SLOVENSKI STANDARD
oSIST prEN ISO 13696:2021

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Optika in optični instrumenti - Preskusne metode za sevanje, razpršeno z optičnimi komponentami (ISO/DIS 13696:2021)

Optics and photonics - Test method for total scattering by optical components (ISO/DIS 13696:2021)

Optik und Photonik - Bestimmung von Streustrahlung, hervorgerufen durch optische Komponenten (ISO/DIS 13696:2021)

Optique et photonique - Méthodes d'essai du rayonnement diffusé par les composants optiques (ISO/DIS 13696:2021)

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Optics and photonics — Test method for total scattering by optical components

Optique et photonique — Méthodes d'essai du rayonnement diffusé par les composants optiques

ICS: 31.260

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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).

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

This second edition cancels and replaces the first edition (ISO 13696:2002), which has been technically revised.

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

Scope: measurement range outlined in more detail and limited to 250 nm. For measurements in the deep ultraviolet between 190 nm to 250 nm, specific methods have to be considered and are described.

3.1.6: additional Note 2 inserted for high volume scattering of the specimen

3.1.6: additional Note 3 inserted for comprehensive illustration of the term total scattering

3.1.7: Note extended concerning diffuse reflectance standard for wavelengths below 250 nm down to the deep ultraviolet

3.2: New symbols for total scattering (σ_{TS}), forward scattering (τ_{TS}), and backward scattering (ρ_{TS}) in Table 1.

Figure 1 and 4.2.5: lock-in amplifier optional. For fast data acquisition modules, no Lock-in technique may be necessary

4.2.2: calibration of the monitor detector is not necessary. The power at the sample surface shall be measured by a calibrated detector.

4.2.4: additional Note 1 inserted concerning aging of the diffuse reflecting material on the inner walls of the sphere.

4.2.5: additional Note inserted concerning optional components for a phase sensitive detection scheme with lock-in amplifier.

5.3: change of measurement sequence starting with power measurement calibration procedure, and determination of the signal of the unloaded sphere prior to the measurement of the specimen.

6.1: additional Note 3 inserted concerning specimens larger than the diffuse reflectance standard for the case of single point measurements.

6.1: adaptation of Formulae (1, 2) and (5) to (8) (in the denominator $V_{\mathrm{c}}\left(\mathrm{r_i}\right)$ was adapted to V_{c})

Formula (C2) reads $\sigma_{\mathrm{s}} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(M_S - \rho_{\mathrm{TS,sc}}\left(r_i\right)\right)^2}$

6.1: additional Note 6 inserted concerning calibration samples with arbitrary diffuse reflectance

Annex E: additional Annex inserted concerning alternative method for calibrating total scatter measurements using a calcium fluoride diffuser disk

Bibliography: ISO 31-6:1992 was replaced by current version ISO 80000-7, same for ISO 11146 with ISO 11146-1 and −2, ISO 11554 and ISO 12005 no longer cited dated. Also replacement of former citations [5] and [6] by latest edition of SEMI F1048

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

In most applications, scattering in optical components reduces the efficiency and deteriorates the image-forming quality of optical systems. Scattering is predominantly produced by imperfections of the coatings and the optical surfaces of the components. Common surface features, which contribute to optical scattering, are imperfections of substrates, thin films and interfaces, surface and interface roughness, or contamination and scratches. These imperfections deflect a fraction of the incident radiation from the specular path. The spatial distribution of this scattered radiation is dependent on the wavelength of the incident radiation and on the individual optical properties of the component. For most applications in laser technology and optics, the amount of total loss produced by scattering is a useful quality criterion of an optical component.

This document describes a testing procedure for the corresponding quantity, the total scattering (σ_{TS}) value, which is defined by the measured values of backward scattering and forward scattering. The measurement principle described in this document is based on an Ulbricht sphere as the integrating element for scattered radiation. An alternative apparatus with a Coblentz hemisphere, which is also frequently employed for collecting scattered light, is described in Annex A.

Annexes A to E of this document are for information only.

Optics and photonics — Test method for total scattering by optical components

1 Scope

This document specifies procedures for the determination of the total scattering by coated and uncoated optical surfaces. Procedures are given for measuring the contributions of the forward scattering and backward scattering to the total scattering of an optical component.

This document applies to coated and uncoated optical components with optical surfaces that have a radius of curvature of more than 10 m. Measurement wavelengths covered by this document range from the ultraviolet above 250 nm to the infrared spectral region below 15 µm. For measurements in the deep ultraviolet between 190 nm to 250 nm, specific methods have to be considered and are described. Generally, optical scattering is considered as neglectable for wavelengths above 15 µm.

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 14644-1:2015, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145 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/

3.1.1
scattered radiation
fraction of the incident radiation that is deflected from the specular optical path

3.1.2
front surface
optical surface that interacts first with the incident radiation

3.1.3
rear surface
surface that interacts last with the transmitted radiation

3.1.4
backward scattering

fraction of radiation scattered by the optical component into the backward halfspace

Note 1 to entry: Backward halfspace is defined by the halfspace that contains the incident beam impinging upon the component and that is limited by a plane containing the front surface of the optical component.

3.1.5
forward scattering

fraction of radiation scattered by the optical component into the forward halfspace

Note 1 to entry: Forward halfspace is defined by the halfspace that contains the beam transmitted by the component and that is limited by a plane containing the rear surface of the optical component.

3.1.6
total scattering

ratio of the total power generated by all contributions of scattered radiation into the forward or the backward halfspace to the power of the incident radiation

Note 1 to entry: The halfspace in which the scattering is measured should be clearly stated.

Note 2 to entry: The sum of the measured forward and backward scattering does not include the contribution of the bulk material in the optical component. In case the volume scattering of the component is not negligible, the total scatter losses may exceed the sum of forward and backward scattering.

Note 3 to entry: Total scattering is equal to forward or backward scattering, and is neither the sum of both nor the sum of all scattering contributions.

3.1.7
diffuse reflectance standard

diffuse reflector with known total reflectance

Note 1 to entry: Commonly used diffuse reflectance standards are fabricated from barium sulfate or polytetrafluoroethylene powders (see Table 2). The total reflectance of reflectors freshly prepared from these materials is typically greater than 0,98 in the spectral range given in Table 2, and it can be considered as a 100 % reflectance standard. For increasing the accuracy, diffuse reflectance standards with lower reflectance values can be realized by mixtures of polytetrafluoroethylene powder and powders of absorbing materials. (See Reference [6] in the Bibliography.) Further concepts for diffuse reflectance standards include optical surfaces with specially prepared microstructures, metal-coated diffusers or diffuse transparent reference samples. A versatile method on the basis of a calcium fluoride diffuser disk for the wavelength range from 250 nm down to the deep ultraviolet is described in Annex E.

3.1.8
range of acceptance angle

range from the minimum to the maximum angle with respect to the reflected or transmitted beam that can be collected by the integrating element

3.1.9
angle of polarization

angle between the major axis of the instantaneous polarization ellipse of the incident radiation and the plane of incidence

Note 1 to entry: For non-normal incidence, the plane of incidence is defined by the plane which contains the direction of propagation of the incident radiation and the normal at the point of incidence.

Note 2 to entry: The angle of polarization, γ, is identical to the azimuth, Φ (according to ISO 12005) , if the reference axis is located in the plane of incidence.

3.2 Symbols and units of measure

Table 1 — Symbols and units of measure

Symbol	Term	Unit
λ	Wavelength	nm
α	Angle of incidence	degrees
γ	Angle of polarization	degrees
d_σ	Beam diameter on the surface of the specimen	mm
P_{inc}	Power of the incident radiation	W
P_{bac}	Total power, backward scattered radiation	W
P_{for}	Total power, forward scattered radiation	W
σ_{TS}	Total scattering	
ρ_{TS}	Backward scattering	
τ_{TS}	Forward scattering	
$V_{\mathrm{s,bac}}$	Detector signal for the specimen, backward scattering	V
$V_{\mathrm{s,for}}$	Detector signal for the specimen, forward scattering	V
V_{c}	Detector signal, diffuse reflectance standard	V
V_{u}	Detector signal, test ports open	V
τ_{s}	Transmittance of specimen at wavelength, λ	
ρ_{s}	Reflectance of specimen at wavelength, λ	
r_i	Sample position	mm
N	Number of test sites per surface	

4 Test method

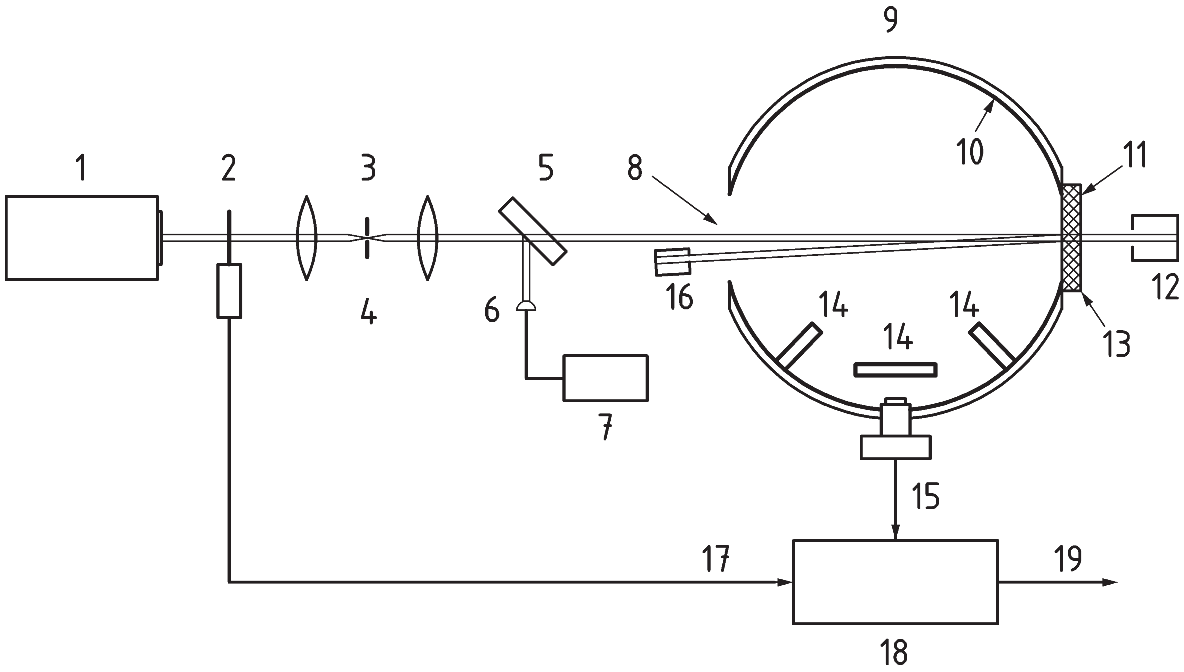
4.1 Principle

The fundamental principle (see Figure 1) of the measurement apparatus is based on the collection and integration of the scattered radiation. For this purpose, a hollow sphere with a diffusely reflecting coating on the inner surface (Ulbricht sphere) is employed. Beam ports are necessary for the transmission of the test beam and the specularly reflected beam through the wall of the sphere. The sample is attached to one of these ports forming a part of the inner surface of the sphere. For the measurement of the backward scattering, the specimen is located at the exit port. The forward scattering is determined by mounting the specimen to the entrance port. The scattered radiation is integrated by the sphere and measured by a suitable detector, which is attached to an additional port at an appropriate position. A diffuse reflectance standard is used for calibration of the detector signal.

4.2 Measurement arrangement and test equipment

4.2.1 General

The measurement facility employed for the determination of the total scattering is divided into four functional sections, which are described in detail below. One functional section consists of the radiation source and the beam preparation system. Two different components are defined by the integration and detection of the scattered radiation. Another section is formed by the sample holder and its optional accessories.



Key

1	Radiation source	11	Exit port
2	Chopper	12	Beam stop
3	Spatial filter	13	Sample
4	Telescope	14	Radiation baffles
5	Beam splitter	15	Detector, diffuser
6	Power detector	16	Beam stop
7	Power meter	17	Chopper signal
8	Entrance port	18	Lock-in amplifier (optional)
9	Ulbricht sphere	19	Detector signal, V_s
10	Coating		

Figure 1 — Schematic arrangement for the measurement of total scattering (configuration for backward scattering with phase sensitive detection scheme)

4.2.2 Radiation source

As radiation sources, lasers are preferred because of their excellent beam quality and the high power density achievable on the sample surface. For special applications involving the wavelength dependence of scattering, different conventional radiation sources may be used in conjunction with spectral filters or monochromators. Different types of discharge, arc or tungsten lamps are suitable for wavelength-resolved total scatter measurements.

The temporal power variation of the radiation source shall be measured and documented. For this purpose, a beam splitter and a monitor detector are installed. The power at the sample surface shall be measured by a calibrated detector for both test locations at the entrance and exit port of the integrating element.

4.2.3 Beam preparation system

The beam preparation system consists of a spatial filter and additional apertures, if necessary, for cleaning the beam. For measurements involving conventional radiation sources, additional optical elements are required for the shaping and collimation of the beam. The beam diameter, d_σ, at the surface