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AMERICAN NATIONAL STANDARD

ANSI Z80.1-2005

for Ophthalmics –

Prescription Ophthalmic Lenses–
Recomendations

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Z80.1-2005
(Revision of
ANSI Z80.1-1999)

American National Standard
for Ophthalmics –

Prescription Ophthalmic Lenses – Recommendations

Secretariat

Optical Laboratories Association

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American National Standards Institute, Inc.

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Foreword (This foreword is not part of American National Standard ANSI Z80.1-2005.)

The Z80 Standards Committee for Ophthalmic Lenses was organized in 1956. Three separate standards were drafted, two relating to the manufacture of lenses and one to the fabrication of ophthalmic lenses into prescription eyewear. A standard relating mainly to lenses, but containing additional tolerances for a mounted pair, was issued in 1964. The tolerances were based largely upon an analysis of measured parameters in typical single-vision, mass-produced lenses assembled into conservatively styled and sized mountings. The standard represented the state-of-the-art for such lenses and a set of quality goals for lenses surfaced in the ophthalmic laboratory on an individual basis.

At the beginning of 1970, the Standards Committee Z80 was reorganized with the Optical Society of America, its former sponsor, serving as Secretariat. In 1972, the committee's scope was broadened to include lenses other than prescription glass ophthalmic lenses in recognition of the importance of plastic ophthalmic materials and the increased use of sunglasses and fashion eyewear. In the 1972 revision, certain tolerances for plastic and heat-treated lenses were relaxed in response to Federally mandated impact-resistant requirements for all ophthalmic lenses.

The 1979 revision reflected a shift in utilization from mass-produced lenses to a basic dependence upon custom-processed lenses at the laboratory level. It was an attempt to define the state-of-the-art in the manufacturing laboratory by recognizing the fact that, while individual tolerances may be reliably met, it is often not possible to achieve all requirements simultaneously. The Standard expressed desirable technical concepts that provide a framework for safety and effectiveness. The title was changed from a "requirement" to a "recommendation" to reflect the committee's intent.

In 1982, the Optical Laboratories Association assumed the responsibilities of the Secretariat. In 1985, the Z80 Committee became an Accredited Standards Committee.

The 1995 revision attempted to write the Z80.1 standard to be consistent with ISO standards. It was subsequently found that applying the ISO power tolerance method to custom fabricated eyewear resulted in unacceptably high rejection rates.

This 2005 revision corrects the change in power tolerancing methodology and brings the tolerance in line with the current "state-of-the-art." The difference in refractive power tolerance between progressive addition lenses and single-vision and multifocal lenses reflects the fact that the tolerance on base curve for progressive addition lenses in ISO standards is looser than the tolerance on single-vision and standard multifocals. The tolerance for cylinder axis uses as its basis the amount of axis error that would be needed to result in an error of 0.12 D, (the tolerance for cylinder refractive power). Additionally, the clause on the lens measurement method has been rewritten to include automatic focimeters and better describe the method for measuring prism.

The standard remains a recommendation. Therefore, it is the specific intent of the Z80 Committee that this standard not be used as a regulatory instrument.

This standard contains five informative annexes, which are not considered part of the standard.

Suggestions for improvement of this standard will be welcome. They should be sent to the Optical Laboratories Association, 11096 Lee Highway, A101, Fairfax, VA 22030-5039, USA.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Ophthalmics, Z80. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the Z80 Committee had the following members:

Thomas C. White, M.D., Chairman
Quido Cappelli, Vice-Chairman
Robert Rosenberg, O.D., Secretary

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Veterans Administration	John Townsend Sharon R. Atkin (Alt.)
Vision Council of America	Kenneth O. Wood Steve Drake (Alt.) Darryl Meister (Alt.) Greg Chavez (Alt.) Dick Whitney (Alt.)

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Dean Bancroft
William Brown
Steven Drake
Kenneth Frederick
Herbert Hoover
Susie Lesher
Darryl Meister
Nick Mileti
Arthur Newman
Dale Pfriem
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Richard Phillips
Jonathan Schwartz
Richard Waido
Richard Whitney
Kenneth Wood
John Young

American National Standard for Ophthalmics –

Prescription Ophthalmic Lenses – Recommendations

1 Scope and Purpose

1.1 Scope

This standard applies to the processing of all prescription ophthalmic spectacle lenses in edged or assembled form. It is a processing guideline for optical laboratories applicable to prescription eyewear prior to transfer for dispensing, and for the dispenser prior to the delivery of the finished eyewear to the patient. Relevant optical specifications and tolerances of this standard should apply also to uncut lenses supplied by an optical laboratory to be used in filling a specific prescription.

This standard does not apply to products covered by *American National Standard for Ophthalmics – Nonprescription Sunglasses and Fashion Eyewear - Requirements*, ANSI Z80.3-2001.

1.2 Purpose

This standard reflects the shift in utilization from mass-produced lenses to a basic dependence upon custom-processed lenses at the laboratory level. It does not represent tolerances that describe the state-of-the-art of the ophthalmic laboratory, but provides quality goals for new pristine lenses prepared to individual prescription. The individual performance parameters listed in this standard can be achieved reliably. However, it is difficult to meet all of the requirements simultaneously in any given lens or mounted pair. The fact that, under rigorous application of this standard, a significant number of spectacles (approximately 25%, based upon industry data) will not achieve all parameters simultaneously, must be accepted as a reflection of the state-of-the-art (see Annex E – *Optical Index*). As such, this standard expresses desirable technical concepts that provide a frame of reference for safety and effectiveness and is not designed as a regulatory instrument.

2 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI Z80.17-2001, *Focimeters*[1]

ANSI Z87.1-2003, *Practice for Occupational and Educational Eye and Face Protection*[1]

ANSI/ASTM F803-2003, *Eye Protectors for Use by Players of Selected Sports*[1]

ASTM D2103-2003, *Specifications for polyethylene film and sheeting*[2]

Title 21, Code of Federal Regulations, 801.410[3]

[1] Available from the American National Standards Institute, 25 West 43rd Street, New York, NY 10036 (Website: www.ansi.org).

[2] Available from the ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428 (Website: www.astm.org).

[3] Available from the Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954 (Website: www.fda.gov).

3 Definitions

3.1 Aberration

The failure of a refracting surface or lens to bring all rays from an object point toward a desired image point. This can result in image blur. Aberration also results in curvature in the image of a straight line (see 3.11). Aberration may be inherent in the design of a lens or may result from errors in processing (see 3.27 and 3.28).

3.2 Addition

The difference in vertex power, normally referred to as the surface containing the add, between the reading, or intermediate portion of a multifocal lens, and its distance portion. An addition (or add) is commonly equivalent to a positive spherical lens superimposed on a distance prescription to permit the wearer to focus more easily upon near objects.

3.3 Axis

3.3.1 Cylinder Axis

That principal meridian which contains only the spherical power component of a sphero-cylinder lens.

3.3.2 Optical Axis

A straight line perpendicular to both faces of a lens. A ray will pass through a lens along such a line without deviation. It represents the part of the lens at which the prism power is zero. In most lenses, there is only one line normal to both faces. In a plus spherical lens, the optical axis penetrates the thickest part and, in a minus spherical lens, the optical axis penetrates the thinnest part. If the lens has prism power, the optical axis may lie outside the lens. If the two surfaces are concentric in a given meridian, any line in such a meridian that is normal to both surfaces may be selected to represent an optical axis. If the surfaces are concentric in all meridians, then any line may be selected to represent the optical axis.

3.4 Boxing System

A system of measurement used to define various prescription requirements relative to lens and frame dimensions (see Annex C).

3.5 Center, Optical

The point on the front surface of a lens intersected by the optical axis of the lens (see 3.3.2).

3.6 Clock, Lens (or Lens Measure)

An instrument designed to measure the sagitta of a lens curve and usually calibrated to express the measurement in dioptric tool surface power (see 3.19.5.4).

3.7 Curve

3.7.1 Base

The standard or reference curve in a lens or series of lenses; for example, the manufacturer's marked or nominal tool surface power of the finished surface of a semi-finished spherical lens or the marked minimum tool surface power of the finished surface of a semi-finished toric lens.

3.7.2 Cross

The tool surface power of a toric surface at 90° from the base curve meridian.

3.8 Diopter

A unit of measurement in inverse meters (plus or minus) used to express the power of a lens. The diopter is also used to express the curvature of surfacing tools and the refracting power of curved surfaces (see 3.19.3, 3.19.5, and 3.19.6). The symbol 'D' is used to designate the diopter.

3.9 Diopter, prism

A unit of measurement used to express the angle of deviation of a ray of light by a prism or lens. Prism power, in these units, is measured as the displacement of the ray, in centimeters, perpendicular to its line of incidence at a distance of one meter. The symbol Δ is used to designate the prism diopter.

3.10 Dispersion

Dispersion is a measure of the ability of a material to refract light into its various component wavelengths. Reciprocal relative dispersion is used in optical design calculations. It is also called the *nu value* or the *Abbe value* and is defined by the following formula:

$$\nu_d = \frac{\eta_d - 1}{\eta_F - \eta_C}$$

where:

ν_d is the relative reciprocal dispersion using the helium d-line as the reference wavelength;

η_d is the index of refraction for radiation of wavelength 587.5618 nm (helium d-line);

η_F is the index of refraction for radiation of wavelength 486.1327 nm (hydrogen F-line);

η_C is the index of refraction for radiation of wavelength 656.2725 nm (hydrogen C-line).

In the US, the reference wavelength used is 587.5618 nm.

3.11 Distortion

An aberration that results in straight lines being imaged as curves.

3.12 Focimeter

An instrument for determining vertex power, cylinder axis location, optical center, prism reference point location, and prism power at a given point on an ophthalmic lens.

3.13 Index of Refraction

The ratio of the velocity of light of a given wavelength in air to that in a medium. This ratio expresses the ability of a lens material to refract or bend a ray of light. The index of refraction is given for a specified reference wavelength (see 3.22).

3.14 Intermediate

That area in a trifocal lens or progressive lens that has been designated to correct vision at ranges intermediate to distant and near objects.

3.15 Interpupillary Distance

3.15.1 Distance, Binocular

The separation between the visual axes of the eyes in their primary position, as the subject fixates on an infinitely distant object. This distance is measured from pupil to pupil.

3.15.2 Near, Binocular

The separation between the visual axes of the eyes, at the plane of the spectacle lenses, as the subject fixates on a near object at the intended working distance.

NOTE - This distance is conventionally 40 cm from the spectacle plane for add powers equal to or less than 2.50 D. For higher adds, this distance (expressed in meters) is the reciprocal of the add power.

3.15.3 Monocular

The separation between the center of the bridge of the nose and the visual axis of the designated eye (i.e., right or left) for either distance or near fixation. The right and left interpupillary distances may not necessarily be equal. Their sum is equal to the binocular interpupillary distance. When the monocular interpupillary distance is not specified, it is assumed to be one half of the binocular interpupillary distance.

3.16 Lens(es)

3.16.1 Aspheric

A lens in which one or both surfaces are aspheric (see 3.25.1)

3.16.2 Assembled

A lens or lenses that has (have) been combined with a frame or mounting.

3.16.3 Cylinder

A special case of the sphero-cylinder lens in which one of the principal meridians has zero refractive power (see 3.16.22).

3.16.4 Edged

A lens whose periphery has been ground (flat, rimless, grooved, or beveled) to a specified size and shape.

3.16.5 Finished

A lens with both surfaces optically finished and produced to a desired power and thickness.

3.16.6 Impact-Resistant Lenses for Dress Eyewear

Lenses that conform to the detailed requirements for impact resistance in 6.1.1. Dress (or street-wear) lenses are not to be confused with special-purpose occupational, educational, or recreational protective lenses.

3.16.7 Impact-Resistant Lenses for Occupational and Educational Protection

Lenses that conform to the requirements of the most recent edition of ANSI Z87.1.

3.16.8 Iseikonic

A type of lens made with special thickness, surface curvatures, and bevel edge location to control the magnification of an image while maintaining the prescribed refractive power.

3.16.9 Laminated

A lens constructed as a sandwich of multiple layers of glass, plastic, or both, bonded together as a single unit.

3.16.10 Lenticular

A lens, usually of strong refractive power, in which the prescribed power is provided over only a limited central region of the lens, called the lenticular portion. The remainder of the lens is called the carrier and provides no refractive correction but gives dimension to the lens for mounting.

3.16.11 Minus

A lens having negative refractive power. It is thinner at the center than at the edge and causes the divergence of a parallel beam of light.

3.16.12 Mounted Pair

Two finished lenses of any type mounted in a frame to create complete spectacles.

3.16.13 Multifocal

A lens designed to provide correction for two or more discrete viewing distances.

3.16.14 Bifocal

A lens designed to provide correction for two discrete viewing distances.

3.16.15 Trifocal

A lens designed to provide correction for three discrete viewing distances.

3.16.16 Plano

A lens having essentially zero refractive power.

3.16.17 Plus

A lens having positive refractive power. It is thicker at the center than at the edge and causes the convergence of a parallel beam of light.

3.16.18 Progressive Addition

A lens designed to provide correction for more than one viewing distance in which the power changes continuously rather than discretely.

3.16.19 Semi-finished

A lens having only one surface finished to a specific curve.

3.16.20 Single-vision

A lens designed to provide correction for a single viewing distance.

3.16.21 Spherical Power

A lens that has the same refractive power in all meridians.

3.16.22 Sphero-cylinder

A lens having different refractive power in the two principal meridians. It is sometimes referred to as an astigmatic or toric lens or, commonly though imprecisely, as a cylinder lens (see 3.16.3).

3.16.23 Ultraviolet Absorption

A lens in which the average transmittance between 290 nm and 315 nm (UVB) and the average transmittance between 315 nm and 380 nm (UVA) is specified.

3.16.24 Uncut

A lens with finished optical surfaces on both sides but which has not yet been edged for mounting in a frame.

3.17 Meridian

A line of intersection of a surface with a plane perpendicular to that surface at a specified point. When applied to a lens, it may also be defined as a plane that contains the optical axis.

3.18 Meridians, principal

The two mutually perpendicular meridians in a sphero-cylinder lens in which a maximum and minimum power can be measured. The meridian that has the maximum (furthest from zero) power is the *meridian of highest absolute power*.

3.19 Power

3.19.1 Cylinder

The difference (plus or minus) between powers measured in the two principal meridians of a sphero-cylinder lens.

3.19.2 Prism

The ability of a prism or a lens to deviate a ray of light transmitted through it. It is the deviation of a ray normal to the back surface of a lens and penetrating the front surface at a specified point. The amount of deviation is expressed in prism diopter units. A prism may be specified in terms of its horizontal and vertical components. For example, a 2.83 prism diopter prism base down at 45° O.D. is equivalent to 2.0 prism diopters base-down and 2.0 prism diopters base-out O.D. When prism power is measured with a focimeter, the ray involved is normal to the back surface and coincides with the axis of the focimeter. It is specified in terms of the point on the front surface that it penetrates.

3.19.3 Refractive

The ability of a lens or optical surface to produce a change in the convergence or divergence of a beam of light, usually expressed in diopters.

3.19.4 Sphere

In a spherical lens, the dioptric power of a lens. In a sphero-cylinder lens, the sphere power is located in the cylinder axis meridian.

3.19.5 Surface

3.19.5.1 Marked

The nominal or marked curve of a semi-finished lens indicated in diopters, as expressed by the manufacturer (see 3.7.1).

3.19.5.2 Nominal

See 3.19.5.1

3.19.5.3 Refractive

The refractive power (F_R) of a glass or plastic surface bounded by air is a measure of its ability to change the vergence of a beam of incident light and is defined as follows:

$$F_R = \frac{\eta_d - 1}{0.530} F_T = \frac{\eta_d - 1}{0.001r}$$

where:

η_d is the index of refraction of the material using the helium d-line as the reference wavelength;

r is the radius of curvature of the refracting surface in millimeters;

F_T is the tool power defined in 3.19.5.4.

Since common ophthalmic materials do not have indices of refraction equal to 1.530, there is not a one-to-one correspondence between surface tool power and surface refractive power. For example, common ophthalmic glass has an index of refraction of η_d = 1.523. Therefore, a 1-diopter surface tool power (F_T) will produce a surface refractive power (F_R) of 0.987 diopter.

3.19.5.4 Tool (or True Power)

By common usage in the United States, a tool with a radius of curvature of 530 mm will produce a surface tool power (F_T) of 1 diopter.

Tool power is defined as follows:

$$F_T = \frac{530}{r}$$

where:

r is the actual radius of curvature in millimeters (mm) for the surface it produces.

Tool power is positive when the surface is convex, negative when concave. The term “surface power” when unqualified refers to tool power. If it is clear from the context that it refers to the true power of a surface, the term “surface power” may be used to discriminate between true power of a surface (see 3.19.5.3) and the vertex power of a lens (see 3.19.6).

3.19.6 Vertex

The inverse of the distance, expressed in meters, from the lens vertex to the corresponding focal point. This is expressed in diopters. In a distance prescription, the spherical component of power and the cylindrical component of power are always expressed in terms of rear (or back) vertex power. The add power is normally expressed in front vertex power. Focimeters are designed to measure vertex power directly.

3.20 Prism, Slab-off

A prismatic, component incorporated by bicentric grinding or molding into a portion of an ophthalmic lens to modify the amount of vertical prism for a line of sight through that portion of the lens.

3.21 Reference Point

3.21.1 Distance Reference Point (DRP)

That point on a lens as specified by the manufacturer at which the distance sphere power, cylinder power and axis shall be measured.

3.21.2 Fitting Point or Fitting Cross

That point on a lens specified by the manufacturer which is used as a reference point for positioning the lens in front of a patient’s eye.

3.21.3 Near Reference Point (NRP)

That point on a lens as specified by the manufacturer at which the addition of power is measured.

3.21.4 Prism Reference Point (PRP)

That point on a lens as specified by the manufacturer at which the prism value of the finished lens is to be measured.

Unless otherwise specified the prism reference point is assumed to be at the following geometric locations on the lens: For uncut single-vision lenses, this point is the geometric center of the lens; For uncut multifocal lenses, this point is referenced to the segment and is located vertically at the DRP Above Seg Line and horizontally at a distance from the segment center line equal to half the distance PD minus half the near PD (seg inset) (see Annex C); For edged single-vision and multifocal lenses, this point is at the DRP of the lens (see Annex C); For progressive lenses, this point is specified by the manufacturer.

For non-aspheric single-vision and multifocal lenses, the prism reference point and distance reference point are assumed to be coincident.

3.22 Reference Wavelength

The wavelength of light used when specifying the optical properties and power of a lens.

NOTE - The reference wavelength used in the United States and in this standard is the helium d-line (587.5618 nm).

3.23 Segment

A specified area of a multifocal lens having a different refractive power from the distance portion. This may also refer to the actual piece of material added to the lens in the case of a fused or cemented multifocal lens.

3.24 Spectacles

A pair of finished (surfaced and edged) ophthalmic lenses fitted to a frame or mounting.

3.25 Surface

3.25.1 Aspheric

A nonspherical surface that is rotationally symmetrical with respect to an axis of symmetry. Such surfaces typically have continuously variable curvatures from the vertex to the periphery.

3.25.2 Atoric

A surface having mutually perpendicular principal meridians of unequal power where at least one principal meridian has a non-circular section. These surfaces are symmetrical with respect to both principal meridians.

3.25.3 Plano

A flat surface having zero surface power, or an infinite radius of curvature.

3.25.4 Spherical

A curved surface having the same radius of curvature in all meridians.

3.25.5 Toric

A surface in the form of a torus having different powers in the two principal meridians. The shape may be visualized as a small part of the surface of a doughnut or of a football. A toric surface is generated by rotating an arc of a circle around an axis that does not pass through the center of the circle.

3.26 Thickness, Center

The thickness of a lens at the prism reference point.

3.27 Warpage

A lens defect in which a surfaced lens is bent or twisted in processing or mounting.

3.28 Wave

A local ripple-like irregularity in a lens surface (see 3.11).

4 Classification

Spectacle lenses are classified as:

- Single-vision finished lenses;
- Multifocal finished lenses; or
- Progressive addition finished lenses.

5 Optical Requirements

The tolerances shall apply for a temperature of 23°C ± 5°C (73°F ± 9°F)

NOTE - A summary of optical requirements appears in Annex D.

5.1 General

Both uncut and edged finished lenses shall meet the following requirements:

5.1.1 Distance Refractive Power (Back Vertex Power)

When measured using the method specified in 8.2, lenses shall comply both with the tolerance on the meridian of highest power and with the tolerance on the cylinder. Lenses intended to have a uniform distance power in all meridians (spherical lenses) are considered to have 0.00 D cylinder.

5.1.1.1 Single-Vision and Multifocal Lenses

Single-vision and multifocal lenses shall comply with the tolerances shown in Table 1.

Table 1 – Tolerance on Distance Refractive Power (Single-Vision and Multifocal Lenses)

Absolute Power of Meridian of Highest Power	Tolerance on Meridian of Highest Power	Cylinder ≥ 0.00 D ≤ 2.00 D	Cylinder > 2.00 D ≤ 4.50 D	Cylinder > 4.50 D
From 0.00 up to 6.50 D	± 0.13 D	± 0.13 D	± 0.15 D	± 4%
Above 6.50 D	± 2%	± 0.13 D	± 0.15 D	± 4%

5.1.1.2 Progressive Addition Lenses

Progressive addition lenses shall comply with the tolerances shown in Table 2.

Table 2 – Tolerance on Distance Refractive Power (Progressive Addition Lenses)

Absolute Power of Meridian of Highest Power	Tolerance on Meridian of Highest Power	Cylinder ≥ 0.00 D ≤ 2.00 D	Cylinder > 2.00 D ≤ 3.50 D	Cylinder > 3.50 D
From 0.00 up to 8.00 D	± 0.16 D	± 0.16 D	± 0.18 D	± 5%
Above 8.00 D	± 2%	± 0.16 D	± 0.18 D	± 5%

5.1.2 Cylinder Axis

When measured using the method described in 8.6, the tolerance on the direction of cylinder axis shall be as specified in Table 3.

Table 3 – Tolerance on Direction of Cylinder Axis

Nominal Value of Cylinder Power (D)	> 0.00 D ≤ 0.25 D	> 0.25 D ≤ 0.50 D	>0.50 D ≤ 0.75 D	> 0.75 D ≤ 1.50 D	> 1.50 D
Tolerance on Axis	± 14°	± 7°	± 5°	± 3°	± 2°

5.1.3 Addition Power

When measured by the method described in 8.3, the tolerance on the addition power of multifocal and progressive addition lenses shall be as specified Table 4.

Table 4 – Tolerance on Addition Power for Multifocal and Progressive Addition Lenses

Nominal Value of Addition Power	≤ 4.00 D	> 4.00 D
Tolerance on Addition Power	± 0.12 D	± 0.18 D

NOTE - If the manufacturer applies corrections to compensate for the as-worn position, then this corrected value must be stated in the manufacturer's documentation. These tolerances then apply to the corrected value.

5.1.4 Prism Reference Point Location and Prismatic Power

The prism reference point shall not be more than 1.0 mm away from its specified position in any direction. In addition, the prismatic power measured at the prism reference point shall not exceed 0.33Δ. This tolerance applies to lenses both with and without prescribed prismatic power. When prismatic thinning is used, it is treated as prescribed prism. Measurement shall be done using the method given in 8.4.

5.1.5 Base Curve

When specified, the base curve shall be within ± 0.75 D of specification. The base curve shall be given using an index of refraction of 1.530. The base curve shall be measured using the method given in 8.8.

5.1.6 Localized Errors

Power errors or aberrations detected by visual inspection and caused by waves, warping, or internal defects are permissible, if examination with a focimeter shows no measurable or gross distortion or blur of the focimeter target element. Areas outside a 30-mm diameter circle centered on the distance reference point, within 6 mm of the edge, or beyond the optical area of a lenticular lens, are exempt from this requirement. Progressive addition lenses are also exempt from this requirement. Measurement shall be done using the methods given in 8.12.

5.2 Mounted Lens Pairs

The following are in addition to requirements for finished lenses in 5.1.

5.2.1 Prism Imbalance

In the cases where prismatic thinning is used, the prism thinning prism is considered to be a prescribed prism.

5.2.1.1 Single-vision and Multifocal Lenses

Vertical prismatic imbalance of mounted pairs of single-vision and multifocal lenses with refractive power from 0.00 D to ±3.375 D in the vertical meridian shall not exceed 0.33Δ. Pairs with refractive power greater than ±3.375 D in the vertical meridian shall not have more than 1.0 mm difference in the height of the two lenses prism reference points. Measurement shall be done using the method specified in 8.5.1.

Horizontal prismatic imbalance between mounted single-vision and multifocal lenses with refractive power from 0.00 D to ±2.75 D in the horizontal meridian shall not exceed 0.67Δ. The horizontal distance between the prism reference points of single-vision and multifocal lenses with refractive power greater than ±2.75 D in the horizontal meridian shall not differ from the specified distance interpupillary distance by more than 2.5 mm. Measurement shall be done using the method specified in 8.5.2.

5.2.1.2 Progressive Addition Lenses

Vertical prismatic imbalance of mounted pairs of progressive addition lenses with refractive power from 0.00 D to ±3.375 D in the vertical meridian shall not exceed 0.33Δ. Pairs with refractive power greater than ±3.375 D in the vertical meridian shall not have more than 1.0 mm difference in the height of the two lenses prism reference points. Measurement shall be done using the method specified in 8.5.3.

Horizontal prismatic imbalance between mounted progressive addition lenses with refractive power from 0.00 D to ±3.375 D in the horizontal meridian shall not exceed 0.67Δ. For lenses with greater refractive power, the horizontal position of each lens's prism reference point shall not differ from the specified position by more than 1.0 mm. Measurement shall be done using the method specified in 8.5.3.

6 Mechanical Requirements

NOTE - A summary of mechanical requirements appears in Annex D.

6.1 General

6.1.1 Impact Resistance

6.1.1.1 Prescription Impact-resistant Dress Eyewear Lenses

All lenses must conform to the impact resistance requirements of *Title 21, Code of Federal Regulations*, 801.410 (CFR 801.410). The impact test of CFR 801.410 is described in 8.9. Laminated, plastic and raised-ledge multifocal lenses may be certified by the manufacturer as conforming to the initial design testing or statistically significant sampling as specified by CFR 801.410.

All monolithic (not laminated) glass lenses shall be treated to be resistant to impact.

6.1.1.2 Special Corrective Lenses

Certain lenses prescribed for specific visual needs are not suitable for the drop-ball technique of testing. Wherever possible, such lenses shall be treated to be resistant to impact or made of impact-resistant materials; however, impact testing requirements are waived by the FDA. These lens types include:

- Prism segment multifocals;
- Slab-off prisms;
- Lenticular cataracts;
- Iseikonics;
- Depressed segment one-piece multifocals;
- Biconcaves, myodiscs and minus lenticulars;
- Custom laminates and cemented assemblies.

6.1.1.3 Prescription Lenses Used for Personal Protective Eyewear in Industry and Eye Protectors for Use by Players of Selected Sports

Industrial safety eyewear requirements are found in ANSI Z87.1. Requirements for players of selected sports are found in ANSI/ASTM F803.

6.1.2 Physical Quality and Appearance

In a zone of 30 mm diameter centered around the distance reference point, and over the whole area of the segment if the segment is equal to or less than 30 mm (for segments over the 30-mm-diameter zone centered around the near reference point), the lens, when inspected using the method described in 8.11, shall not exhibit any surface imperfections or internal defects including pits, scratches, grayness, bubbles, cracks, striae, or watermarks that are visible and that would impair function of the lens.

Outside this zone, small isolated material or surface defects or both are acceptable.

6.1.3 Center Thickness

The center thickness of the lens may be specified by the prescriber or may be agreed between prescriber and supplier. When specified, the center thickness shall not differ more than ±0.3 mm from the specified value. Measurement shall be made normal to the convex surface at the prism reference point.

6.1.4 Segment Size

Multifocal segment width, depth, and intermediate depth shall not differ from the nominal value by more than ±0.5 mm when measured using the methods in 8.7.

The difference between the segment dimensions (width, depth, and intermediate depth) in the mounted pair shall not exceed 0.7 mm.

6.2 Mounted Lens Pairs

6.2.1 Eye Wire Closure

The eye wire closure of the lens mounted in the frame shall be sufficient to prevent the lens from rotating.

6.2.2 Warpage

Cylindrical surface power induced in the base curve of a lens as a result of finish processing shall not exceed 1.0 D when measured using the method described in 8.10. This tolerance does not apply within 6 mm of the lens edge.

6.2.3 Segment Location or Fitting Point Location

6.2.3.1 Multifocal Lenses

The vertical location (or height) of the segment for each multifocal lens shall be within ±1.0 mm of specification. In addition, the difference between segment heights for the mounted pair shall not exceed 1.0 mm of specification. Measurement shall be made using the method in 8.7.

The horizontal distance between geometric centers of the segments in the mounted pair shall be within ±2.5 mm of the specified near interpupillary distance. The inset in both lenses shall appear symmetrical and balanced unless monocular insets are specified. The geometric center of a full-width multifocal segment is defined as the thinnest point on its ledge. Measurement shall be made using the method in 8.7.

6.2.3.2 Progressive Addition Lenses

The vertical location (or height) of the fitting point for each progressive addition lens shall be within ±1.0 mm of specification. In addition, the difference between fitting point heights for the mounted pair shall not exceed 1.0 mm of specification. Measurement shall be made using the method in 8.7.

The horizontal fitting point location in progressive addition lenses shall be within ± 1.0 mm of the specified monocular interpupillary distance for that lens. Measurement shall be made using the method in 8.7.

6.2.4 Segment or Horizontal Axis Tilt

The horizontal axis of lenses with straight-top segments and progressive addition lenses shall not be tilted more than 2° from the horizontal when measured using the methods in 8.7. For progressive addition lenses, the horizontal axis is defined by the permanent horizontal reference markings.

7 Transmittance and Attenuation Requirements

7.1 Spectrally Attenuating Materials

Manufacturers of materials which directly transmit optical radiation shall make spectral transmittance characteristics available to processors, fabricators and to the professions. How the manufacturer obtained the data shall be described.

NOTE - Attenuation, in this sense, means loss in transmittance by reflection, scatter, or absorption.

7.2 Ultraviolet (UV) Attenuating Lenses

Manufacturers of lenses who claim specific ultraviolet attenuating properties shall state the average percent transmittance between 290 and 315 nm (UVB) and between 315 and 380 nm (UVA). The method for determining mean ultraviolet transmittance is shown in 8.13.

8 Test Methods

8.1 General

8.1.1 Reference Wavelength

The reference wavelength used shall be the helium d-line (587.5618 nm). Other reference wavelengths may be used but their use requires that each lens be accompanied by a statement giving the wavelength used as well as the index of refraction, Abbe value and lens power measured when using the helium d-line wavelength.

8.1.2 Focimeter Use

The measurement of distance refractive power and addition power shall be carried out using a focimeter that complies with the requirements of ANSI Z80.17.

For manual focimeters:

- Focus the eyepiece of the instrument before attempting to read any power.
- The target should be nearly centered on the reticle to ensure a clear target measurement. If necessary, auxiliary prisms can be used to approximately center the target.
- In reading the power of a lens, always come back into the focus range from the minus side of focus. Do not focus back and forth by small amounts on both sides of the test focus as this procedure stimulates accommodation and produces erroneous readings.

8.2 Distance Power Measurement

Single-vision lenses and the distance portion of multifocals can be measured using the following procedure:

1. Place the back surface of the lens against the lens positioning tube, or stop, of the focimeter. Ensure that the surface of the lens is in intimate contact with the lens stop;
2. Position the lens with the distance reference point centered in front of the lens stop;
   - For non-aspheric single-vision and multifocal lenses, the distance reference point corresponds to both the prism reference point and the fitting point;
   - For progressive addition and aspheric lenses, the distance reference point should be located using either the manufacturer’s recommendation or an appropriate centration chart;
3. When measuring assembled spectacles, ensure that the bottom of the frame is in firm contact with the focimeter stage for both lenses. Adjust the focimeter stage position so that this can be accomplished while fulfilling the requirements of Step 2 above; and
4. With the lens correctly positioned, measure the power in accordance with the focimeter manufacturer’s instructions.

NOTE - As examples of determining the absolute power of the meridian of highest absolute power see the following table.

Sphere	Cylinder	Sphere Meridian	Cylinder Meridian	Meridian of Highest Absolute Power
+ 6.00	+ 2.00	+ 6.00	+ 8.00	+ 8.00
+ 6.00	- 2.00	+ 6.00	+ 4.00	+ 6.00
- 4.00	+ 2.00	- 4.00	- 2.00	- 4.00
- 4.00	- 2.00	- 4.00	- 6.00	- 6.00

8.3 Addition Power Measurement

1. Unless otherwise specified by the manufacturer, the surface chosen for the measurement shall be the side containing the segment or progressive surface. Place the surface of the lens containing the segment or progressive surface against the lens stop of the focimeter. This is especially critical in the case of plus-powered lenses because measurement results can vary significantly if the surface opposite the side containing the segment or surface containing the progressive surface is placed against the focimeter stop;
2. Measure the refractive power through the distance portion;
    - For non-aspheric multifocal lenses, maximum accuracy will be obtained when the distance portion is measured at a point as far above the distance reference point as the near reference point is below it, and along a line passing through both the distance reference point and the near reference point. This is illustrated in Figure 1 below;

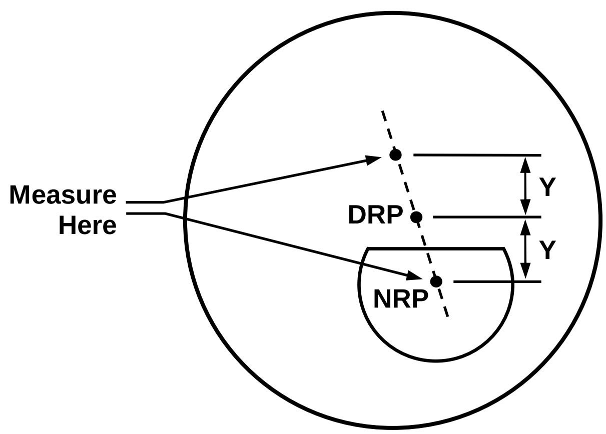

Figure 1 – Measuring Non-aspheric Multifocals

    - For progressive addition and aspheric lenses, the distance portion should be measured at the distance reference point;
3. Reposition the lens with the near reference point (as specified by the manufacturer) centered in front of the lens stop;
4. With the lens correctly positioned, measure the refractive power through the reading portion or segment;
5. The add power is the algebraic difference in measured power between the distance and near values obtained as above.

NOTE - For manual focimeters, both measuring points shall use the most vertical lines of the target as the criteria for determining the add power.

8.4 Prismatic Power Measurement

1. Position the lens on the focimeter stage with the prism reference point centered in front of the lens stop of the focimeter.

    - For non-aspheric single-vision and multifocal lenses that have been edged, the prism reference point corresponds to both the distance reference point and the fitting point. This is located horizontally at a distance from the geometric center of the lens equal to the required decentration for that eye. It is at the vertical location specified by the prescriber or, if not specified, at the center line of the lens (see Figure 2);

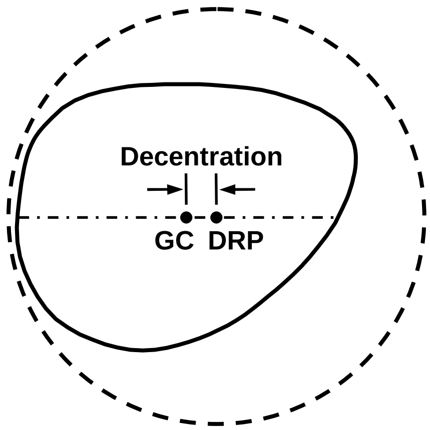

Figure 2 – Locating the Prism Reference Point of an Edged, Unmounted Lens

    - For progressive addition and aspheric lenses, the prism reference point should be located using either the manufacturer's recommendation or centration chart. Customarily, the prism reference point of a progressive lens will be centered between the horizontal reference markings found on the 180° horizontal reference line, (see Figure 6);
    - For uncut single-vision lenses, the prism reference point should be located at the geometric center of the blank, unless otherwise specified;
    - For uncut multifocal lenses, the prism reference point will be located horizontally at a distance from the center of the segment equal to the segment inset. It is located vertically at the DRP Above Seg Line (see Figure 3);

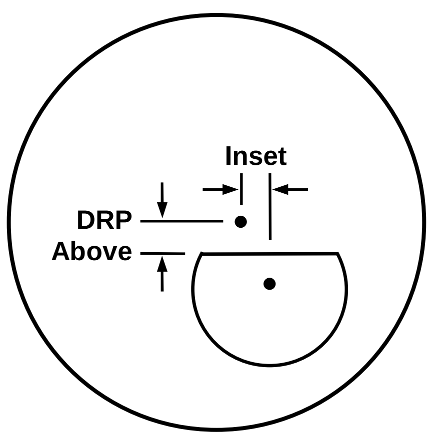

Figure 3 – Locating the Prism Reference Point of an Uncut Multifocal Lens

2. Measure the prism at the PRP. Proceed to Step 3 only if the prism error exceeds 1/3Δ at the prism reference point;

3. Locate and mark the position at which the prismatic requirements of the prescription are met. In the absence of prescribed prism this point corresponds with the optical center. This point must be within 1.0 mm of the prism reference point as specified in 5.1.4.

8.5 Prism Imbalance Measurement of Mounted Pairs

8.5.1 Vertical Imbalance Measurement for Single-Vision and Multifocal Lenses

1. Select the lens with the strongest refractive power through the vertical meridian; if the lenses have similar powers, select the lens with the most prescribed vertical prism (if any);
2. Locate and mark the position at which the prismatic requirements of the prescription are met. Ensure that the bottom rims of the spectacle frame are resting evenly upon the stage of the focimeter. In the absence of prescribed prism, this point corresponds with the optical center;
3. Slide the frame over, without moving the focimeter stage, and position the next lens so that any target displacement is in the vertical (90°) meridian (i.e., no horizontal displacement. Mark the lens, and note the amount of vertical prism imbalance. Proceed to Step 4 only if the prismatic imbalance exceeds 1/3Δ;
4. Reposition the lens in the focimeter, locate and then mark the position at which the prismatic requirements of the prescription are met. If the vertical separation between the first and second markings exceeds 1.0 mm, the lenses fail the vertical imbalance requirement. Otherwise, the lenses are acceptable;

NOTES:

1 – When differing prism reference points or fitting heights are specified, compensation should be made.

2 – In certain cylinder/axis combinations it may not be possible to achieve displacement only in the vertical meridian.

8.5.2 Horizontal Imbalance Measurement for Single-Vision and Multifocal Lenses

1. If the position on each lens where the prismatic requirements of the prescription are met is not already marked as in 8.5.1, do so now;
2. Measure the horizontal distance between these markings;
3. Proceed to Steps 4 and 5 only if this distance is not within 2.5 mm of the specified interpupillary distance;
4. Replace the mounted lens pair in the focimeter, centering the prism reference point of the lens with the strongest refractive power through the horizontal meridian in front of the lens stop. If the measured distance from Step 2 (the distance between the positions at which the prismatic requirements of the prescription are met) is wider than the specified interpupillary distance, slide the lens out until 1/3Δ is induced. Mark the lens at this position. Repeat this for the other lens. If the measured distance is narrower than the specified interpupillary distance, slide the lens in from the lens stop instead;
5. Two sets of focimeter ink markings should now exist on each lens; the inside (nasal) markings on these lenses from the inside pair, and the outside (temporal) markings from the outside pair. If the specified interpupillary distance is narrower than the inside pair, or if the interpupillary distance is wider than the outside pair, the lenses fail the horizontal imbalance requirement. Otherwise, the lenses are acceptable. This is illustrated in Figure 4.

EXAMPLE

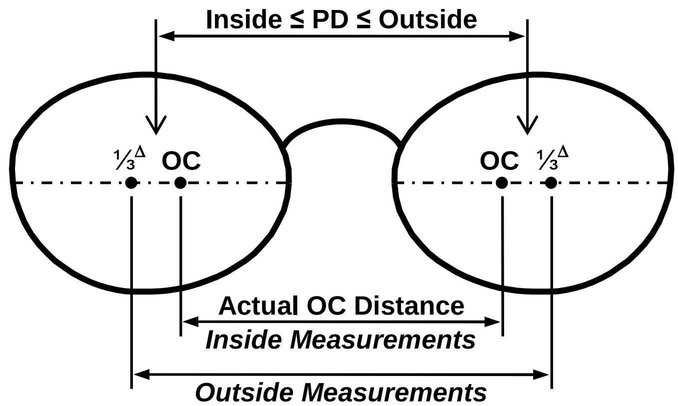

Figure 4 – Horizontal Prism Tolerance Markings

The actual distance between optical centers (OC) is narrower than the specified interpupillary distance (PD). Outside markings have been placed where 1/3Δ has been induced. Because the outside markings are wider than the PD, the pair passes the horizontal requirements.

8.5.3 Vertical and Horizontal Imbalance Measurement for Progressive Addition Lenses

1. Position the right lens on the focimeter stage with the prism reference point centered in front of the lens stop of the focimeter. Ensure that the bottom rims of the spectacle frame are resting evenly upon the stage of the focimeter. Note the amount of unprescribed vertical and horizontal prism, if any.
2. The prism reference point should be located using either the manufacturer's recommendation or centration chart. Customarily, the prism reference point of a progressive lens will be centered between the horizontal reference markings found on the 180° horizontal reference line (see Figure 6). When using the manufacturer's prism reference point markings, first verify that there are no centration errors.
3. Slide the frame over and position the next lens so that the prism reference point is centered in front of the lens stop. Again, note the amount of any unprescribed horizontal or vertical prism;
4. Determine the net prismatic effect, or imbalance. For horizontal prism components (i.e., in or out), add together like base directions and subtract opposite base directions. For vertical prism components (i.e., up or down), subtract like base directions and add opposite base directions. Proceed to Step 5 only if the amount of unprescribed horizontal prism imbalance exceeds 2/3Δ, or if the vertical prism imbalance exceeds 1/3Δ;
5. Locate and mark the positions at which the prismatic requirements of the prescription are met on both lenses. In the absence of prescribed prism, these points will correspond with the optical centers. If the horizontal separation between this point and the prism reference point on each lens exceeds 1.0 mm, or if the combined (or net) vertical separation from the prism reference points of both lenses exceeds 1.0 mm, the lenses fail the prism imbalance requirements. Otherwise, the lenses are acceptable. Allow for monocular fitting heights, when applicable (see Figure 5).

EXAMPLE

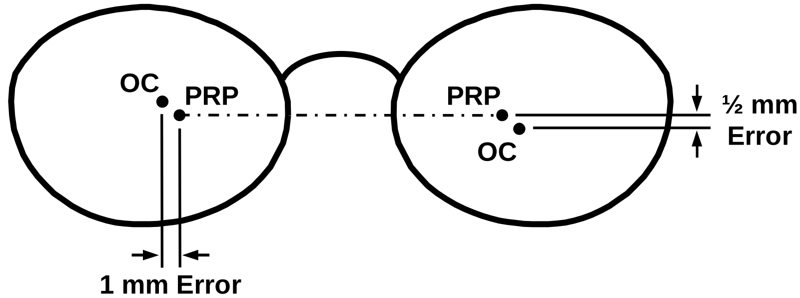

Figure 5 – Horizontal and Vertical Prism Tolerance Markings

The optical center (OC) of the right lens is ½ mm higher than the prism reference point (PRP). The OC of the left lens is ½ mm lower. The OC of each lens is 1.0 mm out from the PRP. Because the horizontal error for each lens does not exceed 1.0 mm and the combined (or net) vertical error does not exceed 1.0 mm, the pair passes the horizontal and vertical requirements.

NOTE – For certain progressive addition lenses, some vertical prism may exist at the prism reference points for thinning purposes. Only the net vertical imbalance needs to be evaluated in this case.

8.6 Cylinder Axis and Prism Axis Measurement

Cylinder axis shall be measured at the distance reference point. Prism axis shall be measured at the prism reference point.

The tolerances, if applicable, are in relation to a horizontal axis determined in one of the following ways:

- For multifocal lenses with noncircular segments, by the orientation of segment;
- For mounted multifocals with circular segments and mounted single-vision, by reference to the frame;
- For progressive addition lenses, by reference to the horizontal reference marks;
- For single-vision uncut cylinder or sphero-cylinder prisms, the axis tolerance is for the angle between the cylinder axis and the prism axis; or
- For uncut round seg bifocals, the distance reference point position and the seg position determine the horizontal reference.

8.7 Segment Size, Location, and Tilt Measurement

Measure the segment size across the widest horizontal part of the segment in a straight line. Segment location and tilt are measured in the plan view of the lens and in accordance with the boxing system of measurement. Suitable methods utilize a shadowgraph, optical comparator fitted with the appropriate reticle or precision millimetric measuring instrument.

8.8 Base Curve Measurement

The base curve of a lens may be measured using any suitable instrument that provides a resultant accuracy to within 0.25 diopter of the surface being measured. For spherical surfaces, instruments such as a lens clock or sag gauge (spherometer) will suffice. For aspheric and progressive addition lens surfaces, the above methods are not suitable. In such instances, an example of one suitable method is to measure the concave spherical curve, lens thickness, and back vertex power. With these measurements along with knowledge of the index of refraction of the lens material, the convex surface curve can be calculated.

NOTE – For such calculations the reference wavelength to which the material's index of refraction value is measured and published must also be known.

8.9 Impact Resistance Test

The following test method is intended to be equal or superior to that described in CFR 801.410.

The impact resistance of lenses subject to individual tests shall be measured with a 15.9 mm (5/8 in) diameter steel ball weighing not less than 16 grams (0.56 oz) dropped from a height of not less than 127 cm (50 in).

Lenses should be placed on the test block and base shown in Figure and Figure A.2 object side up, approximately centered geometrically. The ball should impact within a circle 16 mm (5/8 in) in diameter whose center is approximately at the geometric center of the lens. However, multifocal lenses may be decentered to be certain that the ball does not impact the segment line. During the test, the lens should not be clamped or restricted in any way. However, a collar around the lens on the block may be used, provided it does not touch the lens, and an adequate aperture on the upper side provides free entry of the ball. The lens cap shown in Figure A.3 is a suggested conformation.

To avoid surface damage from the impact of the ball, the lens may be inserted in a polyethylene bag or covered with polyethylene sheet before testing. The thickness of the polyethylene covering the lens should not exceed 0.076 mm (0.003 in), and should conform to the requirements for polyethylene sheeting, Type II, given in ASTM D2103. The protective sheet should be in contact with the lens surface in the test area before the ball is dropped.

NOTE – The use of plastic film cannot be used when impact resistance of lenses is verified by a statistical sampling plan.

8.10 Warpage Test

The curves of the two principal meridians should be measured with a sagitta gauge, such as an ophthalmic lens clock.

8.11 Physical Quality and Appearance Test

The lens inspection is carried out at a light/dark boundary and without the aid of magnifying optics. Inspect the lens within a room with ambient lighting of about 200 lux. Use as an inspection lamp either a fluorescent tube with a minimum of 15 W or an open shaded 40 W incandescent clear lamp. Position the lens about 300 mm from the light source and view against a dark background.

NOTES:

1 – This observation is subjective and requires some experience.

2 – The diaphragm is adjusted to shield the eye from the light source and to allow the lens to be illuminated by the light as shown in Figure B.1.

8.12 Localized Error Test

View a high-contrast grid pattern of dark and light lines through the lens, scanning the lens area by area. The lens should be held approximately 305 mm (12 in) from the eye for weak plus or minus lenses. For strong plus lenses, the eye should be placed near the focus. The target should be at least 305 mm (12 in) from the lens.

Virtually any straight-edged object is suitable for viewing waves through minus lenses. A grid pattern as viewed through the lens should appear smoothly curved and gradually distorted from the center of the field outward.

However, localized ripples or distortions that are visible to the unaided eye are an indication of a possible significant aberration. The area should be marked for evaluation in a focimeter. Localized ripples or distortions that are invisible to the unaided eye may be disregarded.

8.13 Ultraviolet Mean Transmittance Calculation

The mean transmittance, τ (λ1, λ2), of a lens over a spectral range λ1 to λ2 is expressed mathematically as follows:

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

where:

$\tau(\lambda)$ is the spectral transmittance of the lens.

Mean transmittance values are applicable only to the following ultraviolet spectral zones:

UVB (Erythemal zone): λ1 = 290 nm, λ2 = 315 nm;

UVA (Near Ultraviolet Zone): λ1 = 315 nm, λ2 = 380 nm.

The integral may be evaluated by using continuous functions or by dividing the specified spectral range into a finite number of intervals, no greater than 5-nm wide, and replacing the integral by a finite summation as follows:

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

where:

$\Delta\lambda < 5$ nm

NOTE – As examples, the formulas listed below give the mean ultraviolet transmittance according to the above finite summation for intervals of 5 nm width.

UVB: $$\tau_{UVB} = \frac{5}{25} \sum_{i=0}^{4} \tau(292.5 + 5i)$$

UVA: $$\tau_{UVA} = \frac{5}{65} \sum_{i=0}^{12} \tau(317.5 + 5i)$$

8.14 Alternate Test Methods

It is not the intention of this standard to restrict measurement techniques, performance tests, and inspection procedures to those described herein.

However, the proponents of alternate test procedures shall establish functional equivalence to these reference tests. Furthermore, in cases where state or federal jurisdictions apply, variations in test or inspection procedures shall be acceptable only when functional evidence has been demonstrated.

9 Markings for Progressive Addition Lenses

9.1 Permanent Marking

The lens shall be permanently marked with at least the following:

- The alignment reference markings comprising two marks located 34.0 mm + 0.5 mm apart, equidistant to a vertical plane through the prism reference point;

9.2 Optional Permanent Markings

The following optional permanent marking is recommended:

1. Indication of addition power, in diopters; and/or
2. Indication of the manufacturer, or supplier, or tradename, or trademark.

9.3 Optional Nonpermanent Markings

The following optional nonpermanent marking is recommended:

1. The alignment reference marking (ARM);
2. Indication of the distance reference point (DRP);
3. Indication of the near design reference point (NRP);
4. Indication of the fitting point (FP); and/or
5. Indication of the prism reference point (PRP).

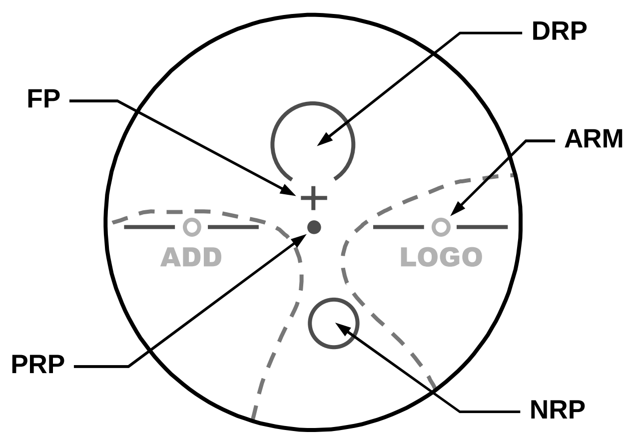

Figure 6 – Progressive Addition Lens Markings

10 Identification

The identification of the completed spectacle or component shall be specified on the package of the completed spectacle or in an accompanying document.

10.1 Information to be Provided by a Supplier of Spectacle Components or Completed Spectacles

10.1.1 For All Lenses

1. Corrective power (using the helium d-line as the reference wavelength)
2. Corrected (compensated) values (if applicable)

    NOTE – Corrected values for focal, prismatic and addition power occur when corrections are made, e.g., for the as-worn position.

3. Color (if not white) and coating
4. Material and material index (using the helium d-line as the reference wavelength), or manufacturer's or supplier's trade name or equivalent. This standard permits the use of other reference wavelengths but requires that a statement always be included giving the index of refraction, Abbe value and lens power using the helium d-line reference wavelength
5. Impact test results (in accordance with requirements of Title 21, CFR 801.410)
6. Distance P.D.
7. Lens style designation or trade name

10.1.2 For Multifocal Lenses

1. Addition power (using the helium d-line as the reference wavelength)
2. Segment dimension (if applicable)
3. Segment height
4. Segment prism

10.1.3 For Spectacle Frames

1. Manufacturer's identification
2. Manufacturer's model identification
3. Color
4. Horizontal boxed lens size
5. Distance between lenses
6. Overall temple length
7. Material identification
8. Country of origin (in accordance with regulation)

10.2 Information to be Supplied by the Laboratory on Request

1. Center or edge thickness
2. Nominal or actual base curve
3. Optical properties (dispersion, transmittance)
4. Thickness reduction prism

10.3 Identification of the Standard

If the manufacturer or supplier claims compliance to this standard, reference shall be made to ANSI Z80.1-2005, either on the package or in available literature.

Annex A Technical Addendum to Impact Testing
(Informative)

This annex is included as a recommendation and guideline to complement this standard in the processing of currently available impact-resistant lenses.

A.1 Thickness Guidelines
Air-tempered glass lenses should be no less than 2.0 mm thick at the prism reference point and have no less than a 1.0-mm edge thickness at the thinnest point of the edged lens.

A.2 Strengthening Techniques

A.2.1 Air Tempering (Thermal Toughening)

A.2.1.1 Process Description
Air tempering (thermal toughening) is a process whereby a glass lens is heated in a furnace to a temperature near but below the softening point of the glass for a period of time dependent upon its size and weight or average thickness. The lens is then quickly removed from the furnace and subjected to rapid chilling (quenching) by use of forced-air blasts on its surfaces. The controlled heating-cooling cycle places the surfaces and edges of the lens in a state of compression and the inner core of the lens in a state of tension.

A.2.1.2 Process Monitoring
Air-tempering (thermal toughening) equipment must be maintained by periodic inspections. Weight scales or calipers, timers, air filters, and furnace temperatures should be monitored at regular intervals and maintained in accordance with the manufacturer’s instruction manual.

A.2.2 Chemical Tempering (Ion-Exchange Toughening)

A.2.2.3 Process Description
Chemical tempering, like air tempering, strengthens glass lenses by placing their surfaces into a state of compression, while placing the interior of the lens into a state of tension. The process for currently available white crown and most tints involves exchanging sodium ions in the surface of the lens for potassium ions from a molten salt bath. Some photochromic materials require a sodium-for-lithium ion exchange system, as adequate results cannot be obtained using the white crown system. The temperature and purity of the molten salts and time of immersion will determine the quality of the strengthening (depth of penetration of the exchange layer and surface compression value.)

A.2.2.4 Process Monitoring
Chemical tempering equipment must be inspected at periodic intervals and maintained and operated in accordance with the manufacturer’s instruction manual. Salt should be added when needed to maintain the proper bath level. Lenses must be completely submerged during processing. Since the activity of the ion exchange salts decreases as more lenses are processed, the salt should be replaced or replenished periodically, according to manufacturer’s recommendations.

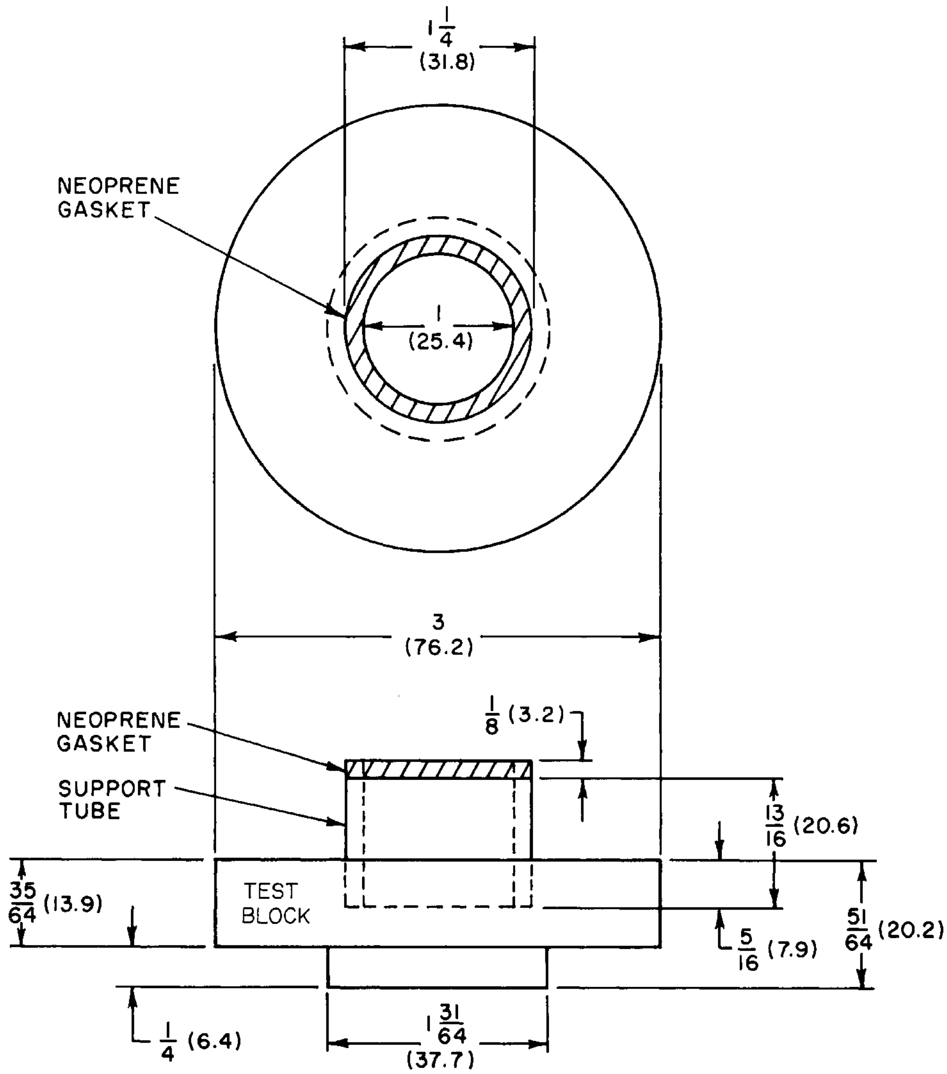

Figure A.1 – Lens Test Block

NOTES:

1 – Measurements are given in inches, with corresponding metric measurements in parentheses.

2 – This test block is to be inserted in the base plate described in Figure A.2 of this standard.

The neoprene gasket must have a hardness of 40 ± 5 Shore A, as determined by ASTM D2240, a minimum tensile strength of 1200 psi (8.274 kPa), as determined by ASTM D412, and a minimum ultimate elongation of 400%, as determined by ASTM D412. The support tube is made of a rigid material such as methyl methacrylate or steel and has an outside diameter of 1-1/4 in (31.8 mm) and an inside diameter of 1 in (25.4 mm).

The gasket must be securely bonded to the support tube. The test block must be made of cold-rolled steel, American Iron and Steel Institute No. C1018, or equivalent.

This test block is applicable to the majority of ophthalmic lenses. However, if a diameter of the edged lens is less than 1-1/4 in (31.8 mm), a substitute support may be used. the outside diameter of which is equal to or less than the smallest diameter of the edged lens. The wall thickness of the neoprene gasket is a nominal 1/8 in (3.2 mm).

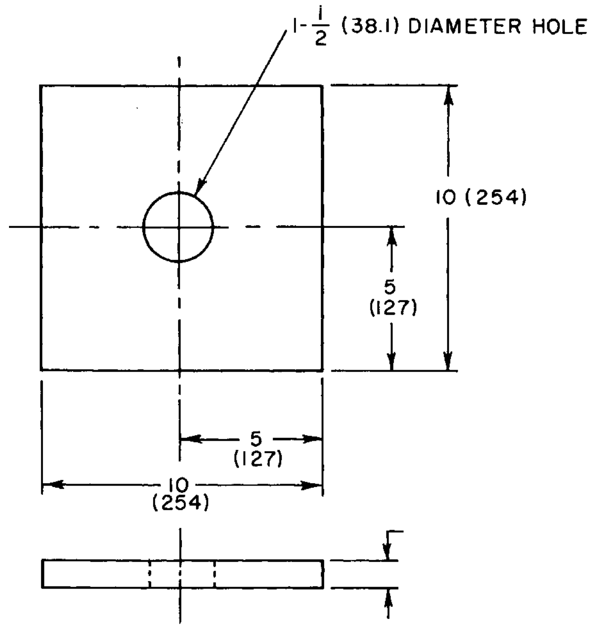

Figure A.2 – Base Plate

NOTES:

1 – Measurements are given in inches, with corresponding metric measurements in parentheses.

2 – Only one base plate is required. The material is cold-rolled steel (ground stock), American Iron and Steel Institute No. C1018, or the equivalent. A base of alternate geometric design may be used, providing it is an inflexible iron or steel member, and the total intrinsic weight of the member and rigidly attached fixtures of the device itself, is not less than 27 lb (12.25 kg).

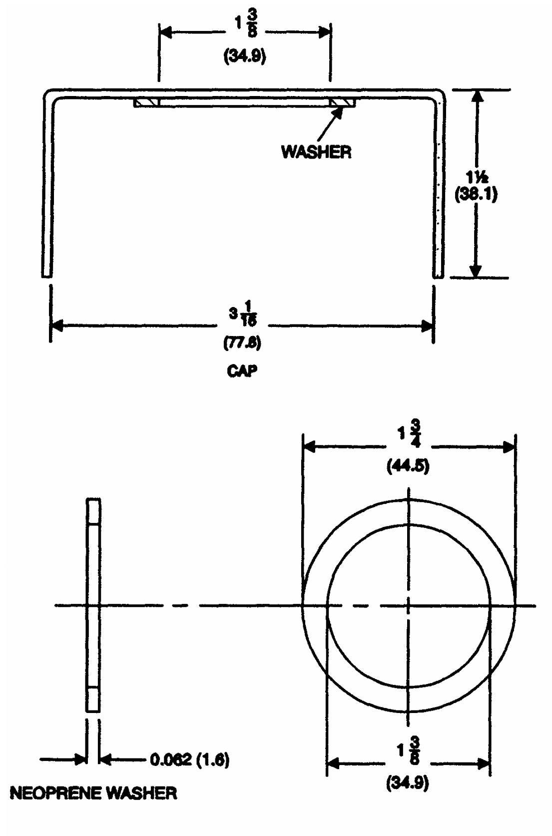

Figure A.3 – Lens Cap

NOTES:

1 – Measurements are given in inches, with corresponding metric measurements in parentheses.

2 – This cap is designed to fit over the test block and rest on the base plate. The clearance between the washer on the lens support tube and the washer on the cap is about 0.276 in (7 mm). This should provide clearance for most lenses. Should a lens contact the cap washer, the cap should be shimmed up so that the washer will clear the lens.

Annex B Recommended System for Visually Inspecting Lens for Defects

(Informative)

The recommended system for visually inspecting a lens for localized errors is shown inFigure .

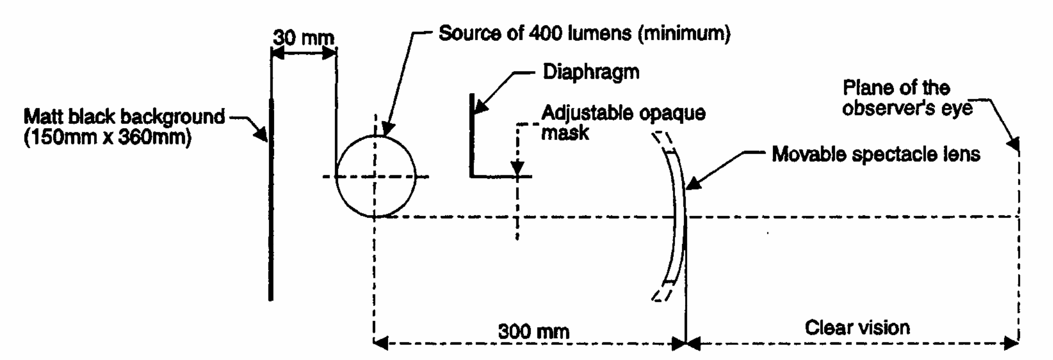

Figure B.1 – Recommended System for Visually Inspecting Lens for Defects

Annex C The Boxing System of Measurement

(Informative)

A unit of frame and lens measurement, called the boxing system, was instituted in 1962. Since that time, most products manufactured in the United States conform to this system. The salient features of the system, as it applies to this standard, are shown in Figure . Basically, all measurements are made from frame or lens centers and the lens bevel apexes and are expressed in millimeters.

A – The horizontal box dimension or the horizontal distance between two vertical tangents to the lateral extremities of the lens shape;

B – The vertical box dimension or the vertical distance between two horizontal tangents to the vertical extremities of the lens shape;

DBL – Distance between lenses (measured between two vertical tangents to the nasal extremities of the lens bevels);

DBC – Distance between centers (the distance between the two geometric centers of the frame eyewires), see GC;

GC – The geometric center of the box, eyewire, or lens shape;

NPD – Near interpupillary distance or the horizontal distance between segment geometric centers;

DPD – Distance interpupillary distance or the horizontal distance between major reference points;

DRP – Distance reference point (see 3.21.1);

θ – Angle of the cylinder axis, measured in a counterclockwise direction from 0 degrees. Zero degrees, by convention, always is the right extremity of the box when viewing the patient (i.e., the patient's left);

OD – Right eye;

OS – Left eye.

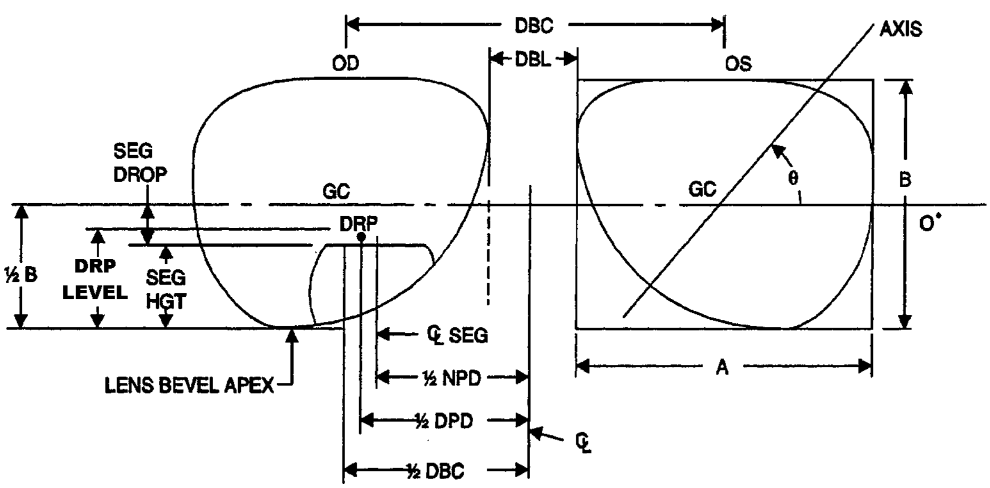

Figure C.1 – The Boxing System of Measurement

Annex D Optical and Mechanical Tolerances Summary

(Informative)

		MEASURE	POWER RANGE	TOLERANCE	SECT.	COMMENTS
General Optical Tolerances, Individual Lenses (edged or uncut)	Distance Refractive Power	Highest Meridian For SV and MFs	≥ 0.00 D, ≤ ±6.50 D > ±6.50 D	± 0.13 D ± 2%	5.1.1.1	 2% of meridian power
		Highest Meridian For Progressives	≥ 0.00 D, ≤ ±8.00 D > ±8.00 D	± 0.16 D ± 2%	5.1.1.2	 2% of meridian power
		Cylinder Power For SV and MFs	≥ 0.00 D, ≤ 2.00 D > 2.00 D, ≤ 4.50 D > 4.50 D	± 0.13 D ± 0.15 D ± 4%	5.1.1.1	 4% of cylinder power
		Cylinder Power For Progressives	≥ 0.00 D, ≤ 2.00 D > 2.00 D, ≤ 3.50 D > 3.50 D	± 0.16 D ± 0.18 D ± 5%	5.1.1.2	 5% of cylinder power
		Cylinder Axis	> 0.00 D, ≤ 0.25 D > 0.25 D, ≤ 0.50 D > 0.50 D, ≤ 0.75 D > 0.75 D, ≤ 1.50 D > 1.50 D	± 14° ± 7° ± 5° ± 3° ± 2°	5.1.2	
	Add	Add Power	≤ +4.00 D > +4.00 D	± 0.12 D ± 0.18 D	5.1.3	
	Δ	Prism PRP Location		≤ 0.33Δ at PRP ≤ 1.0 mm from specified PRP	5.1.4	
		Base Curve		± 0.75 D	5.1.5	When specified
Mounted SV & Multifocal	Δ Imbalance	Vertical Prism	≥ 0.00 D, ≤ ±3.375 D > ±3.375 D	≤ 0.33Δ ≤ 1 mm difference in height of PRPs	5.2.1.1	
		Horizontal Prism	≥ 0.00 D, ≤ ±2.75 D > ±2.75 D	≤ 0.67Δ PRPs ≤ ± 2.5 mm from specified distance interpupillary distance	5.2.1.1	
	Segment	Segment Tilt		± 2°	6.2.4	Measured from 180°
		Vertical Location Vertical Difference		± 1.0 mm ≤ 1.0 mm	6.2.3.1	Each lens Between lenses
		Horizontal Location		±2.5 mm	6.2.3.1	From specified near interpupillary distance

Mounted PAL	Δ Imbalance	Vertical Prism (PAL imbalance)	≥ 0.00 D, ≤ ±3.375 D > ±3.375 D	≤ 0.33Δ ≤ 1 mm difference in height of PRPs	5.2.1.2	Between lenses
		Horizontal Prism (PAL imbalance)	≥ 0.00 D, ≤ ±3.375 D > ±3.375 D	≤0.67Δ PRPs ≤ ±1.0 mm from specified monocular interpupillary distance	5.2.1.2	
	Fitting point	Vertical Location		± 1.0 mm	6.2.3.2	Each lens
		Vertical Difference		≤ 1.0 mm	6.2.3.2	Between lenses
		Horizontal Location		± 1.0 mm	6.2.3.2	From specified monocular interpupillary distance
		Horizontal Axis Tilt		± 2 degrees	6.2.4	Using the permanent horizontal reference markings
Misc.		Center Thickness		± 0.3 mm	6.1.3	When specified
		Segment Size		± 0.5 mm	6.1.4	
		Warpage		≤1.0 D	6.2.2	Cyl induced on front

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(Informative)

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