



Standard Specification for Eye Protective Devices for Paintball Sports¹

This standard is issued under the fixed designation F1776; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This is the specification for eye, face, and head protective devices, or EHPD, to be used in the sport of paintball. Paintball is a sport that, like all sports, has intrinsic hazards. These hazards include being hit by paintballs. Protective equipment cannot eliminate all injuries but will substantially reduce their severity and frequency. Participation in this sport by a player implies acceptance of injury risk. The goal of protective equipment is to minimize the risk of injury.

Performance requirements are presented and are intended to minimize injury with minimal impairment of the form and appeal of the sport. This specification is subject to revision as indicated by subsequent injury statistics.

The impact requirements are designed to give eye, adnexa of eye, and head protection from paintball impacts likely to be encountered under game conditions. While the EHPD also may protect the user from other potential impacts, such as running into tree branches, there are many conceivable impacts, including falls from heights, which could exceed the specification and result in eye injury despite the use of the EHPD.

1. Scope

1.1 This specification applies to eye, face, and head protective devices, designed for use by players of the sport of paintball, which minimize or significantly reduce injury to the eye, adnexa of eye, face, and head due to paintball impact or penetration, or both.

1.2 EHPDs by nature provide three types of protection. The first type of protection is for the eyes and adnexa of eye and not necessarily for any other parts of the face or head. The second type of protection adds coverage for the ears and face. The third type of coverage adds cranial coverage in addition to that provided to types II and III. These coverage types are defined in Section 8.

1.3 This specification does not limit the wearing of eye-glasses or contact lenses when used in conjunction with the EHPD.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

- 2.1 *ASTM Standards:*²
- C1027 Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile
 - D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics
 - F803 Specification for Eye Protectors for Selected Sports
 - F1979 Specification for Paintballs Used in the Sport of Paintball
 - F2272 Specification for Paintball Markers
- 2.2 *ANSI Standards:*
- ANSI Z80.3 Requirements for Nonprescription Sunglasses and Fashion Eyewear³
 - ANSI Z87.1 Practice for Occupational and Educational Eye and Face Protectors³

¹ This specification is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.57 on Eye Safety for Sports.

Current edition approved July 1, 2012. Published August 2012. Originally approved in 1997. Last previous edition approved in 2010 as F1776 – 10. DOI: 10.1520/F1776-12.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

2.3 *Federal Standards*:⁴

No. 406

No. 3022

2.4 *CSA Standard*:⁵

CSA Z262.6 Specifications for Facially Featured Headforms

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *adnexa, n*—adjunct parts of the eye, including the orbit, orbital contents, eyelids, and the lacrimal apparatus.

3.1.2 *astigmatism, n*—a condition in a lens that creates two axially separated line foci of each object point, the lines being mutually perpendicular. In other words, the lens has two different refractive powers in meridians that are 90° apart.

3.1.3 *base-in, adj*—relating to the type of prism imbalance that tends to cause parallel rays of light passing through an EHPD, spaced apart by the interpupillary distance, to converge.

3.1.4 *base-out, adj*—relating to the type of prism imbalance that tends to cause parallel rays of light passing through an EHPD, spaced apart by the interpupillary distance, to diverge.

3.1.5 *binocular, adj*—relating to the field of view that is shared by both eyes simultaneously.

3.1.6 *caliber, n*—the term used to refer to the size of a paintball projectile. Related to the measurement of the diameter of the paintball.

3.1.7 *central viewing zone, n*—that part of a lens that has its center in line with the wearer's line of sight when looking straight ahead. The zone is circular in shape. For the purpose of this specification, it shall be considered to be 38 mm in diameter. The center of the central viewing zone shall be the point of intersection of the line of sight with the lens as mounted on the CSA adult headform,⁵ as specified by the manufacturer.

3.1.8 *cleanable, adj*—the ability of an EHPD to be made readily free of dirt or grime without being damaged during an appropriate cleaning process, such as the use of soap and water.

3.1.9 *corneal apex, n*—The most anterior point of the cornea when the eye is in the primary position.

3.1.10 *coverage, n*—those areas of the eye, face, and head as covered by the EHPD as defined in 8.3.

3.1.11 *definition, optical, n*—the characteristic of a lens that allows separate distinct points in close proximity to be discerned when looking through the lens.

3.1.12 *dislodge, v*—remove or force an object from its original position.

3.1.13 *eye, n*—relating to the eye of the headform or the eye of a person wearing an EHPD or that part of an EHPD through which a wearer's eye would normally look.

3.1.14 *eye of the headform, n*—all structures contained within the orbital rim of the CSA headform.

3.1.15 *EHPD, n*—device that provides protection to the wearer's eyes, face, and head against paintball impact or penetration, or both.

3.1.16 *haze, n*—the fraction of the total transmitted light from a normally incident beam that is not transmitted in a focused condition but scattered by inclusions or surface defects. Excessive haze will reduce contrast and visibility.

3.1.17 *headform, n*—as utilized within this standard for the as-worn assessment of EHPDs, key dimensions of which are as provided in CSA Z262.6.

3.1.18 *lens, n*—transparent part of an EHPD through which the wearer normally sees.

3.1.18.1 *Discussion*—The most common configurations for lenses are single pane and thermal double pane. Thermal double pane lenses are usually constructed from a single pane lens which has a second clear airtight thermal barrier affixed to it to reduce the effects of lens fogging. Some lenses also are treated with chemical solutions to reduce lens fogging.

3.1.19 *lens retention component(s), n*—components, separate from the lens, that are designed to retain the lens in the frame or body of the EHPD.

3.1.20 *luminous transmittance, n*—luminous transmittance is a function of the spectral transmittance of the lens weighted by the corresponding ordinates of the photopic luminous efficiency distribution of the CIE (1931) standard colorimetric observer and by the spectral intensity of standard Illumination C (see ANSI Z80.3).

3.1.21 *paintball, n*—spherical ball, comprised of a shell and a fill manufactured in accordance with the requirements of Specification **F1979** and designed to be expelled from a paintball marker.

3.1.22 *paintball fragment, n*—a part of the shell of the paintball that will not be surrounded completely by a 3 by 5-mm rectangle.

3.1.23 *paintball marker, n*—device specifically designed to discharge paintballs which conforms with Specification **F2272**.

3.1.24 *orbital area, n*—the area contained in a circle $r = 20$ -mm centered on the pupil of the headform.

3.1.25 *power imbalance, n*—a condition that exists when the refractive power created by the right lens of the EHPD is different from that of the left lens.

3.1.26 *prism, n*—the angular deviation of a ray of light as it passes through a lens resulting from the angle at which the ray strikes each surface of the lens and the index of refraction of the material from which it is made.

3.1.27 *prism imbalance*:

3.1.27.1 *horizontal imbalance, n*—the difference in prismatic deviation of incident parallel light beams on the two eyes of an EHPD in the horizontal meridian (see **base-in** and **base-out**).

3.1.27.2 *vertical imbalance, n*—the difference in prismatic deviation between parallel light beams incident on the two eyes of an EHPD in the vertical meridian.

3.1.28 *refractive power, n*—the focusing effect of a lens expressed in diopters.

⁴ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁵ Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, <http://www.csa.ca>.

3.1.29 *spherical power, n*—the average of the maximum meridional astigmatic power and the minimum meridional astigmatic power of a lens.

4. Performance Requirements

4.1 Optical Requirements:

4.1.1 *Field of View*—When tested in accordance with 6.1, the basic EHPD, without any accessories such as a sun visor installed, shall have a field of view equal to or exceeding the following:

4.1.1.1 *Temporal Field*—50°.

4.1.1.2 *Nasal Field*—30°.

4.1.1.3 *Superior Field*—30°.

4.1.1.4 *Inferior Field*—30°.

4.1.2 *Refractive Tolerances*—When tested in accordance with 6.6, the spherical power shall not be less than -0.37 diopters and shall not exceed $+0.06$ diopters.

4.1.3 *Astigmatism*—When tested in accordance with 6.6, the astigmatism shall not exceed 0.25 diopters.

4.1.4 *Power Imbalance*—When tested in accordance with 6.6, the power imbalance in corresponding meridians between the two eyes for straight ahead seeing shall not exceed 0.18 diopters.

4.1.5 *Prism*—When tested in accordance with 6.4 or 6.8, the primary viewing position of either eye of a shield shall not exceed 0.5 prism diopters.

4.1.6 *Prism Imbalance*—When tested in accordance with 6.4 or 6.8, the prism imbalance shall meet the following criteria:

4.1.6.1 *Vertical Imbalance*, shall not exceed $+0.25$ diopters.

4.1.6.2 *Horizontal Imbalances*—Negative values (base-in) shall not be less than -0.25 prism diopters, and positive values (base-out) shall not be more than $+1.0$ prism diopters.

4.1.7 *Luminous Transmittance*—When tested in accordance with 6.3, the luminous transmittance shall not be less than 60 % for clear lenses and not less than 20 % for tinted lenses, unless labeled **very dark** in which case the minimum transmittance shall be no less than 8 %. All tinted lenses shall be labeled “**Not for use in low light conditions.**”

4.1.8 *Haze*—When tested in accordance with 6.5, the haze of the EHPD lens shall not exceed 3 %.

4.1.9 *Optical Quality*—Within the central viewing zone, striae, warpage, surface ripples, or other defects that are apparent under the optical inspection test conditions of 6.2 shall be considered a failure. An exception is when small specks or inclusions, which are not seen when the lens is held close to the eye in the as-worn position, shall not be a cause of rejection.

4.1.10 *Physical Lens Defects*—Within the central viewing zone, pits, scratches, grayness, bubbles, cracks, water marks, or other defects that are apparent under the visible inspection test conditions of 6.7 shall be considered a failure. An exception that small specks or inclusions, which are not seen when the lens is held close to the eye in the as-worn position, shall not be cause of rejection.

4.2 Mechanical Requirements:

4.2.1 When tested in accordance with Section 7, the basic EHPD, without any accessories such as a sun visor installed:

4.2.1.1 No contact by components of the EHPD or paintball fragments with the orbital area of the headform shall be permitted.

4.2.1.2 Any visible fracture of the lens, frame, or EHPD constitutes a failure.

4.2.1.3 Any dislodging of the lens from the frame constitutes a failure.

4.2.1.4 Any dislodging of a lens retention component from the EHPD constitutes a failure.

4.2.1.5 Any dislodging of a component of the EHPD that would permit free passage and contact of a 5-mm diameter probe to the orbital area of the headform constitutes failure.

4.2.1.6 Any contact of an intact paintball, on the portion of the headform protected by the EHPD, after said paintball penetrated or passed through the protective portion of the EHPD, constitutes failure.

4.2.1.7 Any rotation of the headgear system in the headform that would permit free passage and contact of a 5-mm diameter probe to the orbital area of the headform constitutes failure.

5. Sample Preparation

5.1 Eye and Head Protective Devices:

5.1.1 Only new and complete EHPDs as offered for sale shall be tested.

5.1.2 EHPDs shall be subjected to a single impact test.

5.1.3 The EHPD shall be conditioned for a minimum of 4 h at the specified temperature prior to each test.

5.2 Test Temperatures:

5.2.1 *Cold Test*, $-12.2^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($10^{\circ}\text{F} \pm 3.5^{\circ}\text{F}$).

5.2.2 *Room Temp*, $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($73^{\circ}\text{F} \pm 3.5^{\circ}\text{F}$).

5.2.3 *Hot Test*, $37.8^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($100^{\circ}\text{F} \pm 3.5^{\circ}\text{F}$).

5.3 Paintballs:

5.3.1 All impact testing shall be done using 68 caliber paintballs manufactured in accordance with the requirements of Specification F1979 and obtained within 30 days of the testing date. The paintball bulk container shall be resealed immediately after each group of paintballs is removed. Paintball storage and nontest handling shall be done at a relative humidity below 55 % and at a temperature between 12.7 and 29°C (55 and 85°F).

5.3.2 Paintballs used for impact testing shall be conditioned in a sealed packet (bag) for at least 4 h at the specified temperature for each test. Impact testing shall be completed within 3 min after removal of the paintballs from their temperature conditioning atmosphere.

TEST METHODS

6. Optical Test Methods

6.1 Field of View (Angle of Vision):

6.1.1 *Purpose*—This test method is intended to determine the relative unobstructed angle visually available to the user. With the EHPD mounted on the standard headform, the corneal apex shall be visible to an observer when sighted from the required field angles in accordance with 4.1.1. Any sighting method may be used. Paragraphs 6.1.2-6.1.4 give one method.

6.1.2 *Apparatus*—The concept is to mount a CSA headform, size specified by the manufacturer or chosen by the test lab, in

a gimbal. Any gimbal that is sufficiently large and sturdy and properly inscribed with horizontal and vertical protractor markings is acceptable. Figs. 1-3 show front and side vertical schematic views of a wooden gimbal that can be constructed with simple tools. Item A is the base and support for horizontal rotation. A protractor should be marked on the base with its center coincident with the axis of rotation. Base A should protrude forward to allow for the protractor markings. These indicate the position of B. Item B comprises the main carriage of the gimbal. Item C comprises the vertically rotating member. Sections CR and CL are the right and left vertical supports. Fig. 2 shows the horizontal view. A window in the left of the vertical B support makes the protractor markings on section CL visible for accurate setting. Section CL can be pie-shaped, providing that a 60° angle can be read. The markings should be made every 5° and marked every ten. A set screw should be threaded into the B section or a ¼-20 nut can be inlaid if section B is wooden. Ensure that ¼-20 thumb screws are available readily for use as the set screw. The location of the standard head should be planned to obtain a good balance for vertical rotations. The horizontal rotation axis should be in the plane of the corneas. The axis themselves can be 12-mm (½-in.) dowels or 6-mm (¼-in.) metal rods. Fig. 3 shows the location of the pivots for their respective rotations. Fig. 4 shows an example of a test setup. The total path from gimbal to the eye, camera, or light source should be at least 7.31 m (24 ft). Using a mirror facilitates adjusting the gimbal while observing the position of the corneas in the protector. A low power telescope or simply a monocular eye locating ring or washer can be substituted for the video camera. The corneas should be painted white or covered with white or reflecting tape in the form of an 8-mm disk. A high level ambient light is desirable. Visual optics may be replaced with photo detectors in the corneas having separate readout means for the two eyes. A strong light source would replace the video camera in which case a low level of ambient light is desirable. A collimating lens would increase the signal to noise ratio of the photo-detectors. The set up as indicated in the drawing introduces a horizontal angle of error of -0.2° and a vertical angle of error

of approximately -0.6° at 60° . The location of the vertical angle of tip is centered in the headform to help balance the gimbal. These errors can be accounted for in the decision process. A longer path between the input and output devices will decrease the errors proportionately.

6.1.3 *Test Procedure*—Mount the EHPD to be tested on the headform in the intended wearing position. Set the gimbal in the straight ahead position and verify the visibility of metered response of the two eyes. The gimbal then is rotated to determine the horizontal and vertical extreme angles of view in all four directions along which the appropriate corneas can be seen monocularly.

6.1.4 *Report*—Record and report the maximum angles of view in all four directions.

6.2 *Optical Quality*—Localized power errors or aberrations that are detected by the visual inspection procedure of 6.2.1 are permissible if no measurable or gross foci meter or telescope target distortion or blur is found when the localized area is examined with an instrument as indicated in 6.2.2.

6.2.1 *Inspection Procedure*—One method of optical inspection is to view a high-contrast grid pattern of dark and white lines through the lens, scanning it area by area and moving it about. The grid pattern should be at least 45 by 45 cm (18 by 18 in.) and constructed of high contrast black lines on a white background (the white separations being equal to the black lines, both being approximately 6 mm [¼ in.] wide). The target should be at least 1.8 to 2.5 m (6 to 8 ft) from the observer, and the lens should be held at least 45 to 60 cm (18 to 24 in.) from the eye. Any ripples in the lens detected by this test method should be further examined in accordance with 6.2.2.

6.2.2 The referee method of detecting optical defects and local aberrations is to scan the central viewing zone, especially areas of suspicion arising from the visual test of 6.2.1. The lens of shield should be scanned with a precision foci meter or an 8 to 10× telescope using the targets and arrangements described in 6.6.2-6.6.3.2. The aperture should be 5 to 7 mm for this examination. Areas outside the central viewing zone or within 6 mm of the edge need not be tested. When the central

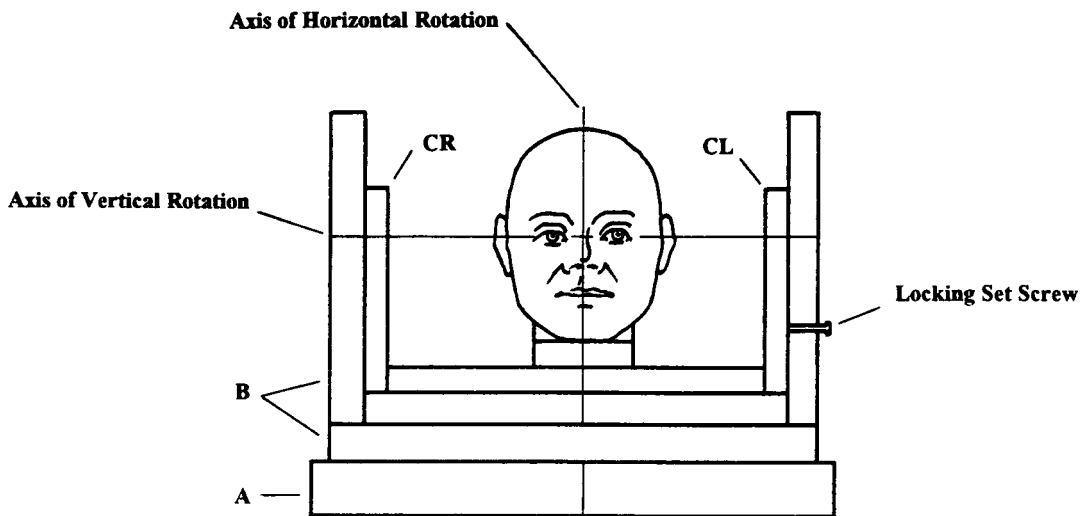


FIG. 1 Schematic of Gimbal for Supporting Standard Head

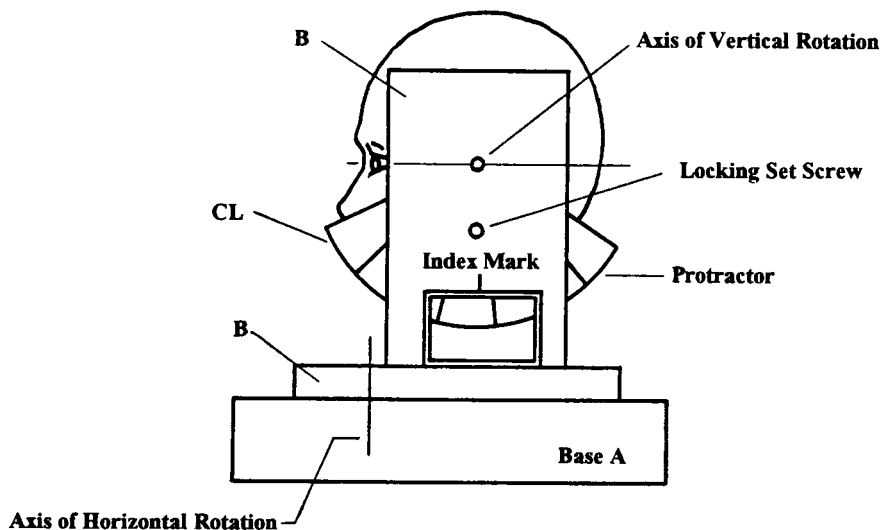


FIG. 2 Side View of Gimbal

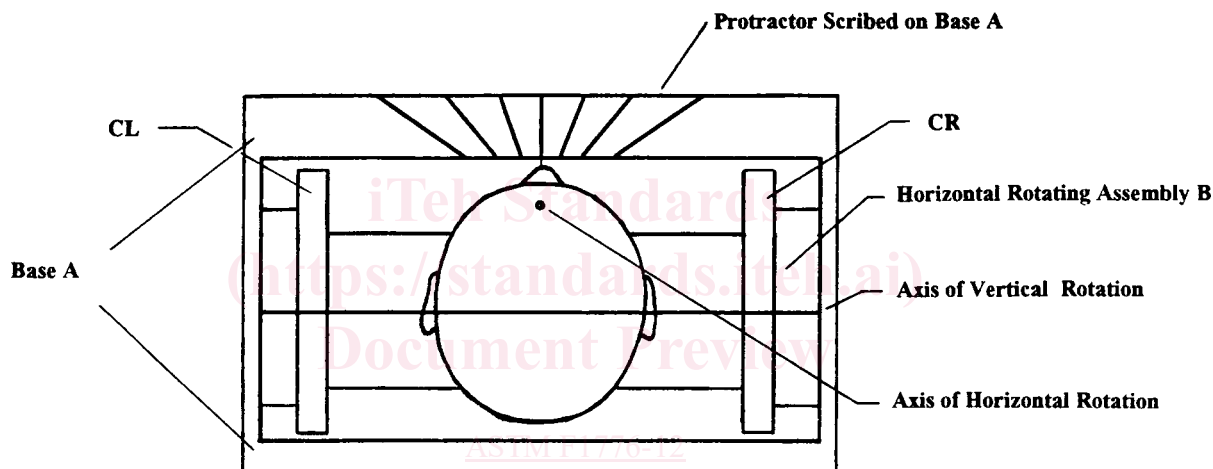


FIG. 3 Top View Showing Base for Horizontal Rotation

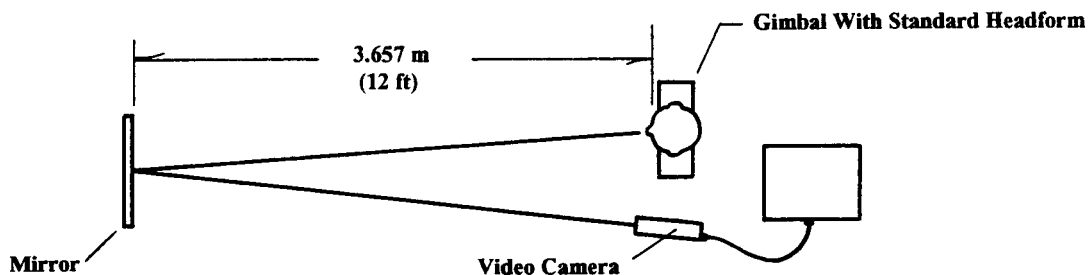


FIG. 4 Bench-Top Field-of-View Setup

viewing area is scanned, there shall be no sudden jump, doubling, or blurring of the image greater than 0.08 diopters change in power. Gradual variations in the central viewing zone shall be within the power imbalance tolerances. An optical foci meter with electronic readout repeatable to 0.02 diopters is a satisfactory alternate method. These scanning procedures may be made by scanning across the lens surface not necessarily in the "as worn" mode.

6.3 *Luminous Transmittance*—Use a suitable photometer, such as a Gardner Hazemeter, or other device comprised of a

light source of CIE Illuminant A at 2856° K color temperature and a photometric probe and meter capable of reading transmission in percent over a range from 1 to 100 %. Use a suitable enclosure to block against stray light and contain the test samples. Following the manufacturers instruction for the use of the instrument, measure the specimen for percent transmittance within each of the two central viewing zones. The measured values shall meet the established criteria for the device. A spectrophotometer, followed by appropriate photometric calculation, also may be used.

6.3.1 For the purposes of this specification, luminance transmittance may be measured with inexpensive photometers. A fixturing device should be devised to exclude ambient light. The source need not be strictly illuminate C. A tungsten lamp or a screw-in fluorescent lamp provides adequate simulation of the use environment.

6.4 Prismatic Deviation Measurements:

6.4.1 *Purpose*—This test is intended to measure the angular deviation of light rays created by the EHPD as they pass through the lens(es).

6.4.2 *Apparatus*—A telescope, equipped with a cross hair reticule having a magnification of 8× to 10× and an aperture 19 mm in diameter shall be used. The test method outlined in ANSI Z87.1 has been found satisfactory for this purpose. Other methods that yield comparable results may be used. For this test method, the target distance is 4 m. This target is easier to achieve than longer distances. The target can be metric graph paper divided into 1-cm and 5-mm squares or constructed with a ruler and compass. A circle with a 2-cm radius and a center dot about 1.5 mm in diameter will provide the tolerance for overall prism in one eye. If the 1-cm and 5-mm grids are darkened for 20 mm in each direction from center, with the center lines emphasized, measurements will be easier. Each 5 mm of the scale represents 0.125 prism diopters. The prism values off-center can be labeled along one edge of the 4-cm square vertically and horizontally departing from the central zero. The right side of the target should be labeled plus (+) and the left side minus (−) and vertical top plus (+) and bottom minus (−).

6.4.3 *Test Procedure*—The normal wearing position can be defined as the line of sight through the lenses, which is parallel with the temples when the lenses are held in a normal expected wearing position. Mount the lenses on a fixture such that the right and left eye positions for the testing line of sight are 64 mm apart. One such device is a board with four dowel sticks inserted so that the device can be supported in front of the telescope on a suitable bench or table. A single telescope can be used for straight ahead monocular readings. The fixturing device, for example the block of wood, can be slotted to move 64 mm transversely to easily measure the prism and prism imbalance. The telescope should be focused on the target at 4 m and be aligned carefully with the cross hairs on the zero position of the target. A two meridian screw-adjusted support will help. The readings for the right and left eyes must be recorded by using the graph paper target. The monocular prism test is achieved by noting whether the cross hairs remain in the 20-mm radius circle. Each 5 mm equals 0.125 prism diopters. For the prism imbalance test, readings in prism diopters for each eye must be taken. This is done by recording the amount and direction of displacement of the cross hairs on the target. Apparent movement of the cross hairs in the plus direction is base-out for the right eye and base-in for the left eye whether or not reversed by the telescope. The same is true for vertical measurements. Record the apparent position of the cross hairs on the target with plus and minus signs, in terms of prism diopters. Subtract the left eye readings from the right eye readings. For vertical prism imbalance, the absolute value of the resulting figure is the imbalance. For horizontal prism

imbalance, a net positive value indicates the base-out prism imbalance. A net negative value indicates base-in prism imbalance.

6.4.3.1 *Alternate Prism Tests (see 6.8.1)*—Table-top systems with a 1-m sample-to-target distance also are acceptable. The target dimensions should be ¼ of those given in 6.4.2.

6.5 Haze:

6.5.1 Measure the EHPD for percent haze within the central viewing zones, with the EHPD rotated so that the passing beam of light is as perpendicular to the testing surface as is practical, in accordance with Test Method **D1003**. The measured values shall meet the established criteria for the device.

6.5.2 Haze also may be determined with a commercially available Gardner Hazemeter.

6.6 Refractive Power Measurements:

6.6.1 *Purpose*—This test method is intended to measure spherical and cylindrical refractive power induced by the EHPD.

6.6.2 *Apparatus*—An 8-power telescope with an effective aperture of 19 mm shall be used in conjunction with an illuminated target located a distance of 10.67 m from the telescope objective. The focus adjustment of the telescope shall be calibrated in at least 0.01 diopter increments. The test target shall be that specified by ANSI Z87.1.

6.6.3 Test Procedure:

6.6.3.1 Adjust the telescope by setting the calibrated focus adjustment to zero power, then adjust the eyepiece so that the tests target is resolved clearly without the EHPD in front of the telescope. The quality of the telescope and the observer's vision should be such that Pattern 40 of the High Contrast Test Chart⁶ is clearly resolved.

6.6.3.2 Mount the EHPD in front of the telescope such that the telescope axis passes through either one of the central viewing zones. The angular orientation of the EHPD should be the same as used for prismatic deviation measurements. Take refractive power measurements for both central viewing zones.

6.6.3.3 Focus the telescope in the radial lines of the test target until they appear as sharp as possible. Two possibilities may occur.

6.6.3.4 If all radial lines appear equally well focused (sharp) at the same telescope power setting, the EHPD has no measurable astigmatism and the power reading of the telescope at that position is the spherical refractive power of the EHPD lens.

6.6.4 Measure the maximum meridional power for each eye, recording the extremes, the most plus readings, and the most negative readings. There will be four readings. If any are more plus than 0.06 or more minus than 0.37 diopter, the power test fails. Also, if any of the readings are more than 0.25 diopters apart, the EHPD is failed for either astigmatism or power imbalance. If the widely spaced errors are on one side of the lens, it is astigmatism.

6.6.5 Alternate methods of measuring refractive power and astigmatism, such as foci meters, visual, and electronic, may be used. Custom optical bench systems are acceptable provided it

⁶ See NIST Special Publication 374.