

TECHNICAL SPECIFICATION

**Safety of laser products -
Part 13: Measurements for classification of laser products**

CONTENTS

FOREWORD	4
1 Scope	6
2 Normative references	6
3 Terms and definitions	6
4 Applicability	8
4.1 General	8
4.2 Initial considerations	8
5 Instrumentation requirements	10
6 Classification flow	11
7 Parameters for calculation of accessible emission limits	15
7.1 Wavelength (λ)	15
7.1.1 Wavelength determination	15
7.1.2 Ocular hazard regions	16
7.2 Multiple wavelength sources	17
7.2.1 General	17
7.2.2 Single hazard region	17
7.2.3 Two or more hazard regions	18
7.3 Spectrally broad sources	18
7.3.1 General	18
7.3.2 Spectral regions with small variation of the AEL with wavelength	18
7.3.3 Spectral regions with large variation of the AEL with wavelength (302,5 nm to 315 nm, 450 nm to 500 nm and 1 050 nm to 1 400 nm)	18
7.3.4 Spectral regions containing hazard-type boundaries (400 nm and 1 400 nm)	19
7.3.5 Very broad sources	19
7.4 Temporal characteristics	20
7.4.1 Emission duration and time base	20
7.4.2 Sources with limited "ON" time	20
7.4.3 Repetitively pulsed or modulated sources	20
7.5 Angular subtense (α)	28
7.5.1 General	28
7.5.2 Location of the reference point	30
7.5.3 The angular subtense (α) used to determine T_2	31
7.5.4 Methods for determining angular subtense (α)	31
7.5.5 Multiple sources and simple non-circular beams	37
7.5.6 Radiance limit – conventional lamp replacement	42
7.6 Class 1C – scattered light leakage	43
7.7 Measurement conditions	43
7.7.1 General	43
7.7.2 Measurement conditions for classification	43
7.7.3 Measurement conditions for hazard evaluation	44
7.8 Scanning beams	48
7.8.1 General	48
7.8.2 Stationary angular subtense (α_s)	48
7.8.3 Scanned emission duration (T_p)	49
7.8.4 Scanning angular subtense (α_{scan})	50

7.8.5	Bi-directional scanning	51
7.8.6	Number of scan lines in aperture (n)	52
7.8.7	Most restrictive position	53
7.8.8	Gaussian beam coupling parameter (η).....	54
7.8.9	Scan angle multiplication factor	54
Annex A	(informative) Examples	56
A.1	Large source classification example.....	56
A.1.1	General	56
A.1.2	Limit for unaided viewing	56
A.1.3	Analysis for aided viewing	57
A.2	Scanning beam examples	59
A.2.1	Simple faceted mirror polygon	59
A.2.2	Scanning Raster	63
A.2.3	Bi-directional scanning	64
A.2.4	Laser projector classification	66
A.3	Collimated laser diode example	70
A.4	Single mode fiber example	72
A.5	Beam waist example	75
A.6	Multiple wavelength laser example.....	76
A.7	Linear array of laser fibres example	77
A.8	Linear array of lasers example	78
A.9	Example for an analysis of a complex source.....	79
Annex B	(informative) Useful conversions	84
B.1	Solid angle (Ω) and linear (full) angle (or divergence) (ϕ).....	84
B.2	Gaussian beam divergence or diameter	84
B.3	Degrees and radians.....	84
B.4	Multimode fibre diameter.....	84
B.5	Single mode fibre diameter	84
Annex C	(informative) Differences between IEC-60825-1:2014 and the European deviation EN 60825-1 A11 2021.....	85
Bibliography	86
Figure 1	– Continuous wave laser classification flow.....	13
Figure 2	– Pulsed laser classification flow.....	14
Figure 3	– Wavelength and wavelength ranges with high AEL variability	15
Figure 4	– Emission duration definition for a single pulse	23
Figure 5	– Flat-topped and irregular pulses	23
Figure 6	– Example of groups of pulses	25
Figure 7	– Example of a pulse train consisting of groups of pulses, with group duration longer than T_i and individual emission durations shorter than T_i	27
Figure 8	– Example of a train of pulses consisting of pulses with a duration of 7 μ s and 3 μ s	28
Figure 9	– Angular subtense	29
Figure 10	– Location of beam waist for a Gaussian beam	31
Figure 11	– Measurement setup using a lens to image the apparent source onto a field stop	33
Figure 12	– Direct measurement setup where the field stop is placed at the source	36

Figure 13 – Linear array apparent source size	38
Figure 14 – Measurement geometries	40
Figure 15 – Long and short angular subtense of a non-circular source	41
Figure 16 – Imaging a stationary apparent source located beyond the scanning beam vertex	49
Figure 17 – Imaging a scanning apparent source located beyond the scanning beam vertex	50
Figure 18 – Scanning mirror with an arbitrary scan angle multiplication factor	55
Figure A.1 – Multiple raster lines crossing the aperture stop at distance from scanning vertex where $C_6 = 1$	64
Figure A.2 – Source pattern for the example of 20 diode emitters	80
Figure A.3 – Example of two cases of subgroups	81
Table 1 – Reference points	30
Table 2 – Four source array	39
Table A.1 – Number of source cases	78
Table A.2 – Number of source cases	79

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Safety of laser products -
Part 13: Measurements for classification of laser products**

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 60825-13 has been prepared by IEC technical committee 76: Optical radiation safety and laser equipment. It is a Technical Specification.

This first edition cancels and replaces the second edition of IEC TR 60825-13 published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TR 60825-13:2011:

- a) minor changes and additions have been made in the definitions;
- b) classification flow has been updated;
- c) apparent source sections have been clarified;
- d) scanning has been updated;
- e) more examples and useful conversions have been added to the annexes.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
76/786/DTS	76/791/RVDTS

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 Technical Specification 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/publications.

This document is to be used in conjunction with IEC 60825-1:2014.

A list of all parts of the IEC 60825 series, published under the general title *Safety of laser products*, can be found on the IEC website.

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, or
- revised.

1 Scope

This part of IEC 60825, which is a Technical Specification, provides manufacturers, test houses, safety personnel, and others with practical guidance on methods to perform radiometric measurements or analyses to establish the emission level of laser energy or power in accordance with IEC 60825-1:2014. The measurement procedures described in this document are guidance for classification of laser products in accordance with IEC 60825-1:2014. It is possible that other procedures are better or more appropriate.

Information is provided for calculating accessible emission limits (AELs) and maximum permissible exposures (MPEs), since some parameters used in calculating the limits are dependent upon other measured quantities.

This document applies to lasers, including extended sources and laser arrays. The procedures described in this document for extended source viewing conditions can yield more conservative results than when using more rigorous methods.

NOTE Work continues on more complex source evaluations and will be provided as international agreement on the methods is reached.

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*¹

Bibliography

- [1] IEC 62471:2006, *Photobiological safety of lamps and lamp systems*
- [2] IEC 60825-2:2021, *Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCSS)*
- [3] ISO 11554, *Optics and photonics - Lasers and laser-related equipment - Test methods for laser beam radiant power, radiant energy and temporal characteristics*
- [4] GALBIATI, Enrico. *Evaluation of the apparent source in laser safety*. Journal of Laser Applications 2001,13, p.141-149
- [5] LYON, Terry. *Hazard Analysis Technique for Multiple Wavelength Lasers*. Health Physics, August 1985, 49(2):221-226
- [6] SCHULMEISTER, Karl. *Classification of extended source products according to IEC 60825-1*. ILSC 2015 Proceedings Paper #C101, p 271 – 280;
- [7] Download of amended proceedings paper:
http://laser-led-lamp-safety.seibersdorf-laboratories.at/fileadmin/uploads/intranet/dateien/ILSC_2015_Extended_Source_Products_IEC_60825-1_Schulmeister.pdf
- [8] SCHULMEISTER, Karl. *Notes on the determination of the angular subtense of the apparent source in laser safety*, ILSC 2019, 1205 (2019)
<https://doi.org/10.2351/1.5118538>
- [9] Kotzur, S, Wahl, S, Frederiksen, A. *Wave optical simulation of retinal images in laser safety evaluations*, J. Biophotonics, 2020;e20200033,
<https://doi.org/10.1002/jbio.202000339>
- [10] Kotzur, S, Wahl, S, Frederiksen, A., *Retinal image analysis for eye safety evaluations of products emitting optical radiation*, Proc. SPIE 11238, Optical Interactions with Tissue and Cells XXXI, 1123808 (20 February 2020); <https://doi.org/10.1117/12.2545673>
- [11] SCHULMEISTER, Karl. *The European Amendment A11:2021 to EN 60825-1*, Seibersdorf-Laboratories,
https://laser-led-lamp-safety.seibersdorf-laboratories.at/fileadmin/uploads/intranet/dateien/le/laser/whitepaper_a11_to_en_60825-1_v2_2022.pdf
- [12] Joint Committee for Guides in Metrology (JCGM) Publications, JCGM 100:2008, <https://www.bipm.org/en/committees/jc/jcgm/publications/>
- [13] ISO/IEC Guide 98-3:2008, *Uncertainty Of Measurement - Part 3: Guide To The Expression Of Uncertainty In Measurement (GUM:1995)*
- [14] IEC TR 60825-14:2022, *Safety of laser products - Part 14: A user's guide*
- [15] ISO 11146-1:2021, *Lasers and laser-related equipment - Test methods for laser beam widths, divergence angles and beam propagation ratios - Part 1: Stigmatic and simple astigmatic beams*
- [16] ISO/TR 11146-3:2004, *Lasers and laser-related equipment - Test methods for laser beam widths, divergence angles and beam propagation ratios - Part 3: Intrinsic and geometrical laser beam classification, propagation and details of test methods*