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American National Standard for Testing and Labeling of Laser Protective Equipment

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American National Standard for Testing and Labeling of Laser Protective Equipment

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American National Standard

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Contents

Contents

SECTION **PAGE**

Contents

SECTION **PAGE**

Contents

SECTION **PAGE**

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1. General

1.1 Scope.

This standard provides recommendations for testing and labeling laser protective materials and protective equipment such as eye protection, barriers, and windows designed for use with lasers and laser systems that operate at wavelengths between 180 nm and 10^6 nm. All appendices are informative.

NOTE 1—This standard does not include personal protective equipment (PPE) for high energy lasers (HEL) that require an optical density (OD) greater than seven (7).

NOTE 2—This standard may not be adequate for very high pulse or continuous wave (CW) power lasers.

1.2 Application.

The objective of this standard is to provide reasonable, rational, and adequate guidance regarding the test methods, protocols and specifications for devices used to provide eye protection from lasers and laser systems. The test procedures are provided to ensure that eyewear, windows, and barriers maintain their specified level of protection throughout the life cycle of the products.

Such protective devices include laser protective eyewear, instrument filters, window filters, area protective barriers, and screens or beam blocking curtains. Depending on the protective device, type of laser, temporal mode of operation and wavelength(s), different test methods may be required.

Other standards, such as ANSI/ISEA Z87.1:2020 *Occupational and Educational Personal Eye and Face Protection Devices*, will need to be used in conjunction with this standard to provide complete testing of laser protective materials. The recommended ordered approach for using this standard is as follows:

a) Determine the type of protective equipment: eyewear, barrier, or window.

b) Determine the filter technology used: absorptive dye or glass, reflective, or hybrid (combination of dye and reflective).

c) Determine the material type of the protective equipment under study: metal, plastic, glass, or hybrid.

d) Determine the wavelength(s) or wavelength band of the laser protection.

e) Determine the pulse duration: continuous wave (CW), Q-switched, sub-nanosecond, or some combination of pulse durations.

f) Determine the specified OD or barrier threshold limit (BTL) by following the test requirements.

g) Determine the specified OD or BTL by following the test requirements above and comply with labeling requirements for protective equipment.

2. Definitions

The definitions listed below are based on a pragmatic rather than a basic approach. The terms defined are therefore limited to those used in this standard and its appendices, and are in no way intended to constitute a dictionary of terms used in the field of lasers as a whole.

absorption. Transformation of radiant energy to a different form of energy by interaction with matter.

absorption band. An inclusive range of wavelengths within which a material attenuates the incident radiant power. For example, a device labeled "4 OD @ 500-800 nm", has an absorption band from 500 nm to 800 nm where the device must reduce the laser radiation by four (4) orders of magnitude (10^4) that equals at least 4 OD of protection.

acuity. A measure of the eye's ability to resolve detail. 20/20 acuity corresponds to a resolution of one arc minute. Conversion factors for commonly used spatial units are presented in Table 1.

aided. For this standard, viewing the laser source with devices that change the level of irradiance, such as binoculars, or radiance, such as night vision goggles.

aperture. An opening, window, or lens through which optical radiation can pass. The aperture limits the energy or power for measurement or exposure.

as-worn. The position of the lens relative to the line of sight when the eyewear is properly fitted with the user looking straight ahead.

attenuation. The decrease in the radiant flux as it passes through an absorbing or scattering medium.

average power (Φ). The total energy in an exposure or emission divided by the duration of that exposure or emission.

bandwidth. The range of wavelengths that are generated, transmitted, or attenuated by a given device, defined at the points where intensity, transmission, or attenuation falls to a predetermined level.

barrier. Moveable or fixed equipment (devices) used to block or attenuate laser radiation. Typically placed on or around where a laser is in use. See also *laser protective windows, view ports, barriers*, and *filter*.

3.2.1 Beam Characterization. The beam shall be characterized according to Section 4.2.4 prior to measuring OD such that the irradiance/radiant exposure at the sample is determined.

3.3 Optical Power.

Optical power, spherical, cylindrical, and prism, of eyewear shall be measured in accordance with, and meet the requirements as specified in ANSI/ISEA Z87.1:2020 or more strenuous requirements as determined by the end user.

3.4 Optical Quality of Material and Surface.

3.4.1 Material and Surface Defects. Filters shall be free from any material or surface defects likely to impair visibility through the eyewear or inhibit the intended use of the material. The material shall be tested in accordance with Section 4.4.

Defects can include:

a) Flaws.

b) Crazing.

c) Warping.

d) Gross flaws.

e) Cloudiness.

f) Delamination.

g) Sharp edges or burrs.

h) Striations or waviness.

i) Stains or discolorations.

j) Cracks, holes, chips, or breaks.

k) Blemishes or clusters of blemishes.

3.4.2 Defect location. There should be minimal defects in the critical viewing area. Defects in the non-critical viewing area are allowable. See Figures 2, 3, and 4 for location of critical viewing area of a visor, goggle, or lens.

3.4.3 Haze. Haze is a measure of the optical clarity of a device expressed as the ratio of scattered to transmitted light. Haze shall meet the requirements as specified in ANSI/ISEA Z87.1:2020 unless otherwise specified.

3.5 Environmental Stability (LEP).

Environmental stability test data shall be available from the manufacturer or distributor upon request.

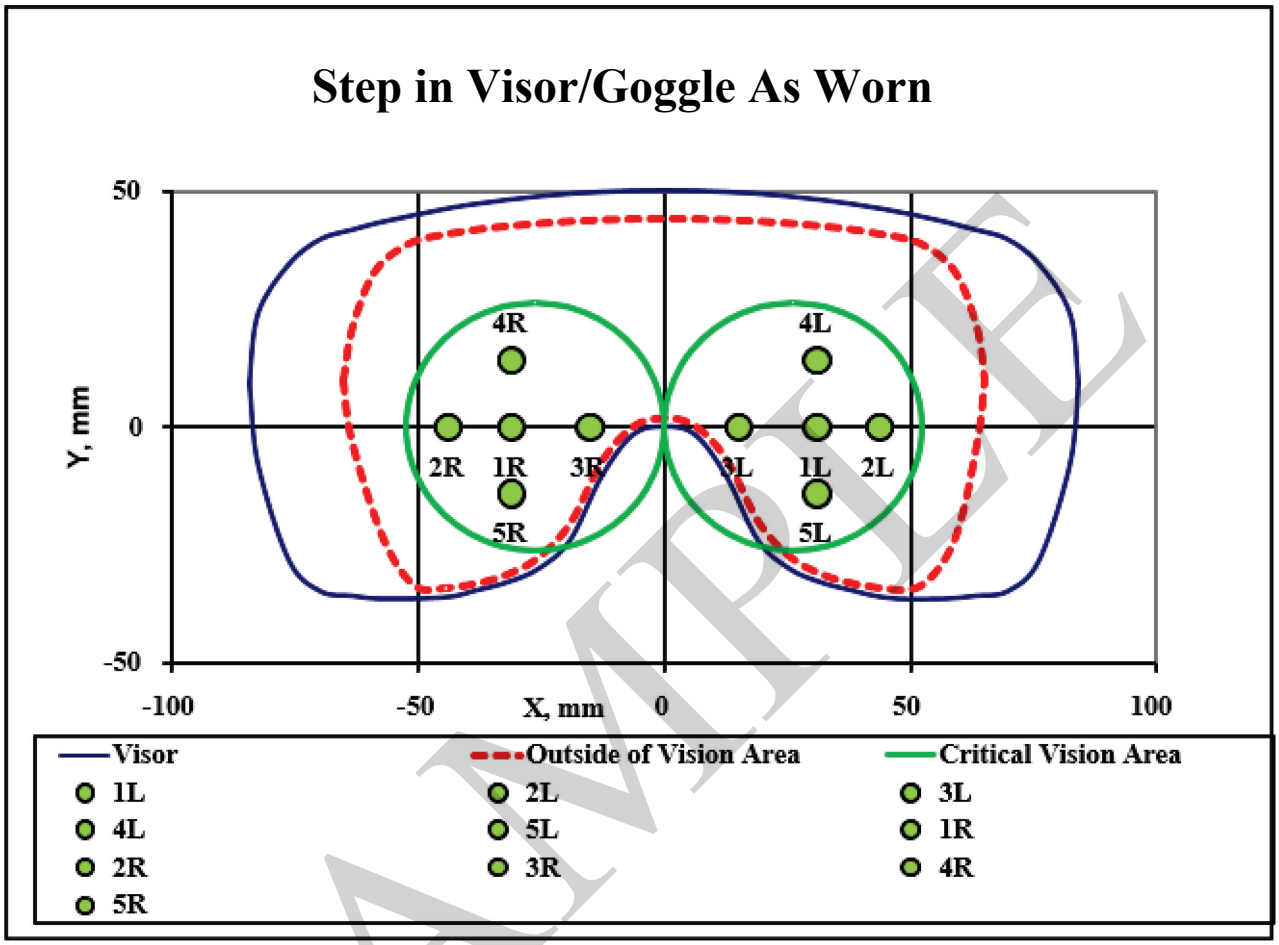

Figure 3. Critical Viewing Area - Step in Visor / Goggle Test Locations for Hybrid Reflective and Dye Technologies.

Table A1. Photopic and Scotopic Values

Wavelength	V(λ)	V'(λ)	$\tau(\lambda)$	V(λ)·$\tau(\lambda)$	V'(λ)·$\tau(\lambda)$
380	0.0000	0.0006	**0.0000**	0.0000	0.0000
385	0.0001	0.0011	**0.0000**	0.0000	0.0000
390	0.0001	0.0022	**0.0000**	0.0000	0.0000
395	0.0002	0.0045	**0.0000**	0.0000	0.0000
400	0.0004	0.0093	**0.0000**	0.0000	0.0000
405	0.0006	0.0185	**0.0000**	0.0000	0.0000
410	0.0012	0.0348	**0.0000**	0.0000	0.0000
415	0.0022	0.0604	**0.0000**	0.0000	0.0000
420	0.0040	0.0966	**0.0000**	0.0000	0.0000
425	0.0073	0.1436	**0.0000**	0.0000	0.0000
430	0.0116	0.1998	**0.0000**	0.0000	0.0000
435	0.0168	0.2625	**0.0000**	0.0000	0.0000
440	0.0230	0.3281	**0.0000**	0.0000	0.0000
445	0.0298	0.3931	**0.0000**	0.0000	0.0000
450	0.0380	0.4550	**0.0000**	0.0000	0.0000
455	0.0480	0.5129	**0.0000**	0.0000	0.0000
460	0.0600	0.5672	**0.0000**	0.0000	0.0000
465	0.0739	0.6205	**0.0000**	0.0000	0.0000
470	0.0910	0.6756	**0.0000**	0.0000	0.0000
475	0.1126	0.7337	**0.0000**	0.0000	0.0000
480	0.1390	0.7930	**0.0000**	0.0000	0.0000
485	0.1693	0.8509	**0.0001**	0.0000	0.0001
490	0.2080	0.9043	**0.0000**	0.0000	0.0000
495	0.2586	0.9491	**0.0000**	0.0000	0.0000
500	0.3230	0.9817	**0.0000**	0.0000	0.0000
505	0.4073	0.9984	**0.0000**	0.0000	0.0000
510	0.5030	0.9966	**0.0000**	0.0000	0.0000
515	0.6082	0.9750	**0.0000**	0.0000	0.0000

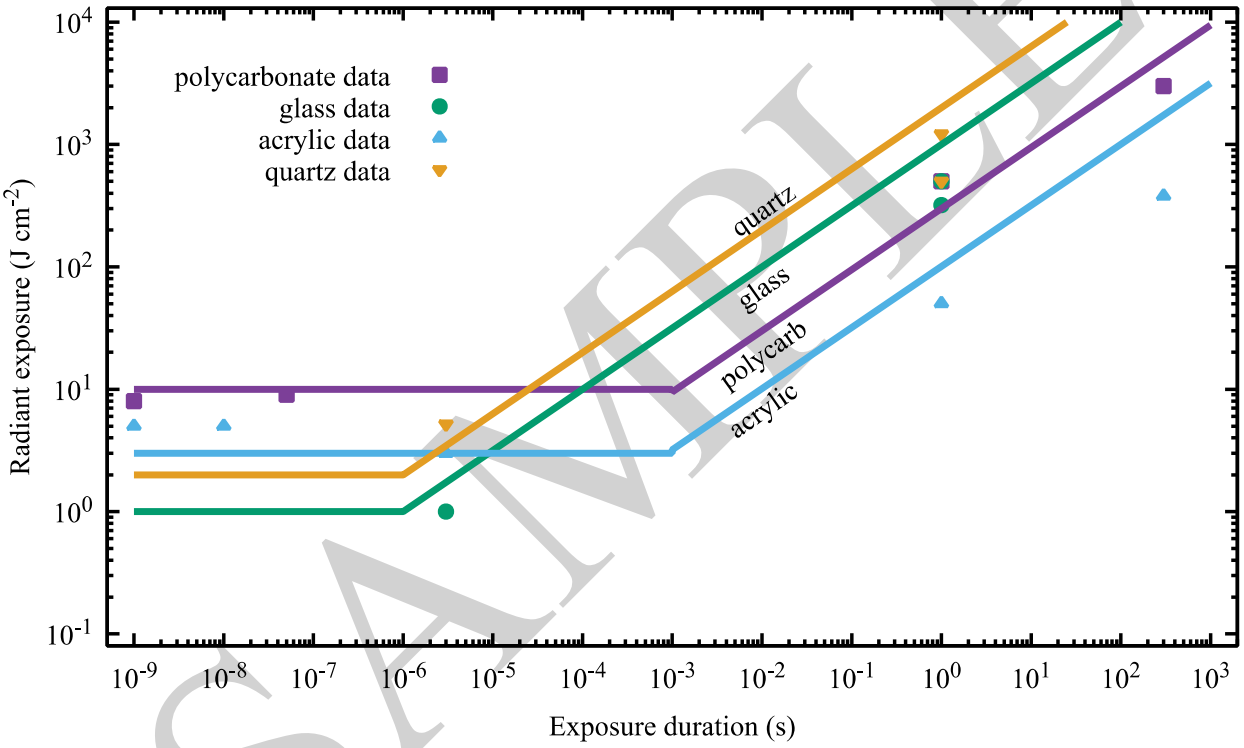

Figure B1. LIDT for Absorbing Substrates.

Table E1. Values Used Throughout This Example

Angular Performance Parameters	
Parameter	**Value (mm) unless specified**
Pupil diameter	8
Eye movement	35 degree
Fit tolerance	±8[a]
Filter relief	15
Lens/Eye Parameters	
Frame pupillary distance	78
Interpupillary distance	64
Horizontal decentration: Distance from lens center to eye wire center (1/2 A - B)	7
Eye wire height (B)	52
Vertical decentration	0
Lens radius of curvature (mm)	85
Face form angle	6 deg
Pantoscopic tilt	4 deg

[a] Fit tolerance is widest in the horizontal direction where the single size is intended to cover the 5th to 95th percentile IPD (54 to 70 mm). Vertical tolerance assumed to be the same as the horizontal in this example.

Table E2. Laser Parameters

Laser Parameters	
Wavelength	532 nm
Bandwidth	20 GHz (<0.05nm)
Power (cw)	3 milliWatts (cw)
Polarization	Vert (>100:1)
Spatial profile	Top hat, 2mm dia.

Appendix G
Barrier Testing Parameters and Protocol

G1. Test Procedure

a) The required laser wavelength will be selected at the beginning of each series of protective barrier tests.

b) The required temporal mode of operation, CW or pulsed, will be selected at the beginning of the series of tests.

c) The prepared samples of the protective barrier should be:

1. At least 250 mm x 250 mm in size.
2. Of representative thickness and of dimensions not less than three times the maximum beam dimension (1/e) encountered at the exposure location.
3. Supported such that overlap of the sample edge and the mount will not exceed 3 mm.
4. Placed in a stable mount that holds the sample at $\pm$3 degrees of normal relative to the incident laser beam at the position at which the incident beam irradiance was determined.
5. Placed no further than three times the focal length of the focusing lens, if applicable.

d) If deemed necessary, a band bass filter will be inserted in the beam path to assure that only radiation at the laser wavelength will be measured.

e) Determine and specify the TEM mode in the report.

f) Laser incident beam diameter will be established at this laser power setting by the aperture transmission method or other established method. The beam diameter and area will be determined at the position at which the protective barrier is to be placed, assuring that the measured diameter is the incident diameter at the surface of the protective barrier.

g) It is recommended that beam diameters between 3 – 10 mm be included in the test data. For certain applications, beam diameters outside these dimensions could also be used, but shall be supported by technical data.

h) The beam irradiance shall be calculated and confirmed by a calibrated power meter for each condition of beam power and diameter size.

i) Care will be taken to maintain a constant incident beam diameter on the surface of the protective barrier.

j) The incident laser power (irradiance) will then be increased incrementally, specifying