CSA Z94.3:20
National Standard of Canada

Eye and face protectors

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CSA Z94.3:20
Eye and face protectors

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Preface

This is the ninth edition of CSA Z94.3, *Eye and face protectors*. It supersedes the previous editions, published in 2015, 2007, 2002, 1999, 1992, 1988, 1982, and 1969.

Major changes to this edition include the following:
- ignition resistance requirements for plano eyewear have been clarified and refined (Clause 6.2);
- the flammability requirements and testing were deleted (Clause 6.2);
- revised automatic darkening welding filter requirements (Clause 6.5.4);
- added guidance for aftermarket components or accessories(Clause 6.7);
- revised the minimum frontal coverage for plano eyewear (Clause 6.8);
- revised side protection requirements for plano eyewear (Clause 6.9);
- added cover lenses and cover plates for Class 2 protectors (Clause 8.7);
- revised speed of steel balls for impact resistance testing (Clause 12.2.1.3);
- revised the procedure for angular dependence of luminous transmittance test for automatic welding filter lenses (Clause 12.15.3);
- revised marking and user information for plano eyewear (Clause 13.1);
- revised markings for prescription protective eyewear (Clause 15.6);
- added design and testing requirements for photochromic and polarized lenses for eyewear providing sun protection (Clauses 16.2.5, 16.2.6, and 16.3.5);
- increased the number of prescription lens configurations presumed compliant (Table 5);
- added a figure with measurement locations to Figure 9; and
- updated the references (Clause 2) and definitions (Clause 3).

As introduced in the 2002 edition, the basic performance requirements apply to all protectors covered in this Standard, whereas the test procedures specified differ for prescription eyewear and non-prescription eyewear.

As in previous editions, for non-prescription protectors, specified testing procedures are to be conducted using the whole assembled product (not individual components). In contrast, for Class 1 protectors having prescription lenses, performance criteria and test procedures are applied to lenses and frames separately. This Standard sets out requirements for the manufacture of these protectors (e.g., quality assurance). In addition, special allowance has been made in this edition for the role of ophthalmic professionals in adjusting and modifying spectacles to fit the individual wearer. When taken together, these requirements provide a basis for conformity assessment of protective spectacles with prescription lenses.

This Standard is considered suitable for use for conformity assessment within the stated scope of the Standard.

CSA Group acknowledges that the development of this Standard was made possible, in part, by the financial support of the Canadian Association of Administrators of Labour Law – Occupational Safety and Health (CAALL-OSH), including Provincial and Territorial Governments, as well as the Government of Canada. CSA Group is solely responsible for the content of this Standard, and CSA Group and the funding bodies disclaim any liability in connection with the use of the information contained herein.

This Standard was prepared by the Technical Committee on Eye and Face Protection, under the jurisdiction of the Strategic Steering Committee on Occupational Health and Safety, and has been formally approved by the Technical Committee.

This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Notes:

1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
3) *This Standard was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
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   a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
   b) *provide an explanation of circumstances surrounding the actual field condition; and*
   c) *where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.*

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   c) *wording of the proposed change; and*
   d) *rationale for the change.*

CSA Z94.3:20
Eye and face protectors

1 Scope

1.1
This Standard applies to eye and face protectors used in all occupational and educational operations or processes involving hazards to the eyes or face. Typical hazards include flying objects and particles, splashing liquids, molten metal, and ultraviolet, visible, and infrared radiation, but do not include X-rays, gamma rays, high-energy particulate radiation, radioactive materials, or masers.

Note: *The guidelines for protection outlined in Table A.1 should be followed when similar potentially hazardous activities are conducted in the home, at leisure, and in recreational environments. For certain sports activities, other Standards should be consulted (e.g., CSA Z262.2).*

1.2
This Standard sets minimum performance requirements in the tests described herein but does not cover factors of design such as comfort, service life, or appearance.

Note: *The conformance of protectors with these requirements does not imply equality of performance, nor should it be interpreted to mean that protectors are capable of affording greater protection than is specified in this Standard.*

1.3
In this Standard, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the Standard; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the Standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications
This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below.

CSA Group

Z94.1-15
Industrial protective headwear — Performance, selection, care, and use

Z94.3.1-16
Guideline for selection, use, and care of eye and face protectors

Z262.2-15
Face protectors for use in ice hockey

Z462-18
Workplace electrical safety

ACGIH (American Conference of Governmental Industrial Hygienists)
Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 2014

ANSI (American National Standards Institute)
Z80.3-2018
Ophthalmics — Nonprescription Sunglasses and Fashion Eyewear — Requirements

Z80.5-2010
Ophthalmics — Requirements for Ophthalmic Frames

Z136.1-2014
Safe Use of Lasers

Z136.7-2008
Testing and Labeling of Laser Protective Equipment

ASTM International
D1003-13
Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics

F2178-17
Standard Test Method for Determining the Arc Rating and Standard Specification for Face Protective Products

CEN (European Committee for Standardization)
EN 168:2001
Personal eye-protection — Non-optical test methods

ISO (International Standards Organization)
ISO/CIE 11664-1:2019
Colorimetry — Part 1: CIE standard colorimetric observers

11664-2:2007(CIE S 014-1/E:2006)
Colorimetry — Part 2: CIE standard illuminants

12311:2013
Personal protective equipment — Test methods for sunglasses and related eyewear

12312-1:2013
Eye and face protection — Sunglasses and related eyewear — Part 1: Sunglasses for general use

Other publications

Moon, P. 1940. Proposed Standard Solar-Radiation Curves for Engineering Use, *Journal of the Franklin Institute,* Vol. 230, No. 5.

Oyaide-Ofenor, M. 2014. *Studies on Impact Resistance of Spectacle Lens Materials.* MSc thesis, University of Waterloo, Waterloo, Ontario.

3 Definitions

The following definitions shall apply in this Standard:

Absorption — the process by which radiant energy is converted into other forms of energy, usually heat, by passage through a medium.

Note: *Absorbed light is neither transmitted nor reflected in an optical system, but can be re-emitted as light of another wavelength, as in the case of fluorescence or luminescence.*

Accessory — an item that is added to a complete protector

Note: *An accessory might or might not affect the fit, form, or function of a protector.*

Aftermarket accessory — an accessory not originally supplied with the complete protector.

Note: *An accessory might or might not be supplied by the protector manufacturer.*

Aftermarket component — a component not originally supplied with the protector.

Note: *These components might or might not be supplied by the manufacturer.*

Arc flash — a dangerous condition associated with the possible release of energy caused by an electric arc.

Note: *An arc flash results from an electrical breakdown of the resistance of air that produces a plasma discharge.*

Automatic-darkening welding filter — a zero-power filter that automatically switches from a light state (shade) to a dark state (shade) in response to a change in incident light intensity.

Bib — a protective device that guards the neck and head regions from splash and sparks in welding.

Chin protector — on a face shield, the part that extends over and around the chin and upper throat.

Component — a part combined with other parts to form a complete protector.

Cover lens/plate — a clear lens for use in front of a filter lens to protect it from weld spatter, pitting, or scratches.

Crown protector — on a face shield, the part that extends above the front and side of the forehead to cover the front portion of the crown of the head.

Dark state — the lowest operating luminous transmittance (highest shade number) of an automatic-darkening welding filter.

End piece — the part of the front that attaches to the temple.

Eye protector — any form of eye protective equipment worn or held by the user that covers at least the eye area and permits vision.

Eyewire — the part of the front into which a spectacle lens is mounted.

Face shield — a device that has a transparent window or visor supported in front of the face to shield the eyes and face.

Filter — a lens that reduces dangerous light intensity and ultraviolet and infrared radiation to a predetermined level (see Table 1).

Note: *This definition does not include tinting of lenses for sun protection or other purposes.*

Fracture —

a) a crack through the entire thickness of a protector, including a laminar layer on a lens (if any), dividing it into two or more separate pieces; or

b) detachment from the ocular surface of the protector of any material visible to normal or corrected-to-normal vision

Note: *See exemplars in Annex F.*

Front — the part of a spectacle frame that holds the lenses or lens, exclusive of the temples.

Glare — an uncomfortably bright light without hazardous levels of ultraviolet or infrared radiation.

Goggles — a device contoured for full facial contact and held in place by a headband or other suitable means, for the protection of the eyes and eye sockets (see Clause 8).

Note: *The lenses may be either plano or prescription.*

Hand shield — a rigid hand-held protector that shields the eyes and face during welding operations.

Haze — the percentage of transmitted light that passes through a specimen and deviates from the incident beam by forward scattering.

Note: *Excessive haze causes blurring of vision.*

Headgear (suspension) — the part of a protective helmet, hood, or face shield that supports the device on the wearer's head.

Note: *Headgear usually consists of both a headband and a crown strap.*

Hidden bevel — a flat bevel for prescription lenses intended to enhance lens retention in a Class 1 eye protector.

Hood — a rigid or non-rigid protector that completely covers the head, neck, and portions of the shoulders.

Housing — the support mechanism for a lens or carrier.

Impact resistance — the ability of a protector to resist the force of an object that comes into contact with the lens or eye protector at the speed specified in this Standard.

Infrared (IR) radiation — electromagnetic radiation having wavelengths from 760 nm to 1.0 mm.

Note: *Infrared is the significant and primary hazard in electric arc flash.*

Lens — the transparent component of the eye protector through which the user sees.

Note: *The general term "lens" includes plates, covers, windows, and filters.*

Lens for one eye — an unmounted lens that can be installed in either the left or right eye location of the protector.

Light state — the highest operating luminous transmittance (lowest shade number) of an automatic-darkening welding filter.

Luminous transmittance — a function of the spectral transmittance of the lens weighted by the corresponding ordinates of the photopic luminous efficiency distribution of the CIE Standard Colorimetric Observer in ISO/CIE 11664-1 and by the spectral intensity of ISO 11664-2 Standard Illuminant A or D65 (as specified in this Standard).

The luminous transmittance (τ_v) of a lens is expressed mathematically as follows:

$$\tau_v = \frac{\int_{380}^{780} \tau(\lambda)V(\lambda)S(\lambda)d\lambda}{\int_{380}^{780} V(\lambda)S(\lambda)d\lambda}$$

where

$\tau(\lambda)$ = spectral transmittance of the lens measured at the geometric centre or a location specified by the manufacturer if the geometric centre is not appropriate

$V(\lambda)$ = spectral ordinate of the photopic luminous efficiency distribution [(λ)] of the CIE Standard Colorimetric Observer

$S(\lambda)$ = spectral intensity of ISO 11664-2 Standard Illuminant A or D65

Manufacturer — the lens-preparation and final-assembly facility for prescription eyewear (e.g., optical laboratories), or the final assembly point for plano protectors.

Mean transmittance — the mean transmittance, $\tau(\lambda_2, \lambda_1)$, of a lens over a spectral range, λ_1 to λ_2, expressed mathematically as follows:

$$\tau(\lambda_2, \lambda_1) = \frac{1}{\lambda_2 - \lambda_1} \int_{\lambda_1}^{\lambda_2} \tau(\lambda)\, d\lambda$$

where

$\tau(\lambda)$ = spectral transmittance of the lens measured at the geometric centre or a location specified by the manufacturer if the geometric centre is not appropriate

Nationally recognized certification organization — an organization accredited by the Standards Council of Canada to issue certifications of compliance with respect to this Standard.

Non-ionizing radiation — electromagnetic radiation that does not directly or indirectly induce ionization of radiation-absorbing material; electromagnetic radiation having a wavelength greater than 180 nm and an energy not exceeding 12.4 eV.

Photochromic lens — a lens that darkens when exposed to sunlight and lightens when removed from sunlight.

Plano — see **Zero-power lens**.

Plate — a large lens that allows vision for both eyes, usually used for welding.

Prescription (Rx) lens — a lens manufactured to an individual’s corrective prescription.

Primary line of sight — the line through the centre of the pupil of the headform continuing in the straight ahead direction through the protector mounted in the as-worn position.

Prismatic deviation — the change in direction of light rays passing through a prism.

Progressive addition lens — a prescription lens that incorporates an invisible multifocal addition.

Protective frame — a device patterned after a conventional spectacle frame but of more substantial construction and fitted with side shields.

Protective spectacles —
a) a device that enhances eye protection and usually consists of two lenses in a protective frame; or
b) a device with a single, larger lens in a frame to serve both eyes or a one-piece lens-frame combination, worn like conventional two-lens spectacles.

Note: *The lenses may be either plano or prescription.*

Qualified person — a person who has been trained in accordance with the quality control and management systems of a manufacturer.

Qualified professional — a person who is qualified to dispense ophthalmic products in a given jurisdiction.

Note: *Qualified professionals include registered or licensed ophthalmic practitioners.*

Reference point — the location in which measurements are performed. Except for rectangular welding filters for two eyes, lenses are measured in the visual centre if known, otherwise measured at the geometric centre

Respirator facepiece — the portion of a full-face respirator that covers the nose, mouth, and eyes and is designed to make a seal or partial seal (in the case of a loose-fitting hood or helmet) with the perimeter of the face.

Side protection — the protection against hazards directed at the temporal area of the head afforded by any combination of lens, housing, temple, and/or separate side shield.

Side shield — a component permanently affixed to or integral with the spectacles, providing side protection.

Special-purpose lens — any lens, such as a tinted lens, that does not meet the transmittance requirements for filters listed in Table 1, exclusive of lenses specified in Clause 6.4.6.

Suspension — see **Headgear**.

Temple — the part of the protective frame attached to or integral with the front and resting on or dropping behind the wearer's ear, and intended to keep the spectacles in place before the eyes.

Ultraviolet (UV) radiation — electromagnetic radiation having wavelengths from 100 to 380 nm.

Vertex distance — distance between the back surface of the lens and the apex of the cornea, measured with the line of sight perpendicular to the horizontal line joining the pupil centres of the headform.

Visible light — electromagnetic radiation having wavelengths from 380 to 780 nm.

Welding helmet — a rigid protector to be worn on the head to protect the eyes and face during welding operations.

Window — the entire lens in a face shield or respirator facepiece.

Zero-power lens — a lens that does not incorporate a corrective prescription.
Note: *Zero-power lenses for spectacles are commonly referred to as "plano".*

4 Types of hazards

For the purposes of selection of protective devices, the hazard types are defined in Table A.1.

Notes:

1) *Optical radiation refers to that portion of the electromagnetic spectrum ranging in wavelength from* 100 nm *to* 1.0 mm, *taking into account the following subintervals: UV-C, UV-B, UV-A, Visible, IR-A, IR-B, and IR-C.*
2) *Safety spectacles are not designed to provide primary protection for exposure to electric arc and should not be used on their own in circumstances where electric arc exposure is present. In applications where there is a possibility of exposure to electric arcs, eye and face protectors tested and classified in accordance with ASTM F2178 and selected in accordance with CSA Z462 should be used.*

5 Classification of eye and face protective devices

5.1 General

Eye and face protectors are classified in Clauses 5.2 to 5.8.

Note: *For selection of protectors, refer to CSA Z94.3.1.*

5.2 Class 1 — Spectacles

This class includes

a) Class 1A protective spectacles with side protection for impact; and
b) Class 1B protective spectacles for impact and non-ionizing radiation protection with side protection.

Notes:

1) *Class 1B spectacles are not suitable for protection against Hazard Type H in accordance with Annex A (see CSA Z94.3.1).*
2) *See Figure 1.*

5.3 Class 2 — Goggles

This class includes

a) Class 2A direct ventilated goggles for impact protection;
b) Class 2B non-ventilated and indirect ventilated goggles for impact, dust, and splash protection;
c) Class 2C with non-ionizing radiation protection and including Items a) and b);
d) Class 2D with laser radiation protection and Items a) and b); and
e) Class 2E with electric arc protection as part of an acceptable ensemble (see CSA Z462) and Items a) and b).

Note: *See Figure 1.*

5.4 Class 3 — Welding helmets

This class includes a variety of configurations.

Note: *See Figure 1.*

5.5 Class 4 — Welding hand shields

This class includes a variety of configurations.

Note: *See Figure 1.*

5.6 Class 5 — Hoods

This class includes
a) hoods with an impact-resistant window;
b) hoods for dust, splash, and abrasive materials protection;
c) hoods with non-ionizing radiation protection;
d) hoods for high-heat applications; and
e) hoods for electric arc protection.

Notes:
1) *In this context, "hoods" do not include welding helmets.*
2) *See Figure 1.*

5.7 Class 6 — Face shields

This class includes
a) face shields for impact and splash protection;
b) face shields for non-ionizing radiation protection;
c) face shields for high-heat applications; and
d) face shields for electric arc protection.

Notes:
1) *Windows available in Class 6A and 6C protectors can provide various degrees of glare protection. These windows might not meet the requirements of this Standard for ultraviolet and infrared protection (see Clause 13.3).*
2) *See Figure 1.*

5.8 Class 7 — Respirator facepieces

This class includes facepieces
a) for impact and splash protection;
b) for non-ionizing radiation protection;
c) with loose-fitting hoods or helmets; and
d) with loose-fitting hoods or helmets for non-ionizing radiation protection.

Note: *See Figure 1.*

6 General requirements

Note: *See Annex D for guidance on the manufacturing of eye and face protectors.*

6.1 Impact resistance

6.1.1 General

6.1.1.1

With the exception of Class 4 (welding hand shields), protectors shall be tested and assessed as complete devices in accordance with Clause 12.2.

6.1.1.2
For a protector designed for use with a combination of stationary lenses, the combination of stationary lenses shall meet the impact-resistance requirements.

6.1.1.3
For a protector fitted with a lift-front assembly, the lens or pair of lenses in the stationary portion nearest to the eyes shall meet the impact-resistance requirements without relying on protection provided by the lift-front assembly in front of the lens or pair of lenses.

6.1.2 Flexible components
With the exception of housings, flexible components shall be exempt from the impact-resistance requirements.

6.1.3 Testing criteria

6.1.3.1
Except as specified in Clause 6.1.3.2, the test for impact resistance shall be either the impact of a 6.00 ± 0.05 mm diameter steel ball travelling at a speed of 50.5 ± 0.5 m/s or a 6.35 ± 0.05 mm diameter steel ball travelling at a speed of 46.5 ± 0.5 m/s . The test shall be performed in accordance with Clause 12.2.2. No contact with either eye of the headform shall be permitted, nor shall any part become detached from the inner surface of the protector, nor shall the protector fail as defined below:

a) lens failure: a lens shall be considered to have failed if it fractures through its entire thickness into two or more separate pieces, or if any lens material visible to normal or corrected-to-normal vision, including a laminar layer, if any, becomes detached from the ocular surface (see Annex F for exemplars); or
b) housing failure: housing (such as a front, side shield, frame, body, lift-front, or lens holder) shall be considered to have failed if parts or fragments that could contact either eye of the headform are ejected from the protector.

6.1.3.2
For filter lenses or filter plates that are used in welding hand shields (Class 4) or welding helmets (Class 3), the test for impact resistance shall be the impact of a 6.00 ± 0.05 mm diameter steel ball travelling at a minimum speed of 22.0 m/s or a 6.35 ± 0.05 mm diameter steel ball travelling at a minimum speed of 18.0 m/s. The test shall be performed in accordance with Clause 12.2.2. There shall be no contact with either eye of the headform, nor shall any part become detached from the inner surface of the device.

6.2 Ignition resistance
The components of the protector typically exposed during use shall not ignite during steel rod contact, nor continue to glow or be consumed after removal of the steel rod in accordance with Clause 12.3.

Note: *Head straps not integral to the protector (i.e., accessories) are not subject to these requirements.*

6.3 Replacement components
The manufacturer's instructions shall state that replacement components shall be used in accordance with the manufacturer's instructions. The manufacturer shall provide instructions specifying the correct replacement component.

Note: *Certification of eyewear is void if replacement components as specified by the manufacturer are not used.*

6.4 Clear zero-power lenses

6.4.1 Size

Clear zero-power lenses shall meet the size requirements for the appropriate protector (see Clauses 7.1 and 10.2.1).

6.4.2 Refractive (residual) power

6.4.2.1

The refractive power of a clear zero-power lens, at the primary line of sight, shall not exceed ± 0.12 dioptre in any meridian when tested in accordance with Clause 12.4.

6.4.2.2

The reading segment (if any) power shall not differ from that specified by the manufacturer by more than ± 0.12 dioptre.

6.4.3 Resolving power

Clear zero-power lenses shall possess adequate definition to allow resolution of the 60-s* ring throughout the minimal coverage area specified in Clause 7.1, excluding the reading segment (if any), up to 3 mm from the edge of the lens when tested in accordance with Clause 12.5.

* *s means subtended seconds of arc.*

Note: *Some Class 1 protectors include lenses with reading segments.*

6.4.4 Prismatic deviation

The prismatic deviation of clear zero-power lenses shall not exceed the following values when tested in accordance with Clause 12.6:

Prism dioptre	Lens for one eye	Lens for both eyes — Horizontal — Base out	Lens for both eyes — Horizontal — Base in	Lens for both eyes — Vertical
	0.125	0.75	0.25	0.25

6.4.5 Haze

6.4.5.1

At the primary line of sight of a new clear zero-power lens intended for use in a Class 1 or Class 2 protector, the haze shall not exceed 2% when tested in accordance with Clause 12.7.

6.4.5.2

At the primary line of sight a new clear zero-power lens intended for use in a Class 6 protector, the haze shall not exceed 3% when tested in accordance with Clause 12.7.

6.4.6 Luminous transmittance

The luminous transmittance of clear zero-power lenses shall be not less than 85% when tested in accordance with Clause 12.8.5, unless they are double-glazed, in which case the luminous transmittance shall be not less than 78%.

6.5 Zero-power filters

6.5.1 Size, residual power, resolving power, and prismatic deviation

Zero-power filters shall meet the same requirements as clear zero-power lenses for size (Clause 6.4.1), residual power (Clause 6.4.2), resolving power (Clause 6.4.3), and prismatic deviation (Clause 6.4.4). Automatic-darkening welding filters up to shade 4 shall be tested in their light state.

Zero-power filters of shade 5 and higher are exempt from the requirements for residual power (Clause 6.4.2), resolving power (Clause 6.4.3), and prismatic deviation (Clause 6.4.4).

6.5.2 Transmittance

Note: *These requirements do not apply for automatic-darkening welding filters. See Clause 6.5.4.*

6.5.2.1

The luminous transmittance measured at the reference point of the filter shall lie in the range given in Table 1 for the shade number marked on the filter lens or filter plate, when tested in accordance with Clause 12.8.

6.5.2.2

The luminous transmittance of any part of a filter lens for one eye shall lie between 0.89 times and 1.12 times the luminous transmittance at the reference point of the lens. The luminous transmittance of any part of a filter plate or the viewing area of a filter face shield shall lie between 0.79 times and 1.26 times the luminous transmittance at the reference point of the plate.

6.5.2.3

Filter lenses for one eye shall be supplied in pairs in which the ratio of the luminous transmittance of the lighter lens to that of the darker lens, each measured at the reference point of the lens, shall not exceed 1.26:1.

6.5.2.4

The ultraviolet, visible, and infrared transmittance of the filter shall comply with the requirements given in Table 1 for the shade designation number marked on the filter, when tested in accordance with Clause 12.8.

6.5.3 Permanence of filters

Note: *These requirements do not apply for automatic-darkening welding filters. See Clause 6.5.4.*

6.5.3.1

When tested in accordance with Clause 12.9.1, filters shall not change in dimensions by more than 3%.

6.5.3.2

When tested in accordance with Clauses 12.9.1 to 12.9.3, the luminous transmittance of a filter shall not increase to more than 1.10 times its original value. Each filter shall also still comply with the relevant requirements of the Standard for ultraviolet and infrared protection and shall show no cracks, separations of plies, bubbles, or other obvious defects extending more than 3 mm from the filter's edge.

6.5.4 Automatic darkening welding filters

6.5.4.1 Light-state transmittance

The luminous transmittance of automatic-darkening welding filters at any designated light state shall fall within the nominal luminance transmittance range of ± 1 of the shade number as listed in Table 1 when tested in accordance with Clause 12.8 at 23 ± 2 °C.

Automatic-darkening welding filters shall meet the mean spectral transmittance requirements for ultraviolet and infrared transmittance listed in Table 1 for their designated shade while they are in their light state and tested in accordance with Clause 12.8 at 23 ± 2 °C.

6.5.4.2 Dark-state transmittance

The luminous transmittance of automatic-darkening welding filters at any designated dark state shall fall within the nominal luminance transmittance range of ± 1 of the shade number as listed in Table 1 when tested in accordance with Clause 12.8.

Tests shall be performed on filter assemblies conditioned at both -5 ± 2 °C and 55 ± 2 °C.

6.5.4.3 Angular dependence of luminous transmittance

When tested in accordance with Clause 12.15, the values of V15 and V30 of automatic welding filters shall not exceed the values in Table 6 (when tested at a temperature of 23 ± 5 °C). This requirement shall apply to both light and dark states.

6.5.4.4 Zero-power auto darkening filters for one eye

When there are separate filters for each eye the ratio of the luminous transmittance of the lighter lens to that of the darker lens, each measured at the primary line of sight of the lens, shall not exceed 1.26:1.

6.5.4.5 Switching index

6.5.4.5.1 General

The response time of an automatic-darkening welding filter is designated as the switching index and shall be defined by the following integral:

$$\text{Switching index} = \frac{1}{T_{(1)}} \int_{t=0}^{t=(T=3T_{(2)})} T_{(t)}\, dt$$

where

t = 0, the time at which the arc ignites

$T_{(1)}$ = the designated light state

$T_{(2)}$ = the designated dark state

$t(T3T_{(2)})$ = the time at which the luminous transmittance falls to three times the luminous transmittance in the dark state

Note: *In the case of short-term exposure to light, the glare is approximately proportional to the product of the illuminance at the eye and time. The time dependence of the darkening process can differ for different designs of filters where the luminous transmittance varies with time. It is therefore appropriate to define the response time of an automatic-darkening welding lens as an integral of the luminous transmittance over time and not merely by the initial and final luminous transmittance.*

6.5.4.5.2

The switching index of an automatic-darkening welding filter shall be tested in accordance with Clause 12.14 and shall satisfy the requirements of Clause 6.5.4.5.3 or 6.5.4.5.4.

6.5.4.5.3

The switching index shall be measured at temperatures of -5 ± 2 °C and 55 ± 2 °C. The switching index times given in Table 2 shall not be exceeded at either of these temperatures.

6.5.4.5.4

If the requirements of Clause 6.5.4.5.3 are not satisfied, the automatic-darkening welding filter shall be tested at 10 ± 2 °C and 55 ± 2 °C. If it meets the requirements of this Clause, but not those of Clause 6.5.4.5.3, the filter shall be clearly and permanently marked in a readily visible location with the following instructions or equivalent:

WARNING: DO NOT USE AT TEMPERATURES BELOW 10 °C.

and

AVERTISSEMENT: NE PAS UTILISER À UNE TEMPÉRATURE INFÉRIEURE À 10 °C.

6.6 Zero-power special-purpose lenses

Zero-power special-purpose windows or lenses shall meet the same requirements as clear zero-power lenses for size (Clause 6.4.1), residual power (Clause 6.4.2), resolving power (Clause 6.4.3), prismatic deviation (Clause 6.4.4), and haze (Clause 6.4.5.2).

Ultraviolet and infrared transmittance requirements for zero-power filters are not applicable to these lenses.

Special-purpose lenses for one eye shall be supplied in pairs in which the ratio of the luminous transmittance of the lighter lens to that of the darker lens, each measured at the reference point of the lens, shall not exceed 1.26:1.

6.7 Aftermarket components or accessories

Aftermarket components or accessories that are not supplied with the protector and affect the protector’s fit, form, or function shall be tested with the protector to demonstrate their compliance with all requirements applicable to the protector.

The party claiming compliance of the aftermarket component or accessory is responsible for testing the original protector assembled with the aftermarket component or accessory and shall provide evidence of compliance.

6.8 Minimum frontal coverage

The Class 1 or Class 2 protector shall cover an elliptical area of not less than 40 mm wide and 33 mm high in front of each eye, centred on the pupil centre of the medium test headform (see Figure 2).

The Class 1 or Class 2 protector shall cover an elliptical area of not less than 36 mm wide and 26 mm high in front of each eye, centred on the pupil centre of the small test headform (see Figure 2).

Note: *Every Class 1 and Class 2 protector is expected to meet one or the other of these requirements, but not necessarily both.*

6.9 Side protection

When a Class 1 or Class 2 protector is mounted on the test headform in as-worn position, the side protection shall protect an area 20 mm in height starting at, and vertically symmetric around, the apex of the cornea and extending back to a point 10 mm behind the corneal apex, at which point it becomes a 10 mm radius end extending rearward (see Figure 3).

6.10 Tolerances and limits

Throughout this Standard, where a tolerance or a limit is not otherwise provided, values given shall be considered nominal.

7 Class 1 protectors — Spectacles

7.1 Field of view

The monocular field of view of each lens shall be not less than 45° temporally in the horizontal meridian and 80° total in the vertical meridian when tested in accordance with Clause 12.12. Class 1 protectors with a single lens for both eyes shall provide the equivalent field of view.

7.2 Side protection

7.2.1

Protective spectacles shall incorporate side protection that is integrated or permanently affixed to the frame (see Clause 6.9).

Notes:

1) *Some forms of side protection do not offer adequate optical quality for clear peripheral vision.*
2) *"Permanently affixed" is that which cannot be removed without the use of tools.*

7.2.2

Any opening in the coverage area in accordance with Clauses 6.8 and 6.9 shall prevent the direct entry of a rigid rod 1.5 mm in diameter when tested in accordance with Clause 12.11.

7.2.3

Ventilated side protection shall be used only in Class 1A spectacles. Non-ventilated side protection may be used in Class 1A spectacles and shall be used in Class 1B spectacles.

7.2.4

Class 1B spectacles intended for use in welding operations for protection against Hazard Types F and G shall have side protection with a shade number not less than one shade less than that of the filter lens.

8 Class 2 protectors — Goggles

8.1 Field of view

Class 2 goggles shall allow a monocular field of view no less than 45° temporally in the horizontal meridian and 80° total in the vertical meridian when tested in accordance with Clause 12.12.

8.2 Opening within the protector

Any openings shall prevent the direct entry of a rigid rod 1.5 mm in diameter when tested in accordance with Clause 12.11.

8.3 Welders' and cutters' models

8.3.1 Field of view

Class 2C goggles shall allow a monocular field of view no less than 15° temporally in the horizontal meridian and 30° total in the vertical meridian when tested in accordance with Clause 12.12.

8.3.2 Transmittance

Class 2C goggle housings shall have transmittance of no more than a shade 8 filter (see Table 1) in the ultraviolet, visible, and infrared regions.

Welding googles shall not have automatic-darkening welding filter that would reach beyond shade 9 in the dark state.

Note: *Goggles having greater than shade 8 filter cannot provide protection to the face, ears, and front of the neck against intense radiant energy, weld spatter, and impact.*

8.4 Optional lift-front attachments

Class 2C goggles equipped with optional lift-front assemblies shall have the lift portion constructed so that it will stay either up or down, but will not remain in a partially opened position.

Note: *Cover lenses or cover plates may be used over Class 2C goggles to protect the filter lenses from weld spatter, pitting, etc.*

8.5 Laser radiation protection (Class 2D goggles)

Class 2D goggles designed for Class 4 laser radiation (Hazard Type I) (wavelengths of 180 nm - 1 mm) protection shall comply with ANSI Z136.7 (testing and labelling) and be classified in accordance with ANSI Z136.1.

Note: *Class 1, Class 2, and Class 3 lasers are not considered to be sources of significant risk of injury to eyes and facial skin.*

8.6 Electric arc protection (Class 2E goggles)

In applications where there is a possibility of exposure to electric arcs (Hazard Type J), Class 2E goggles shall be tested and classified in accordance with ASTM F2178.

Note: *Class 2E goggles should be selected in accordance with CSA Z462.*

8.7 Cover lenses and cover plates

A cover lens or a cover plate may be used to protect the filter lens from weld spatter, pitting, etc. The cover lens or plates should be the same size and shape as the filter lens. This Clause does not apply to automatic-darkening welding filters.

9 Class 3, Class 4, and Class 5 protectors — Helmets, hand shields, and hoods

9.1 General

9.1.1

The devices described in Clause 9 are intended to provide protection for the eyes, face, ears, and front of the neck against intense radiant energy, weld spatter, and impact.

9.1.2

The helmet and the hand shield have the same basic construction: each has a housing with an opening containing a filter plate that allows the wearer to see the radiant object, yet prevents harmful intensities of radiation from reaching the eyes. The helmet can be supported on the head by headgear. The basic construction can be modified to provide protection against special hazards, but modified equipment shall meet the same requirements as basic equipment.

9.2 Class 3 and Class 4 welding protectors

9.2.1 General

Welding helmets shall be used only in conjunction with Class 1 or Class 2 protectors.

See Annex C for guidance on selection of filter lenses for various welding operations.

9.2.2 Field of view

Class 3 welding helmets shall allow a monocular field of view not less than 8° temporally and 15° nasally in the horizontal meridian and 24° in total in the vertical meridian when tested in accordance with Clause 12.12.

9.2.3 Transmittance

The housing shall have transmittance of no more than a shade 14 filter (see Table 1) in the ultraviolet, visible, and infrared regions.

9.2.4 Cover lenses and cover plates

A cover lens or a cover plate may be used to protect the filter lens from weld spatter, pitting, etc. The cover lens or plate should be the same size and shape as the filter lens. This Clause does not apply to automatic-darkening welding filters.

9.2.5 Helmet headgear

9.2.5.1

Within the helmet, a suspension shall hold the helmet housing on the wearer's head. The suspension shall be readily adjustable. The suspension may be fitted with a removable and replaceable sweatband that covers at least the forehead portion of the headband.

9.2.5.2

When tested in accordance with Clause 12.13, the helmet housing shall be attached to the suspension in such a way that the housing will not come into contact with any part of the head and can be lifted from in front of the face and hold its position above the head.

9.2.5.3

The headgear may be replaced by a protective hat or cap that meets the requirements of CSA Z94.1 and to which the welding helmet housing is connected, provided that the welding helmet housing can be lifted and adjusted to allow unobstructed vision or lowered to furnish maximum protection.

9.3 Class 5 protectors

9.3.1 Materials of construction

Hoods may be made of non-rigid materials (e.g., for use in confined spaces) or may be made of collapsible construction (e.g., for convenient carrying or storing).

9.3.2 Design

Hoods may be of the same general shape as the rigid helmet, except that a more complete head covering is necessary in order to maintain the window in proper position.

9.3.3 Transmittance limit for materials

Hood material shall have transmittance of no more than a shade 14 filter (see Table 1) in the ultraviolet, visible, and infrared regions.

9.3.4 Seams and joins

Stitched seams shall be welted.

9.3.5 Filter plates, cover plates, and mounting frames

The requirements for the filter plates, cover plates, and mounting frames shall be the same as per Clause 9.2.4.

9.3.6 Electric arc protectors (Class 5E hoods)

Class 5E protectors shall be tested and classified in accordance with ASTM F2178.

Note: *Class 5E protectors should be selected, in accordance with CSA Z462, in applications where there is a possibility of exposure to electric arcs (Hazard Type J).*

9.4 Optional attachments

9.4.1

A lift-front assembly as specified in Clause 8.4 may be provided.

9.4.2

Bibs for helmets shall be electrically non-conducting and flexible.

10 Class 6 protectors — Face shields

10.1 General

Face shields are constructed to provide protection to the face, i.e., the front part of the head, including the eyes, forehead, cheeks, nose, mouth, and chin, and, where required, to the front of the neck, from flying particles and sprays of hazardous liquids. The face shield may also have, as required, a crown protector and/or a chin protector.

Class 6 protectors shall be used only in conjunction with Class 1 or Class 2 protectors.

10.2 Windows

10.2.1

Measured over their curved surfaces, windows shall be no smaller than a trapezoid 150 mm high, 240 mm wide at the top, and 220 mm wide at the bottom.

10.2.2

The window shall be designed to fit the contour of the window support and to completely cover the eye area from direct exposure.

10.2.3

Special-purpose windows shall meet the same requirements as clear zero-power lenses for resolving power (Clause 6.4.3), prismatic deviation (Clause 6.4.4), and haze (Clause 6.4.5), with the measurements taken in two places that correspond with the pupil centre of each eye, and a 40 mm diameter area around each of these points.

10.2.4

Filter windows to be used in connection with welding operations, and in other situations where injurious non-ionizing radiation is present, shall meet the requirements of Clause 6.5 for zero-power filters, with the measurements taken in two places that correspond with the pupil centre of each eye, and a 40 mm diameter area around each of these points.

10.2.5

The characteristics and performance requirements provided in Clause 10 for face shields shall not be altered by attaching shields to protective hats and caps.

10.2.6

The attachment of the window to the window support shall meet the impact resistance requirements specified in Clause 6.1.

10.3 Crown protection

The crown protector shall be shaped to cover at least the frontal portion of the head and shall extend around each side, at least to a vertical line at the front of the ears. It may be an integral part of the window support or a separate assembly. The construction shall provide reasonable clearance over the wearer's head.

10.4 Chin protection

The chin protector shall be shaped to cover at least the chin and upper part of the throat. The construction shall provide reasonable clearance under the wearer's chin.

10.5 Electric arc protectors (Class 6D face shields)

Class 6D protectors shall be tested and classified in accordance with ASTM F2178.

Note: *Class 6D protectors should be selected, in accordance with CSA Z462, in applications where there is a possibility of exposure to electric arcs (Hazard Type J).*

11 Class 7 protectors — Respirator facepieces

11.1 Field of view

Class 7A and Class 7C facepieces shall allow a monocular field of view no less than 45° temporally in the horizontal meridian and 80° in total in the vertical meridian when tested in accordance with Clause 12.12.

11.2 Non-ionizing radiation protection

Class 7B and Class 7D facepiece housings shall have a transmittance of no more than a shade 14 filter (see Table 1). Devices having greater than a shade 8 filter shall provide protection to the eyes, face, ears, and front of the neck against intense radiant energy, weld spatter, and impact.

11.3 Optional lift-front attachments

Class 7B facepieces equipped with optional lift-front assemblies shall have the lift portion constructed so that it will stay either up or down, but will not remain in a partially opened position.

12 Test methods

12.1 General

12.1.1

All tests shall be carried out by the methods described in Clause 12 or by related methods known to give equivalent results.

12.1.2

Except where otherwise specified, all tests shall be carried out indoors at a room temperature of 23 ± 4 °C and a relative humidity between 30 and 80%.

12.2 Test for impact resistance

Note: *See Clause 6.1.*

12.2.1 Test apparatus

12.2.1.1

For this test, the protector shall be mounted in the same position as usually worn by the user on a medium-size headform compliant with EN 168.

Exception: protectors that are too small to be securely mounted on this headform or that are intended for smaller-sized heads, as specified by the manufacturer, may be mounted on a small-size headform compliant with EN 168.

Note: *EN 168 specifies two headforms: small and medium size.*

12.2.1.2

The headform shall be rigidly mounted on a solid base.

12.2.1.3

Propulsion equipment shall be capable of propelling either a 6.00 ± 0.05 mm diameter steel ball horizontally at a speed of 50.5 + 0.7/-0.4 m/s or a 6.35 ± 0.05 mm diameter steel ball horizontally at a speed of 46.5 ± 0.5 m/s. The steel balls used in this test shall have a hardness in the range of 56–67 RHC. The 6.00 mm steel ball shall have a mass of 0.88 ± 0.02 g. The 6.35 mm steel ball shall have a mass of 1.04 +0.03/-0.02 g.

Note: *This equipment consists essentially of a barrel or a tube of sufficient length to ensure a constant exit speed of the steel ball, together with a breech or loading mechanism positioning the steel ball at a fixed position from the barrel or tube end, and a spring or compressed gas to provide the means of propulsion. The length of tube or smooth barrel required is a function of the characteristics of the gas supply or spring used for propulsion and the fit of the ball in the tube. Therefore, each individual apparatus could have different characteristics, and it is not possible to specify precise requirements for the length of the barrel and the fit of the ball in the bore in this Standard.*

12.2.1.4

The speed of the test ball shall be determined using timing equipment recording in units of 10 µs or smaller. The recommended method is to use an electronic timer with detectors of the inductance, capacitance, or light-sensitive type. The detectors shall be mounted near the projectile path between the muzzle end of the barrel and the lens under test. The recording of speeds shall be made no further than 250 mm from the point of impact.

Note: *The accuracy of the timing units is dictated by the spacing between the sensing elements and the accuracy that is required for the ball-speed measurement. Present indications are that the spacing between the sensing elements should not exceed* 150 mm *and that, with this particular spacing and the highest speed envisaged, the accuracy of the timing unit should be as stated, in order to allow for variations on other points and still keep the overall speed within the limits specified.*

12.2.2 Test methods

12.2.2.1 General

This test is carried out to assess the resistance to a single impact at any point on the components described in Clause 6.1.1. Thus, there shall be only one impact on a selected point, and no impact on a point where the likelihood of failure can have been significantly increased by a previous nearby impact (e.g., a spectacle lens that has been impacted at its centre shall not then be impacted at its edge). Test balls shall be projected at the target points along a horizontal trajectory.

12.2.2.2 Points of impact

12.2.2.2.1 All classes with plano lenses, windows, plates, or facepieces

All points of impact for all classes of protectors shall be located along a horizontal line from the propulsion barrel to the centres of the pupils of the headform. The following impact points shall be tested:

a) the midpoint of the distance between the pupils (nasal area);

   Note: *If no part of the protector is located at this point, the bridge should be impacted at the closest point to the horizontal reference line.*

b) the point directly in front of the centre of each pupil; and

c) the temporal edges, 15 mm temporal from the centre of the pupils.

12.2.2.2.2 Class 1 protectors with zero-power lenses

For Class 1 protectors with zero-power lenses, the following additional impacts at the following points shall be applied:

a) a frontal impact at the point of attachment of the endpiece to the eyewire (one side);

b) a lateral impact at the point of attachment of the temple to the endpiece (one side); and

c) a lateral impact on the side protector located 10 mm behind the corneal apex and lateral impacts 10 mm above and below this point (one side).

Dual lens Class 1 protectors shall be impacted on the eyewire at its thinnest point or, if applicable, at the point in front of the eyewire screw assembly.

12.2.2.2.3 Class 2 to Class 7 protectors

Class 2 to Class 7 protectors shall also be subject to a lateral impact test 10 mm behind each corneal apex. Class 6 protectors shall also be subjected to additional impact tests specified in Clause 10.2.6.

12.2.2.3 Procedure

The protector shall be placed on the headform in the same position as usually worn by the user. A piece of carbon paper above a piece of white paper, each of adequate size, or indicator paste shall be placed between the protector and the headform to cover the eye areas of the headform, with the white paper next to the headform. The assembled headform and protector shall be placed before the propulsion equipment. The steel ball shall be projected toward the protector at the speed specified in Clause 6.1.3.

12.2.2.4 Class 1 protectors with prescription lenses

12.2.2.4.1 Prescription frames

12.2.2.4.1.1 General

Prescription frames tested under this Clause shall be fitted with polycarbonate lenses with a minimum thickness of 2 mm.

12.2.2.4.1.2 Impact resistance

The following points of impact shall be tested:

a) on non-metal frames:
   i) a frontal impact at the thinnest exposed portion of the eyewire (one side);
   ii) a lateral impact at the point of attachment of the temple to the endpiece (one side); and
   iii) a lateral impact on the side protection located 10 mm behind the corneal apex and impacts 10 mm above and below this point (one side); and

b) on metal frames:
   i) a frontal impact at the point of attachment of the bridge to the eyewire (one side);
   ii) a lateral impact at the point of attachment of the temple to the endpiece (one side);

iii) a lateral impact on the side protection located 10 mm behind the corneal apex and impacts 10 mm above and below this point (one side); and
iv) a frontal impact at the point in front of the eyewire screw assembly.

12.2.2.4.1.3 Lens retention

Prescription frames tested for lens retention shall be fitted with polycarbonate lenses of plano power and a thickness of 2.0 +0.2/-0.0 mm at the reference point. The test shall be a single impact on each lens, with the point of impact being within a 2 mm radius of the reference point.

A prescription frame shall be considered to have failed the test for lens retention if, upon impact, the lens is ejected from the test frame or becomes displaced towards the eye.

12.2.2.4.2 Prescription lenses

12.2.2.4.2.1 General

Tests of impact resistance under this Clause shall be valid only for the material, lens style, minimum lens thickness as listed in Table 5, processing method, and surface treatments, if any, used in the test sample.

12.2.2.4.2.2 Lens preparation

Sample lenses shall consist of equal numbers of lenses with powers plano, – 10.00 D sphere, and + 8.00 - 4.00 × 180. Lenses shall be edged to a diameter of 50 mm with a hidden bevel (the apex of which shall be equidistant from the front and back edges of the lens) and feather bevel (chamfer), with the optical centre of the lens at the geometric centre.

For the purpose of this test, the hidden bevel shall be one in which the angle at the apex of the bevel is 115 ± 5°, with a height of 0.8 ± 0.15 mm and a cross-section at the base of 2.6 ± 0.5 mm (trade name: Hide-a-Bevel®) as shown in Figure 4.

Note: *Other forms of lens bevel are acceptable for use in eyewear that complies with this Standard; however, the hidden bevel is specified to ensure uniformity in testing of prescription protective lenses and frames.*

12.2.2.4.2.3 Lens holder

The sample lens shall be mounted in a holder constructed of stainless steel as shown in Figure 5. The holder shall be mounted on an adjustable base that allows the lens to be aligned with the propulsion equipment.

12.2.2.4.2.4 Points of impact

The sample shall not exhibit lens failure as defined in Clause 6.1.3.1 a) when impacted once as follows:
a) for lenses of power plano or - 10.00 D sphere, the impact point shall be the geometric centre; and
b) for lenses of power + 8.00 - 4.00 × 180, the impact point shall be 20 mm from the geometric centre along the meridian 45° or 135°.

12.3 Ignition resistance test

Note: *See Clause 6.2.*

12.3.1 Apparatus

The following apparatus shall be used:

a) a steel rod, 300 ± 3 mm long and 6 mm in nominal diameter, with end faces that are flat and perpendicular to its longitudinal axis (see Figure 6);
b) a heat source;
c) a thermocouple and temperature-indicating device or equivalent; and
d) a timer capable of measuring an elapsed time of 10 s with an accuracy of ± 0.1 s.

12.3.2 Procedure

One end of the steel rod shall be heated over a length of at least 50 mm to a temperature of 650 ± 20 °C. The temperature of the rod shall be measured by means of the thermocouple attached at a distance of 20 ± 1 mm from the heated end of the rod. The heated face of the rod (positioned vertically) shall be pressed against the surface of the test sample (the contact force being equal to the weight of the rod) for a period of 5.0 ± 0.5 s and then remove it. The test shall be carried out on all exposed parts of the protector. If a given component of the protector consist of more than one type of material, the test shall be carried out on all parts of the component.

12.3.3 Criterion

The protector shall be considered to meet the performance requirement if no component of the protector ignites or continues to glow or be consumed after removal of the steel rod (see Clause 6.2.1).

12.4 Test for refractive (residual) power

Note: *See Clause 6.4.2.*

12.4.1

The target for the test shall be a high-contrast black-on-white “sunburst” pattern with radially-oriented lines placed every 15°, starting in the horizontal meridian. The inner end of the line segments shall lie on the circumference of a circle 15 mm in diameter, and each line segment shall be at least 15 mm long. The thickness of the lines shall be no less than 0.5 mm and no more than 1.0 mm.

12.4.2

A telescope of 8x to 12x magnifying power placed at a distance of 10 m from the target shall be focused on the target with no lens in front of the telescope. The telescope shall be calibrated by placing spherical lenses of known power in front of its objective and recording the amount and direction of adjustment of the eyepiece position required to refocus the target for each lens power.

12.4.3

The zero-power lens under test shall be placed in front of the telescope objective.

12.4.4

If all lines appear equally blurred, the telescope shall be refocused to obtain the power reading at which the lines appear equally sharp. If the line in one meridian appears sharpest at a given focus, the telescope shall be focused to obtain a maximum or minimum power reading in that meridian. The telescope shall then be refocused to obtain the power reading of the opposite extreme.

12.5 Test for resolving power

Note: *See Clause 6.4.3.*

12.5.1
The target for the test shall consist of bright rings of various sizes on a black background, as illustrated in Figure 7. Each ring shall have an inside diameter equal to 1/3 of its outside diameter. The effective size of each ring shall be designated by the arithmetic mean of the two diameters, as expressed in seconds of arc, subtended at the objective of the viewing telescope.

12.5.2
The telescope shall be 5 m or more from the target and shall have a magnification* sufficient to make negligible any effects of eye accommodation. It shall be focused with no sample in place and shall not be refocused during testing. The clear aperture of the telescope objective shall be masked to 5 mm in diameter. The system shall be of at least sufficient quality to allow resolution of the 40-s ring. This resolution shall be maintained at every degree of image brightness to be used in testing.

* *A magnification of 8x to 12x is usually suitable.*

12.5.3
The lens, plate, or cover to be tested shall be placed immediately in front of the telescope objective and normal to its axis.

12.5.4
A ring shall be considered to be resolved if it is identifiable as an unbroken bright ring with a single darker centre, even if the apparent relative widths of the ring and its centre are changed or the ring and its centre cease to appear circular. The ring shall be considered not resolved if the ring is broken, if the dark centre is not seen, or if two or more dark centres that do not overlap are seen.

12.6 Test for prismatic deviation
Note: *See Clause 6.4.4.*

12.6.1 Apparatus set-up

12.6.1.1
The component shall be tested for deviation of incident light passing through the reference points and at points 10 mm above, below, and to either side of each reference point.

12.6.1.2
The requirements of Clause 12.6.1.1 shall not apply to plano spectacles that incorporate a reading segment into the lens.

The test points for plano spectacles with a reading segment shall be
a) through the reference points;
b) at points 10 mm to either side of the reference points; and
c) for reading segments located
   i) in the bottom portion of the lens: 10 mm above the reference points; or
   ii) in the top portion of the lens: 10 mm below the reference points.

If reading segments are located in both the top and bottom portion of the lens, no additional test points (beyond the horizontal meridian) shall be used.

12.6.2 Orientation of light source

The light shall be normally incident on the front surface of the lens. An exception shall be made for any optical component for which the specific optical design indicates the suitability of a different criterion for direction of incident light (e.g., for zero-power "6-base" spectacle lenses, the light shall be incident parallel to the lens axis).

12.7 Test for haze in clear zero-power lenses

Note: *See Clause 6.4.5.*

The test apparatus and test method for measurement of haze in clear zero-power lenses shall be in accordance with ASTM D1003.

12.8 Test for luminous transmittance

Note: *See Clauses 6.4.6, 6.5.2, and 6.5.4.4.*

12.8.1

Measurements of luminous transmittance of lenses shall be of regular transmittance with normal incidence on a 5 mm diameter circular portion of the component.

12.8.2

Measurements of ultraviolet or infrared transmittance shall be of regular transmittance with normal incidence on a 5 mm diameter portion of the component. A spectrophotometer or a spectroradiometer shall be used.

12.8.3 Housing

Measurement of luminous transmittance of a non-optical component, e.g., a helmet housing, shall be of regular transmittance in accordance with Clause 12.8.2.

12.8.4

Luminous transmittance shall be determined with Standard Illuminant A as described in ISO 11664-2.

12.8.5

When luminous transmittance in the visible range is being tested, the methods specified in ASTM D1003 shall be used. For ultraviolet and infrared radiation, a spectrophotometer shall be used.

Note: *A spectrophotometer or a spectroradiometer can be used for all luminous transmittance measurements.*

12.9 Tests for permanence of filters

Note: *See Clause 6.5.3.*

12.9.1 Heat test

The sample shall be inserted into an oven and the temperature shall be raised to 80 °C. The time taken to reach this temperature shall be about 25 min if starting with a cold oven. The required temperature shall be maintained within ± 2 °C for 1 h and then allowed to fall to room temperature. The time taken to reach room temperature shall not exceed 1 h.

12.9.2 Moisture test

The sample shall be suspended in a closed vessel, the bottom of which is covered with water to a depth of at least 13 mm. The vessel shall then be placed in an oven thermostatically controlled at 50 ± 2 °C for 24 h.

12.9.3 Ultraviolet exposure test

12.9.3.1

For this test, the source of ultraviolet radiation shall be a high-pressure xenon lamp of a type that operates at a constant internal pressure of approximately 100 kPa. No reflector shall be used, and the lamp shall be operated under the conditions recommended by the lamp manufacturer for normal ultraviolet output.

12.9.3.2

The sample shall be exposed for 48 h at a distance from the lamp calculated as follows:

$$D = 15.7\sqrt{P}$$

where

D = distance, mm

P = the power consumed by the lamp itself, exclusive of the power dissipated in the ballast, W

For example, if the lamp consumes 500 W, the distance would be 351 mm.

Note: *For lamps operated on direct current, P can be calculated as the product of the current in amperes and the potential difference in volts between the terminals of the quartz burner. For lamps operated on alternating current, a suitable wattmeter should be used to measure P.*

12.9.3.3

The sample shall be mounted normal to the direction of the radiation (with the exterior surface toward the lamp) and, if the outer plies are of different thicknesses, the thinner ply shall be toward the lamp.

12.10 Test for dioptric power

Note: *See Clause 15.4.4.1.*

12.10.1

Suitable instruments for determining dioptric power of prescription spectacles include

a) a lensometer that measures vertex power;

b) a vertometer that measures vertex power; or

c) optical measuring equipment for measuring back-vertex focal length or back-vertex power.

12.10.2

The instrument used to determine dioptric power of prescription spectacles shall have

a) a magnification of at least 5x;

b) a clear aperture at the lens under test of not more than 8 mm in diameter; and

c) a white light and visual observation or other system that gives equivalent values.

Note: *Possible systems include the use of visual observation, with green light to avoid colour fringing.*

12.11 Test for particle penetration of gaps and ventilation openings

Note: *See Clauses 7.2.2 and 8.2.*

12.11.1
The protector shall be mounted on a headform compliant with EN 168 as it would be worn by the user.

Exception: protectors that are too small to be securely mounted on this headform or that are intended for smaller-sized heads, as specified by the manufacturer, may be mounted on a small-size headform compliant with EN 168.

12.11.2
A 1.5 mm diameter rod shall be used as a probe (see Figure 8).

12.11.3
With the specimen in place on the headform, the rod shall probe, without appreciable force, all gaps, vents, and openings in the specified area of the protector in an attempt to reach the eyeball of the headform.

Note: *This test is applied to gaps, vents, and openings within the protector (frame) and not spaces around the protector.*

12.11.4
During the test outlined Clause 12.11.3, if the rod touches the eyeball of the headform, the test shall stop and the protector shall be considered to not comply with the performance requirement.

12.12 Test for field of view
Note: *See Clauses 7.1, 8.1, 8.3.1, 9.2.2, 11.1, and 15.2.2.*

12.12.1 General
Field of view (FOV) tests shall be conducted on a complete protector device that is mounted in the same position as usually worn by the user.

Note: *The following method assumes that a "flat" lens is mounted in the protector. It is known that lenses with highly curved surfaces (wrap lenses) will have larger fields of view than calculated by this method.*

12.12.2 Class 1 Spectacles, Class 2 goggles, Class 3 and 4 welding protectors, Class 7 respirator facepieces — Two lenses

12.12.2.1 Horizontal field of view — Two lenses
The distance *A* shall be measured between two vertical lines that are tangent to the nasal and temporal edges of the lens. The temporal FOV, *H*, is expressed as follows:

$H = \arctan (X/D_V)$

where

X = one-half of the distance A, mm

D_V = vertex distance, mm

12.12.2.2 Vertical field of view — Two lenses
The distance *B* shall be measured between two horizontal lines that are tangent to the upper and lower edges of the lens. The total vertical FOV, *V*, is expressed as follows:

$V = 2 \arctan (Y/D_V)$

where

Y = one-half of the distance *B*, mm

D_V = vertex distance, mm

12.12.3 Class 1 Spectacles, Class 2 goggles, Class 3 and 4 welding protectors, Class 7 respirator facepieces — One lens

12.12.3.1 Horizontal field of view — One lens

The distance *C* shall be measured between two vertical lines that are tangent to the right and left edges of the lens. If a small headform is used, 32 mm shall be replaced by 27 mm.

The temporal FOV, *H*, is expressed as follows:

$H = \arctan((X - 32) / D_V)$

where

X = one-half of the distance *C*, mm

D_V = vertex distance, mm

12.12.3.2 Vertical field of view — One lens

The distance *B* shall be measured between two horizontal lines that are tangent to the upper and lower edges of the lens. The total vertical FOV, *V*, is expressed as follows:

$V = 2 \arctan(Y / D_V)$

where

Y = one-half of the distance B, mm

D_V = vertex distance, mm

12.12.4 Alternative methods

Alternative test methods may be used, but in cases of dispute, the procedure outlined in Clauses 12.12.1 to 12.12.3 shall be used.

12.13 Test for suspension function

The welding helmet shall be mounted on a headform compliant with EN168 as it would be worn by the user, and visually inspected to see if the housing comes in contact with any part of the head. The housing shall then be lifted and checked to see if it will hold its position above the head.

12.14 Test for switching index

Note: *See Clause 6.5.4.5.*

12.14.1 General

The test shall measure the variation in luminous transmittance of an automatic-darkening welding filter, recorded over time, as it is exposed to radiation from a high-pressure xenon lamp, the intensity of which can be switched from a low to a high value.

12.14.2 Test apparatus

A high-pressure xenon lamp light source, capable of being switched from a low to a high level of luminous intensity, shall be used. At the high level, the illuminant shall not be less than 10 000 lx at the filter. The rise time between 10% and 90% of this value shall be no greater than 3% of the required switching index for the device under test. As the light source is switched from low to high intensity, light detector(s) and recording apparatus shall be capable of detecting and recording, against time, the variations of source illuminant and the variations of transmittance of the device under test. Mounting devices shall be capable of mounting the light source, light detectors, and the test specimen normal to the beam of luminance.

12.14.3 Test methods

The test shall be conducted in the following manner:

a) The test specimen (automatic-darkening welding filter) shall be maintained at the appropriate test temperature for a minimum of 2 h before testing and during the test period.
b) The test specimen and light detectors shall be mounted normal to the beam of luminance. The light source shall be operated at its low-intensity setting when the recording device is started.
c) The light source shall be switched to its high-intensity setting and the variations (with time) of source illuminant (at the filter) and luminous transmittance (through the filter) recorded.

The switching index shall be calculated from the integral given in Clause 6.5.4.5.1, taking $t = 0$ as the time when the recorded illuminant reaches 5000 lx.

12.15 Angular dependence of luminous transmittance test for automatic welding filter lenses

12.15.1 Principle

This procedure specifies the method for determining angle dependence of luminous transmittance for an automatic welding filter. The test shall measure the luminous transmittance variations within the viewing cone of angles less than 15° to the normal of the filter and within the viewing cone of angles less than 30° to the normal of the filter.

12.15.2 Apparatus

A suitable method for measuring luminous transmittance, for example the method described in Clause 12.8, shall be used. The parallel ray of light shall have a cross-section area corresponding to the area of a circle with a diameter between 5 and 20 mm (see Figure 9).

12.15.3 Procedure

12.15.3.1 General

All measurements shall be performed at the reference point of the filter:

a) Measure the luminous transmittance normal (90 ± 1°) to the surface of the filter.
b) Measure the luminous transmittance at an angle of incidence of 15 (+0°/-2°) to the normal and angles of rotation around the normal from 0 ± 2° to 315 ± 2° in increments of 45 ± 2° in order to establish the maximum and minimum transmittance (see Figure 9). Calculate the ratios of the maximum and minimum luminous transmittance measured at 15° to the luminous transmittance measured at normal incidence. Also calculate the reciprocals of these ratios. The maximum of these ratios and their reciprocals is V15.
c) Measure the luminous transmittance at an angle of incidence of 30 (+0°/-2°) to the normal and angles of rotation around the normal from 0° to 315 ± 2° in increments of 45 ± 2° in order to establish the maximum transmittance (see Figure 9). Calculate the ratio of the maximum luminous transmittance measured at 30° to the luminous transmittance measured at normal incidence. This ratio is V30.

12.15.3.2 Procedure for polarized automatic welding filter lenses

Using the test method in Clause 12.8 to test polarized filters required by Clause 12.15.3.1 a), the procedure for polarized automatic welding filter lenses shall be as follows:

a) measure the luminous transmittance normal (90 ± 1°) to the surface of the filter with the filter positioned at the as-worn position; and
b) determine the transmittance value of the polarizing filter lens using un-polarized light and calculated as a mean value of the transmittance values determined for two mutually perpendicular orientations of the plane of transmission of the filter lens.

Alternatively the transmittance value of a polarized filter may be determined by rotating the filter lens 45° or –45°.

12.15.4 Test report

The values V15 and V30 shall be reported.

13 Marking and user information

13.1

Protectors that comply with this Standard shall bear the designation "Z94.3".

Note: *This does not apply to prescription protective eyewear. See Clause 15.*

13.2

The following items shall bear a permanent mark identifying the manufacturer or supplier:

a) lenses, excluding covers;
b) spectacle fronts;
c) spectacle temples;
d) goggle eye-cups;
e) goggle housings;
f) helmet housings;
g) helmet headgear;
h) hand shields; and
i) face shield headgear.

Note: *Lenses include plates, filters, windows, and prescription lenses.*

13.3

Zero-power filters and filter windows shall be permanently marked with shade numbers in accordance with all the transmittance requirements for filters given in Table 1.

13.4

Special-purpose lenses shall carry a statement that the lenses are not for use where filter lenses are required.

13.5

For any device certified by a nationally recognized certification organization as meeting this Standard, the mark or other identification of the certification organization shall be permanently placed on at least one component of an assembled product or system.

Note: *This Clause does not imply a requirement for any compliant products to be certified. This Clause states only that if the product has been certified, it must be marked as such.*

13.6

The following information shall be provided with all non-prescription eye and face protectors:

a) assembly instructions where necessary;
b) fitting instructions;
c) cleaning instructions;
d) storing instructions;
e) inspection criteria and determination of end of useful life;
f) maintenance instructions where necessary;
g) hazards for which the protector is appropriate; and
h) limitations of the protector.

14 Transmittance requirements

14.1 General

Clauses 14.2 and 14.3 set out transmittance requirements for general-purpose filters for protection from ultraviolet, visible, and infrared radiation.

14.2 Expressions and calculations

14.2.1

Shade number, *S*, shall be related to luminous transmittance, T_L (expressed as a fraction, not as a percentage), by the equation

$$S = \frac{7}{3}\log_{10}\frac{1}{T_L} + 1$$

14.2.2

The near-ultraviolet average transmittance, (*NUV*), shall be defined as

$$\bar{T}(NUV) = \frac{1}{65}\int_{315}^{380} T(\lambda)\, d(\lambda)$$

14.2.3

When $T(\lambda)$ shall be defined as the spectral transmittance of the filter at wavelength λ, the effective far-ultraviolet average transmittance, (*EFUV*), shall be defined as

$$\bar{T}(EFUV) = \frac{\int_{200}^{315} T(\lambda)S(\lambda)d(\lambda)}{\int_{200}^{315} S(\lambda)d(\lambda)}$$

where

$S(\lambda)$ = the spectral weighting factor given in Table B.1

14.2.4

The luminous transmittance, T_L, shall be defined in this Standard with respect to the light source (ISO/CIE 11664-1 Standard Illuminant A) and the CIE Standard Colorimetric Observer, and shall be expressed as

$$T_L = \frac{\int_{380}^{780} T(\lambda)\bar{y}(\lambda)S(\lambda)d(\lambda)}{\int_{380}^{780} \bar{y}(\lambda)S(\lambda)d(\lambda)}$$

where

(λ) = the relative luminous efficiency function

$S(\lambda)$ = the relative spectral emittance of CIE Standard Illuminant A as defined in ISO 11664-2

$\bar{y}(\lambda)$ = spectral luminous sensitivity of CIE Standard Colorimetric Observer as defined in ISO/CIE 11664-1

These functions are given in Table B.2.

14.2.5

The infrared average transmittance, (*IR*), shall be defined as

$$\bar{T}(IR) = \frac{\int_{780}^{2000} T(\lambda)S(\lambda)d(\lambda)}{\int_{780}^{2000} S(\lambda)d(\lambda)}$$

where in the infrared, the relative spectral emittance, $S(\lambda)$, of CIE Standard Illuminant A as defined in ISO 11664-2 = that of a "black-body" radiator at temperature of 2856 K and is given in Table B.3.

14.2.6

The blue-light transmittance, T_B, shall be defined as

$$T_B = \frac{\int_{400}^{1400} T(\lambda)S(\lambda)d(\lambda)}{\int_{400}^{1400} B(\lambda)d(\lambda)}$$

where

$B(\lambda)$ = the blue-light hazard function defined in Table B.4

14.3 Requirements

Requirements for filter transmittance shall be as given in Table 1 and in the Notes to Table 1.

15 Requirements for prescription protective eyewear

15.1 General

15.1.1

Prescription safety eyewear shall comply with the requirements of Clause 15.

15.1.2
Frames should be selected to ensure proper fit on the face of the wearer.

15.2 Frame criteria

15.2.1
Protective frames intended for use with prescription lenses shall satisfy all the requirements of this Standard for Class 1 protectors. Tests of lens retention are detailed in Clause 12.2.2.4.1.3.

15.2.2
The eyewire and lens shall cover an elliptical area of no less than 40.0 mm wide and 33.0 mm high in front of each eye, centred on the pupil centre of the medium test headform (see Figure 2). The protector shall cover an elliptical area of not less than 36 mm wide and 26 mm high in front of each eye, centred on the pupil centre of the small test headform (see Figure 2). The monocular field of view shall not be less than 45° temporally in the horizontal meridian and 80° total in the vertical meridian when tested in accordance with Clause 12.12.

15.2.3
Protective frames, complying with the design and performance requirements of Clause 15, shall bear the following mark on the frame: “CSA Z94.3”.

15.3 Side protection

15.3.1
Protective spectacles shall incorporate side protection that is integrated or permanently affixed to the frame.

15.3.2
Frames should be selected to ensure proper fit on the wearer’s face. If modifications must be made to side protection in order to ensure proper fit, they shall be made by a qualified professional in a manner that results in optimal coverage for the wearer.

Note: *This Clause does not apply to non-prescription Class 1 protectors.*

15.4 Prescription lens criteria

15.4.1 Impact resistance

15.4.1.1
Prescription lenses used in prescription safety eyewear shall be manufactured from materials, including tints and coatings, meeting the requirements for impact resistance of Clause 12.2.2.4.2.

15.4.1.2
Lenses that meet the criteria of Table 5 are considered to meet the requirement for impact resistance of prescription lenses (i.e., there is no requirement to test these lenses in accordance with Clause 12.2.2.4.2).

15.4.2 Marking of prescription lenses

Each prescription lens shall be distinctly marked in a permanent and legible manner with the manufacturer's monogram, placed so that interference with the wearer's vision is minimal.

15.4.3 Compliance of prescription lenses

15.4.3.1

Prescription lenses shall meet the same size requirements as clear zero-power spectacle lenses (see Clause 7.1).

15.4.3.2

Clear prescription lenses shall meet the haze requirements of Clauses 6.4.5 and the transmittance requirements of Clause 6.4.6.

15.4.3.3

Filter prescription lenses shall meet the requirements of

a) Clause 6.4.5.2 for haze; and

b) Clause 6.5.2 for transmittance when measured at the reference point.

15.4.3.4

Prescription lenses shall be free from inherent defects such as bubbles, grains, clouding, holes, cracks, waves, and dull spots, observable by an evaluator wearing the eye protector, to within 3 mm of the edge. The evaluator shall inspect for defects with his or her eye focused on a variety of focal distances commonly encountered in the workplace.

15.4.4 Compliance with prescriptions

15.4.4.1

A qualified person using an instrument suitable for determining dioptric power, as described in Clause 12.10, shall test prescription lenses for accuracy of fulfillment of the original prescription.

15.4.4.2

The measured values for sphere and cylinder power shall agree with the prescription within the tolerances specified in Table 3. For a sphere-cylinder lens, all three values (the two measured powers and their calculated difference) shall agree with the prescription within the stated tolerances.

15.4.4.3

The bifocal power addition shall not differ from that prescribed by more than ± 0.12 dioptre.

15.4.4.4

The axis of the cylinder shall agree with the prescription within the tolerance specified in Table 4.

15.4.4.5

The prism powers and the locations of the reference point shall correspond with those prescribed accurately enough to ensure that differences from the prescription do not exceed 0.25 prism dioptre for each lens, or 0.50 prism dioptre imbalance in either the vertical or horizontal direction. Induced distortion and prism power that are inherent in the design of progressive addition lenses shall be exempt from this requirement; however, prescription spectacles with progressive addition lenses that incorporate a prism correction shall meet this requirement when measured at the prism control points of the lenses designated by the lens manufacturer.

15.4.4.6
The segment sizes of bifocal power additions shall be within ± 0.5 mm of the prescription.

15.4.4.7
The segment location of bifocal power additions shall be as follows:
a) for horizontal location of segments: the horizontal distance between the distance pupil position and the segment centre of each lens shall be within 1 mm of the value specified on the prescription; and
b) for vertical location of segments: the height of each lens segment shall be within 1 mm of the value specified on the prescription.

15.4.4.8
The horizontal and vertical positions of the designated fitting points of progressive addition lenses used in a pair of protective spectacles shall be within ± 0.5 mm of the prescription.

15.4.4.9
To control warpage, the curvatures of the principal meridians of the lens mounted in the protector shall be within ± 0.5 dioptre of the design specification of the lens. These values apply to measurements made with an ophthalmic lens clock; that is, they represent the surface powers of the lens.

15.5 Manufacture of prescription protective spectacles

15.5.1 General
Prescription protective spectacles shall be fabricated by manufacturers competent in spectacle manufacturing.

See Annex D for general guidance on the manufacturing of eye and face protectors.

15.5.2 Quality-control and management systems
The manufacturer shall have in place documented quality-control and management systems. These systems shall ensure control and traceability of component sources (i.e., frames, lenses, tints, and coatings).

15.5.3 Lens-processing quality
The manufacturer shall have in place quality-control and management systems to ensure proper preparation of lenses, including surfacing, edging, and mounting of lenses, as well as the application of tints and coatings in compliance with this Standard.

15.6 Markings
Prescription frames shall be marked for size in accordance with the system described in ANSI Z80.5. Fronts shall be marked with the A and DBL. Temples shall be marked with their overall length.

16 Sun protection for outdoor workers

Note: *Compliance with Clause 16 is optional (i.e., manufacturers may choose whether or not to claim compliance) as an additional protective feature.*

16.1 Application

Clause 16 applies to Class 1 and Class 2 eye protectors. Clause 16 also provides guidance on sun protection for the eyes of outdoor workers.

16.2 Transmittance requirements

16.2.1 Luminous transmittance

When calculated in accordance with Clause 16.3.1, the luminous transmittance of a lens shall be between 8% and 40%. The intended primary function of the lens shall be in accordance with Table 7.

16.2.2 Mean transmittance

When calculated in accordance with Clause 16.3.2, the mean transmittance of a lens shall be
a) for UVA, no greater than luminous transmittance; and
b) for UVB, no greater than 0.125 of luminous transmittance.

16.2.3 Transmittance properties related to traffic signal recognition

Note: *See Annex E.*

16.2.3.1 Colour limits

When calculated in accordance with Clause 16.3.3, the *x* and *y* chromaticity coordinates of traffic signals and average daylight (D65), as viewed through the lens, shall fall within the prescribed regions on the CIE Standard Chromaticity diagram in accordance with Table 7 for the intended primary function. The regions of acceptance shall be as shown in Table 8 and shall be defined as follows:
a) For red traffic signals, colour limits are not required.
b) For yellow traffic signals, the colour limits are as follows:
Corners of yellow region

x	*y*
0.435	0.565
0.375	0.565
0.655	0.345
0.595	0.345

c) For green traffic signals, the colour limits are as follows:
Corners of green region

x	*y*
0.038	0.330
0.205	0.330
0.345	0.440
0.313	0.620
0.080	0.835

d) For average daylight (D65), the colour limits are as shown in Table 8.

16.2.3.2 Traffic signal transmittance

When calculated in accordance with Clause 16.3.4, the traffic signal transmittance of a lens shall be a minimum of 8% for the red signal, a minimum of 6% for the yellow signal, and a minimum of 6% for the green signal.

16.2.4 Ultraviolet transmittance

The maximum transmittance of a lens in the ultraviolet range shall be

a) for UVA: no greater than the luminous transmittance; and

b) for UVB: no greater than 0.125 of luminous transmittance.

16.2.5 Photochromic lenses

The categories of the photochromic lens shall be determined by its luminous transmittance in its faded state τ_{vo} and its luminous transmittance in its darkened state τ_{v1} achieved after 15 min irradiation in accordance with Clause 16.3.5. In both states, the requirements specified in Clauses 16.2. and 16.2.3 shall be met. For photochromic filters, τ_{vo}/τ_{v1} shall be ≥ 1,25.

16.2.6 Polarized lenses

Polarized lenses shall comply with the requirements of ISO 12312-1 (Clause 5.3.4.2) based on the relevant test procedure in ISO 12311.

16.3 Tests

16.3.1 Luminous transmittance test

16.3.1.1

The luminance transmittance shall be calculated in accordance with either Clause 16.3.1.2 or 16.3.2.

16.3.1.2

The integrals given in the definition of luminous transmittance (see Clause 3) may be evaluated by using continuous functions or by dividing the spectral range, 380 to 780 nm, into a finite number of intervals, no greater than 10 nm wide, and replacing the integrals by finite summations as follows:

$$\tau_v = \frac{\sum_{\lambda=380}^{780} \tau(\lambda)\ V(\lambda)\ S(\lambda)\,\Delta\lambda}{\sum_{\lambda=380}^{780} V(\lambda)\ S(\lambda)\,\Delta\lambda}$$

where

$\Delta\lambda \leq 10$ nm

Products of the foregoing constants at 10 nm intervals and the value of the denominator are given in Table 9. The spectral transmittance measurements τ (λ) shall be obtained with a spectrophotometric instrument with a resolution of 10 nm or better.

16.3.1.3

The luminous transmittance of a lens may be determined by a photometer that has been colour corrected to produce a spectral sensitivity equivalent to the spectral distribution of ISO 11664-2 Standard Illuminant D65, as perceived by the CIE Standard Colorimetric Observer. The allowable error of this method shall be 5%.

16.3.2 Mean transmittance test

The integral given in the definition of mean transmittance (see Clause 3) may be evaluated by using continuous functions or by dividing the specified spectral range into a finite number of intervals, no greater than 10 nm wide, and replacing the integral by a finite summation as follows:

$$\tau(\lambda_2, \lambda_1) = \frac{\sum_{\lambda=\lambda_1}^{\lambda_2} \tau(\lambda)\ \Delta\lambda}{\sum_{\lambda=\lambda_1}^{\lambda_2} \Delta\lambda}$$

where

$\Delta\lambda \leq 10$ nm

16.3.3 Chromaticity coordinates test

16.3.3.1

The integrals given in Clause E.1 may be evaluated by using continuous functions or by dividing the spectral range, 380 to 780 nm, into a finite number of intervals, no greater than 10 nm wide, and replacing the integrals by finite summations as follows:

a) for traffic signals as viewed through the lens:

$$X_{sig} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_A(\lambda)\, \tau_{sig}(\lambda)\bar{x}(\lambda)\Delta\lambda$$

$$Y_{sig} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_A(\lambda)\, \tau_{sig}(\lambda)\bar{y}(\lambda)\Delta\lambda$$

$$Z_{sig} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_A(\lambda)\, \tau_{sig}(\lambda)\bar{z}(\lambda)\Delta\lambda$$

where
$\Delta\lambda \leq 10$ nm
Products of the foregoing constants at 10 nm intervals for red, yellow, and green traffic signals are given in Table 9.

b) for average daylight as viewed through the lens:

$$X_{D65} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_{D65}(\lambda)\bar{x}(\lambda)\Delta\lambda$$

$$Y_{D65} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_{D65}(\lambda)\bar{y}(\lambda)\Delta\lambda$$

$$Z_{D65} = \sum_{\lambda=380}^{780} \tau(\lambda)\ S_{D65}(\lambda)\bar{z}(\lambda)\Delta\lambda$$

where
$\Delta\lambda \leq 10$ nm
Products of the foregoing constants at 10 nm intervals are given in Table 9.

16.3.3.2

Any test that can be demonstrated to yield test results at least functionally equivalent to those obtained by the test described in Clause 16.3.3.1 may be used.

16.3.4 Traffic signal transmittance test

16.3.4.1

The integrals given in Clause E.2 may be evaluated by using continuous functions or by dividing the spectral range, 380 to 780 nm, into a finite number of intervals, no greater than 10 nm wide, and replacing the integrals by finite summations as follows:

$$\tau_{sig} = \frac{\sum_{\lambda=380}^{780} \tau(\lambda)\ V(\lambda)\, S_A\,(\lambda)\, \tau_{sig}(\lambda)\, \Delta\lambda}{\sum_{\lambda=380}^{780} V(\lambda)\ S_A\,(\lambda)\, \tau_{sig}(\lambda)\, \Delta\lambda}$$

$$= \frac{Y_{sig}}{\sum_{\lambda=380}^{780} V(\lambda)\ S_A\,(\lambda)\, \tau_{sig}(\lambda)\, \Delta\lambda}$$

where

$\Delta\lambda \leq 10$ nm

Products of the foregoing constants at 10 nm intervals and the value of the denominator are given for red, yellow, and green traffic signals in Table 9.

16.3.4.2

Any test that can be demonstrated to yield test results at least functionally equivalent to those obtained by the test described in Clause 16.3.4.1 may be used.

16.3.5 Photochromic lens qualification test

16.3.5.1 Spectrophotometric method

16.3.5.1.1 Light source

A source shall be used whose spectral distribution simulates, as closely as possible, the values of solar irradiation at sea level, *E* (λ), given in Table 10.

16.3.5.1.2 Conditioning of test sample for luminous transmittance in the faded state

Unless the manufacturer specifies a different procedure to reach the faded state in the information supplied with the product, photochromic filters shall be conditioned by the following procedure:

a) Store filters in the dark at 65 ± 5 °C for 2 ± 0.2 h.
b) Store filters in the dark at 23 ± 5 °C for at least 12 h.

c) Expose filters to 15 000 ± 1500 lx at 23 ± 1 °C for 15 min using a source similar to the one described in Clause 16.3.5.1.1.
d) Store filters in the dark at 23 ± 1 °C for 60 min.

16.3.5.1.3 Measurement of luminous transmittance in faded state

The spectral transmittance shall be measured from 280 nm to 780 nm (or to 2000 nm if IR is included) in accordance with Clause 16.3.1. The temperature during the test shall be 22 ± 3 °C.

16.3.5.1.4 Conditioning of test sample for luminous transmittance in the dark state

Lenses shall be exposed to the source described in Clause 16.3.5.1.1 at 22 ± 3 °C for 15 min.

16.3.5.1.5 Measurement of luminous transmittance in dark state

The spectral transmittance shall be measured from 280 nm to 780 nm (or to 2 000 nm if IR is included) in accordance with Clause 16.3.1. The temperature during the test shall be 22 ± 3 °C.

16.3.5.2 Alternative test methods

Any test that can be demonstrated to yield test results at least functionally equivalent to those obtained by the test described in Clause 16.3.5.1 may be used.

16.3.6 Test for polarized lenses

16.3.6.1 Test for plane of transmission

16.3.6.1.1 Apparatus

A pair of individually mounted split-field polarizers cut to give planes of transmission at a + 3° and a - 3° angle about the horizontal, or the prescribed axis shall be used for this test. The top and bottom halves of the polarizers shall be joined together and glass mounted, with the line of the join horizontal or perpendicular to the prescribed axis. The polarizers shall be capable of being rotated by means of a lever carrying a corresponding pointer. The pointer transverses a scale calibrated in degrees left or right of zero. The split fields shall be illuminated from behind by a diffused light source.

16.3.6.1.2 Test procedure

The sunglass shall be mounted on the apparatus (see Figure 10), with the front towards the split fields on a horizontal register bar. The split field shall appear in the centre of the filter by means of vertical adjusters. The pantoscopic angle and the face form angle shall be ”as worn”.

For the left filter, the lever shall be moved from side to side until the top and bottom halves of the illuminated split field appear of equal luminance when viewed through the filter.

The pointer position shall be read to give the deviation in degrees (plus or minus) of the plane of transmission of the filter from the horizontal or the prescribed orientation. The procedures shall be repeated for the right filter.

16.3.6.2 Test for polarizing efficiency

16.3.6.2.1 Principle

The luminous transmittance for visible light is measured with plane polarized light with the plane of oscillation set to provide the maximum and the minimum transmittance of the lens. This may be done by the spectrophotometric method and calculation method (the reference method) or by the broadband method using a detector with the sensitivity of the human eye (peak at 555 nm) and a source equivalent to CIE Standard Illuminant D65.

16.3.6.2.2 Test procedure for the spectrophotometric method

The procedure shall be carried out as follows.

a) Mount the linear polarizers with their planes of transmission parallel in the reference and sample beams of the spectrophotometer. The linear polarizers shall have a polarization at least one order of magnitude better than the requirement being tested against [e.g. if the requirement for the filter is a polarizing efficiency of 80% (9:1), the linear polarizers shall have an efficiency of at least 97.5% (90:1)].
b) Mount the polarizing filter in the spectrophotometer.
c) With the spectrophotometer wavelength set to (550 ± 5) nm, rotate the filter to the point of maximum transmittance.
d) At this orientation, measure the spectral transmittances, $\tau_{pmax}(\lambda)$ in the range 380 nm to 780 nm at 5 nm intervals.
e) Rotate the filter 90° and measure the spectral transmittances, $\tau_{pmin}(\lambda)$, in the same way.
f) Calculate the luminous transmittances for the two conditions providing two values of luminous transmittance, τ_{pmax} and τ_{pmin}.

$$\tau_{pmax} = 100 \times \frac{\int_{380}^{780} \tau_{pmax}(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$

$$\tau_{pmin} = 100 \times \frac{\int_{380}^{780} \tau_{pmin}(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$

where

λ = the wavelength, nanometers

$V(\lambda)$ = the relative sensitivity of the human eye, as defined in ISO/CIE 11664-1

$S_{D65}(\lambda)$ = the spectral energy distribution of CIE Standard Illuminant D65, as defined in ISO/CIE 11664-1

g) Calculate the polarizing efficiency P as a percentage:

$$P = 100 \times \frac{\tau_{pmax} - \tau_{pmin}}{\tau_{pmax} + \tau_{pmin}}$$

Note: Polarization is sometimes described by the polarizing ratio *(R_{pol}):*

$$R_{pol} = \frac{\tau_{pmax}}{\tau_{pmin}} : 1$$

16.3.6.2.3 Test procedure for the broadband method

A light source and filter combination to give a correlated colour temperature of 6500 ± 1000 K (approximating CIE Standard Illuminant D65 in the visible region, see ISO 11664-2) shall be used to produce a collimated beam of diameter 5 ± 2 mm to illuminate the filter under test at the reference point defined in ISO 12312-1. The light shall be polarized using the same specification linear polarizer as in Clause 16.3.6.2.2 a).

The light incident on a detector shall have approximately the spectral sensitivity of the CIE 2° Standard Observer (ISO/CIE 11664-1). The responsivity of the detector shall be linear to within ± 0.5% in the range of illuminance measured.

The filter or the linear polarizer shall be rotated to the point of maximum transmittance. At this orientation, the luminous transmittance, τ_{pmax}, shall be recorded. The filter or linear polarizer shall then be rotated 90° and the luminous transmittance, τ_{pmin}, shall be recorded.

Table 1
Transmittance requirements for clear lenses and general-purpose filters
(See Clauses 3, 6.5.2.1,6.5.2.4, 6.5.4.4, 8.3, 9.3.3,, 11.2, 13.3, and 14.3 and Table C.1.)

Shade number	Luminous transmittance			Maximum effective far-ultraviolet average transmittance %	Maximum infrared average transmittance %
	Maximum %	Nominal %	Minimum %		
CLEAR	100	—	85	—	—
1.3	85	74.5	67	0.1	<30
1.5	67	61.5	55	0.1	25
1.7	55	50.1	43	0.1	20
2.0	43	37.3	29	0.1	15
2.5	29	22.8	18.0	0.1	12
3.0	18.0	13.9	8.50	0.07	9.0
4	8.50	5.18	3.16	0.04	5.0
5	3.16	1.93	1.18	0.02	2.5
6	1.18	0.72	0.44	0.01	1.5
7	0.44	0.27	0.164	0.007	1.3
8	0.164	0.100	0.061	0.004	1.0
9	0.061	0.037	0.023	0.002	0.8
10	0.023	0.0139	0.0085	0.001	0.6
11	0.0085	0.0052	0.0032	0.0007	0.5
12	0.0032	0.0019	0.0012	0.0004	0.5
13	0.0012	0.00072	0.00044	0.0002	0.4
14	0.00044	0.00027	0.00016	0.0001	0.3

Notes:
1) *The near-ultraviolet average transmittance shall be less than one-tenth of the luminous transmittance: (NUV) < T_L /10.*
2) *The blue-light transmittance shall be less than the luminous transmittance (excluding clear lenses): $T_B < T_L$.*

Table 2
Switching time, ms
(See Clause 6.5.4.5.2.)

Dark shade	Light shade						
	1.7	**2**	**2.5**	**3**	**4**	**5**	**6**
7	300	400	500	700	1000	—	—
8	100	150	200	300	500	1000	—
9	40	50	70	100	200	400	700
10	20	20	30	40	70	100	300
11	6	7	10	15	30	50	100
12	2	3	4	5	10	20	40
13	0.8	1	1.5	2	4	7	10
14	0.3	0.4	0.5	0.7	1	3	5
15	0.10	0.15	0.2	0.3	0.5	1	2
16	0.04	0.05	0.07	0.1	0.2	0.4	0.7

Table 3
Sphere and cylinder power
(See Clause 15.4.4.2.)

Prescribed power (dioptre)	Maximum tolerance (dioptre)
0.00	± 0.06
Over 0.00 up to 6.00	± 0.12
Over 6.00 up to 12.00	± 0.18
Above 12.00	± 0.25

Table 4
Axis of cylinder
(See Clause 15.4.4.4.)

Prescription power (dioptre)	Maximum tolerance (degrees)
0.12 to 0.37	± 3
Over 0.37 up to 1.00	± 2
Above 1.00	± 1

Table 5
Minimum thickness of presumed-compliant prescription lenses, mm
(See Clauses 12.2.2.4.2.1 and 15.4.1.2.)

The following combinations of spectacle lens materials, surface treatments, and minimum thicknesses (in mm) meet the impact resistance requirements for prescription lenses (described in Clauses 6.1 and 12.2.2.4.2), and for lens retention by prescription frames (described in Clause 12.2.2.4.1.3). This matrix is intended for use in determining minimum thickness requirements of prescription safety eyewear. Lens thickness for non-prescription eyewear is determined by the impact test in Clause 6.1. The lens power parameters described in Clause 12.2.2.4.2.2 are waived for stock and surfaced lens designs (i.e., multifocal, progressive addition, aspheric, etc.) in these materials, surface treatments, and thicknesses.

Material		SRC coated		SRC and ARC	Anti-fog	Blue light filter	Tints solid/ Gradient
		1 side	2 sides				
Glass		—	—	—	—	—	—
CR 39		3.0	3.0	N/A	—	N/A	3.0
Polycarbonate		2.0	2.0	2.0	2.0	2.0	2.0
Trivex		2.5	2.5	2.5	2.5	2.5	2.5
Photochromic							
	Glass	—	—	—	—	—	N/A
	CR 39	3.0	3.0	N/A	—	N/A	3.0
	Polycarbonate	2.0	2.0	2.0	2.0	2.0	2.0
	Trivex	—	—	2.5	2.5	2.5	—
Polarized							
	Glass	—	—	—	—	—	N/A
	CR 39	3.0	3.0	N/A	—	N/A	3.0
	Polycarbonate	2.0	2.0	2.0	2.0	2.0	2.0
	Trivex	—	—	2.5	2.5	2.5	—
Hi-vex		—	3.0	3.0	—	—	3.0

Notes:
1) *Materials not listed shall be tested to determine the minimum thickness requirement. At time of publication, no organic lens materials other than those in this Table have been found to meet the impact resistance requirements of this Standard.*
2) *For lens retention adherence to this Standard, no lens material shall be tested below* 2.0 mm *minimum thickness.*

Legend:

Glass = crown glass that has been either chemically hardened or heat treated

SRC = scratch-resistant coating

ARC = anti-reflective coating

(Continued)

Table 5 (Concluded)

Tint = any colour of tint, including solid or gradient, but not including pre-tinted (through-and-through) materials. Pre-tinted materials fall under material type

N/A = not applicable due to the inability of the material type to meet the minimum impact requirements, regardless of minimum thickness

— = not available in this form

Table 6
Angular dependence of luminous transmittance
(See Clause 6.5.4.3)

V15	19.31 (corresponding to 3 scale numbers)
V30	138.95 (corresponding to 5 scale numbers)

Table 7
Transmittance properties for sunglasses*
(See Clause 16.2.3.1.)

Intended primary function†	Luminous transmittance (τ_v)‡	Mean transmittance $\tau(\lambda_2,\lambda_1)$ — Ultraviolet spectral region: UVA (315–380 nm)	UVB (290–315 nm)	Transmittance properties related to traffic signal recognition: Colour limits (x and y chromaticity coordinates)	Traffic signal transmittance (τ_{sig}): Red signal	Yellow signal	Green signal
Cosmetic	Greater than 40%	No greater than τ_v	No greater than 0.125 τ_v	Refer to the colour coordinate tables in Clause 16.2.3.1.	8% min	6% min	6% min
General purpose	8% to 40%	No greater than τ_v	No greater than 0.125 τ_v	Refer to the colour coordinate tables in Clause 16.2.3.1	8% min	6% min	6% min
Special purpose	3% minimum§	No greater than 0.5 τ_v	No greater than 1%	Clause 16.2.3 does not apply			

** Transmittance properties are intended as guidelines and therefore are subject to revision, since there is a need to study further the validity of these property specifications as related to actual normal use requirements.*

† Sunglass lenses can be classified in terms of their intended primary function. An individual lens design can serve several primary functions as determined by these transmittance requirements.

‡ Lenses having a luminous transmittance less than 8% are not recommended for daylight driving.

(Continued)

Table 7 (Concluded)

§ *Care should be taken to provide adequate transmission levels in view of the expected brightness of the environment in which the product will be used.*

Notes:

1) *Lenses of any intended primary function that meet the minimum luminous transmittance of 8% and meet the traffic signal recognition properties are acceptable for daylight driving.*
2) *Lenses of any intended primary function that meet the mean transmittance requirements of special purpose lenses for UVA and UVB can be labelled as suitable for high and prolonged sun exposure.*

Table 8
Points on the boundary of the average daylight (D65) region
(See Clause 16.2.3.1.)

x	*y*
0.455	0.43
0.465	0.41
0.465	0.39
0.455	0.37
0.425	0.34
0.41	0.325
0.385	0.305
0.36	0.29
0.33	0.27
0.295	0.25
0.25	0.23
0.225	0.225
0.2	0.23
0.18	0.25
0.175	0.27
0.18	0.29
0.185	0.31
0.2	0.33
0.215	0.35
0.235	0.37
0.255	0.39
0.28	0.41
0.31	0.43
0.325	0.44
0.35	0.45

(Continued)

Table 8 (Concluded)

x	*y*
0.365	0.455
0.395	0.46
0.425	0.455
0.44	0.445

Table 9
Computational data for transmittance properties
(See Clauses 16.3.1.2, 16.3.3.1, 16.3.4.1, and E.2.)

Wavelength (nm)	Spectral luminance of source C	Product of spectral tristimulus values and source D65			Product of spectral tristimulus values, source A, and spectral transmittance properties of traffic signal filters						
					$S_A(\lambda)\tau_{sig}(\lambda)\bar{x}(\lambda)$		$S_A(\lambda)\tau_{sig}(\lambda)\bar{y}(\lambda)$			$S_A(\lambda)\tau_{sig}(\lambda)\bar{z}(\lambda)$	
(λ)	$V(\lambda)S_C(\lambda)$	$S_{D65}(\lambda)\bar{x}(\lambda)$	$S_{D65}(\lambda)\bar{y}(\lambda)$	$S_{D65}(\lambda)\bar{z}(\lambda)$	Yellow signal	Green signal	Red signal	Yellow signal	Green signal	Yellow signal	Green signal
380	0.0000	0.0007	0.0000	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
390	0.0000	0.0023	0.0001	0.0110	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004
400	0.0002	0.0118	0.0003	0.0562	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0024
410	0.0009	0.0398	0.0011	0.1898	0.0000	0.0024	0.0000	0.0000	0.0001	0.0000	0.0112
420	0.0037	0.1255	0.0037	0.6030	0.0000	0.0104	0.0000	0.0000	0.0003	0.0000	0.0498
430	0.0124	0.2461	0.0101	1.2013	0.0000	0.0300	0.0000	0.0000	0.0012	0.0000	0.1465
440	0.0265	0.3654	0.0241	1.8327	0.0000	0.0482	0.0000	0.0000	0.0032	0.0000	0.2415
450	0.0447	0.3934	0.0445	2.0734	0.0000	0.0604	0.0000	0.0000	0.0068	0.0000	0.3184
460	0.0701	0.3426	0.0707	1.9663	0.0000	0.0653	0.0000	0.0000	0.0135	0.0000	0.3747
470	0.1070	0.2245	0.1046	1.4795	0.0000	0.0526	0.0000	0.0000	0.0245	0.0000	0.3465
480	0.1635	0.1108	0.1611	0.9423	0.0000	0.0296	0.0000	0.0000	0.0430	0.0000	0.2514
490	0.2384	0.0348	0.2263	0.5061	0.0000	0.0110	0.0000	0.0000	0.0715	0.0000	0.1600
500	0.3439	0.0054	0.3534	0.2976	0.0000	0.0018	0.0000	0.0000	0.1199	0.0000	0.1009
510	0.4887	0.0100	0.5422	0.1705	0.0000	0.0036	0.0000	0.0000	0.1943	0.0000	0.0611
520	0.6533	0.0663	0.7441	0.0820	0.0000	0.0241	0.0000	0.0002	0.2704	0.0000	0.0298

(Continued)

Table 9 (Continued)

Wavelength (nm)	Spectral luminance of source C	Product of spectral tristimulus values and source D65			Product of spectral tristimulus values, source A, and spectral transmittance properties of traffic signal filters						
					$S_A(\lambda)\tau_{sig}(\lambda)\bar{x}(\lambda)$		$S_A(\lambda)\tau_{sig}(\lambda)\bar{y}(\lambda)$			$S_A(\lambda)\tau_{sig}(\lambda)\bar{z}(\lambda)$	
(λ)	$V(\lambda)S_C(\lambda)$	$S_{D65}(\lambda)\bar{x}(\lambda)$	$S_{D65}(\lambda)\bar{y}(\lambda)$	$S_{D65}(\lambda)\bar{z}(\lambda)$	Yellow signal	Green signal	Red signal	Yellow signal	Green signal	Yellow signal	Green signal
530	0.8023	0.1782	0.9284	0.0454	0.0017	0.0587	0.0000	0.0086	0.3057	0.0004	0.0150
540	0.9250	0.3032	0.9960	0.0212	0.0721	0.0908	0.0000	0.2370	0.2981	0.0050	0.0063
550	0.9941	0.4507	1.0348	0.0090	0.2633	0.1126	0.0000	0.6046	0.2586	0.0053	0.0023
560	0.9950	0.5945	0.9950	0.0039	0.4661	0.1210	0.0000	0.7801	0.2026	0.0031	0.0008
570	0.9249	0.7339	0.9168	0.0020	0.6747	0.1153	0.0000	0.8428	0.1440	0.0019	0.0003
580	0.8081	0.8778	0.8335	0.0016	0.8850	0.0985	0.0000	0.8403	0.0935	0.0016	0.0002
590	0.6700	0.9103	0.6715	0.0010	1.0707	0.0750	0.0000	0.7897	0.0533	0.0011	0.0001
600	0.5375	0.9560	0.5679	0.0007	1.1843	0.0514	0.0002	0.7035	0.0305	0.0009	0.0000
610	0.4223	0.8983	0.4507	0.0003	1.1879	0.0314	0.0254	0.5960	0.0158	0.0004	0.0000
620	0.3188	0.7493	0.3341	0.0002	1.0725	0.0162	0.2243	0.4782	0.0072	0.0003	0.0000
630	0.2215	0.5351	0.2207	0.0000	0.8517	0.0076	0.2838	0.3513	0.0031	0.0000	0.0000
640											
650	0.0896	0.2268	0.0856	0.0000	0.4150	0.0013	0.1448	0.1566	0.0005	0.0000	0.0000
660	0.0509	0.1322	0.0489	0.0000	0.2521	0.0005	0.0874	0.0933	0.0002	0.0000	0.0000
670	0.0262	0.0719	0.0263	0.0000	0.1391	0.0002	0.0482	0.0509	0.0001	0.0000	0.0000
680	0.0136	0.0366	0.0133	0.0000	0.0773	0.0001	0.0267	0.0281	0.0000	0.0000	0.0000

(Continued)

Table 9 (Continued)

Wavelength (nm)	Spectral luminance of source C	Product of spectral tristimulus values and source D65			Product of spectral tristimulus values, source A, and spectral transmittance properties of traffic signal filters						
					$S_A(\lambda)\tau_{sig}(\lambda)\bar{x}(\lambda)$		$S_A(\lambda)\tau_{sig}(\lambda)\bar{y}(\lambda)$			$S_A(\lambda)\tau_{sig}(\lambda)\bar{z}(\lambda)$	
(λ)	$V(\lambda)S_C(\lambda)$	$S_{D65}(\lambda)\bar{x}(\lambda)$	$S_{D65}(\lambda)\bar{y}(\lambda)$	$S_{D65}(\lambda)\bar{z}(\lambda)$	**Yellow signal**	**Green signal**	**Red signal**	**Yellow signal**	**Green signal**	**Yellow signal**	**Green signal**
690	0.0062	0.0158	0.0057	0.0000	0.0388	0.0000	0.0134	0.0140	0.0000	0.0000	0.0000
700	0.0030	0.0082	0.0029	0.0000	0.0201	0.0000	0.0069	0.0072	0.0000	0.0000	0.0000
710	0.0014	0.0043	0.0016	0.0000	0.0106	0.0000	0.0037	0.0038	0.0000	0.0000	0.0000
720	0.0006	0.0018	0.0006	0.0000	0.0054	0.0000	0.0018	0.0019	0.0000	0.0000	0.0000
730	0.0003	0.0010	0.0003	0.0000	0.0027	0.0000	0.0009	0.0010	0.0000	0.0000	0.0000
740	0.0002	0.0005	0.0002	0.0000	0.0014	0.0000	0.0004	0.0004	0.0000	0.0000	0.0000
750	0.0001	0.0002	0.0001	0.0000	0.0006	0.0000	0.0002	0.0002	0.0000	0.0000	0.0000
760	0.0001	0.0001	0.0000	0.0000	0.0004	0.0000	0.0002	0.0002	0.0000	0.0000	0.0000
770	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
780	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$\sum_{\lambda=380}^{780} V(\lambda)S(\lambda)\Delta\lambda = 10.1110$			$\sum_{\lambda=380}^{780} S_A\tau_{sig}(\lambda)\bar{y}(\lambda)\Delta\lambda$		= 1.0883 for red signal = 6.8348 for yellow signal = 2.1651 for green signal						

Notes:
1) *The spectral intensities of ISO 11664-2 Standard Illuminants A and D65 were normalized to the value 1.000 at 560 nm.*
2) *ȳ (λ) is also defined as the spectral ordinate V(λ) of the photopic luminous efficiency distribution of the CIE Standard Colorimetric Observer;*

(Continued)

Table 9 (Concluded)

that is, $\bar{y}(\lambda) = V(\lambda)$.

3) *The various products given in this Table were computed from the data of Table 2 in ANSI Z80.3.*

Table 10
Solar irradiation at sea level with surface perpendicular to sun's rays, *m* = 2
(See Clause 16.3.5.1.)

λ (nm)	E(λ) (W/m2/μm)	λ (nm)	E(λ) (W/m2/μm)	λ (nm)	E(λ) (W/m2/μm)	λ (nm)	E(λ) (W/m2/μm)	λ (nm)	E(λ) (W/m2/μm)	λ (nm)	E(λ) (W/m2/μm)
295	2.09 × 10–4	420	733	770	968	1120	69.9	1470	45.1	1820	—
296	8.35 × 10–4	430	787	780	907	1130	98.3	1480	83.7	1830	—
297	2.87 × 10–3	440	911	790	923	1140	164	1490	128	1840	—
298	9.87 × 10–3	450	1006	800	857	1150	216	1500	157	1850	—
299	0.0346	460	1080	810	698	1160	271	1510	187	1860	—
300	0.081	470	1138	820	801	1170	328	1520	209	1870	—
301	0.177	480	1183	830	863	1180	346	1530	217	1880	—
302	0.342	490	1210	840	858	1190	344	1540	226	1890	—
303	0.647	500	1215	850	839	1200	373	1550	221	1900	—
304	1.16	510	1206	860	813	1210	402	1560	217	1910	0.705
305	1.91	520	1199	870	798	1220	431	1570	213	1920	2.34
306	2.89	530	1188	880	614	1230	420	1580	209	1930	3.68
307	4.15	540	1198	890	517	1240	387	1590	205	1940	5.3
308	6.11	550	1190	900	480	1250	328	1600	202	1950	17.7
309	8.38	560	1182	910	375	1260	311	1610	198	1960	31.7
310	11	570	1178	920	258	1270	381	1620	194	1970	37.7
311	13.9	580	1168	930	169	1280	382	1630	189	1980	22.6
312	17.2	590	1161	940	278	1290	346	1640	184	1990	1.58
313	21	600	1167	950	487	1300	264	1650	173	2000	2.66
314	25.4	610	1168	960	584	1310	208	1660	163	2010	19.5
315	30	620	1165	970	633	1320	168	1670	159	2020	47.6

(Continued)

Table 10 (Concluded)

295	2.09 × 10–4	420	733	770	968	1120	69.9	1470	45.1	1820	—
316	34.8	630	1176	980	645	1330	115	1680	145	2030	55.4
317	39.8	640	1175	990	643	1340	58.1	1690	139	2040	54.7
318	44.9	650	1173	1000	630	1350	18.1	1700	132	2050	38.3
319	49.5	660	1166	1010	620	1360	0.66	1710	124	2060	56.2
320	54	670	1160	1020	610	1370	—	1720	115	2070	77
330	101	680	1149	1030	601	1380	—	1730	105	2080	88
340	151	690	978	1040	592	1390	—	1740	97.1	2090	86.8
350	188	700	1108	1050	551	1400	—	1750	80.2	2100	85.6
360	233	710	1070	1060	526	1410	1.91	1760	58.9	2110	84.4
370	279	720	832	1070	519	1420	3.72	1770	38.8	2120	83.2
380	336	730	965	1080	512	1430	7.53	1780	18.4	2130	20.7
390	397	740	1041	1090	514	1440	13.7	1790	5.7	2140	—
400	470	750	867	1100	252	1450	23.8	1800	0.92		
410	672	760	566	1110	126	1460	30.5	1810	—		

Source: *P. Moon (1940).*

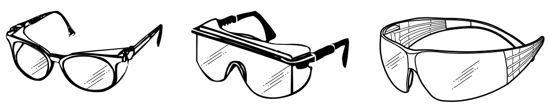
Notes:

1) $\sum_{\lambda=0.78}^{1.40} E(\lambda)\Delta\lambda = 265.2306 \text{ W/m}^2$

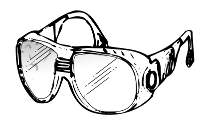
2) *Optical air mass, m, is the ratio of the path length of radiation through the atmosphere at any given angle to the path length toward the zenith (point vertically above observer); m = 2 corresponds to a zenith angle of 60°.*

Figure 1
Examples of eye and face protectors
(See Clauses 5.2–5.8.)

Examples of Class 1 — Spectacles

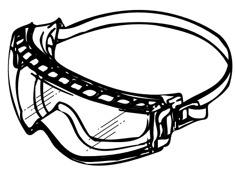


Class 1A
Spectacles with side protection

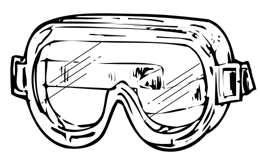


Class 1B
Spectacles with side and non-ionizing radiation protection

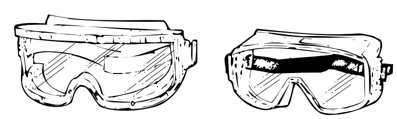
Examples of Class 2 — Goggles



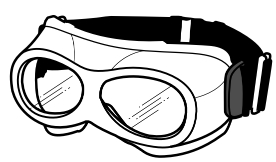
Class 2A
Direct ventilated goggles



Class 2B
Indirect ventilated goggles

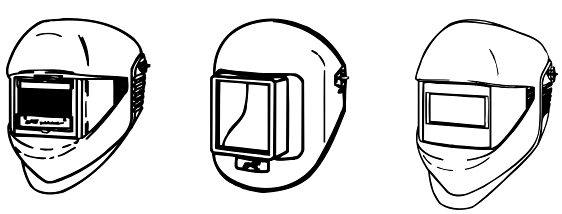


Class 2C
Direct/non-ventilated goggles with non-ionizing radiation protection

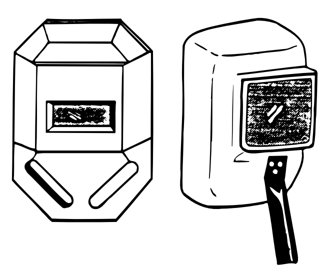


Class 2D and 2E Laser-protective goggles

Examples of Classes 3 and 4 — Welding helmets and hand shields



Class 3
Welding helmets



Class 4
Welding hand shields

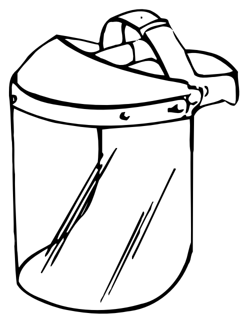
(Continued)

Figure 1 (Concluded)

Examples of Class 5 — Hoods

Class 5A Hood with impact-resistant window
Class 5B Hood for dust, splash, and abrasive materials protection
Class 5C Hood with non-ionizing radiation protection
Class 5D Hood for high-heat applications
Class 5E Hood for electric arc protection

Examples of Class 6 — Face shields

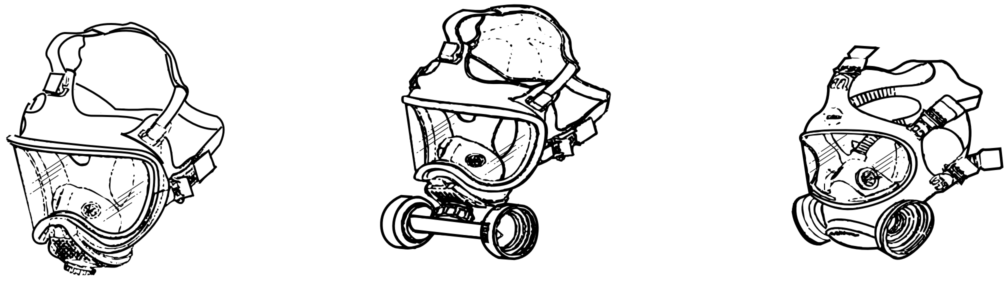


Class 6A Face shield for impact and splash protection
Class 6B Face shield for non-ionizing radiation protection
Class 6C Face shield for high-heat application
Class 6D Face shield for electric arc protection

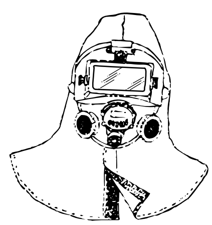
Examples of Class 7 — Respirator facepieces

(Continued)

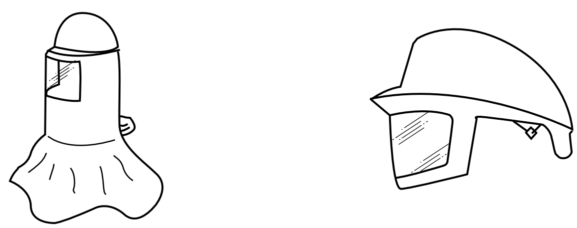
Figure 1 (Concluded)



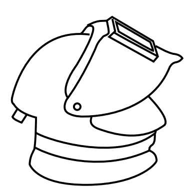
Class 7A
Respirator facepiece for impact and splash protection



Class 7B
Respirator facepiece for non-ionizing radiation protection



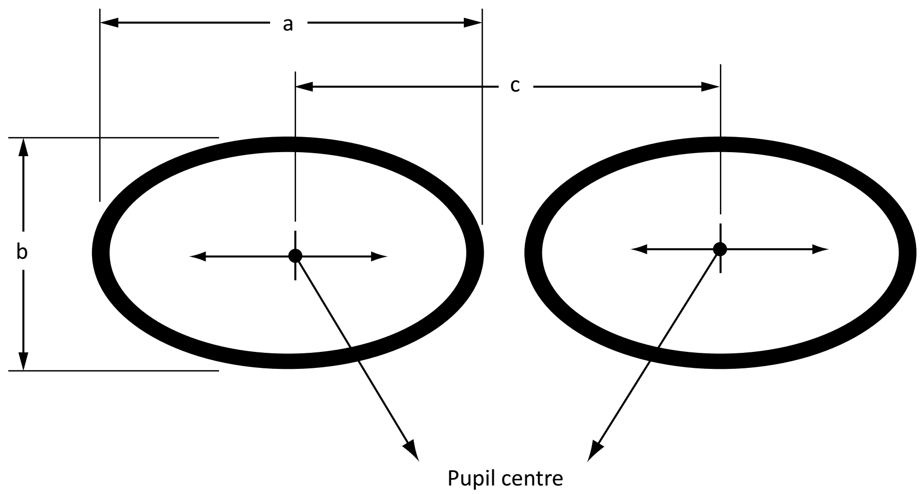
Class 7C
Respirator facepiece with loose-fitting hood or helmet



Class 7D
Respirator facepiece with loose-fitting hood or helmet for non-ionizing radiation protection

Note: *Total coverage includes lens, eyewire rim, and lateral protection lip to the outside edge of the frame.*

Figure 2
Minimum frontal coverage
(See Clause 15.2.2.)



Dimensions (mm)	Small Headform (EN 168)	Medium Headform (EN 168)
a	36	40
b	26	33
c	54	64

Note: *Total coverage includes lens, eyewire rim, and lateral protection lip to the outside edge of the frame.*

Figure 3
Minimum side shield protection
(See Clause 6.9.)

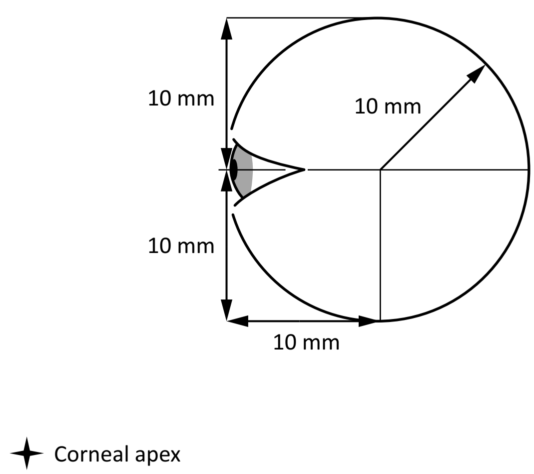
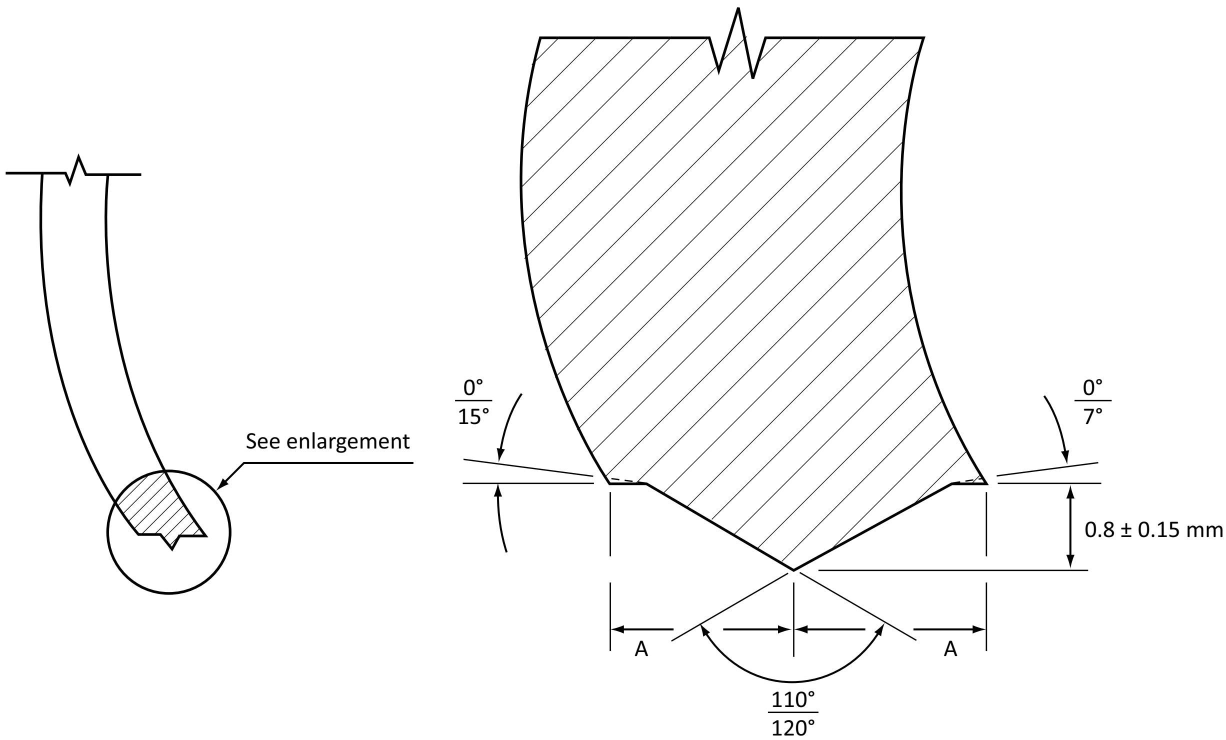


Figure 4
Lens-testing bevel profile
(See Clause 12.2.2.4.2.2.)



Note: *The letter A indicates that the bevel apex of the lens is to be equidistant (*A mm*) from both the front and back surfaces of the edged lens with a tolerance of* ± 0.5 mm*.*

Figure 5
Impact-test lens holder
(See Clause 12.2.2.4.2.3.)

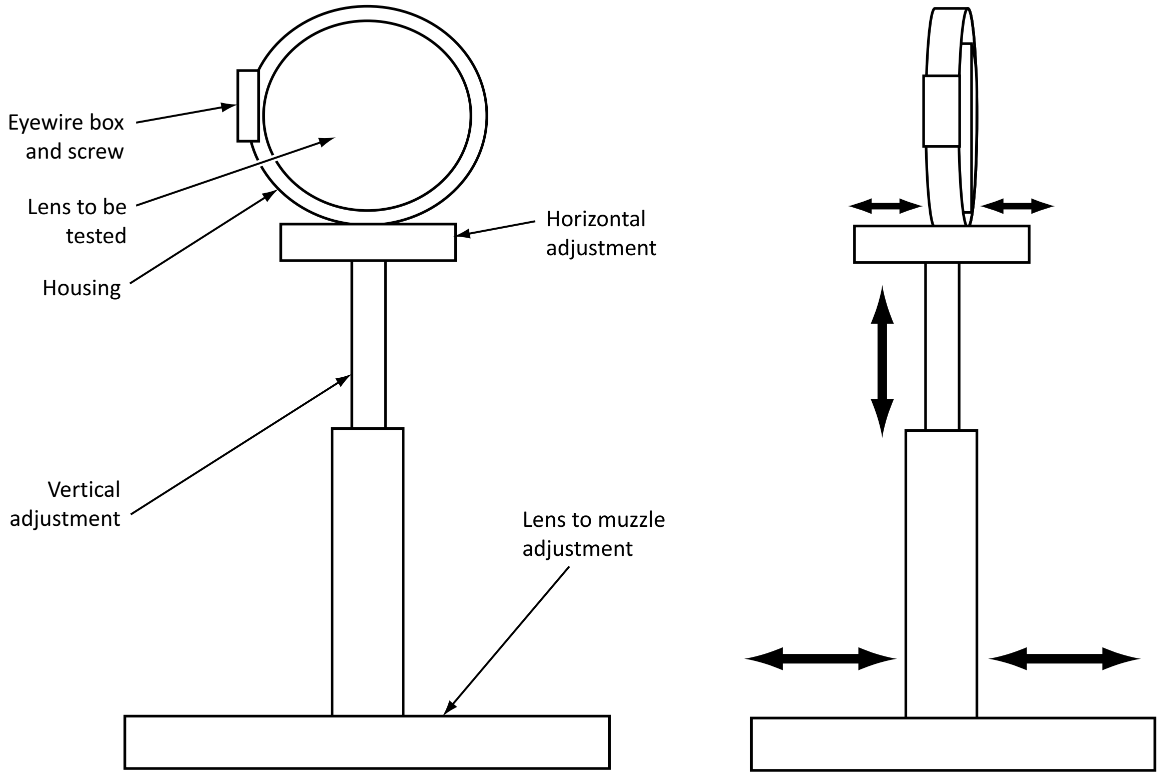


Figure 6
Heated rod
(See Clause 12.3.1.)

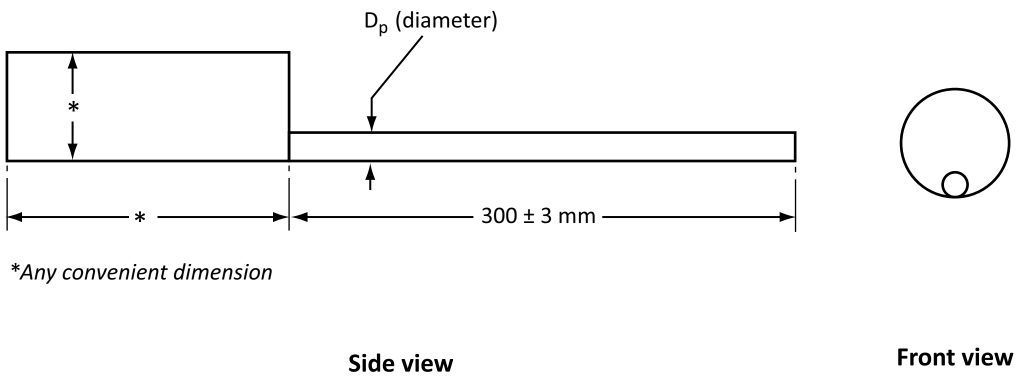


Figure 7
Type of target for test of definition
(See Clause 12.5.1.)

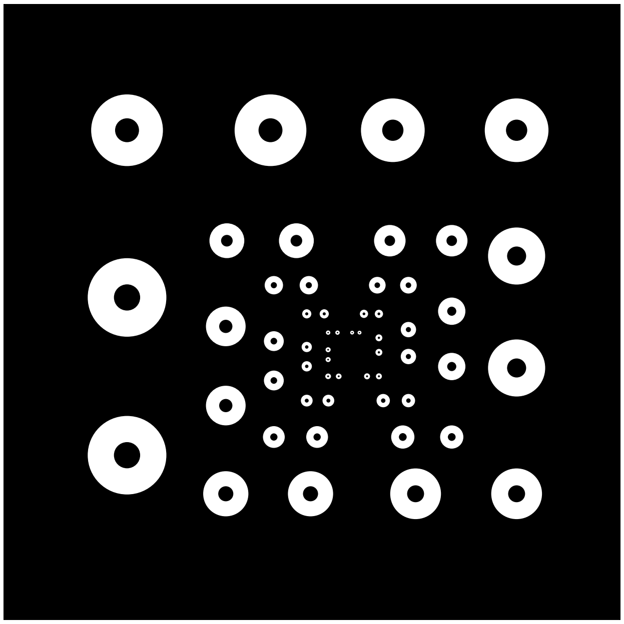


Figure 8
Test probe
(See Clause 12.11.2.)

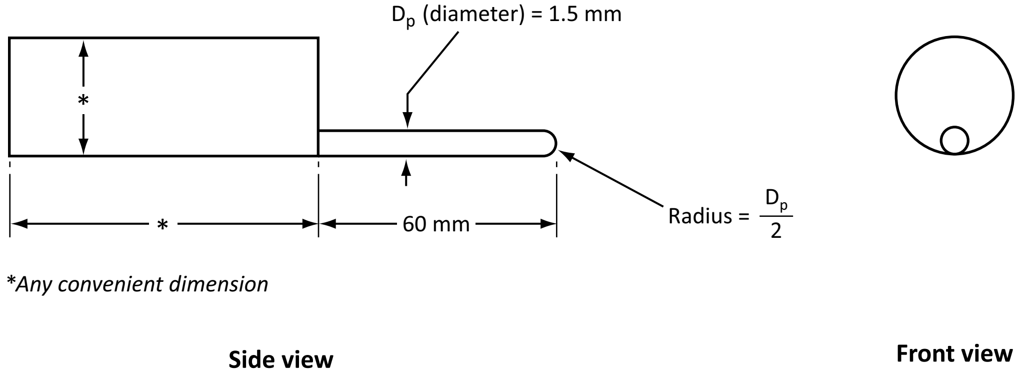
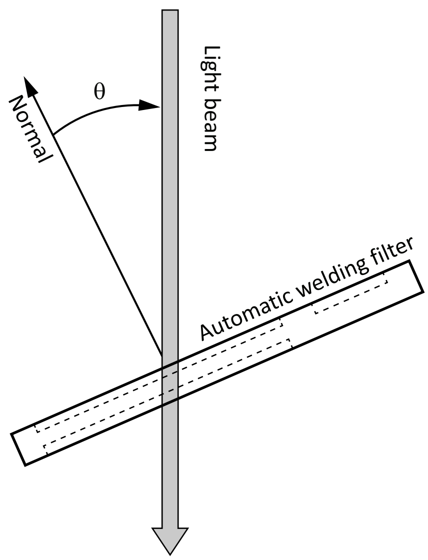
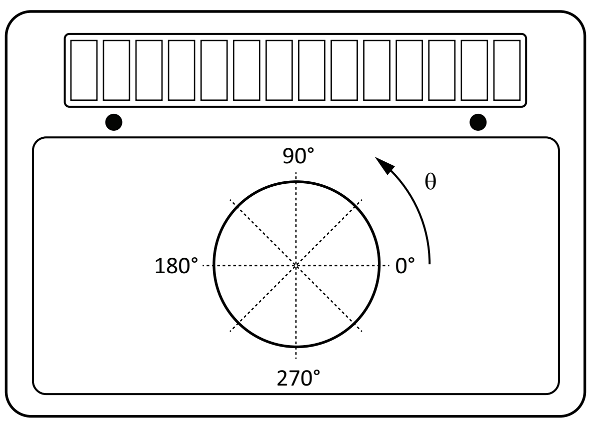


Figure 9
Angular dependence of welding filters
(See Clause 12.15.)



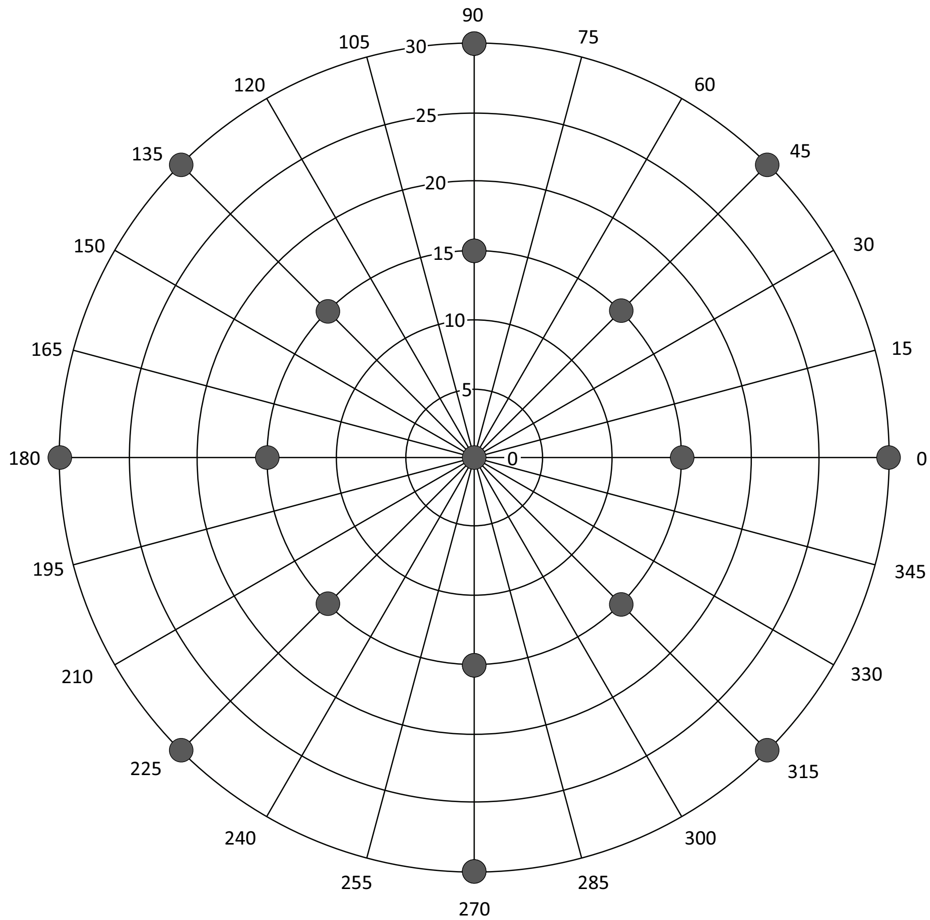
a) Angle of incidence θ



b) Rotation around the normal

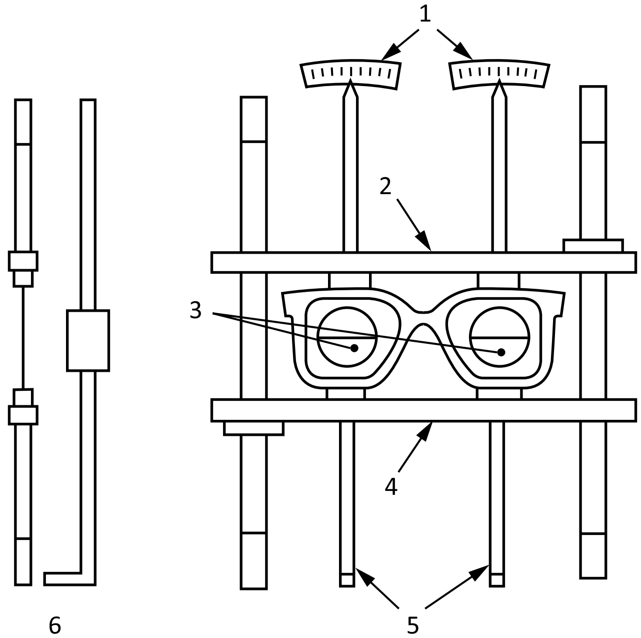
(Continued)

Figure 9 (Concluded)



c) Measurement Locations

Figure 10
Apparatus for the determination of the plane of transmission
(See Clause 16.3.6.1.2.)



Key

1 scales

2 top register bar

3 split-field polarizers

4 bottom register bar

5 split-field rotation lever

6 side view

Annex A (informative)
Classification of hazards and recommended protectors

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See also Clause 4.*

Table A.1
Hazards and recommended protectors
(See Clauses 1.1 and 4.)

Hazard type	Nature of hazard	Hazardous activities involving but not limited to	Spectacles Class 1		Goggles Class 2					Welding helmet Class 3	Welding hand shield Class 4	Hoods Class 5					Face shields Class 6			
			a	b	a	b	c	d	e			a	b	c	d	e	a	b	c	d
A	Flying objects	Chipping, scaling, stonework, drilling; grinding, buffing, polishing; hammer mills, crushing; heavy sawing, planing; wire and strip handling; hammering, unpacking, nailing; punch press, lathework																		
B	Flying particles, dust, wind, etc.	Woodworking, sanding; light metal working and machining; exposure to dust and wind; resistance welding (no radiation exposure); sand, cement, aggregate handling; painting; concrete work, plastering; material batching and mixing																		

(Continued)

Table A.1 (Concluded)

Hazard type	Nature of hazard	Hazardous activities involving but not limited to	Spectacles Class 1		Goggles Class 2					Welding helmet Class 3	Welding hand shield Class 4	Hoods Class 5					Face shields Class 6			
			a	b	a	b	c	d	e			a	b	c	d	e	a	b	c	d
C	Heat, sparks, and splash from molten material	Babbliting, casting, pouring, molten metal; brazing, soldering; spot welding, stud welding; hot-dipping operations																		
D	Acid splash; chemical burns	Acid and alkali handling; degreasing, pickling, and plating operations; glass breakage; chemical spray; liquid bitumen handling																		
E	Abrasive blasting materials	Sand blasting; shot blasting; shotcreting																		
F	Glare, stray light (where slight reduction of visible radiation is required)	Reflection, bright sun, and lights; reflected welding flash; photographic copying																		

(Continued)

Table A.1 (Concluded)

Hazard type	Nature of hazard	Hazardous activities involving but not limited to	Spectacles Class 1		Goggles Class 2					Welding helmet Class 3	Welding hand shield Class 4	Hoods Class 5					Face shields Class 6			
			a	b	a	b	c	d	e			a	b	c	d	e	a	b	c	d
G	Injurious optical radiation (where moderate reduction of optical radiation is required)	Torch cutting, welding, brazing, furnace work; metal pouring, spot welding, photographic copying																		
H	Injurious optical radiation (where large reduction of optical radiation is required)	Babbliting, casting, pouring, molten metal; brazing, soldering; spot welding, stud welding; hot-dipping operations																		

(Continued)

Table A.1 (Concluded)

Hazard type	Nature of hazard	Hazardous activities involving but not limited to	Spectacles Class 1		Goggles Class 2					Welding helmet Class 3	Welding hand shield Class 4	Hoods Class 5					Face shields Class 6			
			a	b	a	b	c	d	e			a	b	c	d	e	a	b	c	d
I	Laser radiation	Laser cutting; laser surgery; laser etching																		
J	Electric arc flash	Electrical installation; electrical maintenance; troubleshooting of electrical systems; disconnecting live electrical systems.																		

Notes:

1) *Highlighted areas are recommendations for protectors. Class 1 and Class 2 protectors are to be used in conjunction with recommendations for Classes 3, 4, 5, and 6 protectors. The possibility of multiple and simultaneous exposure to a variety of hazards are to be considered in assessing the needed protection. Adequate protection against the highest level of each of the hazards should be provided. This Table cannot encompass all of the various hazards that could be encountered. In each particular situation, thorough consideration should be given to the severity of all the hazards in selecting the appropriate protector or combination of protectors. The practice of wearing protective spectacles (Class 1B) with filter lenses under a welding helmet or hand shield is strongly recommended, to ensure impact and flash protection for the wearer when the helmet or lift front is raised or the shield is not in use. Protectors that meet the requirements for ignition and flame resistance are not intended to provide protection in environments that expose the user to open flames or high-energy arcs. If there is a breathing hazard in the work environment in addition to the eye and face hazards listed in Table A.1, use of a Class 7 protector "respirators" should be considered; and*

2) *Welding goggles should not have automatic-darkening welding filter that would reach beyond Shade 9 in the dark state.*

Annex B (informative)
Spectral weighting factors for determination of transmittances

Note: *This Annex is not a mandatory part of this Standard.*

Table B.1
Spectral weighting factors *S*(*λ*) for effective far-ultraviolet average transmittance
(See Clause 14.2.3.)

Wavelength, nm	Relative spectral effectiveness, *S*(*λ*)
200	0.030
205	0.051
210	0.075
215	0.095
220	0.120
225	0.150
230	0.190
235	0.240
240	0.300
245	0.360
250	0.430
255	0.520
260	0.650
265	0.810
270	1.000
275	0.960
280	0.880
285	0.770
290	0.640
295	0.540
300	0.300
305	0.060

(Continued)

Table B.1 (Concluded)

Wavelength, nm	Relative spectral effectiveness, $S(\lambda)$
310	0.015
315	0.003

Note: *This Table is a reproduction of part of Table 1, "Ultraviolet Radiation", from the* Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 2014. *Published by the American Conference of Governmental Industrial Hygienists.*

Table B.2
Values of spectral luminous sensitivity, $\bar{y}(\lambda)$, for the CIE Standard Colorimetric Observer and of relative spectral emittance, $S_A(\lambda)$, for CIE Standard Illuminant A

(See Clause 14.2.4.)

λ, nm	$\bar{y}(\lambda)$	$S(\lambda)$	λ, nm	$\bar{y}(\lambda)$	$S(\lambda)$
380	0.0000	9.80	575	0.9154	110.80
385	0.0001	10.90	580	0.8700	114.44
390	0.0001	12.09	585	0.8163	118.08
395	0.0002	13.35	590	0.7570	121.73
			595	0.6949	125.39
400	0.0004	14.71			
405	0.0006	16.15	600	0.6310	129.04
410	0.0012	17.68	605	0.5668	132.70
415	0.0022	19.29	610	0.5030	136.35
420	0.0040	20.99	615	0.4412	139.99
			620	0.3810	143.62
425	0.0073	22.79			
430	0.0116	24.67	625	0.3210	147.24
435	0.0168	26.64	630	0.2650	150.84
440	0.0230	28.70	635	0.2170	154.42
445	0.0298	30.85	640	0.1750	157.98
			645	0.1382	161.52
450	0.0380	33.09			
455	0.0480	35.41	650	0.1070	165.03
460	0.0600	37.81	655	0.0816	168.51
465	0.0739	40.30	660	0.0610	171.96
470	0.0910	42.87	665	0.0446	175.38
			670	0.0320	178.77

(Continued)

Table B.2 (Concluded)

λ, nm	$\bar{y}(\lambda)$	*S*(*λ*)	*λ*, nm	$\bar{y}(\lambda)$	*S*(*λ*)
475	0.1126	45.52			
480	0.1390	48.24	675	0.0232	182.12
485	0.1693	51.04	680	0.0170	185.43
490	0.2080	53.91	685	0.0119	188.70
495	0.2586	56.85	690	0.0082	191.93
			695	0.0057	195.12
500	0.3230	59.86			
505	0.4073	62.93	700	0.0041	198.26
510	0.5030	66.06	705	0.0029	201.36
515	0.6082	69.25	710	0.0021	204.41
520	0.7100	72.50	715	0.0015	207.41
			720	0.0010	210.36
525	0.7932	75.79			
530	0.8620	79.13	725	0.0007	213.27
535	0.9149	85.52	730	0.0005	216.12
540	0.9540	85.95	735	0.0004	218.92
545	0.9803	89.41	740	0.0002	221.67
			745	0.0002	224.36
550	0.9950	92.91			
555	1.0000	96.44	750	0.0001	227.00
560	0.9950	100.00	755	0.0001	229.59
565	0.9786	103.58	760	0.0001	232.12
570	0.9520	107.18			

Note: *All data are taken from ISO/CIE 11664-1 and ISO 11664-2.*

Table B.3
Relative spectral emittance, *S*(*λ*), of CIE Standard Illuminant A for wavelengths from 700 nm to 2600 nm

(See Clause 14.2.5.)

λ	*S*(*λ*)	*λ*	*S*(*λ*)	*λ*	*S*(*λ*)	*λ*	*S*(*λ*)	*λ*	*S*(*λ*)	*λ*	*S*(*λ*)
700	198.26	1050	289.78	1400	232.72	1750	161.42	2100	108.81	2450	73.94
710	204.41	1060	289.28	1410	230.56	1760	159.63	2110	107.60	2460	73.15
720	210.36	1070	288.66	1420	228.40	1770	157.86	2120	106.40	2470	72.37
730	216.12	1080	287.94	1430	226.23	1780	156.10	2130	105.21	2480	71.60

(Continued)

Table B.3 (Concluded)

λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)
740	221.67	1090	287.12	1440	224.06	1790	154.37	2140	104.04	2490	70.83
750	227.00	1100	286.20	1450	221.90	1800	152.65	2150	102.88	2500	70.08
760	232.12	1110	285.18	1460	219.74	1810	150.94	2160	101.73	2510	69.33
770	237.01	1120	284.08	1470	217.58	1820	149.25	2170	100.60	2520	68.60
780	241.68	1130	282.90	1480	215.42	1830	147.59	2180	99.48	2530	67.87
790	246.12	1140	281.64	1490	213.27	1840	145.93	2190	98.38	2540	67.15
800	250.33	1150	280.30	1500	211.13	1850	144.30	2200	97.29	2550	66.44
810	254.31	1160	278.89	1510	209.00	1860	142.68	2210	96.21	2560	65.74
820	258.07	1170	277.42	1520	206.87	1870	141.08	2220	95.14	2570	65.05
830	261.60	1180	275.89	1530	204.75	1880	139.50	2230	94.09	2580	64.37
840	264.91	1190	274.29	1540	202.64	1890	137.93	2240	93.05	2590	63.69
850	267.99	1200	272.64	1550	200.54	1900	136.38	2250	92.03	2600	63.02
860	270.86	1210	270.94	1560	198.45	1910	134.85	2260	91.01		
870	273.51	1220	269.20	1570	196.38	1920	133.33	2270	90.01		
880	275.95	1230	267.40	1580	194.31	1930	131.83	2280	89.02		
890	278.18	1240	265.57	1590	192.26	1940	130.35	2290	88.05		
900	280.21	1250	236.70	1600	190.22	1950	128.89	2300	87.08		
910	282.04	1260	261.79	1610	188.19	1960	127.44	2310	86.13		
920	283.68	1270	259.85	1620	186.18	1970	126.00	2320	85.19		
930	285.12	1280	257.88	1630	184.18	1980	124.59	2330	84.26		
940	286.39	1290	255.88	1640	182.20	1990	123.19	2340	83.34		
950	287.47	1300	253.86	1650	180.23	2000	121.80	2350	82.43		
960	288.39	1310	251.81	1660	178.28	2010	120.43	2360	81.53		
970	289.14	1320	249.74	1670	176.34	2020	119.08	2370	80.65		
980	289.72	1330	247.66	1680	174.42	2030	117.74	2380	79.77		
990	290.15	1340	245.56	1690	172.51	2040	116.42	2390	78.91		
1000	290.43	1350	243.45	1700	170.62	2050	115.12	2400	78.06		
1010	290.57	1360	241.32	1710	168.75	2060	113.83	2410	77.21		

(Continued)

Table B.3 (Concluded)

λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)	λ	S(λ)
1020	290.57	1370	239.18	1720	166.89	2070	112.55	2420	76.38		
1030	290.43	1380	237.04	1730	165.05	2080	111.29	2430	75.56		
1040	290.17	1390	234.88	1740	163.23	2090	110.04	2440	74.75		

Note: *These values are calculated by the method given in ISO 11664-2.*

Table B.4
Spectral weighting factors for blue-light hazard

(See Clause 14.2.6.)

Wavelength, nm	Blue-light hazard factors, $B(\lambda)$
400	0.100
405	0.200
410	0.400
415	0.800
420	0.900
425	0.950
430	0.980
435	1.000
440	1.000
445	0.970
450	0.940
455	0.900
460	0.800
465	0.700
470	0.620
475	0.550
480	0.450
485	0.400
490	0.220
495	0.160
500	0.100

(Continued)

Table B.4 (Concluded)

Wavelength, nm	Blue-light hazard factors, $B(\lambda)$
505	0.079
510	0.063
515	0.050
520	0.040
525	0.032
530	0.025
535	0.020
540	0.016
545	0.013
550	0.010
555	0.008
560	0.006
565	0.005
570	0.004
575	0.003
580	0.002
585	0.002
590–700	0.001
700–1400	—

Note: *This Table is a reproduction of part of Table 1, "Light and Near-Infrared Radiation", from* Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 2014. *Published by the American Conference of Governmental Industrial Hygienists.*

Annex C (informative)
Shade selection chart

Note: *This Annex is not a mandatory part of this Standard.*

Table C.1
Recommended shade numbers for arc welding and allied processes

<table>
<tr><th rowspan="2">Operation</th><th colspan="9">Current in amperes</th></tr>
<tr><th colspan="9">0.5 2.5 10 20 40 80 125 175 225 275 350 450
1.0 5.0 15 30 60 100 150 200 250 300 400 500</th></tr>
<tr><td>SMAW (covered electrodes)</td><td colspan="2">7</td><td colspan="2">8</td><td>10</td><td colspan="4">11</td></tr>
<tr><td>GMAW (MIG)</td><td colspan="2">7</td><td colspan="2">10</td><td>10</td><td colspan="3">10</td><td></td></tr>
<tr><td>GTAW (TIG)</td><td colspan="2">8</td><td colspan="2">8</td><td colspan="4">10</td><td></td></tr>
<tr><td>Air carbon arc cutting</td><td colspan="8">10</td><td></td></tr>
<tr><td>Plasma arc cutting</td><td></td><td colspan="5">8</td><td>9</td><td colspan="2">10</td></tr>
<tr><td>Plasma arc welding</td><td>6</td><td colspan="2">8</td><td colspan="4">10</td><td colspan="2">11</td></tr>
<tr><td></td><td colspan="9">1.0 5.0 15 30 60 100 150 200 250 300 400 500</td></tr>
</table>

Notes:
1) *For other welding processes (e.g., laser welding, electron beam welding), consult the manufacturer for eye protection recommendations.*
2) *For pulsed GMAW (MIG), use peak current for selecting the appropriate shade number.*
3) *For underwater welding, the minimum shade number shown might not apply.*
4) *See Table 1 for description of shade number.*

Annex D (informative) ***Supplementary manufacturing recommendations***

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See also Clause 6.*

D.1 General criteria for materials

D.1.1
Materials used in the construction of eye and face protectors and that come into contact with the skin should be non-irritating when subjected to perspiration and should not discolour the wearer's skin.

D.1.2
The materials of construction should not be prone to absorption of moisture nor liable to deform at temperatures encountered during normal use.

D.1.3
The manufacturer should test the impact and filter performance of protectors under cold and hot temperature conditions (e.g., -40 °C and 55 °C). Protectors intended for use under these extreme conditions should be specified by the manufacturer or supplier.

D.2 Protective spectacles

D.2.1
Temples should be constructed to fit securely on the wearer.

D.2.2
Hinges joining fronts and temples should be joined in such a way as to resist accidental separation.

D.3 Goggles

D.3.1
The edge of the goggle that bears against the face should not exert undue pressure or cause discomfort to the wearer.

D.3.2
The goggles should be of such shape and size as to protect the entire eye sockets.

D.4 Welding helmets and hand shields

D.4.1 Bibs
Bibs or back-of-head-and-neck protectors should be made of a material that is a good insulator against heat and electricity. The protectors should be constructed for easy attachment to the helmet or helmet headgear.

D.4.2 Housing

D.4.2.1

The housing should be of such size and shape as to protect the face, forehead, ears, and front of the neck.

The inside of the housing should have a low light-reflecting finish.

D.4.2.2

All housing-shell material should be thermally insulating.

Annex E (informative)
Determination of traffic signal transmittance

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See also Clause 16.2.3.*

E.1

The values of X, Y, and Z are determined as follows:

a) for traffic signals as viewed through the lens:

$$X_{sig} = \int_{380}^{780} \tau(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \bar{x}(\lambda) \Delta\lambda$$

$$Y_{sig} = \int_{380}^{780} \tau(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \bar{y}(\lambda) \Delta\lambda$$

$$Z_{sig} = \int_{380}^{780} \tau(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \bar{z}(\lambda) \Delta\lambda$$

b) for average daylight (D65) as viewed through the lens:

$$X_{D65} = \int_{380}^{780} \tau(\lambda) S_{D65}(\lambda) \bar{x}(\lambda) \Delta\lambda$$

$$Y_{D65} = \int_{380}^{780} \tau(\lambda) S_{D65}(\lambda) \bar{y}(\lambda) \Delta\lambda$$

$$Z_{D65} = \int_{380}^{780} \tau(\lambda) S_{D65}(\lambda) \bar{z}(\lambda) \Delta\lambda$$

where

τ (λ) = spectral transmittance of the lens measured at the reference point or a location specified by the manufacturer if the reference point is not appropriate

SA(λ) = spectral intensity of CIE Standard Illuminant A as defined in ISO 11664-2

SD65(λ) = spectral intensity of CIE Standard Illuminant D65 as defined in ISO 11664-2

τ sig(λ) = spectral transmittance of the traffic signal filter (red, yellow, or green)

= CIE Standard Colorimetric Observer (2°) spectral tristimulus values of the equal-energy spectrum

X, Y, Z = tristimulus values

E.2

The traffic signal transmittance (τ sig) of a lens is expressed mathematically as follows:

$$\tau_{sig} = \frac{\int_{380}^{780} \tau(\lambda) V(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \Delta\lambda}{\int_{380}^{780} V(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \Delta\lambda}$$

$$\tau_{sig} = \frac{Y_{sig}}{\int_{380}^{780} V(\lambda) S_A(\lambda) \tau_{sig}(\lambda) \Delta\lambda}$$

where

$\tau(\lambda)$, $SA(\lambda)$, $\tau_{sig}(\lambda)$, Y_{sig} are as defined in Clause E.1.

$V(\lambda)$ = spectral ordinate of the photopic luminous efficiency distribution of the CIE Standard Colorimetric Observer Computational data for transmittance properties are given in Table 9.

Annex F (informative)
Exemplars of lens performance under the impact test

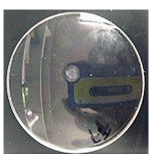
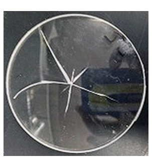
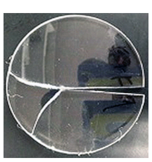
Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *See Clause 6.1.3.1.*

F.1

In accordance with Clause 6.1.3.1, a lens is considered to have failed if it fractures through its entire thickness into two or more separate pieces, or if any lens material visible to normal or corrected-to-normal vision, including a laminar layer, if any, becomes detached from the ocular surface.

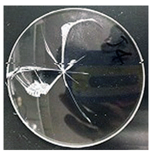
Table F.1 lists examples of lens performance under the ballistic impact test.

Table F.1
Examples of lens performance under the ballistic impact test
(See Clause F.1.)

	There are four full-thickness cracks radiating from the impact point, however the lens has not broken into separate pieces: PASS
	Central dent with no cracks: PASS
	Cracks radiating from the impact point have not propagated to the edge or formed separate pieces: PASS
	Incomplete full thickness crack but the lens has not separated into fragments: PASS
	Although the lens has not broken into separate pieces, a small fragment has been lost from the centre of the back surface: FAIL

(Continued)

Table F.1 (Concluded)

	A fragment of material is missing from the central portion of the lens: FAIL
	Although in one piece after impact, the lens shows loss of a small chip from its back surface: FAIL
	Lens broken into two separate pieces: FAIL

Source: *Oyaide-ofenor (2014).*

Annex G (informative)
Bibliography

Note: *This Annex is not a mandatory part of this Standard.*

CSA Group

Z94.4-18
Selection, use, and care of respirators

ACGIH (American Conference of Governmental Industrial Hygienists)

2014 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

ANSI (American National Standards Institute)

Z87.1-2015
Occupational and Educational Personal Eye and Face Protection Devices

ASTM International (American Society for Testing and Materials)

D635-06
Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

G155-05a
Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

BSI (British Standards Institution)

BS EN 166:2002
Personal Eye Protection — Specifications

BS EN 167:2002
Personal Eye Protection — Optical Test Methods

BS EN 168:2002
Personal Eye Protection — Non-optical Test Methods

BS EN 207:2009
Personal eye-protection equipment — Filters and eye-protectors against laser radiation (laser eye-protectors)

ISO (International Organization for Standardization)

21987:2017
Ophthalmic optics — Mounted spectacle lenses

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