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Eye and face protection — Protection against laser radiation —

Part 1:
Requirements and test methods

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Member bodies are requested to consult relevant national interests in IEC/TC 76 before casting their ballot to the e-Balloting application.

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 94 *Personal safety - Personal protective equipment*, Subcommittee SC 6, *Eye and face protection*. The document was developed as a joint project with IEC/TC 76 "Optical radiation safety and laser equipment".

This document cancels and replaces (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.

ISO 6161 (Personal eye-protectors -- Filters and eye-protectors against laser radiation) 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 and EN 208 in Europe; ANSI Z136.7 in the United States). Preparation of this document, ISO 19818, 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. A guidance document for the selection, use and maintenance of eye and face protectors, ISO 19734, is in preparation.

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.

Eye and face protection — Protection against laser radiation —

Part 1: Requirements and test methods

1 Scope

This document applies to protectors intended to provide protection against accidental exposure to laser radiation within the wavelength range 180 nm to 1 mm. It defines 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 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.

NOTE Laser radiation in the wavelength 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 patient protectors (including those used for periorbital treatment) is given in ISO TR 22463.

The protectors described in this document are intended for use at ambient temperatures of (23 ± 5) °C, unless specified in particular requirement(s).

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

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

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

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

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

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification and requirements*

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
rating for 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*(λ)**
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

[SOURCE: ISO 4007:2018, 3.10.1.21 – modified – Note 2 to entry removed]

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]

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 specified shall be determined in accordance with Table 1. 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 or wavelength range and resistance category (see 4.1.4), the symbol A shall be used.

"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"

Table 1 — Symbols used for test conditions

Pulse duration, s	Symbol
$\geq 10^{-1}$	C[a]
$\geq 10^{-5}$ to $<10^{-1}$	P
$\geq 10^{-10}$ to $<10^{-5}$	S
$<10^{-10}$	U
NOTE A=CPS	
[a] C includes long-pulsed lasers and continuous wave lasers	

4.1.2 Optical density

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

In the case of protectors intended for use at more than one wavelength, the different values of the optical density shall be specified for different wavelengths and/or different wavelength ranges.

Where the optical density is defined for a continuous range of wavelengths, the minimum value across 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 actual optical density minus the uncertainty of measurement rounded down.

The optical density shall be measured in accordance with 5.2. The measured value of the optical density shall not be less than the specified minimum value, taking into account the uncertainty of measurement. See ISO 18526-2:- Annex A.

When 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 lower than the minimum specified value.

Where the specified optical density is limited to the angular range 0° to 30° (see 5.2), a written warning shall be included in the user information supplied with the protector (see 4.7). Special filters, for example dielectric coatings, show an angle-dependent spectral transmittance. For these, the spectral transmittance shall be measured for the entire angular range from 0° to 30° angle of incidence (see 5.2). Where the specified optical density is limited to this range, 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 laser pulse and exposure durations lasers (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

For the intended use of the protector, the resistance category for the specified individual wavelength or wavelength range or the resistance categories for 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 delivered within no more than 10 seconds if possible, and also under conditions of electrical power failure, including (where applicable) the failure or removal of batteries.

Failure 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) that it has a reduced 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 5.6, 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 values of filters and protectors

When assessed in accordance with 5.7, the maximum refractive values of filters and protectors with no corrective effect shall be as given in Table 2.

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

Spherical power	Cylindrical power	Prismatic power difference		
		horizontal		vertical
		base out	base in	
dioptres	dioptres	prism dioptres	prism dioptres	prism dioptres
±0,09	0,09	0,75	0,25	0,25

4.2 Construction of protectors

All parts of the protector shall be designed such 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:

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

The downward limit of β_l (measured downwards from the horizontal plane), in degrees (°), shall be at least:

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

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

Testing shall take place using the 1-M headform as defined in ISO 18526-4:- as a default. If conformity to other headform(s) is claimed, this shall be marked according to 4.6.1.

4.3 Robustness of protectors

4.3.1 Basic requirement

Filters shall satisfy the requirement for minimum robustness as specified in ISO 16321-2:-, 4.3.3.

4.3.2 Optional requirements

For applications where mechanical strength of filters and protectors is required, the basic impact requirement of ISO 16321-1:-, 7.4 or one of the high speed impact resistance requirements specified in ISO 16321-1:-, 7.10 shall be met.

NOTE It may be necessary to have a lens to provide the mechanical protection behind the filter for protection against laser radiation. In ISO 16321-1 the mechanical requirements apply to the element nearest the eye.

4.4 Quality of material and surface of filters

4.4.1 Material and surface defects

The material and surface defects of filters shall be assessed in accordance with 5.8. Except for a marginal area 5 mm wide, filters shall be free from any material or surface defects likely to impair the intended use, such as bubbles, scratches, inclusions, dull spots, mould marks, scoring or other defects originating from the manufacturing process. No holes are allowed anywhere in the filters.

4.4.2 Scattered light

Wide angle scatter of filters with luminous transmittance equal or above 20 % shall not exceed 3 % and shall be determined in accordance with 5.9.

The reduced luminance coefficient l^* (narrow angle scatter) of a filter with luminous transmittance below 20 % shall be determined in accordance with 5.9 and shall not be greater than:

$$l^* = 0{,}5\,(\mathrm{cd/m^2})/\mathrm{lx} \tag{4}$$

4.5 Environmental stability

4.5.1 General

The following subclauses apply to both the filters and those parts of the frame that perform a laser protection function.

4.5.2 Filter resistance to heat and humidity

After exposing the protector to the conditions described in 5.10, the optical density, as defined in 4.1.2, shall not fall below the specified value. The luminous transmittance of the filter, as defined in 4.1.5, shall not fall by more than 10 % of the specified value.

4.5.3 Stability to ultraviolet radiation

When exposed to ultraviolet radiation in accordance with 5.12, the properties of protectors shall not change to such an extent that they no longer satisfy the requirements of 4.1. The relative change in the luminous transmittance of the filter τ_v shall be ≤ ±10 %:

$$\left|\frac{\Delta\tau_v}{\tau_v}\right| \leq 10\% \tag{5}$$

If the luminous transmittance of laser protective filters decreases by more than 10 % but the OD value(s) remain(s) within the range specified in 4.1.2, a second irradiation shall be performed in accordance with 5.12 on the same sample. The relative change of luminous transmittance due to the second irradiation shall not be greater than 10 % and the OD value(s) shall remain within the range specified in 4.1.2.