

# TECHNICAL REPORT

**IEC**  
**TR 60825-14**

First edition  
2004-02

---

---

**Safety of laser products –**

**Part 14:  
A user's guide**



Reference number  
IEC/TR 60825-14:2004(E)

## Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

## Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

## Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site** ([www.iec.ch](http://www.iec.ch))

- **Catalogue of IEC publications**

The on-line catalogue on the IEC web site ([www.iec.ch/searchpub](http://www.iec.ch/searchpub)) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

This summary of recently issued publications ([www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

Email: [custserv@iec.ch](mailto:custserv@iec.ch)  
Tel: +41 22 919 02 11  
Fax: +41 22 919 03 00

# TECHNICAL REPORT

**IEC**  
**TR 60825-14**

First edition  
2004-02

---

---

**Safety of laser products –**

**Part 14:  
A user's guide**

© IEC 2004 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

PRICE CODE **XD**

*For price, see current catalogue*

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope and object.....	7
2 Terms and definitions .....	8
3 Administrative policies.....	16
3.1 Safety responsibilities .....	16
3.2 Competent persons .....	17
3.3 Laser Safety Officer .....	17
3.4 Information and training.....	18
4 Laser radiation hazards.....	19
4.1 Laser products.....	19
4.2 Exposure to laser radiation.....	23
4.3 Determining the level of laser exposure.....	23
5 Determining the maximum permissible exposure (MPE) .....	28
5.1 General remarks.....	28
5.2 Repetitively pulsed or modulated lasers .....	28
5.3 Multiple wavelengths.....	29
5.4 Extended source MPEs .....	30
5.5 Hazard distance and hazard area.....	30
6 Associated hazards .....	31
6.1 Additional health hazards .....	31
6.2 Hazards arising from the laser.....	32
6.3 Hazards arising from the environment .....	33
6.4 Control of associated hazards .....	34
7 Evaluating risk.....	35
7.1 Hazards and risks .....	35
7.2 Risk assessment: Stage 1 – Identifying potentially injurious situations. ....	35
7.3 Risk assessment: Stage 2 – Assessing risk for potentially injurious situations. ....	36
7.4 Risk assessment: Stage 3 – Selecting control measures.....	38
8 Control measures .....	38
8.1 General.....	38
8.2 Hazard reduction.....	39
8.3 Enclosing the hazard.....	39
8.4 Hazard mitigation .....	41
8.5 Equipment servicing .....	46
9 Maintenance of safe operation.....	47
10 Incident reporting and accident investigation .....	48
11 Medical surveillance .....	48
Annex A (informative) Examples of interlock systems for laser controlled areas.....	54
Annex B (informative) Examples of calculations .....	59
Annex C (informative) Biophysical considerations .....	82
Bibliography.....	92

Figure 1 – Laser hazard symbol.....	18
Figure 2a – Measurement set-up using a lens.....	26
Figure 2b – Direct measurement set-up .....	27
Figure 2 – Measurement set-ups.....	27
Figure A.1 – Purpose of an interlock system .....	56
Figure A.2 – Non-locking interlock system .....	57
Figure A.3 – Locking interlock system.....	58
Figure B.1 – Laser diode array with two groupings.....	76
Figure C.1 – Anatomy of the eye.....	89
Figure C.2 – Diagram of laser-induced damage in biological systems .....	90
Table 1 – Default protective control measures for laser products .....	21
Table 2 – The diameter of the limiting aperture applicable to measurements of irradiance and radiant exposure ( $t$ is the exposure duration) .....	25
Table 3 – Duration $T_i$ below which pulse groups are summed up .....	29
Table 4 – Additivity of effects on eye (O) and skin (S) of radiation of different spectral regions .....	30
Table 5 – Maximum permissible exposure (MPE) at the cornea for direct exposure to laser radiation.....	49
Table 6 – Maximum permissible exposure (MPE) at the cornea for direct exposure to laser radiation from extended sources in the wavelength range from 400 nm to 1400 nm (retinal hazard region) .....	50
Table 7 – Maximum permissible exposure (MPE) of skin to laser radiation.....	51
Table 8 – Correction factors for MPEs .....	52
Table 9 – Laser controlled areas.....	53
Table C.1 – Summary of pathological effects associated with excessive exposure to light ....	84
Table C.2 – Explanation of measurement apertures applied to the MPEs .....	88

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF LASER PRODUCTS –****Part 14: A user's guide****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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 60825-14, which is a technical report, has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
76/271/DTR	76/282/RVC

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

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

IEC consists of the following parts, under the general title *Safety of laser products*:

- Part 1: Equipment classification, requirements and user's guide
- Part 2: Safety of optical fibre communication systems
- Part 3: Guidance for laser displays and shows
- Part 4: Laser guards
- Part 5: Manufacturer's checklist for IEC 60825-1
- Part 6: Safety of products with optical sources, exclusively used for visible information transmission to the human eye
- Part 7: Safety of products emitting infrared optical radiation, exclusively used for wireless 'free air' data transmission and surveillance
- Part 8: Guidelines for the safe use of medical laser equipment
- Part 9: Compilation of maximum permissible exposure to incoherent optical radiation
- Part 10: Application guidelines and explanatory notes to IEC 60825-1
- Part 12: Safety of free space optical communication systems used for transmission of information<sup>1)</sup>
- Part 13: Measurements for classification of laser products<sup>1)</sup>
- Part 14: A user's guide

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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

---

<sup>1)</sup> To be published

## INTRODUCTION

To help in the use of this technical report, an outline of the topics that are covered within it is given below. The topics are presented in the order in which they would normally be considered as part of a laser safety programme.

- Safety responsibilities with regard to the operation of lasers and the need for appropriate training are covered in Clause 3.
- The meaning of the laser product classes and the assessment of laser exposure are covered in Clause 4.
- The determination of the maximum permissible exposure (MPE), and the concept of the hazard distance and hazard zone within which the MPE can be exceeded, are covered in Clause 5.
- Associated laser hazards (that is, hazards other than those of eye or skin exposure to the emitted laser beam) are covered in Clause 6.
- A three-stage process for evaluating risk (arising from both the laser radiation hazards discussed in Clauses 4 and 5, and the associated laser hazards discussed in Clause 6) is covered in Clause 7. These three stages are:
  - 1) the identification of all potentially injurious situations,
  - 2) the assessment of the risk arising from these situations and
  - 3) the determination of the necessary protective measures.
- The use of control measures for reducing the risk to an acceptable level is covered in Clause 8.
- The need to ensure the continuation over time of safe laser operation is covered in Clause 9.
- The reporting of laser-related hazardous incidents and the investigation of accidents is covered in Clause 10.
- The role of medical surveillance (eye examinations) is covered in Clause 11.
- Additional information on the use of interlock protection is given in Annex A.
- Examples of laser safety calculations are given in Annex B.
- An explanation of the biophysical effects of laser exposure to the eyes and skin is given in Annex C.



## SAFETY OF LASER PRODUCTS –

### Part 14: A user's guide

#### 1 Scope and object

This technical report provides guidance on best practice in the safe use of laser products that conform to IEC 60825-1. The terms "laser product" and "laser equipment" as used in this document also refer to any device, assembly or system, which is capable of emitting optical radiation produced by a process of stimulated emission. However, unlike IEC 60825-1, this document does not cover light-emitting diodes (LEDs).

Class 1 laser products normally pose no hazard and Class 2 laser products present only a minimal hazard. With these products, it is normally sufficient to follow the warnings on the product labels and the manufacturer's instructions for safe use. Further protective measures as described in this document should not be necessary.

This document emphasizes evaluation of the risk from higher power lasers, but the users of the lower power lasers may benefit from the information contained. See Table 1 for an overview.

This technical report can be applied to the use of any product that incorporates a laser, whether or not it is sold or offered for sale. Therefore, it applies to specially constructed lasers (including experimental and prototype systems).

This technical report is intended to help laser users and their employers to understand the general principles of safety management (Clause 3), to identify the hazards that may be present (Clauses 4 to 6), to assess the risks of harm that may arise (Clause 7), and to set up and maintain appropriate control measures (Clauses 8 to 11).

Laser control measures vary widely. They depend on the type of laser equipment in use, the task or process being performed, the environment in which the equipment is used and the personnel who may be at risk of harm. Specific requirements for certain laser applications is given in other documents in the IEC 60825 series (see the Foreword or bibliography for the titles of these documents).

The terms "reasonably foreseeable" and "reasonably foreseeably" are used in this document in relation to certain specific events, situations or conditions. It is the responsibility of the person using this document to determine what is "reasonably foreseeable" and what might occur "reasonably foreseeably", and to be able to defend, on the basis of risk-assessment criteria, any such judgements that are made.

Reference is made in this document to laser "users". This should be taken to include persons having responsibility for safety in addition to those who actually work with or operate laser equipment.