate conditions, e.g. simulated fibre cable break, and shall be based on the relevant clauses in IEC 60825-1. The assessment of the hazard level shall take place:

- 1 s after the reasonably foreseeable event for unrestricted locations, unless measurement at a later time would result in a larger exposure;
- 3 s after the reasonably foreseeable event for restricted and controlled locations, unless measurement at a later time would result in a larger exposure.

In circumstances where it is difficult to carry out direct measurements, an assessment of hazard level based on calculations may be acceptable. For example, the knowledge of the laser power and fibre attenuation may allow an assessment of the hazard at any particular location.

4.4.2 Additionally, for locations with a hazard level lower than that which would be assigned if no automatic power reduction were employed, the irradiance or radiant exposure during the maximum time to reach the lower hazard level specified in 4.4.1 (1 s for unrestricted, 3 s for restricted or controlled locations) shall not exceed the irradiance or radiant exposure limits (MPE) for the corresponding conditions listed in table 1. The measurement aperture for the MPE at 3 s, for wavelengths greater than or equal to 1 400 nm, shall be 3,5 mm for this subclause only.

The restart of such systems shall not take place for another 100 s minus the reduction time in seconds, unless the continuity of the link can be assured.

NOTE The 100 s interval is the time base for classification of invisible infra-red radiation for unintentional viewing.

Table 1 – Assessment of hazard level during shutdown time for systems employing automatic power reduction (see 4.4.2)

Location type	Maximum time to reach lower hazard level (Exposure time basis for 4.4.2)	Limiting aperture		Distance from aperture to fibre
		400 nm to 1 400 nm wavelengths	Other wavelengths	
Unrestricted	1 s	7 mm	1 mm	100 mm
Restricted	3 s	7 mm	3,5 mm	100 mm
Controlled	3 s	7 mm	3,5 mm	250 mm

4.4.3 Tests shall be carried out under reasonably foreseeable fault conditions.

In some complex systems (e.g. where the optical output is dependent on the integrity of other components and the performance of circuit design and software), it may be necessary to use other recognized methods for hazard/safety assessment (see annex C).

4.4.4 For optical fibre communication systems with automatic power reduction, the hazard level will be determined by the normal level of power in the fibre and the speed of the automatic power reduction. The speed of power reduction required to obtain a specific hazard level can be determined from the AEL tables in IEC 60825-1. For example, a relatively high optical power level on a fibre together with a high speed automatic power reduction could have the same hazard level as a relatively low optical power on the fibre together with a slower automatic power reduction.

4.5 Requirements for installation

4.5.1 Optical fibre communication systems operating in unrestricted locations shall have a hazard level of 1, 2 or 3A.

4.5.2 Optical fibre communication systems operating in restricted locations shall have a hazard level of 1, 2, 3A or $k \times 3A$.

4.5.3 Optical fibre communication systems operating in controlled locations shall have a hazard level of 1, 2, 3A, $k \times 3A$ or 3B.

4.5.4 No optical fibre communication system shall have locations with a hazard level of 4.

4.6 Requirements for restart pulses

Restart pulses used after automatic power shutdown shall be limited to hazard level 1 in unrestricted locations, hazard level 3A in restricted locations and hazard level $k \times 3A$ in controlled locations.

5 Guidance for service and maintenance

5.1 Tests and measurements

5.1.1 Tests, measurements and operations in cable ducts and switching centres should be considered as service or maintenance operations. Wherever possible, diagnostic tests should be carried out in such a way as not to increase the hazard level at any location. It may be necessary to have administrative controls which, in some cases, may involve a permit to work system. When connecting test equipment, due regard should be given to establishing the actual power levels introduced into the system in assessing the hazard.

5.1.2 There shall be clearly defined conditions under which automatic power reduction facilities may be overridden.

When overridden, the hazard level shall be reassessed by the operating organization and the appropriate safety precautions described in 5.2 and its associated subclauses shall be taken as appropriate to the reassessed hazard level.

5.1.3 Any viewing optics for fibre examination and splicing should reduce exposure to below the relevant maximum permissible exposure (MPE) and should be approved for use by the operating organization.

5.1.4 Wherever reasonably practical, servicing, maintenance and repair should be carried out with no power propagating in the fibre, otherwise the system should be operated at the lowest power consistent with the need.