SLOVENSKI STANDARD
oSIST prEN ISO 11554:2023

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Optika in fotonska tehnologija - Laserji in laserska oprema - Preskusne metode za sevalno moč, sevalno energijo in časovne karakteristike laserkih žarkov (ISO/DIS 11554:2023)

Optics and photonics - Lasers and laser-related equipment - Test methods for laser beam radiant power, radiant energy and temporal characteristics (ISO/DIS 11554:2023)

Optik und Photonik - Laser und Laseranlagen - Prüfverfahren für Leistung, Energie und Kenngrößen des Zeitverhaltens von Laserstrahlen (ISO/DIS 11554:2023)

Optique et photonique - Lasers et équipements associés aux lasers - Méthodes d'essai de la puissance rayonnante, de l'énergie rayonnante et des caractéristiques temporelles des faisceaux lasers (ISO/DIS 11554:2023)

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Optique et photonique - Lasers et équipements associés aux lasers — Méthodes d'essai de la puissance rayonnante, de l'énergie rayonnante et des caractéristiques temporelles des faisceaux lasers

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Laser and electro-optical systems*.

This fifth edition cancels and replaces the fourth edition (ISO 11554:2017) which has been technically revised.

The main changes compared to the previous edition are as follows:

a) Whole document: The term “power" and “energy” that mean optical power and optical energy have been replaced by “radiant power” and “radiant energy”, respectively, in order to align with ISO 80000-7: 2019 and the International Electrotechnical Vocabulary.

b) Normative references: IEC 61040: 1990 has been removed because it was withdrawn in August 2011.

c) Subclause 3.1: Definition of RIN has been corrected.

d) Figure 2: Keys 4, 5 and 6 have been amended.

e) Subclause 6.3: Explanatory text has been added instead of referencing IEC 61040: 1990.

f) Subclause 7.9: Measurement procedure has been modified to clarify the method for removing thermal and shot noise terms as well as pre-amplifier noise from the measured noise power.

g) Clause 9, c), 5): The terms “current or energy input”, “pulse energy”, “pulse duration” and “pulse repetition rate” have been modified in order to clarify their characteristics.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The measurement of laser radiant power (radiant energy for pulsed lasers) is a common type of measurement performed by laser manufacturers and users. Radiant power (radiant energy) measurements are needed for laser safety classification, stability specifications, maximum laser output specifications, damage avoidance, specific application requirements, etc. This document provides guidance on performing laser radiant power (radiant energy) measurements as applied to stability characterization. The stability criteria are described for various temporal regions (e.g. short-term, medium term and long term) and provide methods to quantify these specifications. This document also covers pulse measurements where detector response speed can be critically important when analysing pulse shape or peak radiant power of short pulses. To standardize reporting of radiant power (radiant energy) measurement results, a report template is also included.

This document is a Type B standard as stated in ISO 12100.

The provisions of this document may be supplemented or modified by a Type C standard.

Note that for machines which are covered by the scope of a Type C standard and which have been designed and built according to the provisions of that standard, the provisions of that Type C standard take precedence over the provisions of this Type B standard.

Optics and photonics — Lasers and laser-related equipment — Test methods for laser beam radiant power, radiant energy and temporal characteristics

1 Scope

This document specifies test methods for determining the radiant power and radiant energy of continuous wave and pulsed laser beams, as well as their temporal characteristics of pulse shape, pulse duration and pulse repetition rate. Test and evaluation methods are also given for the radiant power stability of cw-lasers, radiant energy stability of pulsed lasers and pulse duration stability.

The test methods given in this document are used for the testing and characterization of lasers.

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.

ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145, ISO/IEC Guide 99 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
relative intensity noise
RIN
R(*f*)
quotient of the radiant power mean square fluctuations to the square of the mean radiant power, normalized to a frequency band of unit width

$$R(f)=\frac{\left\langle \Delta P(f)^2\right\rangle}{\left\langle P\right\rangle^2}\cdot\frac{1}{\Delta f} \qquad (1)$$

where Δf is the equivalent noise bandwidth.

Note 1 to entry: The relative intensity noise $R(f)$ or RIN [see Formula (1)] is explicitly spoken of as the “relative intensity noise spectral density”, but usually simply referred to as RIN.

Note 2 to entry: For further details, see Annex A.

3.2
small signal cut off frequency
f_c
frequency at which the laser radiant power output modulation drops to half the value obtained at low frequencies when applying small, constant input radiant power modulation and increasing the frequency

4 Symbols and units of measurement

The symbols and units specified in ISO 11145 and in Table 1 are used in this document.

Table 1 — Symbols and units of measurement

Symbol	Unit	Term
f	Hz	Frequency
f_c	Hz	Small signal cut-off frequency
$[f_1,f_2]$	Hz	Frequency range for which the relative intensity noise $R(f)$ is given
k	1	Coverage factor for the determination of uncertainty
m	1	Reading
$\bar{m}$	1	Mean value of readings
P	W	Radiant power averaged over the sampling period
$\bar{P}$	W	Mean radiant power, averaged over the measurement period at the operating conditions specified by the manufacturer
ΔP	1	Relative radiant power fluctuation to a 95 % confidence level for the appropriate sampling period [ΔP (1 µs) and/or ΔP (1 ms) and/or ΔP (0,1 s) and/or ΔP (1 s)]
$\bar{Q}$	J	Mean pulse radiant energy
ΔQ	1	Relative pulse radiant energy fluctuation to a 95 % confidence level
$R(f)$	Hz^{-1} or dB/Hz	Relative intensity noise, RIN
$S(t)$	1	Detector signal
s	1	Measured standard deviation
T	s	Pulse repetition period
t	s	Measurement period
U_{rel}	1	Expanded relative uncertainty corresponding to a 95 % confidence level (coverage factor k = 2)
$U_{rel}(C)$	1	Expanded relative uncertainty of calibration corresponding to a 95 % confidence level (coverage factor k = 2)
τ_F	s	Fall time of laser pulse
$\Delta\tau_H$	1	Relative pulse duration fluctuation with regard to τ_H to a 95 % confidence level
τ_R	s	Rise time of laser pulse
$\Delta\tau_{10}$	1	Relative pulse duration fluctuation with regard to τ_{10} to a 95 % confidence level

NOTE 1 For further details regarding 95 % confidence level see ISO 2602[1].

NOTE 2 The expanded uncertainty is obtained by multiplying the standard uncertainty by a coverage factor k = 2. It is determined according to the *Guide to the Expression of Uncertainty in Measurement*.[3] In general, with this coverage factor, the value of the measurand lies with a probability of approximately 95 % within the interval defined by the expanded uncertainty.

NOTE 3 $R(f)$ expressed in dB/Hz equals 10 $\log_{10}R(f)$ with $R(f)$ given in Hz^{-1}.

5 Measurement principles

The laser beam is directed on to the detector surface to produce a signal with amplitude proportional to the radiant power or radiant energy of the laser. The amplitude versus time is measured. Radiation emitted by sources with large divergence angles is collected by an integrating sphere. Beam forming and attenuation devices may be used when appropriate.

The evaluation method depends on the parameter to be determined and is described in Clause 8.

6 Measurement configuration, test equipment and auxiliary devices

6.1 Preparation

6.1.1 Sources with small divergence angles

The laser beam and the optical axis of the measuring system shall be coaxial. Select the diameter (cross-section) of the optical system such that it accommodates the entire cross section of the laser beam and so that clipping or diffraction loss is smaller than 10 % of the intended measurement uncertainty.

Arrange an optical axis so that it is coaxial with the laser beam to be measured. Suitable optical alignment devices are available for this purpose (e.g. aligning lasers or steering mirrors). Mount the attenuators or beam forming optics such that the optical axis runs through the geometrical centres. Care should be exercised to avoid systematic errors.

NOTE 1 Reflections, external ambient light, thermal radiation and air currents are all potential sources of errors.

After the initial preparation is completed, make an evaluation to determine if the entire laser beam reaches the detector surface. For this determination, apertures of different diameters can be introduced into the beam path in front of each optical component. Reduce the aperture size until the output signal has been reduced by 5 %. This aperture should have a diameter at least 20 % smaller than the aperture of the optical component. For divergent beams, the aperture should be placed immediately in front of the detector to ensure total beam capture.

NOTE 2 Remove these apertures before performing the radiant power (radiant energy) measurements described in Clause 7.

6.1.2 Sources with large divergence angles

The radiation emitted by sources with large divergence angles shall be collected by an integrating sphere. The collected radiation is subjected to multiple reflections from the wall of the integrating sphere; this leads to a uniform irradiance of the surface proportional to the collected flux. A detector located in the wall of the sphere measures this irradiance. An opaque screen shields the detector from the direct radiation of the device being measured. The emitting device is positioned at or near the entrance of the integrating sphere, so that no direct radiation will reach the detector.

Figure 1 shows an integrating sphere measurement configuration for a small emitting source positioned inside the integrating sphere. Large sized sources should, of course, be positioned outside the sphere but close enough to the input aperture so that all emitted radiation enters the sphere.