

American National Standard Occupational and Educational Personal Eye and Face Protection Devices

Secretariat
International Safety Equipment Association

Approved May 28, 2015
American National Standards Institute, Inc.

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether they have approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no persons shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published by

**International Safety Equipment Association
1901 North Moore Street, Suite 808, Arlington, Virginia 22209 USA**

Copyright 2015 by ISEA

All rights reserved.

No part of this publication (with the exception of Annex J, Selection Chart) may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Printed in the United States of America

Foreword (This Foreword is not a part of ANSI/ISEA Z87.1-2015)

This document is the latest edition of a standard for eye and face protection that dates back to 1922. Originally part of a government standard that also included respiratory and head protection, the standard first appeared under the Z87.1 designation in 1968, and has been revised five times since then in response to advances in technology, as well as the changing workplace environment.

ANSI/ISEA Z87.1-2015 represents another milestone in this standard's evolution, building on the many years of work that have gone into prior revisions. The document continues to focus on product performance and harmonization with global standards in an effort to allow new and innovative designs responsive to workplace hazards, end-user needs and regulatory obligations.

Since the 2010 revision was a dramatic shift away from product configuration requirements and toward a hazard-based structure, much of the revised language in ANSI/ISEA Z87.1-2015 reflects the effort to fine-tune this approach. Streamlined language for resolution testing provides clarity to test methods to ensure they can be accurately executed, and updated test patterns to complement the language. These patterns can be downloaded from ISEA's website at www.safetysite.org.

Other key updates address the emergence of new technologies that are challenging outdated design restrictions, or which past editions did not contemplate. This includes the acknowledgement of protectors known as "magnifiers" and "readers" that have lenses, or portions of lenses, that incorporate magnification properties. The 2015 revision also eliminates minimum thickness requirements for non-prescription protectors that pass the requirements for impact rated protectors, and eliminates the need to conduct drop-ball testing for a protector that is first tested to and meets the impact-rated requirements. Requirements for angular dependence of luminous transmittance for welding filters have been added to address visual effect that welders can find both alarming and distracting. Such requirements are consistent with criteria in similar global standards.

As the standard continues to focus on specific hazard protection, additional emphasis has been placed on enabling users to select protectors appropriate for the working environment, and presenting end-users with information to assist in the selection process. Examples of acceptable and unacceptable markings for protectors that meet the requirements of the standard are included. In addition, information related to conducting an assessment for potential eye and face hazards and protector use and selection considerations has been expanded.

Suggestions for improvement of this standard are welcome. They should be sent to the International Safety Equipment Association, 1901 N. Moore Street, Suite 808, Arlington, VA 22209, isea@safetysite.org.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Safety Standards for Eye Protection, Z87. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the Z87 Committee had the following members:

J.P. Sankpill, Chairman
Jack B. Hirschmann, Jr., Vice-Chairman

Organization Represented

American Optometric Association

American Society of Safety Engineers
American Welding Society

Individual Member
Individual Member
International Safety Equipment Association

International Staple, Nail and Tool Association

Jones and Company

Kimberly-Clark Professional
The Laboratory Safety Institute

3M Company

MCR Safety
National Association of Optometrists
and Opticians
National Institute for Occupational
Safety and Health (NIOSH)
National Waste & Recycling Association

Oakley

Optical Laboratories Association

Opticians Association of America

Power Tools Institute

Prevent Blindness America
UL LLC

U.S. Department of the Air Force
U.S. Department of the Army

U.S. Department of the Navy

The Vision Council

Younger Optics
ANSI Z80 Committee Ophthalmic Lenses

ANSI Z88 Committee Respiratory Protection
Individual Expert (non-voting)

Name of Representative

Gregory Good, O.D., Ph.D.
Neil Hodur, O.D.
Jack B. Hirschmann, Jr.
Philip M. Johnson
David Sliney
Michael Kertis
Jack Laptad
Jud Crosby
Cristine Z. Fargo
Rick Allen
Mark Hickok
Bruce Hey
John Halliburton
Joann M. Kline, JD
James Kaufmann, Ph.D.
Christina Dillard
Doug Rivers, CSP, FSFPE
Julie A. Tremblay, CIH
J.P. Sankpill
Andrew Petty, CIH, CSP
Nick Mileti
James R. Harris, Ph.D.

Janice Comer Bradley, CSP
David Biderman
Wayne Chumbley
Ben Meunier
Rick Tinson
Michael Vitale
John M. Young
Daryl Neely
Brett Cohen
Al Pierga
Dan Hodge, OHST
Robert Glover
Robin Tutor
Thomas Garrido, Captain
James Auvil, Lt. Colonel
Luis Muniz, Lt. Colonel
Kevin McGowan, Commander
Dr. Michael Pattison
Michael Vitale
Jeffrey Endres
Patrick Mumford
Nancy L.S. Yamasaki, Ph.D.
Dick Whitney
Rick Tinson
Richard Harley
Dale B. Pfriend



Table of Contents

TOPIC	PAGE
Foreword	
1 Preface	1
2 Scope, Purpose, Application, and Interpretations	1
2.1 Scope.....	1
2.2 Purpose.....	1
2.3 Application.....	1
2.4 Interpretations	2
3 Definitions	2
4 Normative References.....	6
5 General Requirements.....	6
5.1 Optical Requirements	6
5.2 Physical Requirements.....	7
5.3 Markings	8
5.4 Other Requirements	8
5.5 Replaceable Lenses.....	10
5.6 Aftermarket Components and Accessories	10
6 Impact Protector Requirements.....	11
6.1 General.....	11
6.2 Impact Requirements	11
7 Optical Radiation Protector Requirements	12
7.1 Protectors with Clear Lenses	12
7.2 Protectors providing Filtration of Optical Radiation	13
7.3 Automatic Darkening Welding Filter Devices.....	13
8 Droplet and Splash, Dust, and Fine Dust Protector Requirements	17
8.1 Droplet and Splash Hazard	17
8.2 Dust Hazard	17
8.3 Fine Dust Hazard	17
9 Test Methods.....	17
9.1 Optical Quality Test.....	18
9.2 Transmittance Test.....	18
9.3 Haze Test	18
9.4 Refractive Power, Astigmatism and Resolving Power Tests.....	18
9.5 Prismatic Power Test	19
9.6 Drop Ball Test.....	19
9.7 Ignition Test.....	20
9.8 Corrosion Resistance Test.....	20
9.9 Light Tightness Test	20

9.10	Lateral Protection Test.....	21
9.11	High Mass Impact Test.....	21
9.12	High Velocity Impact Test.....	22
9.13	Penetration Test	23
9.14	Prescription Lenses Test	24
9.15	Switching Index Test	24
9.16	Angular Dependence of Luminous Transmittance Test for Automatic Welding Filter Devices.....	25
9.17	Droplet and Splash Test.....	25
9.18	Dust Test.....	27
9.19	Fine Dust Particle Test.....	27
10	Instructions, Use and Maintenance	28
10.1	General	28
10.2	Instructions.....	28
10.3	Inspections	28
10.4	Maintenance and Care	29
10.5	Training.....	29
Annexes		
Annex A	Samples for Testing (normative).....	30
Annex B	Reference Headforms (normative)	31
Annex C	Spectral Factor Tables (normative)	33
Annex D	Lateral (Side) Coverage Illustration (Medium Headform) (informative).....	37
Annex E	Test Apparatus (informative)	38
Annex F	Calibration of Test Telescope (informative)	42
Annex G	Illustrations to Aid in Refractive Power, Astigmatism and Resolving Power Testing (informative)	43
Annex H	Sources for Test Apparatus (informative)	44
Annex I	Resource Publications (informative)	45
Annex J	Eye and Face Selection Guide (informative).....	46
Annex K	Hazard Assessment and Protector Selection (informative)	50
Annex L	Examples of Protector Markings (informative).....	56
Tables		
Table 1	Tolerance on Refractive Power, Astigmatism and Resolving Power.....	6
Table 2	Tolerance on Prism and Prism Imbalance	7
Table 3	Marking Requirements	9
Table 4	Minimum Thickness Requirements for Prescription Lenses.....	10
Table 5	High Velocity Impact Testing	11
Table 6	Transmittance Requirements for Welding Filter Lenses.....	15
Table 7	Transmittance Requirements for Ultraviolet Filter Lenses	15
Table 8	Transmittance Requirements for Infrared Filter Lenses.....	16
Table 9	Transmittance Requirements for Visible Light Filter Lenses	16
Table 10	Transmittance Requirements for Special Purpose Filter Lenses	16
Table 11	Switching Index Requirements for Automatic Darkening Welding Filter Lenses	17
Table 12	Angular Dependence of Luminous Transmittance.....	17

American National Standard for Occupational and Educational Personal Eye and Face Protection Devices

1. Preface

This standard for personal eye and face protectors is, as far as possible, designed to be performance oriented.

Every effort should be made to eliminate eye and face hazards in occupational and educational settings. Protectors do not provide unlimited protection. In the occupational and educational environment, protectors are not substitutes for machine guards and other engineering controls. Protectors alone should not be relied on to provide complete protection against hazards, but should be used in conjunction with machine guards, engineering controls, and sound safety practices.

In 1992, the U.S. Occupational Safety and Health Administration began regulating occupational exposure to bloodborne pathogens and, as a result, employers are required to provide personal protective equipment (PPE) including eye and face protection for employees exposed to these hazards. At the time of the publication of this standard, no standards existed for eye and face protection intended to provide protection from bloodborne pathogens. Nevertheless many employers have elected to provide their employees with PPE conforming to the requirements of ANSI/ISEA Z87.1. These products may or may not provide adequate protection against bloodborne pathogens. Extreme caution must be exercised in the selection and use of personal protective equipment in applications for which no performance requirements or standardized testing exist.

2. Scope, Purpose, Application, and Interpretations

2.1 Scope

This standard sets forth criteria related to the general requirements, testing, permanent marking, selection, care, and use of protectors to minimize the occurrence and severity or prevention of injuries from such hazards as impact, non-

ionizing radiation and liquid splash exposures in occupational and educational environments including, but not limited to, machinery operations, material welding and cutting, chemical handling, and assembly operations. Certain hazardous exposures are not covered in this standard. These include, but are not limited to: bloodborne pathogens, X-rays, high-energy particulate radiation, microwaves, radio-frequency radiation, lasers, masers, and sports and recreation.

2.2 Purpose

This standard provides minimum requirements for protectors including selection, use, and maintenance of these protectors as devices to minimize or prevent eye and face injuries.

2.3 Application

2.3.1 The requirements of this standard apply to protectors when first placed in service.

2.3.2 Protectors bearing the permanent marking Z87 shall meet all applicable requirements of this standard in its entirety. All components of eye and face protectors shall comply with the requirements of this standard. Accessories installed by the manufacturer shall not cause the protector to fail the requirements of this standard. Manufacturers of components, aftermarket components, accessories and complete protectors shall ensure that all required tests have been performed to demonstrate conformance.

2.3.3 Compliance with this standard cannot always be assured when components are replaced or accessories are added. End users should exercise extreme care in the selection and installation of components to ensure compliance with this standard.

2.3.4 Non-compliant components shall not be used with ANSI/ISEA Z87-compliant components.

2.3.5 The protector manufacturer shall provide test results to the purchaser upon request.

2.4 Interpretations

Requests for interpretations of this standard shall be in writing and addressed to the secretariat (isea@safetysafetyequipment.org) of this accredited standard committee.

3. Definitions

For purposes of this standard, the following definitions shall apply:

accessory. An item that is added to a complete device that may or may not affect the performance of that complete device.

aftermarket component. A component that may or may not be manufactured by the complete device manufacturer and is not supplied with the original complete device.

astigmatism. A condition in a lens of a protector in which there is a difference in refractive power in one meridian from that in another meridian.

automatic darkening welding filter lens. A filter lens that automatically switches from a light state to a dark state in response to a change of light intensity.

blue light transmittance T_B . Transmittance of optical radiation weighted by its ability to cause photochemical damage to the retina is defined as:

$$T_B = \frac{\int_{400}^{700} T(\lambda) B(\lambda) d\lambda}{\int_{400}^{700} B(\lambda) d\lambda}$$

where $B(\lambda)$ is the BlueLight Hazard Function defined in Table C4 of Annex C.

chin protector. That portion of a device that offers protection to a wearer's lower face, chin and neck.

complete device. A product with all its components in their configuration of intended use.

component. A functional part of a complete device that is addressed by the performance re-

quirements of this standard (e.g. lens, frame, crown).

cover lens. An expendable lens used to protect another lens from surface damage and that is not intended to contribute to user protection. It is not a safety plate.

crown. A component that offers protection to a wearer's forehead.

dark state. The lowest operating luminous transmittance of an automatic darkening filter lens.

diopter (D). A unit of measurement (plus or minus) used to express the power of a lens. It is expressed as the reciprocal of the focusing distance given in meters. The diopter is also used to express the curvature of surfacing tools and the refracting power of curved surfaces.

effective far-ultraviolet average transmittance

$\bar{T}$ (EFUV). Transmittance of optical radiation with wavelengths from 200 to 315 nanometers weighted by its ability to damage the cornea. When $T(\lambda)$ is defined as the spectral transmittance of the filter at wavelength, $\bar{T}$ (EFUV) is defined as:

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

where $W(\lambda)$ is the Spectral Weighting Factor given in Table C1 of Annex C.

faceshield. A protector intended to shield the wearer's face, or portions thereof from certain hazards, as indicated by the faceshield's markings.

filter lens. A lens that attenuates specific wavelengths of ultraviolet, visible, and/or infrared radiation.

fracture. A lens, frame, or lens housing or carrier cracks through its entire thickness to the inner surface into two or more separate pieces.

frame. A structure which holds the lens or lenses.

front. That part of a spectacle frame that is intended to contain the lens or lenses.

full facepiece respirator. A tight fitting respirator that covers the nose, mouth and eyes from approximately the hairline to below the chin.

goggle. A protector intended to tightly fit the face surrounding the eyes in order to shield the eyes from certain hazards, as indicated by the goggle's markings.

handshield. A hand-held welding helmet. See "welding helmet."

haze. The percent of incident light that is not transmitted in a straight line through the lens but forward scattered, greater than 2.5° diverging.

headform. Apparatus constructed in accordance with specifications outlined in EN168:2001, Section 17 utilized in the testing of protective devices as specified in Section 9, Test Methods. (Refer to Annex B)

infrared average transmittance. Transmittance of optical radiation with wavelengths from 780 to 2000 nanometers weighted by its ability to damage the cornea. When $T(\lambda)$ is defined as the spectral transmittance of the filter at wavelength, $\bar{T}$ (IR) is defined as:

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

where, in the infrared, the relative spectral emittance $S(\lambda)$ of Illuminant A is that of a full ("Black-body") radiator at temperature 2856° K (4681 ° F) and is given in Table C3 of Annex C.

infrared radiation (IR). As related to this standard, electromagnetic energy with wavelengths from 780 to 2000 nanometers.

inner surface. The inward facing portions of any

component of a complete device which have a direct line to the eye or lateral coverage area per Section 6.1.3.

lens. A component through which the wearer sees.

lens housing or carrier. A component that holds a lens or lenses.

lift-front. A moveable lens housing that can be positioned either inside or outside of the wearer's line of sight.

light. Optical radiation weighted by its ability to cause visual sensations.

light state. The highest luminous transmittance of an automatic darkening welding filter lens, when not in a dark state.

loose fitting respirator. A respiratory inlet covering that is designed to form a partial seal with the face, or that completely covers the head and neck, and may cover portions of the shoulder.

luminous transmittance (T_L). The fraction of light (380-780 nm) passing through a medium, is defined in this standard with respect to the light source CIE Illuminant A and the CIE 1931 Standard Colorimetric Observer, and is 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 $\bar{y}(\lambda)$ is the relative luminous efficiency function and $S(\lambda)$ is the relative spectral emittance of Illuminant A as defined by the CIE. These functions are given in Table C2 of Annex C.

magnifier. A mass-produced lens (non-prescription) that incorporates plus refractive power throughout the entirety of the lens. This includes spectacle lenses but does not include magnifiers inserted into welding devices, which are considered to be accessories.

manufacturer. The business entity that marks or directs the permanent marking of the components or complete devices as compliant with this standard, and sells them as compliant.

near-ultraviolet average transmittance.

Transmittance of optical radiation with wavelengths from 315 to 380 nanometers. When $T(\lambda)$ is defined as the spectral transmittance of the filter at wavelength, $\bar{T}$ (NUV) is defined as:

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

non-removable lens. A lens and holder that are homogeneous and continuous or a lens that cannot be removed from the frame/front without damage to the device.

optical radiation. As related to this standard, that portion of the electromagnetic spectrum ranging in wavelength from 200 nm to 2000 nm.

permanent mark/markings. A mark that cannot be removed without evidence of removal.

photochromic lens. A lens which darkens when exposed to, and fades when removed from, ultraviolet radiation and/or sunlight.

plano lens. A lens that does not incorporate a corrective prescription; this lens is not necessarily flat.

power. See "refractive power", "resolving power", and "prismatic power".

prescription lens (Rx). A lens manufactured to the wearer's individual corrective prescription.

prescription lens carrier. A lens housing for mounting prescription lenses behind a protective lens.

prismatic power, "prism". A measure of the angular deviation expressed in prism diopters (Δ) of a light ray after passing along the viewing path through a lens. One prism diopter equals a deviation of 1 cm per meter of path length.

tion of 1 cm per meter of path length.

protector. A complete device meeting, at a minimum, the requirements of Section 5 of this standard.

reader. A mass produced non-prescriptive spectacle that incorporates plus refractive power in a portion of the lens.

refractive power, "power". A measure of the ability of a lens to focus light rays, expressed in diopters (D).

removable lenses. Lenses fabricated to fit a single spectacle frame.

replaceable lenses. A lens that is intended by the manufacturer to be interchangeable by the user.

representative test lenses. Lenses produced of the same materials, coatings, minimum thicknesses, lens surfacing and framing processes as used by the manufacturer.

resolving power. The measure of the ability of a lens to form separate images of two objects close together.

retained. In this standard, the use of the word "retained" means that the lens is not separated or visibly displaced from the frame by more than 25% of its intended mounting structure or support.

safety plate. The lens portion of the device that provides impact protection in the lens region of the protector. This is not a cover lens.

scale. A designator in which the first character indicates the type of radiation protector and the second character is a number which increases with more attenuation. The radiation protector characters are U for an ultraviolet radiation attenuator, R for infrared radiation attenuator and L for visible radiation attenuator.

screen. A mesh or gauze material made of any suitable substance (e.g. metal wire, plastic filament or fiber).

shade, S. Related to luminous transmittance, T_L (expressed as a fraction, not as a percent) by the equation:

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

shall. In this standard, the use of the word "shall" indicates a mandatory requirement.

shell. A component of a welding helmet or hand-shield that covers the wearer's face, ears and neck.

should. In this standard, the use of the word "should" indicates a recommendation.

sideshield. A component of a spectacle that provides lateral protection.

special purpose filters/lenses. Filters and lenses which meet the requirements of Table 10, but may or may not meet the requirements of Table 6, 7, 8 or 9. They are designed for specific applications.

spectacle. A protector intended to shield the wearer's eyes from certain hazards, as indicated by the spectacle's marking.

switching index. The response time of an automatic darkening welding filter lens is defined as:

$$\text{Switching Index} = \frac{1}{T_1} \int_{t=0}^{t(T=3T_2)} T(t) dt$$

where: $t = 0$ is the time at which the arc ignites, T_1 is the luminous transmittance at the designated light state, T_2 is the luminous transmittance at the designated dark state, $t[T=3T_2]$ is the time at which the luminous transmittance falls to three times the luminous transmittance in the dark state.

NOTE: During short term exposure to light, the discomfort of bright light 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 filter lens as an integral of the luminous transmittance over time and not merely by the initial and final luminous transmittance.

temple. A spectacle component that extends partially around the head or behind the ear of the wearer.

tinted lens. A lens with color such as amber, smoke, or cobalt which may not meet the requirements of Table 6, 7, 8 or 9.

type tests. One or more tests performed on an item to approve a material, construction, model or design to determine if it is capable of meeting the requirements of a product standard.

ultraviolet radiation (UV). Electromagnetic energy with wavelengths from 200 to 380 nanometers.

variable tint lens. A lens which darkens or fades by some mechanism, excluding automatic darkening welding filters. These are typically photochromic lenses and may or may not meet the requirements of Table 6, 7, 8 or 9.

visible light filter. A filter lens intended for the attenuation of visible light. This may be a sunglass or special purpose lens.

welding goggle. A goggle intended to provide optical radiation protection for limited welding applications.

welding faceshield. A faceshield intended to provide optical radiation protection for specific welding applications.

welding filter lens. A lens specified for use for welding or brazing.

welding helmet. A device intended to provide protection specifically to the eyes and face against welding-related optical radiation and weld spatter.

welding respirator. A respirator intended to provide optical radiation protection for welding operations.

window. The lens portion of a faceshield (see “lens”).

4. Normative References

The following documents contain provisions, which, through reference in this text, constitute mandatory provisions of this standard. Other resource materials, which do not contain mandatory provisions, are listed in Annex I.

American Conference of Governmental Industrial Hygienists - *Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices for 2008*

ANSI Z80.1-2010, *American National Standard for Ophthalmics - Prescription Ophthalmic Lenses – Recommendations*

ANSI Z80.3-2010, *American National Standard for Ophthalmics - Nonprescription Sunglasses and Fashion Eyewear – Requirements*

ANSI Z80.5-2010, *American National Standard Requirements for Ophthalmic Frames*

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

EN 168:2001, *European Standard – Personal eye protection – Non-optical test methods*

5. General Requirements

Unless otherwise stated, all values for measurements are to be considered as nominal.

All protectors shall satisfy all applicable requirements of Section 5.

5.1 Optical Requirements

5.1.1 Optical Quality

When tested in accordance with Section 9.1, protector lenses shall be free of striae, bubbles, waves and other visible defects which would impair the wearer's vision.

5.1.2 Luminous Transmittance

When tested in accordance with Section 9.2, clear lenses shall have a luminous transmittance of not less than 85%.

5.1.3 Haze – Clear Lenses Only

When tested in accordance with Section 9.3, clear plano lenses shall not exhibit more than 3% haze.

5.1.4 Refractive Power, Astigmatism, Resolving Power, Prism and Prism Imbalance for Plano Protectors

When tested in accordance with Section 9.4, the tolerance on refractive power, astigmatism and resolving power shall be as indicated in Table 1. When tested in accordance with Section 9.5, the tolerance on prism and prism imbalance shall be as indicated in Table 2. Filter lenses of shade 9 or higher are exempt from this section.

Table 1. Tolerance on Refractive Power, Astigmatism and Resolving Power

Protector	Refractive Power	Astigmatism	Resolving Power
Spectacle Reader	± 0.06 D	≤ 0.06 D	Pattern 20
Goggle Full-facepiece respirator	± 0.06 D	≤ 0.06 D	Pattern 20
Faceshield windows Loose-fitting respirator	No requirement	No requirement	Pattern 20
Welding helmet lenses	± 0.06 D	≤ 0.06 D	Pattern 20

Table 2. Tolerance on Prism and Prism Imbalance

Protector	Prism	Vertical Imbalance	Base In Imbalance	Base Out Imbalance
Spectacle Reader	$\leq 0.50 \Delta$	$\leq 0.25 \Delta$	$\leq 0.25 \Delta$	$\leq 0.50 \Delta$
Goggle Full-facepiece respirator	$\leq 0.25 \Delta$	$\leq 0.125 \Delta$	$\leq 0.125 \Delta$	$\leq 0.50 \Delta$
Faceshields Loose-fitting respirator	$\leq 0.37 \Delta$	$\leq 0.37 \Delta$	$\leq 0.125 \Delta$	$\leq 0.75 \Delta$
Welding helmet lenses	$\leq 0.50 \Delta$	$\leq 0.25 \Delta$	$\leq 0.25 \Delta$	$\leq 0.75 \Delta$

5.1.5 Refractive Power, Astigmatism, Prism and Prism Imbalance for Prescription Protectors and Magnifiers

For prescription protectors and magnifiers, the tolerance on refractive power, astigmatism, prism and prism imbalance shall be those contained in ANSI Z80.1-2010.

NOTE: There is no resolving power requirement for prescription lenses and magnifiers.

5.2 Physical Requirements

Protectors shall be free from projections, sharp edges or other defects which are likely to cause discomfort or injury during use.

5.2.1 Drop Ball Impact Resistance

When tested in accordance with Section 9.6, the protector shall fail if any of the following occur when impacted by a 25.4 mm (1 in.) diameter steel ball when dropped from a height of 127 cm (50 in.):

- lens (lens only) fractures
- piece fully detached from the inner surface
- projectile penetrates the inner surface
- lens not retained

Glass welding filter lenses shall be tested and used in conjunction with a safety plate in order to comply with the drop ball impact performance criteria.

Protectors first tested to and meeting the requirements of Section 6.2 are exempt from drop ball impact testing.

5.2.2 Ignition

When tested in accordance with Section 9.7, protectors shall not ignite or continue to glow once the rod is removed. Each externally exposed material (exclusive of textiles or elastic bands) shall be tested.

5.2.3 Corrosion Resistance of Metal Components

When tested in accordance with Section 9.8, metal components used in protectors shall be corrosion resistant to the degree that the function of the protector shall not be impaired by the corrosion and the protector can be worn as intended. Lenses and electrical components are excluded from these requirements.

5.2.4 Minimum Coverage Area

The frames, lens housings or carriers and lens(es) shall cover in plane view an area of not less than 40 mm (1.57 in.) in width and 33 mm (1.30 in.) in height (elliptical) in front of each eye, centered on the geometrical center of the lens.

Frames, lens housing or carrier and lens(es) designed for small head sizes shall cover in plane view an area of not less than 34 mm (1.34 in.) in width and 28 mm (1.10 in.) in height (elliptical), centered on the geometrical center of the lens.

Frames, lens housing or carrier and lens(es) designed for small head sizes shall be tested on the small headform. Frames that are tested using the small headform shall be marked on the frame with the letter "H."

5.3 Markings

5.3.1 Required Protector Markings

All protectors shall bear the permanent and legible markings in specified locations as shown in Table 3. Markings for lens type and use applications shall be required only when claims for protection against the hazard or indicated use are made by the manufacturer.

The components of frames that are intended for prescription protector use shall be marked for size in accordance with the system described in ANSI Z80.5-2010. Fronts shall be marked with the A-dimension (eye size) and DBL (distance between lenses). Temples shall be marked with their overall length.

5.3.2 Placement of Markings

Protector markings shall be placed in relatable proximity to each other on the product in the sequence specified below:

- Manufacturer's marks or logos
- Designation of standard (Z87 or Z87-2, for prescription devices)
- Individual claims of compliance
 - impact-rated marking (+)
 - lens type
 - use applications.

Manufacturer's marks or logos are exempt from the proximity requirement if they are clearly present elsewhere on the product. Markings representative of other standards shall not interfere with or be intermixed with the markings required by this standard. Examples of acceptable and not acceptable product markings can be found in Annex L.

5.3.3 Prescription Lens Carriers

Prescription lens carriers used behind plano protectors shall be marked with the manufacturer's mark or logo but shall not be marked with other Z87 markings.

5.4 Other Requirements

5.4.1 Vented Goggles

If the goggle is equipped with adjustable ventilation, the protector shall be tested in the maximum open position.

5.4.1.1 Direct Ventilation

The vented portion of the goggle shall be such that the openings exclude spherical objects 1.5 mm (0.06 in.) in diameter or greater.

5.4.1.2 Indirect Ventilation

The vented portion of the goggle shall be such that no direct straight-line passage from the exterior to the interior of the goggle exists.

5.4.2 Screen Windows and Screen Lenses

Exposed borders of screen windows and cutouts in the screen window (combination plastic and screen) shall be finished in such a manner as to eliminate any sharp, rough or unfinished edges. Screen windows and lenses are exempt from penetration and optical requirements.

5.4.3 Welding Protectors

5.4.3.1 Transmittance of Non-Lens Areas for Welding Helmets

When tested in accordance with Section 9.2, the non-lens area of welding helmets with removable lenses shall transmit no more optical radiation than that permitted by Table 6 for shade number 14. Non-lens areas of welding helmets with non-removable lenses shall transmit no more optical radiation than that of the lens.

5.4.3.2 Light Tightness

When tested in accordance with Section 9.9, there shall be no penetration of direct visible light in all non-lens areas including the space between the lens and lens housing or carrier.

5.4.3.3 Cover lenses

Cover lenses are exempt from all requirements of this standard. Cover lenses do not provide protection from optical radiation or impact. Cover lenses shall not be marked "Z87."

Table 3. Marking Requirements				
Type of Mark	Lenses & Replacement Lenses		Frame ¹	Marking for Complete Device (no replaceable components) ²
	Spectacles	All Other		
All protectors shall bear the markings below.				
Manufacturer’s Mark or Logo	Yes	Yes	Yes	Yes
Standard				
Plano, Readers, Magnifiers		Z87	Z87	Z87
Rx		Z87	Z87-2	Z87-2
Coverage (small head sizes) ³	H		H	
The following shall be required only when claims of impact rating, a specific lens type and/or use are made by the manufacturer.				
Impact Mark				
Impact Rated Plano, Readers Magnifiers	+	Z87+	Z87+	Z87+
Impact Rated Rx	+	Z87+	Z87-2+	Z87-2+
Lens Type				
Clear				
Welding Filter (see table 5)	W shade	W shade		W shade
UV Filter (see table 6) ⁴	U scale number	U scale number		U scale number
Visible Light Filter (see table 8) ⁴	L scale number	L scale number		L scale number
IR Filter (see table 7) ⁴	R scale number	R scale number		R scale number
Variable Tint	V	V		V
Special Purpose Lenses	S	S		S
Use				
Splash / Droplet			D3	D3
Dust			D4	D4
Fine Dust			D5	D5

- Frame components subject to marking vary by type of protector.
 - Spectacles: Frame and at least one temple. Both detachable sideshields are marked Z87+, if impact rated
 - Goggles: Frame and lens housing or carrier
 - Faceshields: Crown and chin protector
 - Welding helmets and handshields: Shell and lens housing or carrier
 - Respirators: None
 - Prescription frames: Size marking on front and temples in accordance with ANSI Z80.5-2010
- A complete device (no replaceable components) shall have at least one set of markings. The markings may be on the lens or the frames or both the lens and the frame.
- For spectacle protectors, coverage marking "H" shall be on the lens for rimless or semi-rimless lens retention systems.
- In case of multiple filter type compliance, designations shall be listed in the order given in this table: U, L, R.

5.4.3.4 Information Provided with Welding Protectors

A welding protector shall, as sold, be accompanied by lens and retention information. The information shall include, at a minimum:

- A list of all lens and retention components, plus the shell model.
- Information sufficient to allow the user to install the lenses in the correct order. A simple statement that the lens list is ordered from, for example, outside to inside is sufficient.
- A clear statement that the protection marked in accordance with this standard is only provided when all lens and retention components are installed according to the list or other manufacturer's instructions.
- The nominal thickness and material type of unmarked cover lenses.

5.4.4 Frames for Removable Lenses

All frames which can house removable lenses shall be supplied with detailed specifications on the required lens bevel design or mounting technique and nominal lens sizing.

5.4.5 Minimum Lens Thickness for Prescription Spectacles

The minimum lens thickness for prescription spectacles shall be those indicated in Table 4.

Table 4. Minimum Lens Thickness for Prescription Lenses	
Spectacle	≥ 3.0 mm (0.12 in.) ≥ 2.5 mm (0.10 in.) if power in the most plus meridian of the distance portion is $\geq +3.00$ D
Spectacle, impact rated	≥ 2.0 mm (0.079 in.) *

* This requirement shall also apply to removable lenses made with a plano power to fit an impact rated prescription spectacle.

5.5 Replaceable Lenses

5.5.1 Goggles

Round lenses measuring 50 mm (1.97 in.) shall have a dimensional tolerance of ± 0.2 mm (0.008 in.).

Rectangular lenses measuring 51 x 108 mm (2.00 x 4.25 in.) shall have a dimensional tolerance of ± 0.8 mm (0.031 in.).

5.5.2 Welding Helmets and Handshields

Rectangular lenses measuring 51 x 108 mm (2.00 x 4.25 in.) and 114 x 133 mm (4.49 x 5.24 in.) shall have a dimensional tolerance of ± 0.8 mm (0.031 in.).

5.6 Aftermarket Components and Accessories

All original equipment manufacturers (OEM) and non-OEM aftermarket components or accessories not sold with the original device shall be tested assembled with the original complete device in the as-worn condition to show compliance with all applicable requirements in Sections 5, 6, 7 and 8 as claimed for the original device. For aftermarket sideshields, the sideshields shall be tested on representative frames for which the product is specified to fit. Documentation listing all devices that the component or accessory (OEM or non-OEM) has been tested and is approved for shall be made available by the manufacturer.

The entity claiming compliance of the component or accessory is responsible for testing the original complete device assembled with the components or accessories and shall provide evidence of compliance upon request.

Except for automatic darkening filters, replacement welding and goggle filters and lenses that meet the size restrictions specified in Section 5.5.2 shall be tested on one type of representative frame as needed to verify compliance with applicable requirements in Sections 5, 6, 7 and 8.

6. Impact-Rated Protector Requirements

6.1 General

6.1.1 Protectors Marked for Impact Protection

Protectors and replaceable components marked for impact protection in accordance with Table 3 shall meet applicable requirements of Section 6.

6.1.2 Frames and Shells

Frames and shells shall meet the requirements for high mass impact and high velocity impact in order to be impact-rated. These components shall be tested as a complete device. For frames and shells to be used with prescription lenses, they shall be fitted with representative test lenses having a nominal plano power and the minimum lens thickness to be used by the manufacturer, in no case less than 2.0 mm (0.079 in.). Frames and shells are exempt from the penetration requirement.

6.1.3 Lateral (Side) Coverage

When tested in accordance with Section 9.10, impact rated protectors shall provide continuous lateral coverage (i.e. no openings greater than 1.5mm (0.06 in.) in diameter) from the vertical plane of the lenses tangential to a point not less than 10 mm (0.39 in.) posterior to the corneal plane and not less than 10 mm (0.39 in.) in height (or 8 mm (0.32 in.) for the smaller headform) above and not less than 10 mm (0.39 in.) in height (or 8 mm (0.32 in.) for the smaller headform) below the horizontal plane centered on the eyes of the headform. The probe shall not contact the headform within the defined coverage area. (See Annex D).

6.2 Impact Requirements

6.2.1 Protector Acceptance Criteria

When each type test is conducted as indicated in Sections 6.2.2, 6.2.3 and 6.2.4 and, as applicable Section 6.2.6, a complete device shall fail if any of the following occurs:

- any part, fragment or material visible to the unaided eye becomes detached from the inner surface of any complete device, as determined by inspection of the device or of the contact

- paste;
- fracture;
- penetration of the inner surface either by the projectile passing completely through the lens, frame or housing component, or by rupture of the inner lens surface;
- lens not retained;
- for the high-velocity test, the unaided eye observes any piece adhering to the contact paste, or observes contact paste on the projectile or complete device.

In the case of plano protectors with a prescription lens carrier, contact of the prescription lens carrier with the headform does not constitute a failure.

6.2.2 High Mass Impact

When tested in accordance with Section 9.11, the complete device shall meet the protector acceptance criteria when impacted by a pointed projectile weighing a minimum of 500 g (17.6 oz) dropped from a height of at least 127 cm (50.0 in.).

6.2.3 High Velocity Impact

When tested in accordance with Section 9.12, the complete device shall meet the protector acceptance criteria when impacted by either steel ball traveling at its respective velocities specified in Table 5.

Table 5. High Velocity Impact Testing

Device type	Minimum Velocity	
	6.35 mm (0.25 in.) diameter steel ball	6.00 mm (0.24 in.) diameter steel ball
Welding helmets	45.7 m/s (150 ft/s)	50.9 m/s (167 ft/s)
Spectacles Readers Magnifiers	45.7 m/s (150 ft/s)	50.9 m/s (167 ft/s)
Goggles Full facepiece respirators	76.2 m/s (250 ft/s)	84.7 m/s (278 ft/s)
Faceshields Loose-fitting respirators	91.4 m/s (300 ft/s)	101.5 m/s (333 ft/s)
Note: The paired velocities and ball diameters are designed to provide impacts of comparable kinetic energy.		

6.2.4 Penetration Test (lenses only)

When tested in accordance with Section 9.13, lenses for all complete devices shall meet the protector acceptance criteria when penetrated by a weighted needle with minimum a total weight of 44.2 g (1.56 oz) dropped from a height of at least 127 cm (50.0 in.).

6.2.5 Prescription Lens Material Qualification

When tested in accordance with Section 9.14, representative test lenses for use in prescription protectors shall be capable of resisting impact from either a 6.0 mm (0.24 in.) or a 6.35 mm (0.25 in.) diameter steel ball traveling at the respective velocities specified in Table 5.

When tested in accordance with this section, the lens shall fail if any of the following occurs:

- posterior displacement of the lens completely through the test holder;
- fracture of the lens;
- any detachment of a portion of the lens from its inner surface; or
- any full thickness penetration of a lens.

Failure of any lens constitutes a failure. If all test lenses pass, then any prescription lens of the same or greater thickness at its thinnest point, which is made by the same manufacturer, from the same material, with the same coatings and processes may bear the “+” mark.

6.2.6 Prescription Lens Mounting Qualification

When tested in accordance with Section 9.11 and Section 9.12 complete devices using representative test lenses meeting the requirements of Section 6.2.5 and having the thinnest lens thickness to be used by the manufacturer, in no case less than 2.0 mm (0.079 in.) shall be capable of resisting high mass and high velocity impact. For each type of lens retention system offered for sale, one set of 10 complete devices shall be tested. Failure of any device as a result of the six (6) high velocity or four (4) high mass tests shall constitute failure for a set. Failure of a set constitutes failure of that lens retention system.

Lens retention systems are:

- Full rim eyewires that require bevel designs like a “safety V bevel and other lens bevels” for metal frames.
- Full rim eyewires that require bevel designs like a “safety V bevel and other lens bevels” for plastic frames.
- Grooved metal frame style (T-Eyewire).
- Grooved semi rimless with half metal rim and suspension cord mountings.
- Three-piece rimless drill mount.
- Any mounting that is configured differently than described above to secure the lens and that is design/process dependent such that it requires a different lens beveling process or mounting technique.

Manufacturers shall also conduct the test if it incorporates frames with different lens retention systems into the product offering.

This type testing shall be performed when any substantive change in production occurs that could affect the ability of the device to pass the tests as described in Sections 9.11 and 9.12.

6.2.7 Devices with Lift Fronts

Complete devices with lift fronts shall meet the applicable requirements of Section 6 with the lift front in the “up” position.

7. Optical Radiation Protector Requirements

Optional transmittance characteristics of a protector are represented by a scale/shade number indicating its ability to filter optical radiation. They shall meet the requirements, including markings, of Tables 6, 7, 8 and 9, if claims of compliance are made. Special purpose filters shall meet the requirements of Table 10.

7.1 Protectors with Clear Lenses

When tested in accordance with Section 9.2, clear plano, reader, magnifier and prescription lenses shall have a luminous transmission of not less than 85%. Representative test lenses of plano

power may be substituted for prescription, reader or magnifier lenses in this test.

7.2 Protectors providing Filtration of Optical Radiation

7.2.1 Filter Lenses

7.2.1.1 Transmission Requirements

When tested in accordance with Section 9.2, plano, reader, magnifier and prescription lenses that are marked as filtering optical radiation shall comply with requirements of Table 6 (welding filters), Table 7 (ultraviolet filters), Table 8 (infrared filters), Table 9 (visible light filters) and/or Table 10 (special purpose filters). Special purpose filters may or may not comply with Tables 7, 8 or 9, but shall comply with the requirements of Table 10 for special purposes.

Representative test lenses of plano power may be substituted for prescription, reader or magnifier lenses in this test.

7.2.1.2 Visible Light Filters

Visible light filters, including photochromic and mechanical or manual adjustment types, shall meet the requirements and be marked in accordance with Table 9.

Visible light filters in the range of L1.3 through L3 shall also meet the transmittance requirements of Table 4 of ANSI Z80.3-2010, including traffic signal recognition and UV transmittance (high and prolonged exposure). Visible light filters in the range of L4 through L10 are too dark to be used for driving, but shall meet the UV transmittance (high and prolonged exposure) requirements of Table 4 of ANSI Z80.3-2010.

7.2.1.3 Variations in Luminous Transmittance

Measurements shall be taken according to Section 9.2.

For shades 1.3 through 3.0, the ratio of the two measured transmittances, one for each lens of a removable pair, or at points directly in front of each eye for a non-removable lens, shall not be less than 0.90, nor more than 1.11.

For shades 4.0 through 14 inclusive, the ratio of

the two measured transmittances shall be not less than 0.80 nor more than 1.25. Variation in transmission shall be measured in the darkest state.

For prescription lenses, readers and magnifiers, the same requirements apply, except when variations are due to thickness variations based on the lens design.

7.2.2 Transmittance of Non-Lens Components

When tested in accordance with Section 9.2, frames/housings of goggles, including those with non-removable lenses, shall comply with the requirements of Tables 6, 7 and 8 according to the maximum scale number of the lens with which they will be fitted.

Frames/housings of faceshields are exempt from frame transmittance requirements.

Frames/housings of spectacles are exempt from frame transmittance requirements. Sideshields shall be tested.

Frames/housings that provide protection only against visible light (see Table 9) are exempt from transmittance requirements.

7.3 Automatic Darkening Welding Filter Lenses

7.3.1 Luminous Transmittance

Automatic darkening welding filter lenses shall meet the luminous transmittance requirements of Table 6 when tested in both the darkest and lightest designated (marked) dark states in accordance with Section 9.2. Tests for luminous transmittance shall be performed at temperatures of:

- $-5^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($23^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$);
- $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($73.4^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$); and
- $55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($131^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$).

The dark state tolerance is ± 1 shade number for luminous requirements.

7.3.2 UV/IR Transmittance

When measured in the lightest state, automatic darkening welding filters shall meet the require-