AS/NZS IEC 60825.4:2023
IEC 60825-4:2022

Australian/New Zealand Standard™

Safety of laser products

Part 4: Laser guards

Documents
Document Sharing Hub

AS/NZS IEC 60825.4:2023

This Joint Australian/New Zealand Standard™ was prepared by Joint Technical Committee SF-019, Personal Protection Against Laser Radiation. It was approved on behalf of the Council of Standards Australia on 15 August 2023 and by the New Zealand Standards Approval Board on 02 August 2023.

This Standard was published on 8 September 2023.

The following are represented on Committee SF-019:

Australian Dental Association
Australian Radiation Protection and Nuclear Safety Agency
Capability and Sustainment Group (Australian Government)
Chorus New Zealand
Department of Defence (Australian Government)
Spark, NZ
University of Auckland

This Standard was issued in draft form for comment as DR AS/NZS IEC 60825.4:2023.

Keeping Standards up-to-date

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au

www.standards.govt.nz

ISBN 978 1 76139 311 2

Documents
Document Sharing Hub

Full document details: AS NZS IEC 60825.4-2023

Australian/New Zealand Standard™

Safety of laser products

Part 4: Laser guards

Originated as AS/NZS 2211.4:2002.
Revised and redesignated as AS/NZS IEC 60825.4:2016.
Second edition 2023.

© IEC Geneva Switzerland 2023 — All rights reserved
© Standards Australia Limited/the Crown in right of New Zealand, administered by the New Zealand Standards Executive 2023

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of either the IEC or the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth) or the Copyright Act 1994 (New Zealand). If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please see the contact details on the back cover or the contact us page of the website for further information.

Documents
Document Sharing Hub

Full document details: AS NZS IEC 60825.4-2023

Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee SF-019, Personal Protection Against Laser Radiation, to supersede AS/NZS IEC 60825.4:2016.

The objective of this document is to specify 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.

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

This document is identical with, and has been reproduced from, IEC 60825-4:2022, *Safety of laser products – Part 4: Laser guards*.

As this document has been reproduced from an International document, the following apply:

(i) In the source text "this part of IEC 60825" should read "this document".

(ii) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms "normative" and "informative" are used in Standards to define the application of the appendices or annexes to which they apply. A "normative" appendix or annex is an integral part of a Standard, whereas an "informative" appendix or annex is only for information and guidance.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

NOTES

Documents
Document Sharing Hub

Full document details: AS NZS IEC 60825.4-2023

CONTENTS

FOREWORD 5
INTRODUCTION 7
1 Scope 8
2 Normative references 8
3 Terms and definitions 8
4 Requirements for laser guards 11
4.1 Requirement 11
4.2 Design requirements 12
4.3 Performance requirements 12
4.4 Validation 12
4.5 User information 13
5 Proprietary laser guards 13
5.1 General 13
5.2 Design requirements 13
5.3 Performance requirements 13
5.4 Specification requirements 14
5.5 Test requirements 14
5.6 Labelling requirements 14
5.7 User information 15
Annex A (informative) General guidance on the design and selection of laser guards 16
A.1 Design of laser guards 16
A.2 Selection of laser guards 16
Annex B (informative) Assessment of foreseeable exposure limit (FEL) 18
B.1 General 18
B.2 Reflection of laser radiation 19
B.3 Examples of assessment conditions 19
B.4 Exposure duration 22
Annex C (informative) Elaboration of defined terms 25
C.1 Distinction between FEL and PEL 25
C.2 Active guard parameters 25
Annex D (normative) Proprietary laser guard testing 27
D.1 General 27
D.2 Test conditions 27
D.3 Protection time corresponding to the specified protective exposure limit (PEL) 31
D.4 Information supplied by the manufacturer 31
Annex E (informative) Guidelines on the arrangement and installation of laser guards 33
E.1 Overview 33
E.2 General 33
E.3 Risk assessment 34
E.4 Examples of risk assessment 36
E.5 Aids to risk assessment 39
Annex F (informative) Guideline for assessing the suitability of laser guards 42
F.1 Identification of hazards 42
F.2 Risk assessment and integrity 44

AVA Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

F.3 General design 45
F.4 Selection of safeguards 46
F.5 Guard design and construction 46
F.6 Guard construction and materials 48
F.7 Other safety devices 50
F.8 Interlocking considerations 51
F.9 Environmental considerations 55
F.10 Installation consideration – Environmental factors – Services 56
F.11 Maintenance and service considerations 56
Annex G (normative) Guided beam delivery systems 67
G.1 General 67
G.2 General requirements 67
G.3 Verification of safety requirements or protective measures 69
G.4 Information for users 69
G.5 Examples of risk assessments 70
Bibliography 75

Figure B.1 – Calculation of diffuse reflections 19
Figure B.2 – Calculation of specular reflections 19
Figure B.3 – Some examples of a foreseeable fault condition 20
Figure B.4 – Four examples of errant laser beams that might have to be contained by a temporary guard under service conditions 21
Figure B.5 – Illustration of laser guard exposure during repetitive machine operation 22
Figure B.6 – Two examples of assessed duration of exposure 23
Figure B.7 – Assessed duration of exposure for a machine with no safety monitoring 24
Figure C.1 – Illustration of guarding around a laser processing machine 25
Figure C.2 – Illustration of active laser guard parameters 26
Figure D.1 – Simplified diagram of the test arrangement 29
Figure D.2 – Simplified diagram of the ventilation for the guard under test 29
Figure F.1 – Damage resistance of 1 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 57
Figure F.2 – Damage resistance of 1 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 58
Figure F.3 – Damage resistance of 2 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 58
Figure F.4 – Damage resistance of 2 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 58
Figure F.5 – Damage resistance of 3 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 59
Figure F.6 – Damage resistance of 3 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 59
Figure F.7 – Damage resistance of 2 mm thick aluminium sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 59
Figure F.8 – Damage resistance of 2 mm thick aluminium sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 60

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

Figure F.9 – Damage resistance of 1 mm thick stainless steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 60

Figure F.10 – Damage resistance of 1 mm thick stainless steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 60

Figure F.11 – Damage resistance of 6 mm thick polycarbonate sheet derived from 10 s exposure to a defocused beam during experiments using a CW CO_2 laser 61

Figure F.12 – Damage resistance of 6 mm thick polycarbonate sheet derived from 100 s exposure to a defocused beam during experiments using a CW CO_2 laser 61

Figure F.13 – Damage resistance of 1 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 62

Figure F.14 – Damage resistance of 1 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 62

Figure F.15 – Damage resistance of 2 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 63

Figure F.16 – Damage resistance of 2 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 63

Figure F.17 – Damage resistance of 3 mm thick zinc coated steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 64

Figure F.18 – Damage resistance of 3 mm thick zinc coated steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 64

Figure F.19 – Damage resistance of 2 mm thick aluminium sheet derived from 10 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 65

Figure F.20 – Damage resistance of 2 mm thick aluminium sheet derived from 100 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 65

Figure F.21 – Damage resistance of 1 mm thick stainless steel sheet derived from 10 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 66

Figure F.22 – Damage resistance of 1 mm thick stainless steel sheet derived from 100 s exposure to a defocused beam during experiments using a CW Nd:YAG laser 66

Table D.1 – Laser guard test classification 30

Table F.1 – Application of ALARP 45

Table G.1 – Beam delivery systems using free space beam delivery systems 70

Table G.2 – Beam delivery systems using fibre optic cables 72

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

SAFETY OF LASER PRODUCTS –

Part 4: Laser guards

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

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

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

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

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.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

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.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

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.]

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

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

AVA Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

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.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

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.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

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.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

5.4 Specification requirements

The full specification of a PEL shall include the following information:

a) the magnitude of irradiance or radiant exposure at the front surface of the laser guard (in units of W m^{-2} or J m^{-2}, respectively) used to measure its passive guard protection time and mean value and standard deviation of its tested exposure time limit for calculating its passive guard protection time, specifying any upper limit to the area of exposure;

b) the quoted passive guard protection time including safety factor of 0,7 (see Clause D.3 for calculation of the quoted protection time for passive laser guards);

c) the wavelength(s) for which this PEL applies;

d) the angle of incidence and (if relevant) the polarization of the incident laser radiation;

e) any minimum dimensions to the irradiated area (for example, as might apply to an active laser guard with discrete sensor elements so that a small diameter laser beam could pass through the guard undetected);

f) for an active laser guard, the active guard protection time.

NOTE 1 See Clause B.1 for an elaboration of terms.

NOTE 2 In all cases, a range or set of values can be stated rather than a single value.

NOTE 3 A graphical form of presentation is acceptable (for example, irradiance plotted against duration with all other parameters constant).

5.5 Test requirements

5.5.1 General

Testing shall be performed using the complete laser guard or an appropriate sample of the material used to construct the guard. In either case, the condition of the guard or sample shall be such as to replicate or exceed the worst permissible physical condition of the front surface, including reduced surface reflection and damage permitted within the scope of the routine maintenance instructions (see 5.7).

The front surface irradiation shall be either as specified by the PEL or, in the case of sample testing, as specified in 5.5.2.

When the front surface is subjected to the PEL exposure conditions, the accessible laser radiation measured at the rear surface of the laser guard shall not exceed the Class 1 AEL (tests as specified in Clause 5 of IEC 60825-1:2014). This requirement applies over the exposure duration specified in the PEL or, in the case of an active guard, over the specified active guard protection time measured from the moment an active guard termination signal is issued.

NOTE In cases where materials opaque at the laser wavelength(s) are used (for example metals), the transmitted radiation can rise only to the Class 1 AEL when complete (or almost complete) physical removal of material along a path through to the rear surface has been achieved. In such cases, the rise from zero transmission to a value greatly in excess of the Class 1 AEL will therefore be rapid, and sensitive radiation detectors will not be required.

5.5.2 Sample testing

Sample guard testing shall be performed by irradiating the front surface of the guard material using the procedure and methodology as specified in Annex D.

5.6 Labelling requirements

5.6.1 All labelling shall be placed on the rear surface of the guard.

5.6.2 The rear surface of the guard shall be clearly identified if the orientation of the guard is important.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

5.6.3 If only part of the front surface of the guard is a laser guard, this area shall be clearly identified by a bold coloured outline and words to indicate the outer boundary of the laser guard.

5.6.4 The labelling shall state the full PEL specification.

5.6.5 The manufacturer's name, the date and place of manufacture in accordance with ISO 11553-1, and a statement of compliance with this document shall be provided.

5.7 User information

In addition to the specifications listed in 5.4, the following information shall be supplied to the user by the manufacturer of a proprietary laser guard:

a) a description of the permitted uses of the laser guard;

b) a description of the form of mounting and connection of the laser guard;

c) information on the installation of the laser guard – for active laser guards this shall include interface and supply requirements for the guard;

d) maintenance requirements, including for example details of inspection and test procedures, cleaning, replacement or repair of damaged parts;

e) 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;

f) the labels in 5.6 and their locations. If only part of the front surface of the guard is a laser guard, this area shall be identified;

g) a statement of compliance with this document.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

Annex A
(informative)

General guidance on the design and selection of laser guards

A.1 Design of laser guards

A.1.1 Passive laser guards

Examples of a passive laser guard include the following:

a) a metal panel relying on thermal conduction, if necessary enhanced by forced air or water cooling, to maintain the surface temperature below its melting point under normal and reasonably foreseeable fault conditions;

b) a transparent sheet, opaque at the laser wavelength, which is unaffected by low value of laser exposure under normal operation of the laser processing machine.

c) non-metal panels relying on thermal sublimation without melting and similar materials

A.1.2 Active laser guards

Examples of an active laser guard include the following:

a) a guard, with discrete embedded thermal sensors, which detects overheating;

The spacing between sensors should be considered in relation to the minimum dimensions of an errant laser beam.

b) a laser guard comprising two panels between which is contained a pressurized liquid or gaseous medium in combination with a pressure-sensing device capable of detecting the pressure drop following perforation of the front surface.

A.1.3 Hazard indication (passive laser guards)

Visible indication of exposure of the laser guard to hazardous amounts of laser radiation should be provided where feasible (for example by adding a layer of an appropriate paint on both sides of the laser guard).

A.1.4 Power supply (active laser guards)

If power is required for the proper functioning of an active guard, its supply should be arranged so that laser operation is not possible in the absence of such power.

A.2 Selection of laser guards

A.2.1 Selection requirements

A simple selection process is as follows.

a) Identify the preferred position for the laser guard and estimate the FEL at this position. Annex B gives guidance on the estimation of FEL values.

b) If necessary, minimize the FEL under fault conditions, preferably by including automatic monitoring in the machine which will detect the fault conditions and limit the exposure time. Examples of alternatives include the following:

1) ensure that the laser guard is sufficiently far away from beam focus produced by focusing optics;

2) install vulnerable parts of the laser guard (such as viewing windows) away from regions that could be exposed to high irradiance;

3) move the laser guard farther away from the laser process zone;

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

4) require in the essential servicing documentation for temporary laser guards, additions such as:
   - one or more persons to be present to supervise the condition of the front surface of the laser guard, to reduce the assessed exposure duration of a passive laser guard;
   - a hold-to-operate controller to be used by the person(s) supervising the condition of the front surface of the laser guard, to reduce the assessed exposure duration of a passive laser guard;
   - additional local temporary guarding, apertures and beam dumps to be employed, to absorb any powerful errant laser beams;
   - the danger zone to be bounded by errant beam warning devices and the guard placed beyond this zone to reduce the assessed exposure duration;
5) incorporate in the design of the machine, when using temporary laser guards, beam control features to facilitate improved laser beam control during servicing operations, such as:
   - holders for precise location of additional beam forming components (for example turning mirrors) required during servicing;
   - mounts which allow only limited scope for beam steering.

Three options then follow. The order below does not indicate a preference.

A.2.2 Option 1: passive laser guard

This is the simplest option.

Design and quality control are particularly important considerations where the absorption at the laser wavelength is dominated by a minority additive, such as a dye in a plastic. In such cases, where the manufacturer of the material does not specify the concentration of the absorber or the material optical attenuation at the laser wavelength, samples from the same batch of the material should first be tested as described in 4.4.1.

A.2.3 Option 2: active laser guard

If the FEL cannot be reduced to a value where common guarding materials provide adequate protection in the form of a passive laser guard, an active laser guard may always be used.

A.2.4 Option 3: proprietary laser guard

A proprietary laser guard may be used if the assessed FEL values are less than the PEL values quoted by the laser guard manufacturer.

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

Annex B
(informative)

Assessment of foreseeable exposure limit (FEL)

B.1 General

FEL values may be assessed either by measurement or by calculation (see below).

ISO 12100 provides a general methodology for risk assessment. The assessment should include consideration of cumulative exposure in normal operation (for example, during each part processing cycle of the machine) over the maintenance inspection interval.

From this assessment, the most demanding combinations of irradiation, area of exposure and exposure duration should be identified; see Figure B.1, Figure B.2 and Figure B.3. It is quite likely that several FELs will be identified; for example, one condition may maximize the duration of exposure at a relatively low irradiance, while another may maximize the irradiance over a shorter duration of exposure; see Figure B.3 and Figure B.4.

The full specification of an FEL comprises the following information.

a) The maximum irradiance at the front surface of the laser guard, see Figure B.1 and Figure B.2.

NOTE 1 Irradiance is expressed as the total power or energy divided by the area of the front surface of the guard, or specified limited area, as appropriate.

b) Any upper limit to the area of exposure of the front surface at this level of irradiance.

NOTE 2 No limit to the area would be appropriate for protection against scattered laser radiation while an upper limit to the exposed area would be appropriate for direct exposure to laser beams.

c) The temporal characteristics of the exposure, i.e. whether continuous wave (CW) or pulsed laser radiation, and if the latter, then the pulse duration and pulse repetition frequency.

d) The full duration of exposure.

NOTE 3 See Clause B.4 for an elaboration of this term.

e) The wavelength(s) of the radiation.

f) The angle of incidence and (if relevant) the polarization of the radiation, see Figure B.1 and Figure B.2.

NOTE 4 Stipulation of angle of incidence is particularly important for laser guards exploiting interference layers to reflect impinging laser radiation.

CAUTION: At Brewster's angle of incidence "p", polarized radiation is strongly coupled into the surface of the guard.

g) Any minimum dimensions to the irradiated area (for example as might apply to an active laser guard with discrete sensor elements so that a small diameter laser beam could pass through the laser guard undetected).

h) For an active laser guard, the active guard protection time.

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

B.2 Reflection of laser radiation

B.2.1 Diffuse reflections

Assuming a Lambertian reflector with 100 % reflectivity,

$$E_A = \frac{P_o}{\pi} \cdot \frac{\cos\theta}{R^2} \cdot \cos\varphi$$

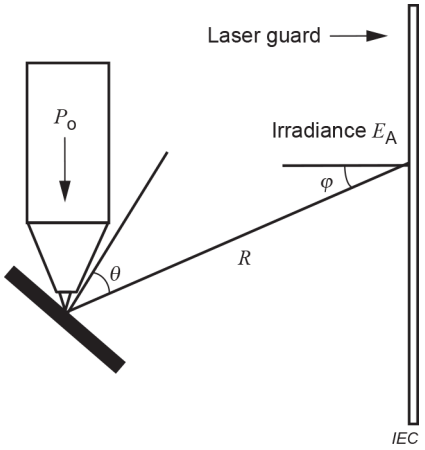

Figure B.1 – Calculation of diffuse reflections

B.2.2 Specular reflections

It is difficult to generalize for the case of specular reflections.

For a circularly symmetric laser beam with a Gaussian distribution, power P_o and diameter d_{86} at the focusing lens, focal length f, the maximum irradiance (at the centre of the Gaussian distribution) in a normal plane at a distance R from the focus is:

$$E_{AA'} = \frac{4 \cdot P_o \cdot \rho}{\pi \cdot d_{86}^2} \left(\frac{f}{R} \right)^2$$

where ρ is the reflectivity of the workpiece surface.

CAUTION: Certain curved surfaces can increase the reflection hazard.

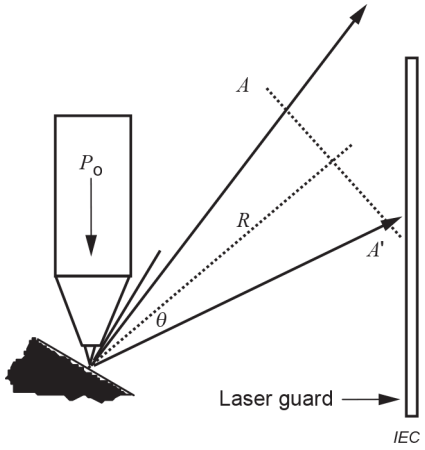

Figure B.2 – Calculation of specular reflections

B.3 Examples of assessment conditions

FELs should be assessed for the worst reasonably foreseeable combination(s) of available laser parameters, workpiece materials, geometry and processes likely to be encountered during normal operation (IEC TR 60825-14 provides guidance for users).

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023

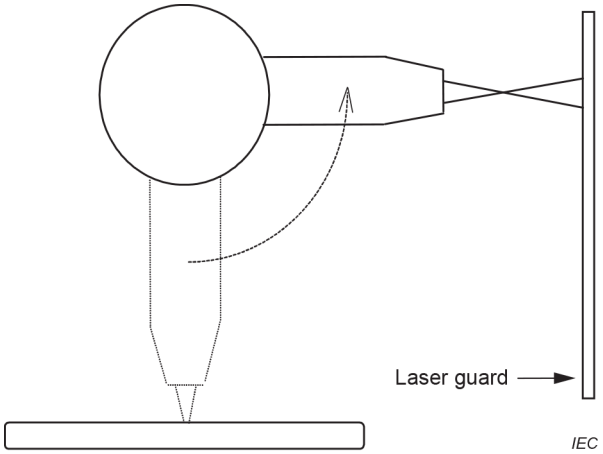

Figure B.3a – Software failure

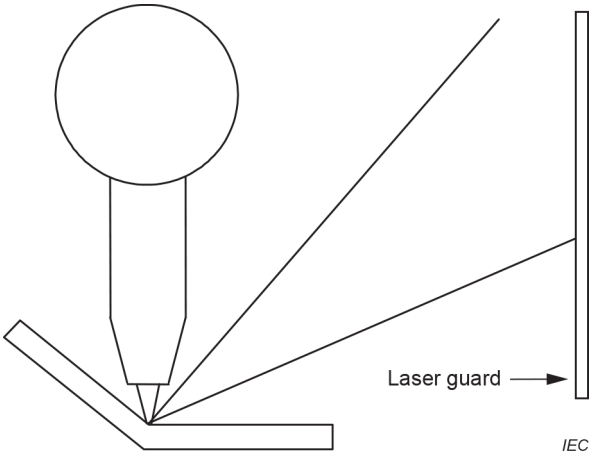

Figure B.3b – Workpiece bends or is inadequately clamped

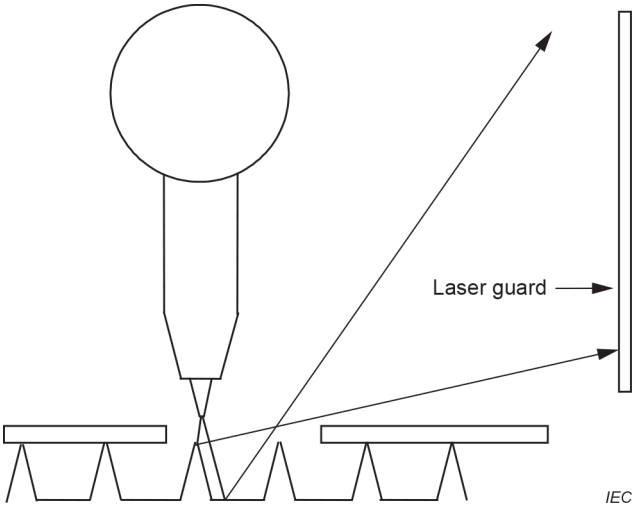

Figure B.3c – Workpiece missing

Figure B.3 – Some examples of a foreseeable fault condition

Documents
Document Sharing Hub

© Standards Australia Limited/Standards New Zealand 2023

Full document details: AS NZS IEC 60825.4-2023

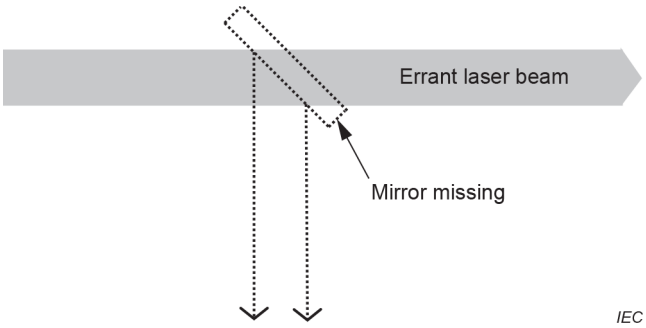

Figure B.4a – Laser is operated with turning mirror missing

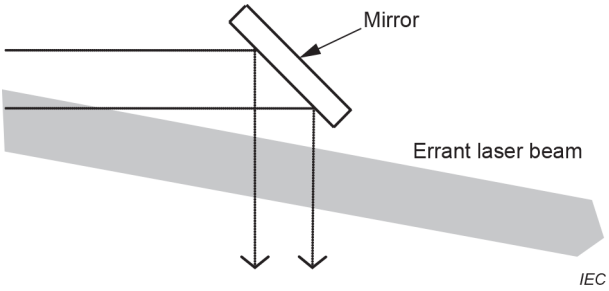

Figure B.4b – Beam displaced off mirror during alignment procedure

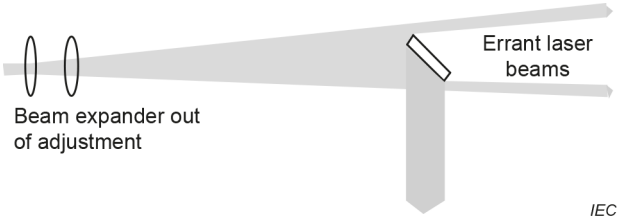

Figure B.4c – Beam expands beyond range of optics

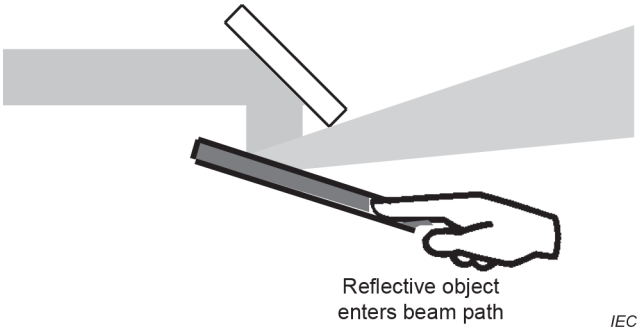

Figure B.4d – Reflective objects intercept laser beam

Figure B.4 – Four examples of errant laser beams that might have to be contained by a temporary guard under service conditions

Documents
Document Sharing Hub
© Standards Australia Limited/Standards New Zealand 2023
Full document details: AS NZS IEC 60825.4-2023