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Edition 3.0 2022-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Safety of laser products – Part 4: Laser guards

Sécurité des appareils à laser – Partie 4: Protecteurs pour laser

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Safety of laser products – Part 4: Laser guards

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FOREWORD

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IEC 60825-4 has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2006, Amendment 1:2008 and Amendment 2:2011. This edition constitutes a technical revision.

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

a) Significant amendments have been included and this edition has been prepared for user convenience.

The text of this International Standard is based on the following documents:

Draft	Report on voting
76/704/FDIS	76/711/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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- replaced by a revised edition, or
- amended.

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INTRODUCTION

At low levels of irradiance or radiant exposure, the selection of material and thickness for shielding against laser radiation is determined primarily by a need to provide sufficient optical attenuation. However, at higher levels, an additional consideration is the ability of the laser radiation to remove guard material – typically by melting, oxidation or ablation; processes that could lead to laser radiation penetrating a normally opaque material.

IEC 60825-1 deals with basic issues concerning laser guards, including human access, interlocking and labelling, and gives general guidance on the design of protective housings and enclosures for high-power lasers.

Laser guards may also comply with standards for laser protective eyewear, but such compliance is not necessarily sufficient to satisfy the requirements of this document.

Where the term "irradiance" is used, the expression "irradiance or radiant exposure, as appropriate" is implied.

SAFETY OF LASER PRODUCTS –

Part 4: Laser guards

1 Scope

This part of IEC 60825 specifies the requirements for laser guards, permanent and temporary (for example for service), that enclose the process zone of a laser processing machine, and specifications for proprietary laser guards.

This document applies to all component parts of a guard including clear (visibly transmitting) screens and viewing windows, panels, laser curtains and walls.

In addition, this document indicates

a) how to assess and specify the protective properties of a laser guard, and

b) how to select a laser guard.

NOTE Requirements for beam path components, beam stops and those other parts of a protective housing of a laser product which do not enclose the process zone are contained in IEC 60825-1.

This document deals with protection against laser radiation only. Hazards from secondary radiation that may arise during material processing are not addressed.

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 60825-1:2014, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

ISO 11553-1, *Safety of machinery – Laser processing machines – Laser safety requirements*

ISO 12100, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13849-1, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60825-1 and the following 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 panel
panel which when removed or displaced gives human access to laser radiation

Note 1 to entry: Sheathing around a fibre, tubing used as an enclosure component or any device serving the function of a removable or displaceable panel, can also be an "access panel" within the terms of this definition.

3.2
active guard protection time
minimum time for a given laser exposure of the front (incident) surface of an active laser guard, measured from the issue of an active guard termination signal, for which the active laser guard can safely prevent laser radiation accessible at its rear surface from exceeding the Class 1 AEL

3.3
active guard termination signal
signal issued by an active guard in response to an excess exposure of its front surface to laser radiation and which is intended to lead to automatic termination of the laser radiation

Note 1 to entry: The action of a safety interlock becoming open circuit is considered a "signal" in this context.

3.4
active laser guard
laser guard which is part of a safety-related control system whereby failure of the front surface of the laser guard triggers a termination signal

3.5
beam delivery system
system comprised of all those components, including all optical beam components and potential beam paths and their enclosures, which when combined, transfer laser radiation emitted from the laser radiation generator (the laser) to the workpiece

Note 1 to entry: These components may include all elements for guiding, shaping and switching the laser beam as well as the enclosure of and support for the beam path components. See Annex G for detail on guided beam delivery systems.

3.6
beam diameter
d_{86}
diameter of the smallest circular aperture in a plane perpendicular to the beam axis that contains 86 % of the total laser power (or energy)

Note 1 to entry: In the case of a Gaussian beam (TEM_{00}), d_{86} corresponds to the point where the irradiance (radiant exposure) falls to $1/e^2$ of its central peak value and the second order moments of the power density distribution (ISO 11146-1:2005 3.2).

3.7
beam path component
optical component which lies on a defined beam path

Note 1 to entry: Examples of a beam path component include a beam steering mirror, a focus lens or a fibre optic cable connector.

[SOURCE: IEC 60825-1:2014, 3.16, modified — Example has been removed and Note 1 to entry has been added.]

3.8
beam shaping component
optical component introduced in the beam path to transform the profile or cross-section of the laser beam by means of apertures, or reflective, refractive or diffractive optical components

3.9
beam switching component
optical component or an assembly of components introduced in the beam path to direct or divert, under external control, the beam path along predetermined direction(s) with the external control allowing the beam path to be switched from one predetermined direction to another

3.10
fibre optic cable
optical beam guiding component that enables the transmission of laser radiation along a transparent medium

Note 1 to entry: A fibre optic cable may have a glass or other core that carries the laser radiation and be surrounded by cladding. The outside of the fibre is protected by cladding and may be further protected by additional layers of other material such as a polymer or a metal to protect the fibre from mechanical deformation, the ingress of water, etc. This term also includes other forms of transmission devices such as waveguides.

3.11
foreseeable exposure limit
FEL
maximum laser exposure on the front surface of the laser guard, within the maintenance inspection interval, assessed under normal and reasonably foreseeable fault conditions

Note 1 to entry: The full specification of an FEL comprises different elements, including irradiance and exposure duration. More details are given in Annex B.

3.12
front surface
face of the laser guard intended for exposure to laser radiation

3.13
laser guard
physical barrier which limits the extent of a danger zone by preventing laser radiation accessible at its rear surface from exceeding the Class 1 AEL

3.14
laser processing machine
machine which uses a laser to process materials and is within the scope of ISO 11553-1

3.15
laser termination time
maximum time taken, from generation of an active guard termination signal, for the laser radiation to be terminated

Note 1 to entry: Laser termination time does not refer to the response of an active laser guard but to the response of the laser processing machine, in particular the laser safety shutter.

3.16
maintenance inspection interval
time between successive safety maintenance inspections of a laser guard

3.17
passive guard protection time
minimum time determined for a laser exposure equal to a specified protective exposure limit (PEL) at the front (incident) surface of a passive laser guard for which the passive laser guard can reliably prevent laser radiation accessible at its rear surface from exceeding the class 1 AEL

3.18
passive laser guard
laser guard which relies for its operation on its physical properties only

3.19
process zone
zone where the laser beam interacts with the material to be processed

3.20
proprietary laser guard
passive or active laser guard, offered by a manufacturer of laser guards as an independent product placed on the market with a specified protective exposure limit

3.21
protective exposure limit
PEL
maximum laser exposure of the front surface of a laser guard which prevents laser radiation accessible at its rear surface from exceeding the Class 1 AEL for the determined passive or active guard detection time

Note 1 to entry: In practice, there may be more than one maximum laser exposure.

Note 2 to entry: Different PELs may be assigned to different regions of a laser guard if these regions are clearly identifiable (for example, a viewing window forming an integral part of a laser guard).

Note 3 to entry: See 5.3 for the performance requirements and 5.4 for the full specification. The full specification of a PEL comprises different elements, including irradiance and exposure duration.

3.22
rear surface
surface of a laser guard that is remote from the associated laser radiation and usually accessible to the user

3.23
reasonably foreseeable
<event or condition> credible and whose likelihood of occurrence or existence cannot be disregarded

3.24
safety maintenance inspection
documented inspection performed in accordance with manufacturer’s instructions

3.25
temporary laser guard
substitute or supplementary active or passive laser guard intended to limit the extent of the danger zone during some service operations of the laser processing machine

4 Requirements for laser guards

4.1 Requirement

Clause 4 specifies the requirements for laser guards that enclose the process zone and are supplied by the laser processing machine manufacturer.

4.2 Design requirements

4.2.1 Guard requirement

A laser guard shall satisfy ISO 12100 with respect to the general requirements for guards and also the more specific requirements with regard to its location and method of fixture. In addition, the following specific laser requirements shall be met for a laser guard.

4.2.2 General requirements

A laser guard, in its intended location, shall not give rise to any associated hazard at or beyond its rear surface when exposed to primary laser radiation or secondary optical radiation up to the foreseeable exposure limit. Annex F provides guidance on assessing the suitability of laser guards.

NOTE 1 Examples of associated hazards include high temperature, plasma, excessive ultra-violet radiation, the release of toxic materials, fire, explosion, and electricity.

NOTE 2 See Annex B for assessment of foreseeable exposure limit.

4.2.3 Consumable parts of laser guards

Provision shall be made for the replacement of parts of a laser guard prone to damage by laser radiation.

NOTE An example of such a part would be a sacrificial or interchangeable screen.

4.3 Performance requirements

4.3.1 General

When the front (incident) surface of a laser guard is subjected to exposure to laser radiation at the foreseeable exposure limit, the laser guard shall prevent laser radiation accessible at its rear surface from exceeding the Class 1 AEL at any time over the period of the maintenance inspection interval. For automated laser processing machines intended for unattended and/or unsupervised operation, the minimum value of the maintenance inspection interval shall be 8 h.

This requirement shall be satisfied over the intended lifetime of the laser guard under expected conditions of operation.

NOTE 1 This requirement implies both low transmission of laser radiation and resistance to laser-induced damage.

NOTE 2 Some materials can lose their protective properties due to ageing, exposure to ultraviolet radiation, certain gases, temperature, humidity and other environmental conditions. Additionally, some materials will transmit laser radiation under high-intensity laser exposure, even if there is no visible damage (i.e. reversible bleaching).

4.3.2 Active laser guards

a) The active guard protection time shall exceed the laser termination time up to the foreseeable exposure limits.

b) If an active guard detects an excessive exposure, i.e. is triggered, it shall give rise to a visible or audible warning. A manual reset is required before laser emission can recommence.

NOTE See Annex C for an elaboration of terms.

4.4 Validation

4.4.1 General guard validation

If the laser processing machine manufacturer chooses to make a laser guard, the manufacturer shall confirm that the guard complies with the design requirements and can satisfy the performance requirements set out in 4.3.

NOTE See Annex A for guidance on the design and selection of laser guards.

4.4.2 Validation of performance

4.4.2.1 The complete laser guard, or an appropriate sample of the material of construction of the laser guard, shall be tested at each FEL identified.

It is intended that a table of predetermined PELs for common combinations of lasers and guarding materials, together with suitable testing procedures, will be issued as an informative annex in a future amendment to this document. This could provide a simple alternative to direct testing for the majority of cases.

NOTE See Annex B for the assessment of FEL and Annex C for further elaboration of the terms PEL and FEL.

4.4.2.2 For testing purposes, the FEL exposure shall be achieved either:

a) by calculating or measuring the exposure and reproducing the conditions; or
b) without quantifying the FEL, by creating the machine conditions under which the FEL is produced.

The condition of the laser guard or sample shall be such as to replicate those physical conditions of the front surface permitted within the scope of the routine inspection instructions and within the service life of the guard, which minimize the laser radiation protective properties of the laser guard (for example, wear and tear and surface contamination) (see 4.5.2).

4.5 User information

4.5.1 The manufacturer shall document and provide to the user the maintenance inspection interval for the laser guard, and details of inspection and test procedures, cleaning, replacement or repair of damaged parts, together with any restrictions of use.

4.5.2 The manufacturer shall document and provide to the user instructions that after any actuation of the safety control system of an active guard, the cause shall be investigated, and checks shall be made for damage. The instructions shall also include the necessary remedial action to be taken before resetting the control system.

5 Proprietary laser guards

5.1 General

Clause 5 specifies the requirements to be satisfied by suppliers of proprietary laser guards.

5.2 Design requirements

A proprietary laser guard shall not create any associated hazard at or beyond its rear surface when exposed to laser radiation up to the specified PEL when used as specified in the user information (see 5.7).

5.3 Performance requirements

The accessible laser radiation at the rear surface of the laser guard shall not exceed the Class 1 AEL when its front surface is subjected to laser radiation at the specified PEL at least during the passive guard protection time. For an active laser guard, this requirement shall apply to laser radiation accessible over the period of the active guard protection time, measured from the moment an active guard termination signal is issued.

This requirement shall be satisfied over the intended lifetime of the guard under expected service conditions.