IEC 60825-4

Edition 2.0 2011-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

AMENDMENT 2
AMENDEMENT 2

Safety of laser products – Part 4: Laser guards

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

IEC 60825-4:2006/A2:2011

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 60825-4

Edition 2.0 2011-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

AMENDMENT 2
AMENDEMENT 2

Safety of laser products – Part 4: Laser guards

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX

G

ICS 31.260

ISBN 978-2-88912-431-2

FOREWORD

This amendment has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment.

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

Enquiry draft	Report on voting
76/428/CDV	76/442/RVC

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

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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

———————

Replace the existing Annex D with the following new Annex D:

Annex D
(normative)

Proprietary laser guard testing

D.1 General

This annex contains details of the test conditions to be adhered to and the documentation to be supplied by manufacturers of proprietary laser guards.

It should be noted that it is inappropriate to use higher power lasers to simulate low power laser parameters or use low powered lasers to simulate high powered, by changing irradiance or by adjustment of the distance from the focal point, because beam quality and other characteristics of the laser beam are likely to be different or unexpected. Manipulating characteristics of lasers of a certain power level to make or extrapolate estimates of a laser in a different level (higher or lower power) is not permitted.

The evidence of the tests described herein is relevant only for, and is limited to, the laser parameters used. Thus the results of these tests should serve only for comparison of laser guards.

The protective exposure limit (PEL $W \cdot m^{-2}$) shall be applicable only for the beam dimensions at the guard used in the tests. These dimensions at the guard shall be stated by the laser guard manufacturer because the PEL, which indicates protection, decreases as the laser beam dimensions increase. If the PEL is exceeded, the guard can be damaged and eventually disintegrates. For the purposes of this annex the protection time is the time interval from initial irradiation of the front surface until the laser radiation emitting beyond the rear surface exceeds the accessible emission limit (AEL) for Class 1 as defined in IEC 60825-1.

D.2 Test conditions

A variety of exposure limit tests with different materials and different lasers may cause non-reproducible results that can lead to false interpretations for the protective exposure limit and overestimated lifetime predictions of laser guards. Thus equal and comparable conditions for repeated tests must be ensured to maintain the integrity of the results.

As part of ensuring the integrity of the results, effort shall be made to eliminate or at least minimise systematic or other errors that may also result in false interpretations for the PEL or overestimation of the guard lifetime. Such errors may arise from:

a) material: reflecting surfaces, where reflectivity changes through oxidation or contamination;

b) laser: with high power lasers (e.g. multi-kilowatt lasers), especially those with good beam quality (i.e. fibre lasers and disk lasers), reactions have been seen that have considerable influence on the actual irradiance on the surface of the laser guards.

Thus during testing, it is important that no mechanical or physical effects (such as described below) occur between the beam aperture and the point of incidence on the guard material that adversely affect any optical properties. It is important to note that testing conditions should be accurately replicated, otherwise the resultant PEL or protection times may not be reliably reproduced.

Examples of effects that influence test results include but are not limited to:

- generation of fine metallic fume, whereby laser radiation is absorbed (e.g. thermal blooming) or scattered (e.g. Mie effect) in the metallic fume;

- change of the focal point (thermal induced focal shift), whereby there is a change of the power density at the surface of the laser guard. These effects may reduce the laser power on the sample under test;
- establishment of an equilibrium (i.e. thermal equilibrium or balance between, incident and reflected or reemitted radiation) leading to a practically infinite PEL or protection time in one test, while a repeated test under assumed equal conditions leads to a finite PEL or protection time.

The tested exposure limit ($W \cdot m^{-2}$ for CW lasers or $J \cdot m^{-2}$ for pulsed lasers) shall be determined by tests performed when irradiating at least six samples by irradiating one surface of each sample. Each sample shall be of representative thickness and composition, having a front test surface prepared to give worst case absorption to laser radiation. Dimensions of these samples shall be not less than 3 times the beam diameter measured at the points where the intensity distribution has decreased to a value of $1/e^2$ of the peak at the exposure location (thereby guaranteeing that the radiant heat flow is taken into account). Structural connecting elements shall only be included in the tests if they are necessary to ensure the construction and integrity of the guard. In the case of non-circular beams, the geometry of the beam used in the test shall be specified. Non-circular beams are those where the difference between the major and the minor dimension is greater than 10 %. The tests shall be performed in both pulsed and CW mode where pulsed and CW laser operation is possible as the pulsed radiation may lead to different results.

NOTE 1 The parameters of pulsed radiation used in these tests should be representative of the parameters to be used in any specified application.

NOTE 2 The geometry of the test beam is required to be specified because it affects the distribution of heat in the sample.

NOTE 3 Particular care should be taken in the preparation of samples when testing laser guards using aluminium, copper, stainless steel and materials with zinc coated surfaces. It has been observed for these and other similar materials, the PEL and protection time is highly dependant on sample preparation and experimental setup that affects the repeatability of the PEL and protection time measurements.

NOTE 4 The worst case absorption should take into account the reflectivity of the guard material and the changes to the surface of the laser guard material over the foreseeable lifetime of the laser guard. However, the test plate should not have been treated beforehand, in any possible way that could alter absorption conditions artificially, except for accelerated natural reflectivity change of the guard material and the accelerated natural changes to the surface of the laser guard material reasonably expected over the foreseeable lifetime of the laser guard. Qualification test should be done in normal conditions for the laser shielding."

If a sample holder is necessary for the tests, then its maximum overlap on the sample edge shall not exceed 3 mm from the edge of the sample. The holding arrangement in contact with the sample shall be thermally insulating (e.g. ceramic, etc.) compatible with use at the temperatures generated.

The sample shall be normal (or tilted no more than ±3° to avoid retro-reflections) to the laser beam with the beam axis centred on the sample at a distance 'F1' as shown in Figure D.1. The distance F1 past the focal point shall be not greater than 3 times the focal length (F) of the focusing lens. If for a specific application the guard is to be positioned at a distance less than 3 times the focal length (F) away from the focal point, the minimum distance between the focal point and the guard has to be taken as the distance F1.

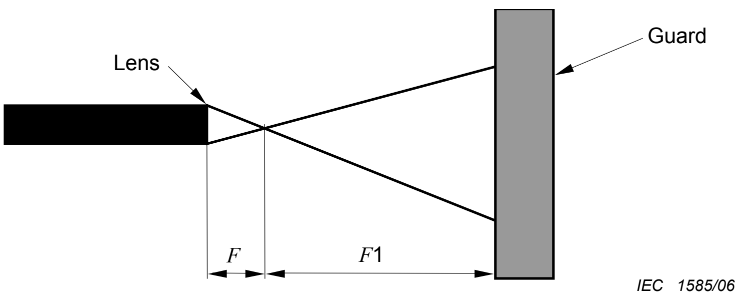

Figure D.1 – Simplified diagram of the test arrangement

NOTE 5 Test should be performed with horizontally directed beam as shown in Figure D.1. If different beam direction were used, mention the test arrangement regarding the beam direction in the qualification report.

The surface of the sample under test shall be sufficiently ventilated (e.g. by using a cross jet) to ensure that the test surface and the space between the test sample and the beam shaping optics remain clear of debris, fume, etc. during the period of the test. The ventilation shall have the same effect as the air circulation in the intended application.

In addition, where there are multiple layers to the sample guard, all internal surfaces and internal spaces shall be sufficiently ventilated (e.g. by using a cross jet) to ensure that all surfaces remain clear of debris, fume etc. during the period of the test.

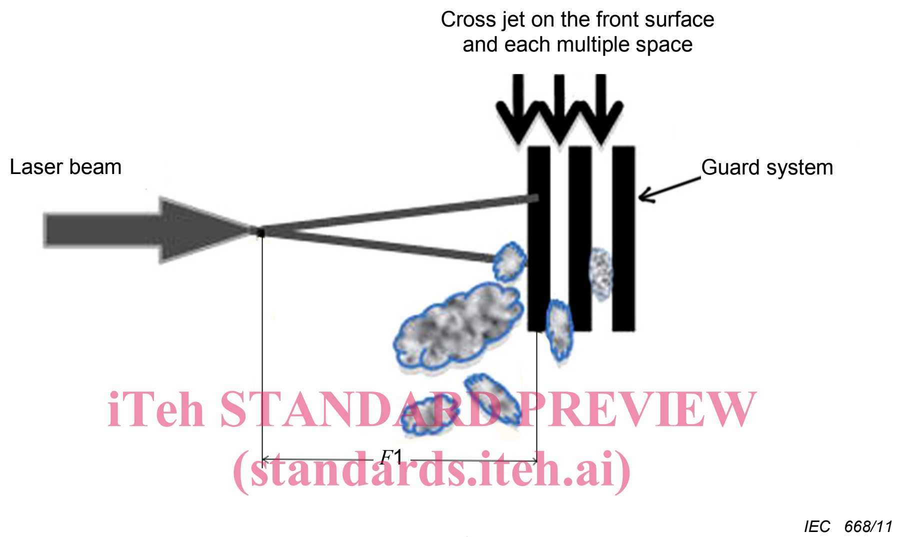

Figure D.2 – Simplified diagram of the ventilation for the guard under test

For passive guards: the accessible laser radiation at the rear surface of the sample shall not exceed Class 1 AEL during the test exposure, the duration of which is dependant on the period of exposure set by the manufacturer of the proprietary guard. The protection time of the guard must exceed the maintenance inspection interval as defined in Table D.1 subject to the intended laser guard usage.

Maintenance inspection intervals of proprietary laser guards should be specified by their manufacturer using test classifications T1, T2 or T3 as defined in Table D.1. Maintenance inspection intervals represent the time interval after which the guard is completely inspected and verified as not damaged or deteriorated. This is to ensure that the guard is in a state that can tolerate exposure to laser radiation for a further maintenance interval.

Table D.1 – Laser guard test classification

Test classification	Maintenance inspection interval s	Suggested laser guard usage
T1	30 000	For automated machine usage
T2	100	For short cycle operation and intermittent inspection
T3	10	For continuous inspection by observation

For active guards the following shall be required:

a) If the active guard is a part of a safety-related control system of a machine, the relevant and appropriate standard for safety-related control systems shall be applied.

b) The active laser guard shall output the laser termination signal, (which is intended to lead to automatic termination of the laser radiation) in response to any exposure of its front surface to laser radiation in excess of the specified exposure (level and duration). A reasonably foreseeable fault within the active guard system shall not lead to the loss of the safety function. A reasonably foreseeable fault within the guard element shall be detected at or before the next demand upon the safety function.

c) The accessible laser radiation at the rear surface of a sample of the passive laser guard, incorporated in the active laser guard, shall not exceed Class 1 AEL in response to any exposure of its front surface to laser radiation up to and including the specified exposure for an exposure duration greater than the specified active guard protection time (as defined in Clause 3.1).

d) If automatic functionality checks within the active guard system are made during periods of laser emission that temporarily interrupt the operation of the active laser guard system, the accumulated time taken to complete these checks shall take into account the effect of any repetitive laser pulses and shall not exceed the active guard protection time or cause any reduction in the overall performance of the active laser guard.

e) The operation of an active guard is dependent on changes of physical parameters causing the initiation of the active guard termination signal. The active guard shall be continuously monitored during the period of potential laser exposure. At other periods, the active guard shall be unaffected by parameter changes (for example, smoke, humidity, vibration or shocks, temperature changes) and any other changes in the environment, thus preventing the active guard from being inadvertently disabled.

f) Any damage to the active guard shall be detected at or before the next demand for protection and until that damage has been rectified, further operation shall be prevented.

D.3 Protective exposure limit (PEL)

The protective exposure limit (PEL) (as defined in 3.13) or protection time shall be determined from the results obtained from the measurements made. When calculating the protection time from the sampled data, the central limit theorem shall be applied presuming an underlying normal distribution. A confidence level of 99 % is required and is ensured by using $\pm 3\sigma$, where σ is the standard deviation in the normal distribution as given by

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2} \right)$$

Where $p(x)$ = probability of x, x = individual value of a sample and μ = mean of the samples.

The quoted PEL shall be equal to 0,7 × tested exposure limit.

The protection time shall be equal to 0,7 × ($\mu - 3\sigma$).

NOTE The factor 0,7 referred to in the equation for PEL or protection time is introduced as an additional safety factor.

D.4 Information supplied by the manufacturer

The manufacturer shall provide with the set of test sample data at least the following information:

a) name and address if the organisation conducting the tests;

b) the number of this standard;

c) the material and its specification or internationally recognised standard to which it is made or rated, used for the samples. Details of any heat treatment, work hardening, surface finishes or other process applied to the material shall be included in this specification;

d) the number of samples used in the tests;

e) details of the laser parameters used including at least:

   i) the laser wavelength;

   ii) the power or energy (specifying peak or average) at which testing was conducted;

   iii) the pulse duration and repetition rate (for tests using a pulsed laser);

   iv) the beam diameter at the input of the focal lens;

   v) the beam quality expressed appropriately, for example, the beam parameter product or M^2;

   vi) a measurement of the radiant exposure or irradiance of the beam at the surface under test;

f) focal length of the focus lens used in the tests;

g) the distance F1;

h) the maintenance inspection interval applicable to the laser guard;

i) the resultant PEL and/or protection time together with any calculations and statistical analyses made.