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Eye and face protection — Protection against laser radiation —

Part 1: Requirements and test methods

Protection des yeux et du visage — Protection contre le rayonnement laser —

Partie 1: Exigences et méthodes d'essai

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Foreword

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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).

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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 94, *Personal safety — Personal protective equipment*, Subcommittee SC 6, *Eye and face protection*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 85, *Eye protective equipment*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement). The document was developed as a joint project with IEC/TC 76, "Optical radiation safety and laser equipment".

This first edition of ISO 19818-1 cancels and replaces the first edition of ISO 6161:1981, which has been technically revised.

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

This document was developed in response to the worldwide stakeholders' demand for minimum requirements and test methods for laser eye and face protectors traded internationally.

Preparation of this document aimed to draw upon the best aspects of these preceding standards, and offer improvements where appropriate. The document was developed by a Joint Working Group involving experts from ISO/TC 94/SC 6 (Eye and Face Protection) and IEC/TC 76 (Optical Radiation Safety and Laser Equipment), to bring together the two aspects of personal protection and laser safety.

In the general context of eye and face protection ISO 4007 gives the terms and definitions. The test methods are given in the ISO 18526 series, while the requirements for occupational eye and face protectors are given in the ISO 16321 series. Eye protectors for specific sports are mostly dealt with by the ISO 18527 series. ISO 19734 is a guidance document for the selection, use and maintenance of eye and face protectors.

A guidance document addressing selection and use of personal eye and face protection against lasers is currently under development and will form a guide to users of protectors described in this document.

NOTE ISO 6161 was published in 1981 but was not widely adopted. The document was four pages in length. No development of that document has taken place since 1981, although comparable regional standards have since been developed (EN 207[5] and EN 208[6] in Europe; ANSI Z136.7[7] in the United States).

Eye and face protection — Protection against laser radiation —

Part 1: Requirements and test methods

1 Scope

This document is applicable to protectors intended to provide protection against accidental exposure to laser radiation within the wavelength range 180 nm to 1 mm. It specifies the requirements, test methods and marking. Protectors intended for adjustment work on lasers are included in the scope of this document and are marked in the same way as other protectors, but selection of appropriate eyewear for a specific application is a choice of the user. Laser protective filters used as viewing windows in laser equipment machinery or incorporated into optical instruments such as operating microscopes and loupes that may be used for deliberate viewing of laser radiation as part of their function are outside the scope of this document.

Laser radiation in the wavelength range below 180 nm is absorbed in air, therefore eye and face protection should not be required.

This document is applicable to devices intended for patient protection during medical laser procedures except for treatment in the periorbital area. Guidance on eye protectors for patients (including those used for periorbital treatment) is given in ISO/TR 22463.

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 4007, *Personal protective equipment — Eye and face protection — Vocabulary*

ISO 16321-1:2021, *Eye and face protection for occupational use — Part 1: General requirements*

ISO 16321-2:2021, *Eye and face protection for occupational use — Part 2: Additional requirements for protectors used during welding and related techniques*

ISO 18526-1:2020, *Eye and face protection — Test methods — Part 1: Geometrical optical properties*

ISO 18526-2:2020, *Eye and face protection — Test methods — Part 2: Physical optical properties*

ISO 18526-3:2020, *Eye and face protection — Test methods — Part 3: Physical and mechanical properties*

ISO 18526-4:2020, *Eye and face protection — Test methods — Part 4: Headforms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4007 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 http://www.electropedia.org/

3.1
resistance category
RC
rating for a protector that specifies its ability to withstand a given level of irradiance or radiant exposure without compromise to its protective properties

Note 1 to entry: Laser filters and frames may provide different resistance categories for different laser modes, wavelengths or wavelength ranges.

3.2
optical density (spectral)
OD
$D(\lambda)$
logarithm to the base 10 of the reciprocal of the (spectral) transmittance

Note 1 to entry: Optical density is therefore expressed by the formula:

$$D(\lambda) = -\log_{10} \tau(\lambda)$$

where $\tau(\lambda)$ is the spectral transmittance.

Note 2 to entry: Practically OD can be considered a measure of the orders of magnitude of attenuation experienced by laser energy passing through a filter.

[SOURCE: ISO 4007:2018, 3.10.1.21 – Note 1 to entry and Note 2 to entry have been modified.]

3.3
pulse duration
time interval between the half-peak power points at the leading and trailing edges of a pulse

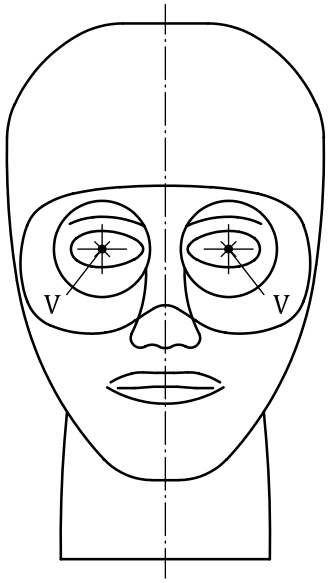
Note 1 to entry: For ultrashort pulses, pulse duration is linked to spectral bandwidth.

[SOURCE: IEC 60825-1:2014, 3.69 modified – "increment" changed to "interval" in the definition, Note 1 to entry added and "measured" removed from the definition.]

3.4
reference points (for testing)
visual centres
mounted lenses points on each lens corresponding to the intersection of the horizontal and vertical planes through the pupils of the appropriate headform when the protector is correctly fitted on it

Note 1 to entry: See Figure 1.

[SOURCE: ISO 4007:2018, 3.8.7 modified – internal references in ISO 4007 have been removed from the definition.]



Key

V reference points (for testing)

Figure 1 — Reference points for mounted lenses

4 Requirements for the protector[1)]

4.1 Performance requirements

4.1.1 Laser pulse and exposure duration

The laser pulse and exposure duration for which the protector is designated shall be determined in accordance with Table 1.

Table 1 — Laser type classification

Pulse/exposure duration	Laser type
s	
$\geq 10^{-1}$	C[ab]
$\geq 10^{-5}$ to $<10^{-1}$	P[a]
$\geq 10^{-10}$ to $<10^{-5}$	S[a]
$<10^{-10}$	U

[a] If the protector is intended for more than one type of laser emission, all intended pulse and exposure durations shall be stated. If the protector is used for all the laser pulse and exposure durations C, P and S for the same wavelength range and resistance category (see 4.1.4), the symbol A shall be used.

[b] C includes long-pulsed lasers and continuous wave lasers.

C = Continuous

P = Pulsed

S = Short Pulsed

U = Ultra Short Pulsed

1) For the purposes of this document, “protector” is used as a general term for eye protector and/or eye and face protectors used for laser protection.

4.1.2 Optical density (OD)

The optical density shall be defined for each wavelength of intended use of the protector.

In the case of protectors intended for use at more than one wavelength, the value of the optical density shall be specified for each wavelength and/or wavelength range.

Where the optical density is defined for a continuous range of wavelengths, the minimum value of the optical density in the wavelength range shall be specified.

For optical densities greater than 2,9, the optical density shall be expressed as a whole number that is no greater than the actual optical density minus the uncertainty of measurement and no greater than 8. For optical densities of 2,9 or less, the optical density shall be expressed to a maximum of one decimal place and indicate the rounded down value of the actual optical density minus the uncertainty of measurement.

The optical density shall be measured in accordance with 5.2. The optical density of any part of the filters or frames through which exposure to incident laser radiation could occur to the eyes (in the case of eye protectors) or the face (in the case of face protectors) shall not be less than the minimum value defined by the manufacturer, taking into account the uncertainty of measurement. See ISO 18526-2:2020, Annex A.

Special filters, for example filters with dielectric coatings, show an angle-dependent spectral transmittance. For these filters, the spectral transmittance shall be measured for the entire angular range from 0° to 30° angle of incidence at intervals no more than 5° (see 5.2). Where the specified optical density is limited to this range of angles, a written warning shall be included in the user information supplied with the protector (see 4.7).

4.1.3 Transmittance to short pulses

The spectral transmittance of the protectors intended for use with S and/or U pulse and exposure durations (see Table 1) shall be tested for saturable absorption using a laser with pulse or exposure duration corresponding to S and/or U (see Table 1) in accordance with 5.3.

4.1.4 Resistance category (RC)

For the intended use of the protector, the resistance category for the specified individual wavelength or wavelength range shall be determined. For protectors with multiple specified wavelengths or wavelength ranges, the resistance categories of each of the specified multiple wavelengths or each of the specified wavelength ranges shall be determined. The resistance category/categories shall be tested in accordance with 5.4.

The filter(s), side-shields and other parts of the frame or support that have a protective function shall maintain at least the specified optical density under the level of exposure specified in 5.4 for at least five seconds or at least 50 pulses, whichever is the longer period, delivered, if possible, within no more than 10 s.

Failure or decrease of protective properties could be due to burn, cracks, structural melting, photobleaching including reversible photobleaching, delamination of coatings, saturable absorption. This list is not exhaustive. Visible damage to the filter or the frame is permitted provided this does not affect its protective properties.

4.1.5 Luminous transmittance

The photopic luminous transmittance of the protective filters shall be specified and determined in accordance with 5.5. Where the luminous transmittance is less than 20 %, a warning shall be included in the information supplied with the protector [see 4.7 i)] that it has a low luminous transmission that may affect the wearer's awareness of other hazards.

4.1.6 Dynamic protection

For filters that exhibit an increase in optical density in response to an exposure to incident laser radiation, the time taken for the optical density to reach its full specified protective level should be determined and specified. Dynamic protectors should provide protection whenever laser radiation is incident on any protective part of the protector.

4.1.7 Field of view

When measured in accordance with ISO 18526-3:2020, 6.2, protectors, in the as-worn position, shall have a minimum unobstructed field of view in front of each eye of 40° temporally and 20° nasally in the horizontal meridian, and 30° superiorly and inferiorly in the vertical meridian.

4.1.8 Refractive power of filters and protectors

When assessed in accordance with ISO 18526-1:2020, Clause 6, the maximum refractive power of filters and protectors with no corrective effect shall be as given in Table 2.

Table 2 — Maximum refractive power of filters and protectors with no corrective effect

Spherical power	**Cylindrical power**	**Prism imbalance**		
		horizontal		**vertical**
Mean value of the focal powers (F_1, F_2) in the two principal meridians $(F_1 + F_2)/2$	Absolute difference between the focal powers (F_1, F_2) in the two principal meridians $\lvert F_1 - F_2 \rvert$	**base out**	**base in**	
dioptres (D)	dioptres (D)	prism dioptres (Δ)	prism dioptres (Δ)	prism dioptres (Δ)
±0,09	0,09	0,75	0,25	0,25

The tests for determining the refractive power and prism imbalance of filters and protectors shall be carried out in accordance with ISO 18526-1:2020, Clause 6.

4.2 Construction of protectors

All parts of the protector shall be designed so that no hazardous laser radiation can penetrate from the sides, or from above or below the horizontal plane. This requirement is met if, for a horizontal angular range α from −50° (nasal side) to +90° (temporal side), the specified level of protection is provided within the vertical angular range β, where β is subtended at the corneal vertex and satisfies the following two conditions.

The upward limit of β_u (measured upwards from the horizontal plane), in degrees (°), shall be at least, as given by Formula (1):

$$\beta_u = 55 - 0{,}0013 \cdot (\alpha - 12)^2 - 1{,}3 \times 10^{-6} \cdot (\alpha - 12)^4 \quad (1)$$

The downward limit of β_d (measured downwards from the horizontal plane), in degrees (°), shall be at least, as given in Formula (2):

$$\beta_d = -70 + 10^{-5} \cdot (\alpha - 22)^2 + 2{,}3 \times 10^{-6} \cdot (\alpha - 22)^4 \quad (2)$$

NOTE The protected area does not apply to filters having limited angular coverage, e.g. dielectric interference coatings.

The filter and frame shall meet the requirements of ISO 16321-1:2021, 6.6, for frame transmittance, paying particular attention to air vents or gaps in the protector.