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Personal protective equipment — Eye and face protection — Vocabulary

Équipement de protection individuelle — Protection des yeux et du visage — Vocabulaire

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 6, *Eye and face protection*.

This third edition cancels and replaces the second edition (ISO 4007:2012), which has been technically revised. This third edition builds on the second edition, which was partly based on EN 165.

The main changes compared to the previous edition are as follows.

— The word "*ocular*" has been changed to "*lens*" to describe the transparent material through which the wearer looked.

— Some terms have been moved and renumbered to more suitable positions, e.g. some of the terms that were in the "properties of materials" subclause are now in the "transmittance" subclause.

— 52 new terms have been added, over 100 terms or definitions have been modified and sources have been updated. Greater information about the source of definitions is given where these have been copied from other standards.

— The following terms have been deleted: *giant-pulsed laser, haze, He-Ne laser, optical class, protective ocular, radiation power, untinted ocular, very-high-pressure (intensity) mercury vapour lamp*.

— A term relating to the transmittance between 380 nm and 400 nm has been added. Although the definition for UV-A continues to take the wavelength limits of 315 nm to 380 nm, many of the terms and definitions relating to UV-A allow the upper limit to be either 380 nm or 400 nm, depending upon the application.

— Terms relating to "*mesh protectors*" and "*additional lenses*" have been added for use in the appropriate standards.

— hyphens have been removed from many terms relative to the second edition, e.g. in "*eye-protector*" and "*dark-state*", but have been kept in "*as-worn*", "*blue-light*" and "*gradient-tinted*", and in those cases where they would generally be used in English.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Personal protective equipment — Eye and face protection — Vocabulary

1 Scope

This document defines and explains the principal terms used in the field of personal eye and face protection.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

NOTE See also the CIE International lighting vocabulary: Available at: http://eilv.cie.co.at/.

3.1 Risks and hazards

3.1.1
safety, noun
freedom from *risk* (3.1.4) that is not tolerable

Note 1 to entry: The term "safe" is often understood by the general public as the state of being protected from all *hazards* (3.1.3). However, this is a misunderstanding: "safe" is rather the state of being protected from recognized hazards that are likely to cause *harm* (3.1.2). Some level of *risk* is inherent in products or systems. The use of the terms "safety" and "safe" as descriptive adjectives should be avoided when they convey no useful extra information. In addition, they are likely to be misinterpreted as an assurance of freedom from risk. The recommended approach is to replace, wherever possible, the terms "safety" and "safe" with an indication of the objective. For example, use "protective helmet" instead of "safety helmet". See also ISO/IEC Guide 51:2014, Clause 4.

[SOURCE: ISO/IEC Guide 51:2014, 3.14, modified — the term has been identified as a noun, and "which" in the definition has been changed to "that".]

3.1.2
harm
injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

3.1.3
hazard
potential source of *harm* (3.1.2)

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.1.4
risk
combination of the probability of occurrence of *harm* (3.1.2) and the severity of that harm

Note 1 to entry: The probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event and the possibility to avoid or limit the harm.

[SOURCE: ISO/IEC Guide 51:2014, 3.9]

3.1.5
intended use
use in accordance with information provided with a product or system, or, in the absence of such information, by generally understood patterns of usage

[SOURCE: ISO/IEC Guide 51:2014, 3.6]

3.1.6
reasonably foreseeable misuse
use of a product or system in a way not intended by the supplier, but which can result from readily predictable human behaviour

Note 1 to entry: Readily predictable human behaviour includes the behaviour of all types of users, e.g. the elderly, children and persons with disabilities. For more information, see ISO 10377[5].

Note 2 to entry: In the context of consumer *safety* (3.1.1), the term “reasonably foreseeable use” is increasingly used as a synonym for both *intended use* (3.1.5) and reasonably foreseeable misuse.

[SOURCE: ISO/IEC Guide 51:2014, 3.7]

3.1.7
blue-light hazard
potential for a photochemically induced retinal injury resulting from *optical radiation* (3.2.1) exposure in the wavelength range 300 nm to 700 nm

3.1.8
infrared lens hazard
potential for a thermal injury to the crystalline lens (and cornea) of the eye resulting from exposure to *optical radiation* (3.2.1) in the wavelength range 780 nm to 3 000 nm

3.1.9
retinal thermal hazard
potential for a thermal retinal injury resulting from exposure to *optical radiation* (3.2.1) in the wavelength range 380 nm to 1 400 nm

3.1.10
ultraviolet hazard
potential for acute and chronic adverse effects to the skin and eye resulting from exposure to *optical radiation* (3.2.1) in the wavelength range 250 nm to 400 nm

3.2 Optical radiation

3.2.1
optical radiation
electromagnetic radiation at wavelengths between the region of transition to X-rays ($\lambda \approx 1$ nm) and the region of transition to radio waves ($\lambda \approx 1$ mm)

Note 1 to entry: Optical radiation is usually subdivided into the following spectral ranges, with a possible overlap at the longer wavelength limit of the UV spectrum:

— *ultraviolet radiation* (3.2.3);

— *visible radiation* (3.2.2);

— *infrared radiation* (3.2.4).

[SOURCE: CIE S 07:2011, 17-848, modified — Note 1 to entry has been added.]

3.2.2
visible radiation
light
any *optical radiation* (3.2.1) capable of causing a visual sensation directly

Note 1 to entry: There are no precise limits for the spectral range of visible radiation since they depend upon the amount of *radiant power* (3.4.7) reaching the retina and the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

Note 2 to entry: For the purposes of standards on eye protection, the limits of the visible spectrum are usually taken to be 380 nm to 780 nm. These limits coincide with those in ISO 20473 which specifies the spectral ranges for optics and photonics standards and avoids the overlap at either end of the visible spectrum in the CIE definition.

Note 3 to entry: For lasers, the visible wavelength band is defined as 400 nm to 700 nm. This is because eye protection against low-power visible lasers often relies on the eye's aversion response, which includes the *blink reflex* (3.5.1.17). For this to happen, the *laser beam* (3.3.14) should appear very bright, hence the need to cut off the extremes of the visible band where the *spectral luminous efficiency* (3.4.11) of the eye is quite low.

[SOURCE: CIE S 017:2011, 17-1402, modified — Notes to entry 2 and 3 have been added.]

3.2.3
ultraviolet radiation
UV radiation
UVR
optical radiation (3.2.1) for which the wavelengths are shorter than those for *visible radiation* (3.2.2)

Note 1 to entry: For standards for protection against solar radiation including, for example, sunglasses for general use, the upper limit of UV-A is sometimes taken as 380 nm. For standards on requirements for protection against radiation from artificial sources, the upper limit of UV-A is usually taken as 400 nm, which is consistent with the CIE definition. The 400 nm upper limit is also used by, amongst others, ICNIRP, ACGIH, the World Health Organization and in the European Artificial Optical Radiation Directive.

Note 2 to entry: The limit of 380 nm coincides with ISO 20473 which specifies the spectral range of ultraviolet radiation for standards in optics and photonics and subdivides the UV range into

— UV-A: 315 nm to 380 nm;

— UV-B: 280 nm to 315 nm;

— UV-C: 100 nm to 280 nm.

[SOURCE: CIE S 017:2011, 17-1367, modified — the word "optical" has been added to the definition and the CIE Notes 1, 2 and 3 have been deleted and replaced by Notes 1 and 2 to entry.]

3.2.4
infrared radiation
IR radiation
optical radiation (3.2.1) for which the wavelengths are longer than those for *visible radiation* (3.2.2), from 780 nm to 1 mm

Note 1 to entry: For infrared radiation, the range between 780 nm and 1 mm is typically subdivided into:

— IR-A 780 nm to 1 400 nm, or 0,78 µm to 1,4 µm;

— IR-B 1,4 µm to 3,0 µm;

— IR-C 3 µm to 1 mm.

Note 2 to entry: A precise border between "visible" and "infrared" cannot be defined because visual sensation at wavelengths greater than 780 nm is noted for very bright sources at longer wavelengths.

[SOURCE: CIE S 017:2011, 17-580, modified — the word "commonly" has been replaced by "typically" in the first CIE note to entry, and the third CIE note has been deleted.]

3.2.5
monochromatic radiation
monochromatic light
optical radiation (3.2.1) characterized by a single frequency

Note 1 to entry: In practice, radiation of a very small range of frequencies which can be described by stating a single frequency.

Note 2 to entry: The wavelength in air or in vacuum is also used to characterize a *monochromatic radiation*. The medium shall be stated.

Note 3 to entry: The wavelength in standard air is normally used in photometry and radiometry.

[SOURCE: CIE S 017:2011, 17-788, modified — the word "optical" has been added in front of "radiation" in the definition.]

3.2.6
illuminant
optical radiation (3.2.1) with a relative spectral power distribution defined over the wavelength range that influences object colour perception

Note 1 to entry: In everyday English, this term is not restricted to this sense but is also used for any kind of light falling on a body or scene.

[SOURCE: CIE S 017:2011, 17-554, modified — the word "optical" has been added in front of "radiation" in the definition.]

3.2.7
CIE standard illuminants
illuminants (3.2.6) A and D65, defined by the CIE in terms of relative spectral power distributions

Note 1 to entry: These *illuminants* (3.2.6) are intended to represent:

— A: Planckian radiation with a temperature of 2 856 K;

— D65: The relative spectral power distribution representing a phase of daylight with a correlated colour temperature of approximately 6 500 K (called also "nominal correlated colour temperature of the daylight illuminant").

Note 2 to entry: Illuminants B, C and other D illuminants, previously denoted as standard illuminants, should now be termed CIE illuminants.

Note 3 to entry: See also ISO 11664-2:2007[8] and CIE 015[22].

Note 4 to entry: Tables defining the CIE standard illuminants A and D65 at 5 nm intervals can be viewed in the downloads section at http://www.cie.co.at/.

[SOURCE: CIE S 017:2011, 17-168, modified — the references to other standards in CIE Note 1 to entry have been moved into a new Note 3 to entry, and a new Note 4 to entry has also been added.]

3.3 Sources of non-ionizing radiation

3.3.1
electric arc
self-maintained gas conduction for which most of the charge carriers are electrons supplied by primary-electron emission

Note 1 to entry: During live working, the electric arc is generated by gas ionization arising from an unintentional electrical conducting connection or breakdown between live parts or a live part and the earth path of an electrical installation or an electrical device. During testing, the electric arc is initiated by the blowing of a fuse wire.

[SOURCE: IEC 61482-1-1:2009, 3.1.17]

3.3.2
air-arc cutting
arc gouging
thermal gouging or cutting method for metallic materials that uses an *electric arc* (3.3.1)

Note 1 to entry: This method uses a carbon electrode that forms a groove by melting or burning, while an air jet attached to the electrode removes the molten material. This groove can be deepened using the same thermal method to form a cut.

3.3.3
arc welding
electric welding method that uses an arc that is generated between the rod-shaped metal electrode and the workpiece

Note 1 to entry: The electrode melting in the hot arc is used as the filler metal for the welded joint.

3.3.4
short-circuit electric arc
intensive arc that can occur through switching or a short-circuit in electricity distribution installations

3.3.5
gas cutting
flame cutting
thermal method of cutting metallic material using gas and oxygen

Note 1 to entry: This method does not use an *electric arc* (3.3.1).

3.3.6
plasma arc cutting
thermal cutting method for metallic materials that uses a constricted *electric arc* (3.3.1) and a high-velocity jet of gas issuing from a constricting orifice to give a high-temperature plasma flame that melts and removes the metallic material

3.3.7
blacklight lamp
ultraviolet radiation source
UV-A radiation source, generally a mercury vapour discharge lamp, with the bulb (high-pressure radiation source) or tube (low-pressure radiation source) made from light-absorbing, but UV-A transmitting, filter *glass* (3.6.1)

Note 1 to entry: The filter *glass* appears almost black in colour.

3.3.8
metal halide lamp
high intensity discharge lamp in which the major portion of the *light* (3.2.2) is produced from a mixture of a metallic vapour and the products of the dissociation of metal halides

Note 1 to entry: Metal halide lamps can be clear or phosphor-coated.

[SOURCE: CIE S 017:2011, 17-765, modified — "the term covers" has been replaced by "metal halide lamps can be".]

3.3.9
low pressure mercury (vapour) lamp
discharge lamp of the mercury vapour type, with or without a coating of phosphors, in which during operation, the partial pressure of the vapour does not exceed 100 Pa

Note 1 to entry: In mercury discharge lamps with a fluorescent layer, the layer is excited by the *ultraviolet radiation* (3.2.3) of the discharge to generate *visible radiation* (3.2.2).

[SOURCE: CIE S 017:2011, 17-701, modified — Note 1 to entry has been added.]

3.3.10
medium pressure mercury (vapour) lamp
non-coherent radiation source containing mercury vapour at pressures ranging from 50 kPa to several hundred kPa[1)]

Note 1 to entry: This type of lamp emits mostly from 200 nm to 1 000 nm with the most intense lines approximately at 218 nm, 248 nm, 254 nm, 266 nm, 280 nm, 289 nm, 297 nm, 303 nm, 313 nm, 334 nm, 366 nm, 406 nm, 408 nm, 436 nm, 546 nm and 578 nm.

[SOURCE: IUPAC, modified — the term name has been altered by the deletion of the hyphen in "medium-pressure" and the the addition of (vapour) to align with the CIE definitions of *low pressure mercury* (*vapour*) *lamp* and *high pressure mercury* (*vapour*) *lamp*.]

3.3.11
high pressure mercury (vapour) lamp
high intensity discharge lamp in which the major portion of the *light* (3.2.2) is produced, directly or indirectly, by radiation from mercury operating at a partial pressure in excess of 100 kPa

Note 1 to entry: High-pressure mercury (vapour) lamps can be clear, phosphor coated (mercury fluorescent) and blended lamps. In fluorescent mercury discharge lamps, the *light* is produced partly by the mercury vapour and partly by a layer of phosphors excited by the *ultraviolet radiation* (3.2.3) of the discharge.

[SOURCE: CIE S 017:2011, 17-535]

3.3.12
pulse duration
full duration at half maximum
FDHM
time interval between the half peak power points at the leading and trailing edges of a pulse

[SOURCE: ISO 11145:2016, 3.50]

3.3.13
pulse separation
time between the end of one pulse and the onset of the following pulse, measured at the 50 % trailing and leading edges

[SOURCE: ISO 12609-2:2013, 2.6]

3.3.14
laser beam
optical radiation (3.2.1) from lasers that is generally collimated, directed, monochromatic and coherent

Note 1 to entry: The radiation is correlated in space and time.

3.3.15
laser radiation
coherent electromagnetic radiation with wavelengths up to 1 mm, generated by a laser

[SOURCE: ISO 11145:2016, 3.32]

3.3.16
continuous wave laser
cw laser
laser continuously emitting radiation over periods of time greater than or equal to 0,25 s

[SOURCE: ISO 11145:2016, 3.26]

1) 1 atm = 101,325 kPa.

3.3.17
pulsed laser
laser that emits energy in the form of a single pulse or a train of pulses where the duration of a pulse is less than 0,25 s

[SOURCE: ISO 11145:2016, 3.27, modified — “which” has been changed to “that”.]

3.3.18
mode-locked laser
mode-coupled laser
laser that utilizes a mechanism or phenomenon within the laser resonator to produce a train of very short (typically shorter than a nanosecond, e.g. picosecond or femtosecond) pulses

Note 1 to entry: While this can be a deliberate feature of the laser, it can also occur spontaneously as “self-mode-locking”. The resulting peak powers can be significantly greater than the mean power.

3.3.19
intense pulsed light source
IPL
compact xenon arc lamp, operated in a pulsed mode, usually filtered to emit *visible radiation* (3.2.2) and near-*infrared radiation* (3.2.4)

Note 1 to entry: Although lasers can provide an intense pulsed source of light, when used in the medical or paramedical field, the term is restricted to xenon arc lamps. These have a broad spectral emission. The radiation emitted can be filtered to restrict the emission to the UV, visible or near-IR regions of the electromagnetic radiation spectrum.

3.4 Radiometry and photometry

3.4.1
illuminance
E_v, E
<at a point on a surface> quotient of the *luminous flux* (3.4.4), $\mathrm{d}\Phi_v$, incident on an element of the surface containing the point, by the area, $\mathrm{d}A$, of that element

Note 1 to entry: Equivalent definition: integral, taken over the hemisphere visible from the given point, of the expression $L_v \cos\theta \, \mathrm{d}\Omega$, where L_v is the *luminance* at the given point in the various directions of the incident elementary beams of *solid angle* $\mathrm{d}\Omega$, and θ is the angle between any of these beams and the normal to the surface at the given point.

$$E_v = \frac{\mathrm{d}\Phi_v}{\mathrm{d}A} = \int_{2\pi} L_v \cdot \cos\theta \cdot \mathrm{d}\Omega$$

Note 2 to entry: *Illuminance* is expressed in lux ($\mathrm{lx} = \mathrm{lm{\cdot}m^{-2}}$).

Note 3 to entry: See also *radiation power, irradiance* (3.4.2).

[SOURCE: CIE S 017:2011, 17-550, modified — the second, equivalent, definition has been placed in Note 1 to entry; Note 2 to entry has been modified by replacing the word “unit” with “illuminance is expressed in”; Note 3 to entry has been added.]

3.4.2
irradiance
E_e
<at a point on a surface> quotient of the *radiant flux* (3.4.7), $\mathrm{d}\Phi_e$, incident on an element of the surface containing the point, by the area, $\mathrm{d}A$, of that element

Note 1 to entry: Equivalent definition: integral, taken over the hemisphere visible from the given point, of the expression $L_e{\cdot}\cos\theta{\cdot}\mathrm{d}\Omega$, where L_e is the radiance at the given point in the various directions of the incident elementary beams of *solid angle* $\mathrm{d}\Omega$, and θ is the angle between any of these beams and the normal to the surface at the given point.

$$E_e = \frac{d\Phi_e}{dA} = \int_{2\pi} L_e \cdot \cos\theta \cdot d\Omega$$

Note 2 to entry: *Irradiance* is expressed in $W \cdot m^{-2}$.

Note 3 to entry: See also *illuminance* and *power density*.

[SOURCE: CIE S 017:2011, 17-608, modified — the second, equivalent, definition has been made into Note 1 to entry, Note 2 to entry has been modified by replacing the word "unit" with "*irradiance* is expressed in"; Note 3 to entry has been added.]

3.4.3
luminance
L_v; L
<in a given direction, at a given point on a real or imaginary surface> quantity of *light* (3.2.2) emitted by or reflected from an element of the surface containing the point

Note 1 to entry: Quantity is defined by the formula:

$$L_v = \frac{d\Phi_v}{dA \cdot \cos\theta \cdot d\Omega}$$

where

$d\Phi_v$ is the *luminous flux* transmitted by an elementary beam passing through the given point and propagated in the *solid angle* $d\Omega$ containing the given direction;

dA is the area of a section of that beam containing the given point;

θ is the angle between the normal to that section and the direction of the beam.

Note 2 to entry: *Luminance* is expressed in $cd/m^2 = lm \cdot m^{-2} \cdot sr^{-1}$.

Note 3 to entry: Simplified to the standard case, luminance is the quotient of the luminous intensity, I, divided by the surface area projected perpendicular to the direction of radiation as a projected plane ($A \cdot \cos\theta$):

$$L = I / (A \cdot \cos\theta)$$

[SOURCE: CIE S 017:2011, 17-711, modified — a new verbal definition has been provided and the CIE definition has been made into Note 1 to entry. CIE Note 1 and CIE Note 2 have been omitted and new Notes 2 and 3 to entry have been added.]

3.4.4
luminous flux
Φ_v; Φ
quantity derived from the *radiant flux* (3.4.7), Φ_e, by evaluating the radiation according to its action upon the CIE standard photometric observer

Note 1 to entry: For photopic vision:

$$\Phi_v = K_m \int_0^\infty \frac{d\Phi_e(\lambda)}{d\lambda} \cdot V(\lambda) \cdot d\lambda$$

where

$\frac{d\Phi_e(\lambda)}{d\lambda}$ is the spectral distribution of the radiant flux and $V(\lambda)$ is the *spectral luminous efficiency*.

Note 2 to entry: *Luminous flux* is expressed in lumen (lm).

Note 3 to entry: The CIE standard photometric observer assumes photopic vision. CIE S 017:2011 (luminous efficacy of radiation, 17-730) gives the values of K_m (photopic vision) as 683 lm·W^{-1} for ν_m = 540 × 10^{12} Hz (λ_m ≈555 nm).

[SOURCE: CIE S 017:2011, 17-738, modified — in Note 2 to entry the word "unit" has been replaced by "luminous flux is expressed in", and Note 3 to entry has been added.]

3.4.5
luminance coefficient
q_v; q
<at a surface element of a medium, in a given direction, under specified conditions of illumination> quotient of the *luminance* (3.4.3) of the surface element in the given direction divided by the *illuminance* (3.4.1) on the medium

Note 1 to entry: The luminance coefficient is given by the following formula:

$$q = \frac{L}{E}$$

where

L is the luminance in cd·m^{-2};

E is the illuminance in lx.

Note 2 to entry: In the assessment of eye protective equipment, the *luminance coefficient* is expressed in (cd·m^{-2}) lx^{-1} rather than the CIE unit of sr^{-1}, and is given by the symbol l.

Note 3 to entry: In the assessment of eye protective equipment, this is a measure of the *light* scattered by a *lens*, the *luminance* of the *light* scattered by the *lens* being expressed as a proportion of the amount of *light* falling on the *lens*. See *scattered light* (3.8.14), *wide angle scatter* (3.8.16) and *narrow angle scatter* (3.8.15).

[SOURCE: CIE S 017:2011, 17-712, modified — "divided by" has been added in the definition, the formula has been moved to Note 1 to entry and Notes 2 and 3 to entry have been added.]

3.4.6
reduced luminance coefficient
l^*
<in the assessment of eye protective equipment> *luminance coefficient* (3.4.5) corrected for the *transmittance* (3.10.1.18) of a *filter* (3.10.1.1) or *lens* (3.5.1.3)

Note 1 to entry: The *reduced luminance coefficient* is obtained by dividing the *luminance coefficient*, l, by the *luminous transmittance*, τ_v, of the *filter*, i.e. by the formula:

$$l^* = l/\tau_v$$

where

l^* is the *reduced luminance coefficient*;

l is the *luminance coefficient*;

τ_v is the *luminous transmittance*.

Note 2 to entry: Reduced luminance coefficient is expressed in (cd·m^{-2})·lx^{-1}.

3.4.7
radiant flux
radiant power
Φ_e; P
power emitted, transmitted or received in the form of radiation

Note 1 to entry: Radiant flux is expressed in watts (W).

[SOURCE: CIE S 017:2011, 17-1027, modified — the equivalent term *radiant flux* (17-1025) has been included, and the word "unit" in Note 1 to entry replaced by "*radiant flux* is expressed in".]

3.4.8
radiant energy
Q_e
time integral of the *radiant flux* (3.4.7), Φ_e, over a given duration, Δt

Note 1 to entry: Radiant energy is expressed by the formula:

$$Q_e = \int_{\Delta t} \Phi_e \cdot dt$$

Note 2 to entry: Radiant energy is expressed in J = W·s.

[SOURCE: CIE S 017:2011, 17-1019, modified — the formula has been included in Note 1 to entry and the word "unit" in Note 2 to entry has been replaced with "radiant energy is expressed in".]

3.4.9
radiant exposure
H_e
<at a point of a surface, for a given duration> quotient of the *radiant energy* (3.4.8), dQ_e, incident on an element of the surface containing the point over the given duration, by the area, dA, of that element

Note 1 to entry: Equivalent definition: time integral of the *irradiance* (3.4.2), E_e, at the given point, over the given duration, Δt

$$H_e = \frac{dQ_e}{dA} = \int_{\Delta t} E_e \cdot dt$$

Note 2 to entry: *Radiant exposure* is expressed in $J \cdot m^{-2}$ or $W \cdot s \cdot m^{-2}$.

[SOURCE: CIE S 017:2011, 17-1021, modified — the second definition has been converted into Note 1 to entry, the unit into Note 2 to entry with the addition of the words "*radiant exposure* is expressed in" and the omission of the CIE note.]

3.4.10
power density
$E(x,y)$
beam power that impinges on the area δA at the location (x, y) divided by the area δA

Note 1 to entry: *Power density* is physically equivalent to *irradiance* (3.4.2). Both are measured in watts per unit area. *Power density* is generally used to describe the distribution of radiation within a beam, whereas irradiance is generally used to describe the distribution of radiation incident upon a surface.

[SOURCE: ISO 11145:2016, 3.46, modified — "which" has been changed to "that".]

3.4.11
spectral luminous efficiency
V(*λ*)
<for photopic vision, for a *monochromatic radiation* of wavelength, *λ*> ratio of the *radiant flux* (3.4.7) at wavelength λ_m to that at wavelength *λ*, such that both produce equally intense luminous sensations under specified photometric conditions and λ_m is chosen so that the maximum value of this ratio is equal to 1

Note 1 to entry: Unit: 1 (dimensionless).

Note 2 to entry: The spectral luminous efficiency of the human eye depends on a number of factors, particularly the state of visual adaptation and the size and position of the source in the visual field. For this reason, it is possible to define a number of spectral luminous efficiency functions, for specific visual conditions.

Unless otherwise indicated, the values used for the spectral luminous efficiency in photopic vision are the values agreed internationally in 1924 by the CIE (see Reference [29]), completed by interpolation and extrapolation (ISO 23539:2005/CIE S 010:2004), and recommended by the International Committee of Weights and Measures (CIPM) in 1972.

Note 3 to entry: CIE, considering the discrepancies between the average human spectral luminous efficiency and the *V*(*λ*) function, adopted in 1990 (see CIE 86:1990) the “CIE 1988 modified 2° spectral luminous efficiency function for photopic vision”, $V_M(\lambda)$, and recommended it for applications in visual sciences.

Note 4 to entry: CIE, considering that the spectral luminous efficiency function of the human eye changes with visual angle, adopted in 2005 (see CIE 165:2005) the “CIE 10° photopic photometric observer”, $V_{10}(\lambda)$, to be used if the visual target has an angular subtense larger than 4° or is seen off axis. This standard observer is not used in the assessment of personal protective equipment.

[SOURCE: CIE S 017:2011, 17-1222, modified — Note 1 to entry has been added to explain the dimensionless unit, CIE notes 1 to 3 have been renumbered as Notes 2 to 4, the original CIE notes 4 and 5 and references to scotopic vision have been deleted, and the last sentence in Note 4 to entry has been added.]

3.4.12
candela
unit of luminous intensity of a source

Note 1 to entry: SI base unit for photometry: the *candela*, is the luminous intensity, in a given direction, of a source that emits *monochromatic radiation* of frequency 540 × 10^{12} Hz and that has a radiant intensity in that direction of 1/683 W/sr (16th General Conference of Weights and Measures, 1979).

Note 2 to entry: The *candela* is thus expressed as lumens per steradian, cd = lm·sr^{1}.

[SOURCE: CIE S 017:2011, 17-117, modified — a simpler definition has been made, the CIE definition has been moved to the Note 1 to entry, and the description of the unit has been placed in Note 2 to entry.]

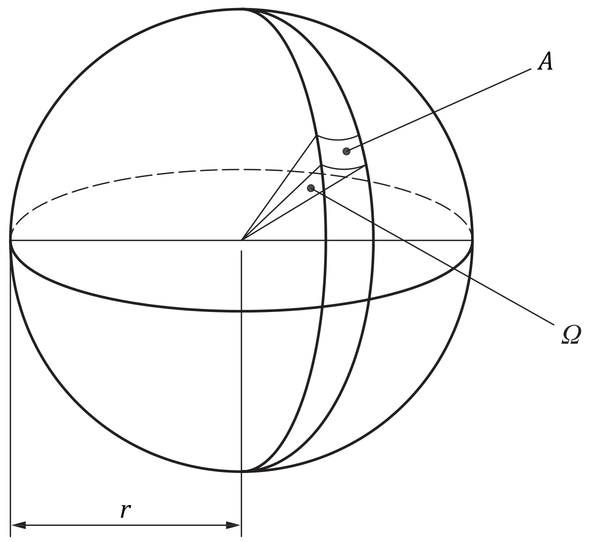
3.4.13
solid angle
Ω
<of an area subtended at a point> area intercepted on a unit sphere, centred at the point, by a cone having the given area as its base and the point as its vertex

Note 1 to entry: If an imaginary sphere is constructed with its centre at the apex of the angle, the value, *Ω*, of the *solid angle* is given by the area, *A*, enclosed by the angle on the surface of the sphere divided by the square of the sphere’s radius, *r*.

Note 2 to entry: *Solid angles* are expressed in steradians (sr).

Note 3 to entry: See Figure 1.

[SOURCE: CIE S 017:2011, 17-1201, modified — the notes to entry have been added.]



Key

Ω the *solid angle*, in steradians ($\Omega = A/r^2$)

A area of surface on the imaginary sphere

r radius of the imaginary sphere

Figure 1 — Diagram representing the derivation of the steradian

3.4.14
exposure limit value
ELV
maximum level of exposure of optical radiation to the eye or skin that is not expected to result in adverse biological effects

Note 1 to entry: These *exposure limit values* are used to determine *hazard* distances in respect to foreseeable photobiological effects.

[SOURCE: IEC/TR 62471-2:2009, 3.4, modified — the second sentence of the definition has been converted into Note 1 to entry.]

3.4.15
ocular hazard distance
OHD
distance at which the beam *irradiance* (3.4.2), radiance, or *radiant exposure* (3.4.9) equals the appropriate ocular *exposure limit value* (3.4.14)

3.4.16
skin hazard distance
distance at which the beam *irradiance* (3.4.2) or *radiant exposure* (3.4.9) equals the appropriate skin *exposure limit value* (3.4.14)

3.5 General terms

3.5.1 Types and components of eye and face protectors

3.5.1.1
protector
<for purposes of eye and *face* protection> generic term that includes all devices regarded as *eye protectors* (3.5.1.2) or *face protectors* (3.5.1.5)

Note 1 to entry: The term *protector* includes, for example, *spectacles*, *goggles*, *face shields* and *eye guards* used for eye or eye and face protection.

3.5.1.2
eye protector
personal protective equipment that is worn or held with the intention of protecting at least the region of the eye

3.5.1.3
lens
DEPRECATED: ocular
generic term for the *light* (3.2.2) transmitting part [made of *glass* (3.6.1) or *plastic* (3.6.2)] of a *protector* (3.5.1.1) that permits vision

Note 1 to entry: The word "ocular" has mostly been used in Europe, "*lens*" in many other countries. For the purposes of eye and face protection, the word "lens" includes *afocal lenses*, *corrective lenses*, *prescription lenses* and is sometimes also used, for example, in sunglasses, for tinted *lenses*, although these are generally termed *filters*.

Note 2 to entry: For the purposes of eye and face protection, the word "*lens*" includes both *lenses* covering a single eye and *lenses* covering both eyes.

Note 3 to entry: When used as an adjective in eye and face protection standards, the word "ocular" has its normal dictionary meaning, i.e. relating to the eye.

3.5.1.4
eye guard
eye shield
protector (3.5.1.1) that provides protection to the eye area

3.5.1.5
face protector
face guard
protector (3.5.1.1) that provides protection to the eyes and a substantial area of the *face* (3.9.2)

3.5.1.6
face screen
face shield
protector (3.5.1.1) that is worn directly or indirectly on the head and covers the eyes and all, or a substantial part, of the *face* (3.9.2)

Note 1 to entry: A *face screen* can be mounted by help of an adjustable or non-adjustable means of fixing onto a protective or non-protective *helmet*, or on the head, either directly or by help of an adjustable or non-adjustable means of fixing onto a support (*headband*) and/or *harness*.

Note 2 to entry: See also *visor* (3.5.1.13).

Note 3 to entry: Coverage can include parts or all of the scalp, the ears, the throat and the neck.

Note 4 to entry: The *areas to be protected* are defined in the relevant standard, and should not automatically be assumed to be the same as the areas covered.

3.5.1.7
goggle
protector (3.5.1.1) that fully encloses the orbital area and fits firmly on the *face* (3.9.2)

3.5.1.8
hand shield
protector (3.5.1.1) [with or without *filtering action* (3.10.1.2)] intended to be held in the hand to give protection to the eyes and all or part of the *face* (3.9.2)

3.5.1.9
helmet
headgear made of shock resistant material intended to protect parts of the wearer's head against a specified *hazard* (3.1.3) or *hazards*

3.5.1.10
protective mask
protector (3.5.1.1) that can be worn either directly on the head (with a support) or mounted on a protective (or non-protective) *helmet* (3.5.1.9), and that protects the eyes and all, or a substantial part, of the *face*

Note 1 to entry: Protection can also include parts or all of the scalp, the ears, the throat and the neck.

3.5.1.11
spectacles
protector (3.5.1.1) in a spectacle configuration that is supported principally on the nose and ears rather than on the head

Note 1 to entry: The front, including the bridge resting on the nose and *lenses*, can be moulded in one piece, or alternatively have an aperture into which separate *lenses* have been inserted/mounted.

Note 2 to entry: The *sides* are sometimes continued behind the head with a *headband*.

Note 3 to entry: A spectacle eye protector can have lateral protection.

3.5.1.12
side, en UK
temple, en USA
sidearm
extension of, or attachment to, the front of *spectacles* (3.5.1.11) passing towards or over the ear

Note 1 to entry: See ISO 7998 for equivalent terms in other languages.

3.5.1.13
visor
protector (3.5.1.1) covering either the eye area or both the eye area and all or parts of the *face*

Note 1 to entry: This term has variable common usage:

— it is sometimes used to mean the same as *face screen* or *face shield*;

— it is sometimes used to mean only the *lens* and its surround, if any, i.e. the part of a *face screen/shield* that provides the protection to the eyes and *face*. "The *lens* and its surround, if any", includes both those *protectors* having a single piece of transparent *plastic* material to form the eye and *face* protection, and others, e.g. for welding, that have a true *lens* (or *filter*) mounted within an opaque shield to protect the rest of the *face*;

— it is sometimes used to mean the *lens* and its surround, if any, that is mounted on a protective or non-protective *helmet*; and

— it is sometimes used to mean the *lens* and its surround, if any, in a full *face* tight- or loose-fitting respiratory protective device.

Note 2 to entry: The protective performance and the *areas to be protected* are defined in the relevant standard; the *areas to be protected* should not automatically be assumed to be the same as the areas covered.

3.5.1.14
clip-on
pair of *lenses or filters* or a one piece *lens* (3.5.1.3) or *filter* (3.10.1.1) designed to clip on over the front of or behind a pair of *spectacles* (3.5.1.11)

3.5.1.15
prescription insert
device for carrying *prescription lenses* (3.8.5) that is intended to be attached on the inside of the *protector* (3.5.1.1), between the eyes of the wearer and the protective *lens* (3.5.1.3)

3.5.1.16
mesh
lattice of protective material providing the *field of view* (3.5.2.6) and covering the *area to be protected* (3.5.1.19)

3.5.1.17
blink reflex
property of the human eyelids to close temporarily in response to, for example, exposure to a sudden very bright *light* (3.2.2)

Note 1 to entry: Not all humans have a *blink reflex* to bright *light*.

3.5.1.18
photophobia
uncomfortable sensation in or around the eye when subjected to *light* (3.2.2)

Note 1 to entry: *Photophobia* can occur with any anterior eye ailment, e.g. conjunctivitis, iritis or keratitis.

Note 2 to entry: The word "*photophobia*" literally means "fear of light".

3.5.1.19
area(s) to be protected
zone(s) of the *face* that is/are intended to be protected against the *hazard*(s) (3.1.3)

Note 1 to entry: Those zones of the appropriate *headform* (size, facial characteristics) specified by the appropriate product's requirements standard.

3.5.1.20
area(s) to be tested
zone(s) of the *protector* (3.5.1.1) that have to be tested in accordance with the appropriate product requirements standard

Note 1 to entry: Areas can be subdivided into those requiring optical testing and those requiring non-optical testing, e.g. a *face guard* might have an area 120 mm wide by 50 mm deep requiring optical testing and a much larger zone, including the *lens*, requiring testing against non-optical *hazards*.

3.5.1.21
minimum robustness
mechanical strength (3.5.1.23) of a *lens* (3.5.1.3) to resist fracture and/or deformation by a quasi-static force on its surface

3.5.1.22
static deformation
bending or deformation of a *lens* (3.5.1.3) or *filter* (3.10.1.1) through the action of a quasi-static force on its surface

Note 1 to entry: This is the deformation produced during the test for *minimum robustness* (3.5.1.21).

3.5.1.23
mechanical strength
indicator of the protective ability against mechanical *hazards* (3.1.3), greater than *minimum robustness* (3.5.1.21), of a *protector* (3.5.1.1) and its *lenses* (3.5.1.3) to resist fracture, deformation, dislodgement and/or penetration by impact

Note 1 to entry: Strengths 1, 2 and Basic are tested by a *drop ball test*, 3, C, D and E by *ballistic tests*, HM by the *high mass test*, see Table 1.

Note 2 to entry: For special cases, such as a squash ball impact test, a different classification symbol is used.

Table 1 — Scheme showing most of the various *mechanical strength* grades

Drop ball test					Ballistic test				
Sunglass									
Category	Diameter mm	Mass (minimum) g	Height m		Category	Diameter mm	Mass (minimum) g	Velocity m/s	Notes
Strength Level 1	ball 16	16	1,27		Strength level 3	ball 6	0,86	45	
Strength Level 2	ball 22	43	1,27						
Occupational									
Category	Diameter mm	Mass (minimum) g	Height m		Category	Diameter mm	Mass (minimum) g	Velocity m/s	Notes
Basic impact level	ball 25,4	66,8	1,27		Impact level C	ball 6	0,86	45	
					Impact level D	ball 6	0,86	80	
Impact level HM (High Mass)	cone	500	1,27		Impact level E	ball 6	0,86	120	
Sports									
Category	Diameter mm	Mass (minimum) g	Height m		Category	Diameter mm	Mass (minimum) g	Velocity m/s	Notes
Strength level 2	22	43	1,27		Squash	ball 40,0	24,0	40	Yellow dot
Impact level HM (High mass)	cone	500	1,27		Racquet-ball and Squash 57	ball 57,3	39,2	40	
NOTE All quantities in this table are nominal. See the applicable requirement standard for the specified tolerances.									

3.5.1.24
drop ball test
test of resistance to impact in which a ball of specified diameter and/or mass is dropped under gravity from a specified height onto the sample

3.5.1.25
high mass test
test of resistance to impact in which a cylinder with a conical tip of specified dimensions and mass is dropped under gravity from a specified height onto the sample

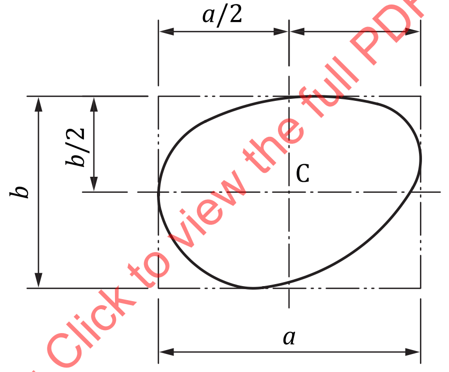
3.5.1.26
ballistic test
test of resistance to impact in which a ball of specified diameter and/or mass is projected at a specified velocity onto the sample

3.5.2 Geometrical properties of eye and *face* protection

3.5.2.1
boxed centre
intersection of the horizontal centreline and the vertical centreline of the rectangular box that circumscribes the *lens* (3.5.1.3) shape in its intended orientation

Note 1 to entry: See point C in Figure 2.

[SOURCE: ISO 8624:2011, 2.1, modified — the word “the” has been added before “vertical”, “in its intended orientation” has been added, “which” has been replaced by “that”, and Note 1 to entry has been added.]



Key

a horizontal boxed *lens* size

b vertical boxed *lens* size

C *boxed centre*

Figure 2 — Boxed centre

3.5.2.2
geometric centre
intersection of the horizontal centreline and vertical centreline of the rectangular box that circumscribes the shape of the blank or uncut *lens* (3.5.1.3)

3.5.2.3
face form angle
angle between the plane of the *eye protector* (3.5.1.2) front and the plane of the right *lens* (3.5.1.3) shape, or of the plane of the left *lens* shape

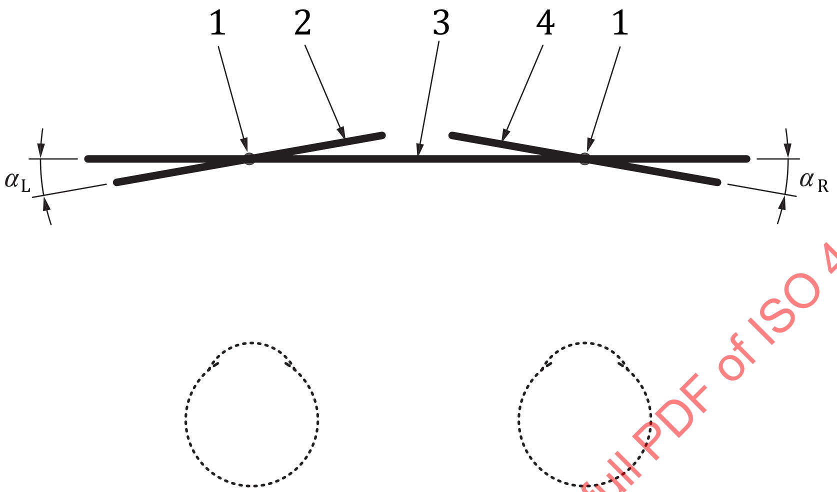
Note 1 to entry: The plane of the *eye protector* front is the plane containing the vertical centrelines of the right and left boxed *lens* shapes, and the plane of the *lens* shape is the plane tangential to the front surface of a *plano lens* at its *boxed centre*, when mounted in the *frame*.

Note 2 to entry: The right or left *face form angle* is regarded as positive if the temporal side of the right or left *lens* is closer to the head than the plane of the *eye protector* front.

Note 3 to entry: The *face form angles* are often measured and specified as the average of the right (α_R) and left (α_L) angles, but the *frame* can be adjusted so that they differ for a specific wearer; the angles should then be specified as α_R and α_L.

Note 4 to entry: See Figure 3.

[SOURCE: ISO 8624:2011, A.13, modified — the word "*spectacle*" has been changed to "*eye protector*", Note 1 to entry has been added to explain the plane of the *eye protector*, and Note 4 to entry has been added.]



Key

1 point of intersection of plane of the *eye protector* front with vertical centreline of the *lens* shape
2 plane of left *lens* shape
3 plane of *eye protector* front
4 plane of right *lens* shape
α_R right *face form angle*
α_L left *face form angle*

Figure 3 — *Face form angle* (schematic representation of the plane of the *eye protector* front and the *lens* shapes, as seen from above)

3.5.2.4
as-worn pantoscopic angle
angle in the vertical plane between the normal to the front surface of the *lens* (3.5.1.3) at its *boxed centre* (3.5.2.1) and the *line of sight* (3.9.8) of the eye when in the *primary position* (3.9.7), usually taken to be the horizontal

Note 1 to entry: The angle is regarded as positive if the lower part of the *lens* lies closer to the *face*.

[SOURCE: ISO 13666:2012, 5.18, modified — the figure and its reference have been omitted.]

3.5.2.5
field of view area
part of a *protector* (3.5.1.1), other than the *frame* (3.5.3.2), that permits vision

Note 1 to entry: This commonly applies to *mesh protectors*.

Note 2 to entry: This is the equivalent of the *lens* area in a *protector* with *lenses*.

3.5.2.6
field of view
extent of vision through the mounted *lens* (3.5.1.3) in the *as-worn position* (3.8.1) measured with reference to the entrance pupil of the stationary eye when placed on the appropriate *headform* (3.11.3)

Note 1 to entry: For the purposes of eye and face protection, the *field of view* through a *protector* is usually specified as the subtense at the *corneal apex*. The entrance pupil is optically the correct reference point for measurements of the *field of view* of the stationary eye. For the moving eye, the *centre of rotation of the eye* is the correct reference point.

Note 2 to entry: The field can be expressed in angular or linear measure, depending upon the product's requirements standard.

Note 3 to entry: The term “field of vision” is usually applied to the unaided eye, but is sometimes incorrectly used for the *field of view* though an optical appliance.

3.5.2.7
area of critical optical quality
zone [or zones for a one-piece *lens* (3.5.1.3) intended to protect both eyes] of the *lens* in which the optical properties of the *lens* are tested

Note 1 to entry: The *area of critical optical quality* can be expressed in angular or linear measure, depending upon the product's requirements standard.

3.5.2.8
field of peripheral awareness
portion of the *field of view* (3.5.2.6) that lies outside the *area of critical optical quality* (3.5.2.7)

Note 1 to entry: The *field of peripheral awareness* can be expressed in angular or linear measure, depending upon the product's requirements standard.

3.5.3 Terms relating to the non-*lens* part of *protectors*

3.5.3.1
comfort band
sweat band
accessory that covers at least the inner surface of the *headband* (3.5.3.4), (3.5.3.5) where it comes into contact with the forehead zone to improve wearer comfort

3.5.3.2
frame
part of the *protector* (3.5.1.1) or *spectacles* (3.5.1.11) to which the *lenses* (3.5.1.3) are mounted

Note 1 to entry: Components of the *frame* (to support the *lenses* on *protectors* excluding those of *spectacle*-type) can be the holders, supports, connecting elements and extension pieces.

3.5.3.3
harness
assembly that provides a means of maintaining a *face shield* (3.5.1.6) or *eye shield* (3.5.1.4) in its intended position on the head

3.5.3.4
headband
headstrap
<*goggles* and *spectacles*> part of the *protector* (3.5.1.1) that is fitted around the back of the head to hold the *protector* in its intended position

3.5.3.5
headband
<*harness*> part of the *harness* (3.5.3.3) that surrounds the head

3.5.3.6
housing
part of the *protector* (3.5.1.1) that supports the *lens* (3.5.1.3) or lens assembly

Note 1 to entry: A lens assembly is where the eye is protected by more than a single *lens*, e.g. *welding filter* provided with either a *cover plate* and/or *backing plate*.

3.5.3.7
browguard
face shield (3.5.1.6) or *eye shield* (3.5.1.4) *lens* (3.5.1.3) holder designed to protect the forehead region, often secured by a *harness* (3.5.3.3)

3.5.3.8
lateral protection
part of a *protector* (3.5.1.1) that is intended to protect the eye against *hazards* (3.1.3) from the side

3.5.3.9
side shield
part of a *spectacle* (3.5.1.11) *frame* (3.5.3.2) that is intended to provide *lateral protection* (3.5.3.8)

3.5.4 Welding protectors[2)]

3.5.4.1
welding protector
device that provides protection to the wearer against harmful optical radiation and other specific *risks* (3.1.4) generated by welding or allied processes

Note 1 to entry: Welding protectors include welding goggles, welding face shields, welding hand shields, welding spectacles and welding helmets.

3.5.4.2
welding goggle
welding protector (3.5.4.1), usually held in position by a *headband* (3.5.3.5), enclosing the orbital region, into which radiation arising from the welding operation can penetrate only through the *filter*(s) (3.10.1.1) and, if provided, *cover plate*(s) (3.5.5.2)

3.5.4.3
welding face shield
face shield (3.5.1.6) with *filtering action* (3.10.1.2) suitable for welding protection

3.5.4.4
welding hand shield
hand shield (3.5.1.8) with *filtering action* (3.10.1.2) suitable for welding protection

3.5.4.5
welding spectacles
spectacles (3.5.1.11), with *lateral protection* (3.5.3.8), fitted with suitable *filters* (3.10.1.1) in front of the eyes to give them protection

Note 1 to entry: *Welding spectacles are* usually held in position with *sides* or with an additional *headband* fitting.

3.5.4.6
protective helmet-mounted welding face shield
welding face shield (3.5.4.3), mounted on a compatible protective *helmet*

3.5.4.7
welding helmet
welding face shield (3.5.4.3), mounted on or integrated into protective or non-protective headgear

Note 1 to entry: A *welding helmet* might also incorporate respiratory protection.

2) Terms relating to the filtering properties of *welding filters* are given in 3.10.3.

3.5.5 Secondary lenses for welding protectors

3.5.5.1
back plate
backing plate
lens (3.5.1.3) placed behind a *welding filter* (3.10.3.1) used mainly to protect the wearer from flying particles or to protect the back surface of the *welding filter* from scratches

Note 1 to entry: *Backing plates* are placed between the *welding filter* and the wearer's *face.*

3.5.5.2
cover plate
lens (3.5.1.3) generally placed in front of a *welding filter* (3.10.3.1) used mainly to protect the *welding filter* from hot particles, splashes of hot liquid or molten metal and scratches

Note 1 to entry: Cover plates are placed between the *welding filter* and the workpiece.

Note 2 to entry: The term "*cover plate*" is sometimes also used to mean a *backing plate* where it is intended to protect the *welding filter* from scratches.

3.5.5.3
protective plate
DEPRECATED: safety plate
generally untinted *lens* (3.5.1.3) that can be placed either in front of or behind the *welding filter* (3.10.3.1) to protect the wearer and/or the *welding filter* from *harm* (3.1.2) and/or damage caused by, for example, flying particles, hot particles and splashes of molten metal

Note 1 to entry: A *protective plate* can also protect the *welding filter* from scratches.

Note 2 to entry: Depending on their exact intended purpose, these *protective plates* are placed either between the *welding filter* and the workpiece or between the *welding filter* and the *face*. It is not necessarily only the plate behind the *welding filter* that protects the wearer from flying particles. For example, many *automatic welding filters* have an untinted *lens* placed in front of the *welding filter* with the function of being the main impact protection.

Note 3 to entry: In practice, the terms "*protective plate*", "*cover plate*", "safety lens" or "protection plate" are often treated as having the same general meaning.

3.5.6 Mesh protectors

3.5.6.1
mesh protector
protector (3.5.1.1) where the *field of view area* (3.5.2.5) is made of *mesh* (3.5.1.16) instead of being a *lens* (3.5.1.3) or *lenses*

Note 1 to entry: *Mesh protectors* include *face shields, goggles, spectacles* and *eye guards* using *mesh* instead of *lenses*.

3.5.6.2
mesh face shield
mesh protector (3.5.6.1) that is worn directly or indirectly on the head and covers the eyes and all, or a substantial part, of the *face* (3.9.2)

3.5.6.3
mesh goggle
mesh protector (3.5.6.1) that fully encloses the orbital area and fits firmly on the *face* (3.9.2)

3.5.6.4
mesh spectacles
mesh protector (3.5.6.1) in a *spectacle* (3.5.1.11) configuration, with or without *lateral protection* (3.5.3.8), that is supported principally on the nose and ears rather than on the head

3.5.6.5
mesh eye guard
mesh protector (3.5.6.1) that provides protection to the eye area

3.5.6.6
mesh visor
part of a *mesh face shield* (3.5.6.2) covering the eye area and all or parts of the *face* (3.9.2) that can be removed from the *frame* (3.5.3.2) and be replaced

3.5.6.7
additional lens
lens (3.5.1.3) used in front of or behind the *mesh* (3.5.1.16) [or *mesh field of view area* (3.5.2.5)] to provide supplementary protection

3.5.6.8
alternative lens
lens (3.5.1.3) replacing the *mesh* (3.5.1.16) [or *mesh field of view area* (3.5.2.5)] to provide specific protection

3.5.6.9
mesh face shield with additional or alternative lens(es)
mesh face shield (3.5.6.2) that is fitted with one or two *additional lenses* (3.5.6.7) or *alternative lenses* (3.5.6.8)

3.5.7 Protection from short circuit electric arc

3.5.7.1
arc protection class
category of arc thermal protection of material and protective clothing tested in the box test (class 1 or class 2)

Note 1 to entry: The *arc protection class* is characterized by the test energy level of arc exposure (arc energy and incident energy).

Note 2 to entry: For the purposes of this document, the product is an *eye protector*.

[SOURCE: IEC 61482-1-2:2014, 3.1.5, modified — the IEC note 2 to entry has been deleted and replaced.]

3.5.7.2
arc rating
<*electric arc* testing> numerical value attributed to a product that describes its protective performance against exposure, when tested in an open-arc test

Note 1 to entry: The *arc rating* can be the *arc thermal performance value* (ATPV), the breakopen threshold energy (EBT) or the incident energy limit (ELIM).

Note 2 to entry: For the purpose of this document, the product is an *eye protector*.

Note 3 to entry: The *arc rating* values are expressed in kJ/m^2 (cal/cm^2).

[SOURCE: IEC 61482-1-1:2009, 3.1.5, modified — the word “a” has been inserted before the word “product” and the comma after “product” has been deleted in the definition and new Note 2 to entry has been added.]

3.5.7.3
arc thermal performance value
ATPV
<*electric arc* testing> numerical value of incident energy attributed to a product that describes its thermal properties of attenuating (reducing) a heat flux generated by an *electric arc* (3.3.1)

Note 1 to entry: The ATPV of a material or material assembly is calculated using logistic regression analysis applied to the data points obtained from testing a set of test specimens. It is the value of incident energy at which the heat transfer through the test specimens is enough to reach the Stoll criteria with 50 % probability.

Note 2 to entry: The ATPV attributed to a garment or garment assembly is either equal to or lower than the ATPV of the material or material assembly, of which it is made, depending on whether tested specimen(s) fulfil also additional visual design and performance assessment criteria.

Note 3 to entry: ATPV is expressed in kJ/m^2 (cal/cm^2).

[SOURCE: IEC 61482-1-1:2009, 3.1.6, modified — the word “a” has been inserted before the word “product” in the definition.]

3.5.7.4
hood
head covering that completely covers the head and neck including the shoulder area and provides 360° protection

[SOURCE: ISO 23269-1:2008 3.5, modified — "which" has been changed to "that", and "and may cover portions of the shoulders" has been changed to "including the shoulder area and provides 360° protection".]

3.5.7.5
balaclava hood
one-piece garment designed to fit closely over the entire head and to extend downwards to cover the neck

Note 1 to entry: A *balaclava hood* is designed to leave at least the area of the eyes and at most the area of the eyes, nose and mouth uncovered.

[SOURCE: ISO 14460:1999, 3.9, modified — Note 1 to entry has been added.]

3.6 Optical materials

3.6.1
glass
mineral glass
material formed by fusion of inorganic substances, cooled down and solidified without crystallization

3.6.2
plastic
material which contains as an essential ingredient a high molecular weight polymer and which, at some stage in its processing into finished products, can be shaped by flow

Note 1 to entry: Elastomeric materials, which are also shaped by flow, are not considered to be *plastics*.

Note 2 to entry: In some countries, particularly in the United Kingdom, the term “*plastics*” is used as the singular form as well as the plural form.

[SOURCE: ISO 472:2013, 2.702, modified — the words “molecular weight” have been added to the definition.]

3.6.3
photochromic material
material that reversibly changes its *luminous transmittance* (3.10.1.32) depending upon the irradiance and wavelength of the radiation falling upon it

Note 1 to entry: The material is designed to react to wavelengths within the solar spectral range, chiefly 300 nm to 450 nm.

Note 2 to entry: Transmittance properties are usually affected by ambient temperature.

[SOURCE: ISO 13666:2018, 3.3.5, modified — the word “characteristics” has been deleted, and “intensity” has been changed to “irradiance”.]

3.6.4
thermal conductivity
material property indicating the amount of heat transmitted perpendicularly through a measured surface area at a given temperature gradient

3.7 Optical properties of components and *lenses*[3)]

3.7.1
dioptre
D
unit of focusing *power* (3.7.9) of a *lens* (3.5.1.3) or surface, or of the vergence of a wavefront, when distances are expressed in metres

Note 1 to entry: When in air, the *power* of a *lens* is given by the reciprocal of the focal length, while vergence, in general, is given by the refractive index divided by the radius of curvature of the wavefront.

Note 2 to entry: Commonly used abbreviations for *dioptre* are D and dpt.

Note 3 to entry: *Dioptres* are expressed in reciprocal metres (m^{-1}).

[SOURCE: ISO 13666:2018, 3.10.1]

3.7.2
spherical power
spherical effect
S
value of the back vertex *power* (3.7.9) of a *spherical power* (3.7.2) *lens* (3.5.1.3) or the back vertex *power* in one of the two *principal meridians* (3.7.3) of an *astigmatic power* (3.7.4) *lens*, depending on the *principal meridian* chosen for reference

Note 1 to entry: *Spherical power* is expressed in D or dpt, or in reciprocal metres (m^{-1}).

[SOURCE: ISO 13666:2018, 3.12.2, modified — Note 1 to entry has been added.]

3.7.3
principal meridians
two mutually perpendicular meridians of an *astigmatic power* (3.7.4) *lens* (3.5.1.3) that are parallel to the two line foci

[SOURCE: ISO 13666:2018, 3.13.2, modified — “one of” at the beginning has been deleted so that this definition is for the two meridians, not just a single *principal meridian*.]

3) The word "lens" is not always italicized in this subclause because the term and definition apply to lenses in general, not specifically to *lenses* in *eye protectors*.

3.7.4
cylindrical power
astigmatic power
C
difference between the back vertex *powers* (3.7.9) in the two *principal meridians* (3.7.3)

Note 1 to entry: *Astigmatic power* is expressed in D or dpt, or in reciprocal metres (m^{-1}).

3.7.5
focal power
general term comprising the *spherical power* (3.7.2) and *cylindrical power* (3.7.4) of a *lens* (3.5.1.3)

Note 1 to entry: *Focal power* is expressed in D and dpt, or in reciprocal metres (m^{-1}).

[SOURCE: ISO 13666:2018, 3.10.2, modified — "spherical and cylindrical *vertex powers*" has been replaced by *spherical power* and *cylindrical power*" and Note 1 to entry has been added.]

3.7.6
focus
focal point
point on the *optical axis* (3.7.10) of a lens to which rays that are initially parallel and close to the *optical axis* of the lens converge, or appear to diverge from, after refraction by the lens

Note 1 to entry: Converging or positive powered lens: if a beam of rays parallel to the *optical axis* is incident on a converging or positive powered lens, they will meet at the *focus* behind the lens after refraction.

Note 2 to entry: Diverging or negative powered lens: if a beam of rays parallel to the *optical axis* is incident on a diverging or negative powered lens, they will appear to diverge from a *focus* in front of the lens after refraction.

Note 3 to entry: This term is not applicable to *afocal lenses*.

3.7.7
focal length
distance between a lens and its corresponding *focus* (3.7.6)

Note 1 to entry: The equivalent *focal length* is measured between the principal plane of a lens and its corresponding *focus*, the vertex *focal length* between the front or back vertex of the lens and its corresponding *focus*.

3.7.8
refractive power
property of lenses to change the curvature of the wavefront passing through them

Note 1 to entry: The unit of *refractive power* of lenses and refractive or reflective surfaces is the *dioptre*.

3.7.9
power
reciprocal of the paraxial *focal length* (3.7.7)

3.7.10
optical axis
straight line joining the centres of curvature of both surfaces of a lens

Note 1 to entry: This line is normal to both optical surfaces so *light* can pass along it undeviated.

Note 2 to entry: For lenses with strong *prismatic power*, the *optical axis* can lie outside the area of the lens.

Note 3 to entry: Power-variation lenses do not have a true *optical axis*.

[SOURCE: ISO 13666:2018, 3.1.8]

3.7.11
plane mirror
plane reflector
reflecting surface that is completely flat

3.7.12
prismatic power
magnitude of the change in direction imposed on a ray of *light* (3.2.2) as a result of refraction

Note 1 to entry: The *prismatic power* is equal to 100 tanδ, where δ is the angle of deviation.

Note 2 to entry: *Prismatic power* is expressed in prism dioptres, abbreviated to Δ or cm/m.

Note 3 to entry: A *prismatic deviation* can be produced by *prismatic power* in the *lens* itself and/or by the position and orientation of the *light* passing through the *lens* relative to its *optical axis*.

Note 4 to entry: Adapted from ISO 13666:2018, 3.11.8, 3.11.9 and 3.11.10. The three terms have been merged.

3.7.13
base setting
direction indicated by the meridian of deviation of the refracted beam after passing through a *lens* (3.5.1.3) or prism corresponding to the direction of the line from the apex to the base in a principal section of a prism

Note 1 to entry: Based on definitions of ISO 13666:2018, 3.11.3. 3.11.4, 3.11.6 and 3.11.7.

3.7.14
base in
base setting (3.7.13) in which the prism *base setting*, relative to the eye concerned, is horizontal and towards the nose

Note 1 to entry: In the test method in ISO 18526-1, the beams cross each other.

3.7.15
base out
base setting (3.7.13) in which the prism *base setting*, relative to the eye concerned, is horizontal and away from the nose

Note 1 to entry: In the test method in ISO 18526-1, the beams do not cross.

3.7.16
base up
base setting (3.7.13) in which the prism *base setting* is vertical and up

3.7.17
base down
base setting (3.7.13) in which the prism *base setting* is vertical and down

3.7.18
prism imbalance
value of the algebraic difference of any unwanted prismatic effect between the right and left *lenses* (3.5.1.3) of a *protector* (3.5.1.1), measured at the *reference points* [(3.8.7), (3.8.8) or (3.8.9)]

Note 1 to entry: *Prism imbalance* is measured as a horizontal and a vertical imbalance.

Note 2 to entry: For horizontal components (i.e. in or out), add together similar base directions and subtract opposite base directions to determine the horizontal *prism imbalance*; for vertical components (i.e. up or down), subtract similar base directions and add opposite base directions to determine the vertical *prism imbalance*.

Note 3 to entry: For example, a pair of *spectacles* having 0,5 Δ *base in* right and 0,2 Δ *base out* left has a *prism imbalance* of 0,3 Δ horizontally.

[SOURCE: ISO 13666:2018, 3.11.13, modified — "of a pair of spectacles" has been replaced by "of a protector", and "at the centration point" has been replaced by "at the *reference points*"; Note 2 to entry is based on ISO 21987:2017, 6.6.]

3.7.19
spatial deviation
visual distortions resulting from localized variation in the *focal power* (3.7.5) and/or *prismatic power* (3.7.12) of a *lens* (3.5.1.3) caused by irregularities in its surface or refractive index

Note 1 to entry: These distortions can give spatial disturbance, distortion and binocular disparities which are more pronounced in dynamic visual activities.

3.7.20
anti-reflective coating
anti-reflection coating
coating on the surface of a lens intended to reduce *light* (3.2.2) reflected from its surfaces

Note 1 to entry: Anti-reflective coatings are generally mono- or multi-layer vacuum coatings that use interference to reduce the originally reflected radiation and, therefore, increase *transmittance*.

[SOURCE: ISO 13666:2018, 3.18.3, modified — Note 1 to entry has been replaced by the new note to entry.]

3.7.21
achromatic lens
lens consisting of a system of optical elements in which the images for two wavelengths, e.g. for the colours red and blue, are positioned at the same point on the *optical axis* (3.7.10) of the lens

Note 1 to entry: The system consists of a convex (converging) lens or lenses and a concave (diverging) lens or lenses made of materials having different optical properties.

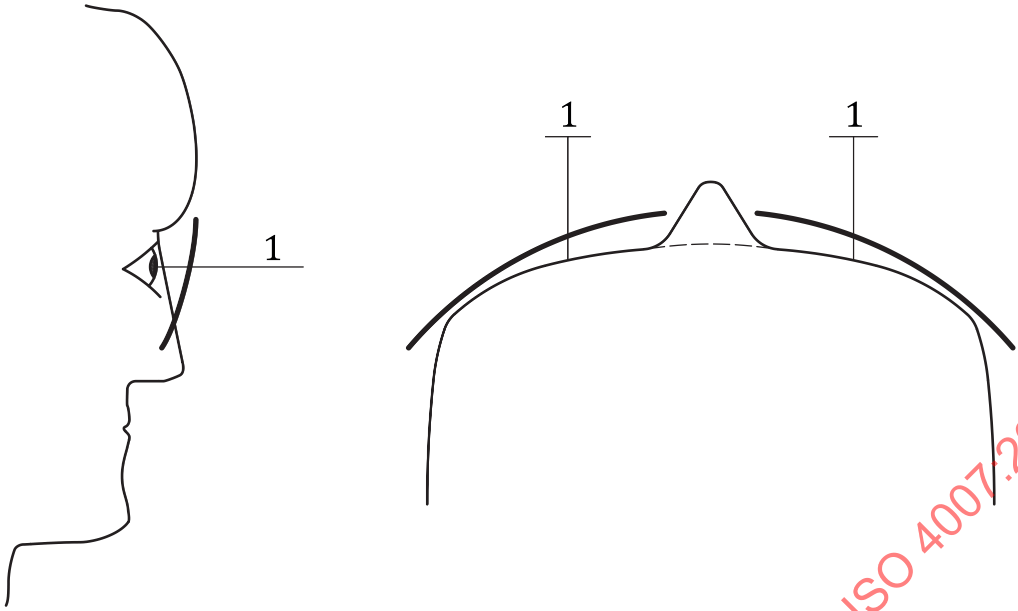
3.7.22
condenser
optical element that collects as large a *solid angle* (3.4.13) of *light* (3.2.2) as possible from a source and focuses it on the required object

3.8 Optical properties of *lenses*, excluding *transmittance*

3.8.1
as-worn position
position and orientation of the *protector* (3.5.1.1) relative to the eyes and *face* (3.9.2) during use

Note 1 to entry: For testing purposes, it is assumed that the *protector* adopts the *as-worn position* when placed on the appropriate *headform* and adjusted for use. In the absence of any specific instructions, the default *headform* for adults is 1-M.

Note 2 to entry: See Figure 4.



Key

1 line of sight

Figure 4 — As-worn position

3.8.2
corrective effect
optical power of a *lens* (3.5.1.3) with a *focal power* (3.7.5) or *prismatic power* (3.7.12) not intended to be equal to zero, stated as the back vertex *power* (3.7.9) in the assumed *spectacle* plane

Note 1 to entry: In a wrap-round *protector* (i.e. one with significant *face form angle*), the individual *lenses* might need to incorporate *prismatic power* to cancel that induced by the *as-worn position*.

3.8.3
plano lens
afocal lens
non-corrective lens
lens (3.5.1.3) without intended *focal power* (3.7.5), with either two plane surfaces or two curved surfaces, one of which is convex and the other concave so that their focal effects cancel out

Note 1 to entry: A *plano lens* can have *prismatic power* to compensate for that induced by orientation in the *as-worn position*.

3.8.4
corrective lens
DEPRECATED: corrective ocular
lens (3.5.1.3) intended to correct the wearer's refractive error or binocular imbalance

Note 1 to entry: *Corrective lenses* include ready-to-wear *corrective lenses* that are mass-produced and *prescription* lenses.

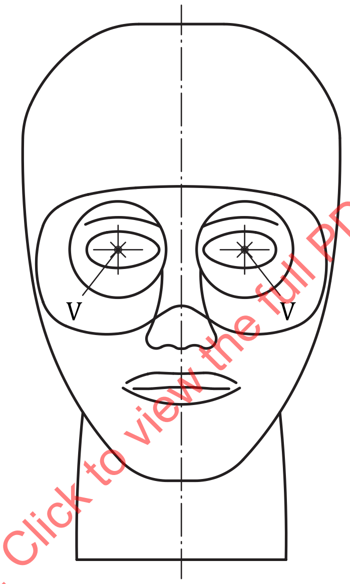
3.8.5
prescription lens
DEPRECATED: prescription ocular
corrective lens (3.8.4) dispensed following a prescription from a registered or authorized practitioner for a named individual

3.8.6
corresponding points
points on the *lens*(*es*) (3.5.1.3) in front of the right and left eyes positioned at an equal distance in the same direction from the *reference point* [(3.8.7), (3.8.8) or (3.8.9)] for each eye

Note 1 to entry: For horizontal distances, this means, for example, both to the right not both towards the nose.

3.8.7
reference point
visual centre
<for testing mounted lenses> points on each *lens* (3.5.1.3) corresponding to the intersection of the horizontal and vertical planes through the pupils of the appropriate *headform* (3.11.3) when the *protector* (3.5.1.1) is correctly fitted on it

Note 1 to entry: See Figure 5.



Key
V reference points (for testing)

Figure 5 — Reference points for mounted lenses

3.8.8
reference point
visual centre
<for testing unmounted lens covering one eye> point on the *lens* (3.5.1.3) specified by the manufacturer as the *design reference point* (3.8.10) and at the specified orientation relative to the test instrument's *optical axis* (3.7.10)

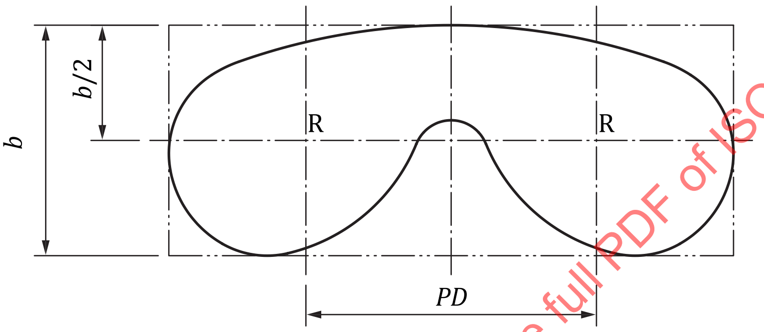
Note 1 to entry: In the absence of any specific instructions, the unmounted *lens* should be tested at its *boxed centre* and normal to its surface.

Note 2 to entry: The values for the *focal power* and *prismatic power* measured normal to the surface might differ from those measured at the specified orientation relative to the eye's *line of sight* because the angle of incidence of the ray path through the *lens* might not be the same.

3.8.9
reference point
visual centre
<for testing unmounted lens covering both eyes> points on the *lens* (3.5.1.3) specified by the manufacturer as the *design reference points* (3.8.10) and at the specified orientation relative to the test instrument's *optical axis* (3.7.10)

Note 1 to entry: In the absence of any specific instructions, the reference test points, R, are on a line equidistant from the tangents to the bottom and top of the *lens*, and situated symmetrically, one on either side of the vertical line bisecting the *lens*. They are separated by the default *interpupillary distance* of 64 mm for *protectors* intended to be used by adults, and by 54 mm for *protectors* intended to be used by persons with small heads (see Figure 6).

Note 2 to entry: The values for the *focal power* and *prismatic power* measured normal to the surface might differ from those measured at the specified orientation relative to the eye's *line of sight* because the angle of incidence of the ray path through the *lens* might not be the same.



Key

b distance between the tangents to the top and bottom of the *lens*

PD specified *interpupillary distance*

R reference points (for testing)

Figure 6 — Reference points for unmounted *lenses* intended to cover both eyes

3.8.10
design reference point
point stipulated by the manufacturer, on the front surface of the *lens* (3.5.1.3), at which the design specifications apply

Note 1 to entry: The specifications might not comply if the *lens* is not held in the *as-worn position*, e.g. when it incorporates a prism to compensate for *face form angle*.

[SOURCE: ISO 13666:2018, 3.2.16, modified — the words “on the finished surface of a blank or” and “finished” and the examples have been deleted.]

3.8.11
visual point
point of intersection of the *line of sight* (3.9.8) with the back surface of a *lens* (3.5.1.3)

[SOURCE: ISO 13666:2018, 3.2.27.]

3.8.12
laminated lens
composite lens
composite of at least two layers of significant thickness bonded together

Note 1 to entry: A *lens* with a coating such as a hard coating or *anti-reflective coating* is not considered to be a *laminated lens*.

3.8.13
multiple glazed protector
protector (3.5.1.1) having two or more *lenses* (3.5.1.3) or *filters* (3.10.1.1) separated from each other by an air gap

3.8.14
scattered light
portion of the spatial distribution of a beam of radiation that is deviated in many directions from its expected direction of travel by a surface or by a medium

Note 1 to entry: *Light* can be scattered in a forward direction or reflected in a backward direction.

Note 2 to entry: *Scattered light* can be caused by imperfections such as cloudiness in, or surface scratches on, the *lens*.

3.8.15
narrow angle scatter
DEPRECATED: diffusion of light
forward *scattered light* (3.8.14) that deviates within a cone, with apex at the point of incidence and subtending less than 2,5° from the expected direction of propagation

Note 1 to entry: The typical apparatus for measuring *narrow angle scatter* collects radiation scattered between 1,5° and 2,0° from the expected direction of propagation.

Note 2 to entry: Measurements of *narrow angle scatter* are expressed as the *reduced luminance coefficient*, *l**.

3.8.16
wide angle scatter
haze
forward *scattered light* (3.8.14) that deviates through angles of more than 2,5° from the expected direction of propagation

Note 1 to entry: This is often measured with a hazemeter.

Note 2 to entry: Measurements are usually expressed as a percentage of the total (regularly and scattered) transmitted *light*.

3.9 Wearer characteristics

3.9.1
interpupillary distance
distance between pupils
PD
distance between the centres of the pupils when the eyes are fixating an object at an infinite distance in the straight ahead position

Note 1 to entry: The *interpupillary distance* is expressed in millimetres.

Note 2 to entry: For *lenses* without *corrective effect*, the *interpupillary distance* is that of the *headform* chosen for test, as specified in the appropriate product standard. The 1-M *headform* that is used in default has a PD of 64 mm.

[SOURCE: ISO 13666:2012, 5.29, modified — notes to entry have been added.]

3.9.2
face
front of the head from the chin to the forehead, including the skin and the muscles and structures of the forehead, eyes, nose, oral cavity, cheeks and jaws, but not the neck

3.9.3
pupil diameter
diameter of the pupil (aperture) in the iris of the human eye

Note 1 to entry: For protection against *laser radiation*, a *pupil diameter* of 7 mm is always assumed.

3.9.4
corneal apex
when in the *primary position* (3.9.7), the most anterior part of the eye

Note 1 to entry: This is approximately the centre of the cornea.

Note 2 to entry: This is the *reference point for testing* for peripheral *fields of view*.

3.9.5
entrance pupil centre
optically, the image of the centre of the eye's real pupil formed by the cornea

3.9.6
centre of rotation of the eye
approximately the centre of curvature of the posterior sclera

Note 1 to entry: For testing purposes, this is taken as a point 13,5 mm behind the *corneal apex*.

3.9.7
primary position
position of the eye relative to the head looking straight ahead at a distant object at eye level

[SOURCE: ISO 13666:2012, 5.31, modified — the word “distant” has been inserted.]

3.9.8
line of sight, en US
visual axis, en UK
ray path from the point of interest (i.e. point of fixation) in object space to the centre of the entrance pupil of the eye and its continuation in image space from the centre of the exit pupil to the retinal point of fixation (generally the foveola)

Note 1 to entry: These two parts of the ray path are distinct and separate segments.

[SOURCE: ISO 24157:2008, 3.1, modified — the word “line” has been changed to ray path, (i.e. point of fixation) and “its continuation in image space”, Note 1 to entry has been added, and the word “continuing” has been deleted.]

3.10 Filters, absorption, transmission and reflection

3.10.1 General terms

3.10.1.1
filter
lens (3.5.1.3) intended to protect the eye from incident radiation by attenuating that radiation, generally within a given wavelength range

Note 1 to entry: *Attenuation* can be by *reflection* and/or *absorption*; it might be neutral (i.e. relatively uniform) or selective (i.e. coloured) across the wavelength range of *optical radiation*, and might be polarizing.

Note 2 to entry: A notch *filter*, usually made by multi-layer interference coating, is substantially neutral but has a pronounced *absorption* over a narrow bandwidth of wavelengths in order to absorb radiation from, for example, an LED or laser source.

Note 3 to entry: Where the principal protective function of the *lens* is its property to attenuate *optical radiation*, the word “*filter*” is frequently used as a synonym for *lens*.

3.10.1.2
filtering action
property of an optical *filter* (3.10.1.1) to reduce the transmitted *optical radiation* (3.2.1) by *absorption* (3.10.1.16) or *reflection* (3.10.1.19), or both

Note 1 to entry: See also *absorption* (3.10.1.16).

3.10.1.3
scale number
number indicating the *transmittance* (3.10.1.18) [and *absorption* (3.10.1.16)] characteristics of a *filter* (3.10.1.1), consisting of a *code number* or *letter* (3.10.1.4) and a *shade number* (3.10.1.5)

3.10.1.4
code number
code letter
part of the *scale number* (3.10.1.3) indicating the type of *filter* (3.10.1.1)

Note 1 to entry: The type of *filter* shows, for example, its purpose of use or spectral *absorption* properties.

Note 2 to entry: See Table 2 for examples of typical *code letters* relating to *filter* properties.

Table 2 — Typical *code letters* relating to *filter* properties

Code letter	Filter properties
F	*Sunglare filter* for occupational use providing UV protection
FI	*Sunglare filter* for occupational use providing both UV and IR protection
I	*Infrared protective filter*; the recognition of signal lights (and colours in general) is possibly affected
IC	*Infrared protective filter* satisfying colour recognition requirements
IR	*Infrared protective filter* with enhanced infrared reflection
IRC	*Infrared protective filter* with enhanced infrared reflection satisfying colour recognition requirements
U	*Ultraviolet protective filter*; the recognition of signal lights (and colours in general) is possibly affected
UC	*Ultraviolet protective filter* satisfying colour recognition requirements
W	*Welding filter*
WC	*Welding filter* satisfying colour recognition requirements
WRC	*Welding filter* with enhanced infrared reflection satisfying colour recognition requirements

Note 3 to entry: See also *scale number* and *shade number*.

Note 4 to entry: See ISO16321-1:—, Table 14 for details of the *code letter* or *code number* for other *eye protector* properties.

3.10.1.5
shade number
number indicating the darkness or *attenuation* (3.10.1.17) of *luminous transmittance* (3.10.1.32) of a *filter* (3.10.1.1)

Note 1 to entry: This is defined by the following formula:

$$N = 1 - \left(\frac{7}{3}\right)\log_{10}\left(\tau_{\mathrm{v}}\right)$$

where τ_{v} is the *luminous transmittance*.

Note 2 to entry: The eye works on a logarithmic scale of brightness, hence equal steps of *shade number* roughly equate to equal steps of brightness.

Note 3 to entry: See also *scale number* (3.10.1.3) and *code number* (3.10.1.4).

3.10.1.6
gradient-tinted filter
filter (3.10.1.1) with a defined *transmittance* (3.10.1.18) and/or colour change within the full size of the *filter* (generally in the vertical direction)

3.10.1.7
linear gradient-tinted filter
gradient-tinted filter (3.10.1.6) in which the change in *transmittance* (3.10.1.18) or colour is in a single linear direction

3.10.1.8
radial gradient-tinted filter
gradient-tinted filter (3.10.1.6) in which the change in *transmittance* (3.10.1.18) or colour radiates from a single point, usually the *reference point* of the *filter* (3.10.1.1)

3.10.1.9
sunglare filter
sunglass filter
filter (3.10.1.1) intended to reduce solar glare and to reduce solar *ultraviolet radiation* (3.2.3) to a safe level

Note 1 to entry: *Sunglare filters* can additionally attenuate *infrared radiation*.

Note 2 to entry: *Sunglare filters* are divided into those for occupational use, to which ISO 16321-1 applies, and those for general and sports use, to which other standards apply.

3.10.1.10
half-width
full width at half maximum
FWHM
difference between the two values of the independent variable for which the dependent variable has half its maximum value (for a function which has a maximum and falls off rapidly on either side of the maximum)

Note 1 to entry: For an optical *filter*, the difference between the wavelength values (*half-width* wavelengths) in the *spectral transmittance* (or *absorptance*) curve at which the *spectral transmittance* (or *absorptance*) has risen to half its peak value and the wavelength at which it has fallen to half the peak value.

Note 2 to entry: The spectral *half-width* is also referred to as spectral bandwidth.

3.10.1.11
induced transmission
Q-switch effect
saturable absorption
transient photobleaching
temporary increase in *spectral transmittance* (3.10.1.22) of the *filter* (3.10.1.1) caused by a high pulse power *laser beam* (3.3.14), e.g. a picosecond or femtosecond *laser beam*

Note 1 to entry: The process is reversible; the low level transmission is not affected.

3.10.1.12
ultraviolet protective filter
ultraviolet filter
UV protective filter
UV filter
filter (3.10.1.1) designed to protect against *ultraviolet radiation* (3.2.3) from solar and artificial ultraviolet sources

Note 1 to entry: Such *filters* can absorb in the visible and infrared spectrum.

3.10.1.13
infrared protective filter
infrared filter
IR protective filter
IR filter
filter (3.10.1.1) designed to protect against *infrared radiation* (3.2.4) from solar and artificial infrared sources

Note 1 to entry: Such *filters* can absorb in the visible and ultraviolet spectrum.

3.10.1.14
interference filter
filter (3.10.1.1) consisting of a *glass* (3.6.1) or *plastic* (3.6.2) substrate having a coating that uses the phenomenon of interference to transmit or reflect radiation in a chosen spectral range, the unwanted radiation being reflected or transmitted respectively

Note 1 to entry: Such *filters* can be broad or narrow band, and usually have high *transmittance* or *reflectance* for the chosen range.

3.10.1.15
absorptance
α
ratio of the absorbed *radiant flux* (3.4.7) or *luminous flux* (3.4.4) to the incident flux under specified conditions

Note 1 to entry: Unit: 1 (dimensionless).

Note 2 to entry: Practically, *absorptance* equals 1 minus the sum of *transmittance* and *reflectance*.

Note 3 to entry: Some manufacturers use the term *absorption* and specify the value of the *absorption* as the difference 1 minus the *transmittance*.

Note 4 to entry: Absorptance can be expressed as a percentage. In this document, it is expressed as a value with a maximum of 1,0.

[SOURCE: CIE S 017:2011, 17-5, modified — (dimensionless) has been added to Note 1 to entry, and Notes 2 and 3 to entry have been added.]

3.10.1.16
absorption
process by which *radiant energy* (3.4.8) is converted to a different form of energy by interaction with matter

Note 1 to entry: See also *absorptance* (3.10.1.15).

[SOURCE: CIE S 017:2011, 17-6, modified — Note 1 to entry has been added.]

3.10.1.17
attenuation
decrease in the *irradiance* (3.4.2) or *radiant exposure* (3.4.9) as *optical radiation* (3.2.1) passes through an absorbing or scattering medium

3.10.1.18
transmittance
τ
<incidence radiation of given spectral composition, *polarization* and geometric distribution> ratio of the *radiant flux* (3.4.7) or *luminous flux* (3.4.4) transmitted by the material to the incident flux in the given conditions

Note 1 to entry: *Transmittance*, τ, is the sum of regular *transmittance*, τ_r, and diffuse *transmittance*, τ_d: $\tau = \tau_r + \tau_d$.

Note 2 to entry: See also *spectral transmittance* (3.10.1.22) and *luminous transmittance* (3.10.1.32).

Note 3 to entry: Transmittance can be expressed as a percentage. In this document, it is expressed as a value with a maximum of 1,0.

[SOURCE: CIE S 017:2011, 17-1337, modified — the word “transmitted” has been moved to after *luminous flux*, and the phrase “by the material” and Note 2 to entry have been added.]

3.10.1.19
reflection
process by which radiation is returned by a surface or medium, without change of frequency of its monochromatic components

Note 1 to entry: Part of the radiation falling on a medium is reflected at the surface of the medium (surface *reflection*); another part can be scattered back from the interior of the medium (volume *reflection*).

Note 2 to entry: Surface *reflection* can be a combination of specular (regular) and scattered (diffuse) *reflection*.

[SOURCE: CIE S 017:2011, 17-1065, modified — the second CIE note discussing the Doppler effect has been omitted and Note 2 to entry has been added.]

3.10.1.20
reflectance
ρ
<incident radiation of given spectral composition, *polarization* (3.10.2.1) and geometrical distribution> ratio of the reflected *radiant flux* (3.4.7) or *luminous flux* (3.4.4) to the incident flux in the given conditions

Note 1 to entry: Unit: 1 (dimensionless).

Note 2 to entry: *Reflectance*, ρ, is the sum of regular *reflectance*, ρ_r, and diffuse *reflectance*, ρ_d: $\rho = \rho_r + \rho_d$.

Note 3 to entry: Reflectance can be expressed as a percentage. In this document, it is expressed as a value with a maximum of 1,0.

[SOURCE: CIE S 017:2011, 17-1058, modified — the unit is expressed as a note to entry.]

3.10.1.21
optical density (spectral)
D(*λ*)
logarithm to the base 10 of the reciprocal of the (spectral) *transmittance* (3.10.1.18)

Note 1 to entry: *Optical density* is therefore expressed by the formula:

$$D(\lambda) = \log_{10}\left(\frac{1}{\tau(\lambda)}\right)$$

where $\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*.

Note 2 to entry: *Optical density* gives a measure of the darkness of a *filter* and, if spectral, for a particular wavelength, λ. *Optical density* is used in the assessment of *filters* for eye protection against *laser beams*.

[SOURCE: CIE S 017:2011, 17-291, modified — the definition has been modified to cover both *optical density* for *visible radiation* and for *spectral values*, the modified formula has been put into a note to entry and an explanation of $\tau(\lambda)$ and Note 2 to entry has been added.]

3.10.1.22
spectral transmittance
τ(*λ*)
ratio of the spectral *radiant flux* (3.4.7) or *luminous flux* (3.4.4) transmitted by the material to the incident spectral *radiant flux* or *luminous flux* at any specified wavelength, λ, for a specified angle of incidence

3.10.1.23
spectral reflectance
$\rho(\lambda)$
ratio of the spectral *radiant flux* (3.4.7) or *luminous flux* (3.4.4) reflected by the material to the incident spectral *radiant* or *luminous flux* at any specified wavelength, λ, for a specified angle of incidence

Note 1 to entry: The value stated is usually that for a single surface. If the *reflectance* noted is that for the *lens* or *filter* as a whole, this should be explicitly stated.

Note 2 to entry: See also *reflectance* (3.10.1.20).

3.10.1.24
air mass
amount of air that solar radiation passes through to reach the earth's surface, which is a product of the air density and the distance traversed through the atmosphere

Note 1 to entry: *Air mass* is expressed as the ratio of the path through the atmosphere to the path when the sun is directly overhead (*air mass* 1). *Air mass* 2 is when the path length is twice as long and the sun is at an angle of 30° above the horizon.

3.10.1.25
ultraviolet transmittance
UV transmittance
general designation of the *transmittance* (3.10.1.18) in the *ultraviolet radiation* (3.2.3) range

Note 1 to entry: *Ultraviolet transmittance* is usually expressed as a percentage.

3.10.1.26
mean UV-A transmittance
$\tau_{\text{mUVA 380}}$
$\tau_{\text{mUVA 400}}$
averaged value of the *spectral transmittance* (3.10.1.22) in the wavelength range from 315 nm to 380 nm or 400 nm, depending upon the application

Note 1 to entry: The *mean UV-A transmittance* is usually expressed as a percentage and calculated from either of the following formulae, depending upon the application:

$$\tau_{\text{mUVA380}} = 100 \times \frac{\int_{315}^{380} \tau(\lambda) \cdot d\lambda}{\int_{315}^{380} d\lambda}$$

$$\tau_{\text{mUVA400}} = 100 \times \frac{\int_{315}^{400} \tau(\lambda) \cdot d\lambda}{\int_{315}^{400} d\lambda}$$

where

λ is the wavelength of the *UV radiation*, expressed in nanometres;

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

3.10.1.27
mean UV-B transmittance
τ_{mUVB}
averaged value of the *spectral transmittance* (3.10.1.22) in the wavelength range from 280 nm to 315 nm

Note 1 to entry: The *mean UV-B transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{mUVB} = 100 \times \frac{\int_{280}^{315} \tau(\lambda) \cdot d\lambda}{\int_{280}^{315} d\lambda}$$

where

λ is the wavelength of the *UV radiation*, expressed in nanometres;

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

3.10.1.28
solar UV transmittance
τ_{SUV380}
τ_{SUV400}
normalized value of the *spectral transmittance* (3.10.1.22) averaged between 280 nm and 380 nm or 400 nm depending upon the application, weighted by the solar spectral power distribution, at sea level for *air mass* 2 (3.10.1.24) and the relative spectral effectiveness function for *ultraviolet radiation* (3.2.3)

Note 1 to entry: The *solar UV transmittance* is usually expressed as a percentage and calculated from either of the following formulae, depending upon the application:

$$\tau_{SUV380} = 100 \times \frac{\int_{280}^{380} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{280}^{380} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{280}^{380} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{280}^{380} W(\lambda) \cdot d\lambda}$$

$$\tau_{SUV400} = 100 \times \frac{\int_{280}^{400} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{280}^{400} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{280}^{400} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{280}^{400} W(\lambda) \cdot d\lambda}$$

where

$\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*;

λ is the wavelength of the *UV radiation* in nanometres;

$E_s(\lambda)$ is the solar spectral power distribution at sea level for *air mass* 2;

$S(\lambda)$ is the relative spectral effectiveness function for *UV radiation*;

$W(\lambda)$ is the complete weighting function: $W(\lambda) = E_s(\lambda) \cdot S(\lambda)$.

Note 2 to entry: The weighting functions $E_s(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in Table A.1.

3.10.1.29
solar UV-A transmittance
$\tau_{SUVA380}$
$\tau_{SUVA400}$
normalized value of the *spectral transmittance* (3.10.1.22) averaged between 315 nm and 380 nm or 400 nm depending upon the application, weighted by the solar spectral power distribution at sea level for *air mass* 2 (3.10.1.24) and the relative spectral effectiveness function for *ultraviolet radiation* (3.2.3)

Note 1 to entry: The *solar UV-A transmittance* is usually expressed as a percentage and calculated from either of the following formulae, depending upon the application:

$$\tau_{SUVA380} = 100 \times \frac{\int_{315}^{380} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{315}^{380} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{315}^{380} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{315}^{380} W(\lambda) \cdot d\lambda}$$

$$\tau_{SUVA400} = 100 \times \frac{\int_{315}^{400} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{315}^{400} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{315}^{400} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{315}^{400} W(\lambda) \cdot d\lambda}$$

where

$\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*;

λ is the wavelength of the *UV radiation* in nanometres;

$E_s(\lambda)$ is the solar spectral power distribution at sea level for *air mass* 2;

$S(\lambda)$ is the relative spectral effectiveness function for *UV radiation*;

$W(\lambda)$ is the complete weighting function: $W(\lambda) = E_s(\lambda) \cdot S(\lambda)$.

Note 2 to entry: The weighting functions $E_s(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in Table A.1.

3.10.1.30
solar UV-B transmittance
τ_{SUVB}
normalized value of the *spectral transmittance* (3.10.1.22) averaged between 280 nm and 315 nm, weighted by the solar spectral power distribution at sea level for *air mass* 2 (3.10.1.24) and the relative spectral effectiveness function for *ultraviolet radiation* (3.2.3)

Note 1 to entry: The solar UV-B transmittance is usually expressed as a percentage and calculated from the following formula:

$$\tau_{SUVB} = 100 \times \frac{\int_{280}^{315} \tau(\lambda) \cdot E_s(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{280}^{315} E_s(\lambda) \cdot S(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{280}^{315} \tau(\lambda) \cdot W(\lambda) \cdot d\lambda}{\int_{280}^{315} W(\lambda) \cdot d\lambda}$$

where

λ is the wavelength of the *UV radiation* in nanometres;

$\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*;

$E_s(\lambda)$ is the solar spectral power distribution at sea level for *air mass* 2;

$S(\lambda)$ is the relative spectral effectiveness function for *UV radiation*;

$W(\lambda)$ is the complete weighting function: $W(\lambda) = E_s(\lambda) \cdot S(\lambda)$.

Note 2 to entry: The weighting functions $E_s(\lambda)$, $S(\lambda)$ and $W(\lambda)$ are given in Table A.1.

3.10.1.31
mean 380 nm to 400 nm transmittance
$\tau_{m380\text{-}400}$
averaged value of the *spectral transmittance* (3.10.1.22) in the wavelength range from 380 nm to 400 nm

Note 1 to entry: The *mean 380 nm to 400 nm transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{m380\text{-}400} = 100 \times \frac{\int_{380}^{400} \tau(\lambda) \cdot d\lambda}{\int_{380}^{400} d\lambda}$$

where

λ is the wavelength of the *optical radiation* in nanometres;

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

3.10.1.32
luminous transmittance
τ_V
ratio of the *luminous flux* (3.4.4) transmitted to the incident *luminous flux* for a specified *illuminant* (3.2.6) and photopic vision

Note 1 to entry: The luminous transmittance is usually expressed as a percentage and calculated from one of the following formulae, depending upon the application and *illuminant*:

$$\tau_{vA} = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot S_A(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_A(\lambda) \cdot V(\lambda) \cdot d\lambda} \text{ for } \textit{CIE standard illuminant} \text{ A}$$

$$\tau_{vD65} = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda} \text{ for } \textit{CIE standard illuminant} \text{ D65}$$

$$\tau_{\text{v1 900 K}} = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot S_{1\,900\,\text{K}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{1\,900\,\text{K}}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$ for a Planckian black body radiator at 1 900 K

where

λ	is the wavelength of the *light* in nanometres;
$\tau(\lambda)$	is the *spectral transmittance* of the *lens* or *filter*;
$V(\lambda)$	is the CIE 2 *spectral luminous efficiency* function for photopic vision. (See ISO 11664-1);
$S_A(\lambda)$	is the spectral distribution of the incident radiation of *CIE standard illuminant* A, $S_A(\lambda)$. (See ISO 11664-2);
$S_{D65}(\lambda)$	is the spectral distribution of the incident radiation of *CIE standard illuminant* D65, $S_{D65}(\lambda)$. (See ISO 11664-2);
$S_{1\,900\,K}$	is the spectral distribution of the incident radiation from a Planckian black body radiator at 1 900 K.

Note 2 to entry: The spectral values of the product $S_A(\lambda)$, $S_{D65}(\lambda)$ and $S_{1\,900\,K}(\lambda)$ with $V(\lambda)$ are given in Tables A.2, A.3 and A.4 respectively. The values of the spectral radiation distribution of *CIE standard illuminants* $S_A(\lambda)$ and $S_{D65}(\lambda)$, and the eye's *spectral luminous efficiency* function, $V(\lambda)$, can be found in the downloads section at http://www.cie.co.at, where $\bar{y}(\lambda) = V(\lambda)$.

3.10.1.33
traffic signal light
green, yellow (amber) and red traffic lights and the flashing blue *light* (3.2.2) of emergency vehicles

3.10.1.34
relative visual attenuation coefficient (quotient) for traffic signal light detection
Q_{signal}
quotient of the *luminous transmittance* (3.10.1.32) of a *filter* (3.10.1.1) or tinted *lens* (3.5.1.3) for the spectral *radiant power* (3.4.7) distribution of the *light* (3.2.2) emitted by a traffic signal to the *luminous transmittance* of the same *filter* or *lens* for *CIE standard illuminant D65* (3.2.7)

Note 1 to entry: The quotient, Q_{signal}, is defined by the formula:

$$Q_{\text{signal}} = \frac{\tau_{\text{signal}}}{\tau_{\text{v D65}}}$$

where

$\tau_{\text{v D65}}$	is the *luminous transmittance* of the *filter* for *CIE standard illuminant* D65;
τ_{signal}	is the *luminous transmittance* of the *filter* for the spectral power distribution of the *traffic signal light*;
signal	is one of red, yellow, green or blue.

Note 2 to entry: The value of $\tau_{\text{v D65}}$ is given in the term *luminous transmittance* (3.10.1.32), and the value of τ_{signal}, expressed as a percentage, is given by the following formula:

$$\tau_{\text{signal}} = 100 \times \frac{\int_{380}^{780} \tau(\lambda) \cdot E_{\text{signal}}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} E_{\text{signal}}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$

where

λ is the wavelength of the *light* in nanometres;

$\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*;

$E_{\text{signal}}(\lambda)$ is the accepted measured value of the relative spectral distribution of *luminance* of the *traffic signal light*;

$V(\lambda)$ is the *spectral luminous efficiency* function for photopic vision (see ISO 11664-1).

Note 3 to entry: Modern *traffic signal lights* use quartz-halogen lamps or LED sources. Calculations using the values for quartz-halogen lamps and LED signals will give different results. The values for incandescent quartz-halogen signals are used at present.

Note 4 to entry: The spectral values for the various parameters required to calculate the *relative visual attenuation coefficients (quotients) for traffic signal light detection* are given in Tables A.3 and A.4.

3.10.1.35
solar blue-light transmittance
τ_{SB}
normalized value of the *spectral transmittance* (3.10.1.22) averaged between 380 nm and 500 nm, weighted by the solar spectral power distribution at sea level for *air mass* 2 (3.10.1.24) and the *blue-light hazard* (3.1.7) function

Note 1 to entry: The *solar blue-light transmittance*, expressed as a percentage, is calculated from the following formula:

$$\tau_{SB} = 100 \times \frac{\int_{380}^{500} \tau(\lambda) \cdot E_s(\lambda) \cdot B(\lambda) \cdot d\lambda}{\int_{380}^{500} E_s(\lambda) \cdot B(\lambda) \cdot d\lambda} = 100 \times \frac{\int_{380}^{500} \tau(\lambda) \cdot W_B(\lambda) \cdot d\lambda}{\int_{380}^{500} W_B(\lambda) \cdot d\lambda}$$

where

λ is the wavelength of the *light* in nanometres;

$E_S(\lambda)$ is the solar spectral power distribution at sea level for *air mass* 2;

$B(\lambda)$ is the *blue-light hazard* function;

$W_B(\lambda)$ is the complete weighting function: $W_B(\lambda) = E_S(\lambda) \cdot B(\lambda)$.

Note 2 to entry: The values of $E_S(\lambda)$, $B(\lambda)$ and $W_B(\lambda)$ are given in Table A.1 and can be interpolated where necessary.

3.10.1.36
blue-light transmittance
τ_B
<artificial source of *optical radiation*>normalized value of the *spectral transmittance* (3.10.1.22) averaged between 380 nm and 500 nm, weighted by the *blue-light hazard* (3.1.7) function

Note 1 to entry: The *blue-light transmittance* for artificial radiation sources is usually expressed as a percentage and calculated from the following formula:

$$\tau_B = 100 \times \frac{\int_{380}^{500} \tau(\lambda) \cdot B(\lambda) \cdot d\lambda}{\int_{380}^{500} B(\lambda) \cdot d\lambda}$$

where

λ	is the wavelength in nanometres;
$\tau(\lambda)$	is the *spectral transmittance* of the *lens* or *filter*;
$B(\lambda)$	is the *blue-light hazard* function.

Note 2 to entry: The values for the *blue-light hazard* function, $B(\lambda)$, are given in Table A.1.

Note 3 to entry: This is calculated for equi-energy sources.

3.10.1.37
optical radiation transmittance
DEPRECATED: blue-light hazard transmittance
τ_{AOR}
<artificial source of *optical radiation*>normalized value of the *spectral transmittance* (3.10.1.22) averaged between 300 nm and 700 nm, weighted by the *blue-light hazard* (3.1.7) function

Note 1 to entry: The *optical radiation transmittance* for artificial radiation sources is usually expressed as a percentage and calculated from the following formula:

$$\tau_{AOR} = 100 \times \frac{\int_{300}^{700} \tau(\lambda) \cdot B(\lambda) \cdot d\lambda}{\int_{300}^{700} B(\lambda) \cdot d\lambda}$$

where

λ	is the wavelength in nanometres;
$\tau(\lambda)$	is the *spectral transmittance* of the *lens* or *filter*;
$B(\lambda)$	is the *blue-light hazard* function.

Note 2 to entry: The values for the *blue-light hazard* function, $B(\lambda)$, are given in Table A.1.

Note 3 to entry: The range of 300 nm to 700 nm covers parts of the UV-B, all UV-A and most of the *visible radiation* spectra; however, the associated *hazard* is commonly referred to as the '*blue-light hazard*'. Blue light strictly speaking covers only the range of approximately 400 nm to 490 nm.

Note 4 to entry: The formula is based on the formula for L_B [effective radiance (blue-light)] in the European Artificial Optical Radiation Directive, 2006/25/EC.

3.10.1.38
infrared transmittance
IR transmittance
general designation of the *transmittance* (3.10.1.18) in the infrared range

Note 1 to entry: *Infrared transmittance* is usually expressed as a percentage.

3.10.1.39
near IR transmittance
τ_{NIR}
averaged value of the *spectral transmittance* (3.10.1.22) for *welding filters* (3.10.3.1) and *infrared protective filters* (3.10.1.13) in the wavelength range from 780 nm to 3 000 nm

Note 1 to entry: The *near IR transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{NIR} = 100 \times \frac{\int_{780}^{3\,000} \tau(\lambda) \cdot d\lambda}{\int_{780}^{3\,000} d\lambda}$$

where

λ is the wavelength of the *infrared radiation* in nanometres;

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

3.10.1.40
IR-A transmittance
τ_{IRA}
averaged value of the *spectral transmittance* (3.10.1.22) for *welding filters* (3.10.3.1) and *infrared protective filters* (3.10.1.13) in the wavelength range from 780 nm to 1 400 nm

Note 1 to entry: The *IR-A transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{IRA} = 100 \times \frac{\int_{780}^{1400} \tau(\lambda) \cdot d\lambda}{\int_{780}^{1400} d\lambda}$$

where

λ is the wavelength of the *infrared radiation* in nanometres;

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

3.10.1.41
IR-B transmittance
τ_{IRB}
averaged value of the *spectral transmittance* (3.10.1.22) for *welding filters* (3.10.3.1) and *infrared protective filters* (3.10.1.13) in the wavelength range from 1 400 nm to 3 000 nm

Note 1 to entry: The *IR-B transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{\mathrm{IRB}} = 100 \times \frac{\int_{1\,400}^{3\,000} \tau(\lambda) \cdot \mathrm{d}\lambda}{\int_{1\,400}^{3\,000} \mathrm{d}\lambda}$$

where

λ is the wavelength of the *infrared radiation* in nanometres;

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

3.10.1.42
solar IR transmittance

τ_{SIR}

normalized value of the *spectral transmittance* (3.10.1.22) averaged between the limits 780 nm and 2 000 nm, weighted by the solar spectral power distribution, at sea level for *air mass* 2 (3.10.1.24)

Note 1 to entry: The *solar IR transmittance* is usually expressed as a percentage and calculated from the following formula:

$$\tau_{\mathrm{SIR}} = 100 \times \frac{\int_{780}^{2\,000} \tau(\lambda) \cdot E_{\mathrm{S}}(\lambda) \cdot \mathrm{d}\lambda}{\int_{780}^{2\,000} E_{\mathrm{S}}(\lambda) \cdot \mathrm{d}\lambda}$$

where

λ is the wavelength of the *infrared radiation* in nanometres;

$\tau(\lambda)$ is the *spectral transmittance* of the *lens* or *filter*;

$E_{\mathrm{S}}(\lambda)$ is the solar spectral power distribution at sea level for *air mass* 2.

Note 2 to entry: The values of $E_{\mathrm{S}}(\lambda)$ are given in Table A.6.

3.10.1.43
luminous reflectance

ρ_{V}

ratio of the *luminous flux* (3.4.4) reflected by the material in a specified form, *lens* (3.5.1.3), coating or *filter* (3.10.1.1), to the incident *luminous flux* for a specified *illuminant* (3.2.6) and photopic vision

Note 1 to entry: The *luminous reflectance* is usually expressed as a percentage and calculated from one of the following formulae, depending upon the application and *illuminant*:

$$\rho_{\mathrm{V\,A}} = 100 \times \frac{\Phi_{\mathrm{R}}}{\Phi_{\mathrm{I}}} = 100 \times \frac{\int_{380}^{780} \rho(\lambda) \cdot S_{\mathrm{A}}(\lambda) \cdot V(\lambda) \cdot \mathrm{d}\lambda}{\int_{380}^{780} S_{\mathrm{A}}(\lambda) \cdot V(\lambda) \cdot \mathrm{d}\lambda} \text{ for } \textit{CIE standard illuminant } \mathrm{A};$$

$$\rho_{v\,D65} = 100 \times \frac{\Phi_R}{\Phi_I} = 100 \times \frac{\int_{380}^{780} \rho(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$ for *CIE standard illuminant* D65;

$$\rho_{v\,1\,900\,K} = 100 \times \frac{\Phi_R}{\Phi_I} = 100 \times \frac{\int_{380}^{780} \rho(\lambda) \cdot S_{1\,900\,K}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380}^{780} S_{1\,900\,K}(\lambda) \cdot V(\lambda) \cdot d\lambda}$$ for a Planckian black body radiator at 1 900 K

where

λ is the wavelength of the *light* in nanometres;

Φ_I is the incident *luminous flux*;

Φ_R is the reflected *luminous flux*;

$\rho(\lambda)$ is the *spectral reflectance*;

$S_A(\lambda)$ is the spectral distribution of *CIE standard illuminant* A;

$S_{D65}(\lambda)$ is the spectral distribution of *CIE standard illuminant* D65;

$S_{1\,900\,K}(\lambda)$ is the spectral distribution of a Planckian black body radiator at 1 900 K.

Note 2 to entry: The value stated is usually that for a single surface. If the *luminous reflectance* noted is that for the *lens* or *filter* as a whole, this should be explicitly stated.

Note 3 to entry: The values of $S_{D65}(\lambda) \cdot V(\lambda)$ are given in Table A.3.

3.10.1.44
near IR reflectance
ρ_{NIR}
average *reflectance* (3.10.1.20) for *welding filters* (3.10.3.1) and *infrared protective filters* (3.10.1.13) in the wavelength range from 780 nm to 3 000 nm

Note 1 to entry: The *near IR reflectance* is usually expressed as a percentage and calculated from the following formula:

$$\rho_{NIR} = 100 \times \frac{\int_{780}^{3\,000} \rho(\lambda) \cdot d\lambda}{\int_{780}^{3\,000} d\lambda}$$

where

λ is the wavelength of the *infrared radiation* in nanometres;

$\rho(\lambda)$ is the *spectral reflectance* of the *lens* or *filter*.

3.10.1.45
photochromic sunglare filter
photochromic sunglass filter
filter (3.10.1.1) that reversibly changes its *luminous transmittance* (3.10.1.32) depending upon the *irradiance* (3.4.2) and wavelength of the radiation to which it is exposed

Note 1 to entry: This change is not instantaneous, but is a function of temperature-dependent and material-dependent time constants. The *luminous transmittance* of the *filter* therefore adjusts itself within certain limits to the ambient *radiant flux*.

Note 2 to entry: See *photochromic material*.

[SOURCE: ISO 13666:2018, 3.5.11, modified — the term has been changed from photochromic lens to *photochromic sunglare filter*, the word “intensity” has been changed to “*irradiance*”, “*lens*” has been changed to “*filter*”, and its notes have been replaced by Notes 1 and 2 to entry.]

3.10.1.46
characteristic luminous transmittance
luminous transmittance (3.10.1.32) of a *photochromic sunglare filter* (3.10.1.45) measured under specified test conditions

Note 1 to entry: These test conditions, with symbols for the *characteristic luminous transmittance*, are:

$\tau_{v\,0}$ *luminous transmittance* in the faded state as reached at (23 ± 1) °C after specified conditioning;

$\tau_{v\,1}$ *luminous transmittance* in the darkened state as reached at (23 ± 1) °C after specified irradiation simulating mean outdoor conditions;

$\tau_{v\,w}$ *luminous transmittance* in the darkened state as reached at (5 ± 2) °C after specified irradiation simulating outdoor conditions at low temperatures;

$\tau_{v\,s}$ *luminous transmittance* in the darkened state as reached at (35 ± 2) °C after specified irradiation simulating outdoor conditions at high temperatures;

$\tau_{v\,a}$ *luminous transmittance* in the darkened state as reached at (23 ± 1) °C after specified irradiation simulating reduced *light* conditions.

3.10.1.47
photochromic range quotient
R_{Phot}
ratio of the difference between the *luminous transmittance* (3.10.1.32) in the faded state and the *luminous transmittance* in the darkened state to the *luminous transmittance* in the faded state

Note 1 to entry: The *photochromic range quotient* is calculated from the following formula:

$$R_{Phot} = \frac{\tau_{v\,0} - \tau_{v\,1}}{\tau_{v\,0}}$$

where

$\tau_{v\,0}$ is the *luminous transmittance* of the *lens* or *filter* in the faded state;

$\tau_{v\,1}$ is the *luminous transmittance* of the *lens* or *filter* in the darkened state.

3.10.1.48
photochromic response
PR
ratio of the *luminous transmittance* (3.10.1.32) in the faded state to that in the darkened state

Note 1 to entry: The *photochromic response* is calculated from the following formula:

$$PR = \frac{\tau_{v\,0}}{\tau_{v\,1}}$$

where

$\tau_{v\,0}$ is the *luminous transmittance* of the *lens* or *filter* in the faded state;

$\tau_{v\,1}$ is the *luminous transmittance* of the *lens* or *filter* in the darkened state.

3.10.1.49
automatic darkening filter
autodarkening filter
ADF
optical *filter* (3.10.1.1) that varies, by electronic means, the *transmittance* (3.10.1.18) in the visible region of the spectrum depending on the presence of *light* (3.2.2) emitted by the source

Note 1 to entry: This is a generic term. See also *automatic welding filter* (3.10.3.2).

3.10.2 *Polarized radiation* and *polarizing filters*

3.10.2.1
polarization
act, process or result of restricting the amplitude of oscillation of the electric vector of *optical radiation* (3.2.1), including *light* (3.2.2), so that it becomes *polarized radiation* (3.10.2.2)

3.10.2.2
polarized radiation
optical radiation (3.2.1) whose electromagnetic field, which is transversal, is oriented in defined directions

Note 1 to entry: *Polarization* can be linear, elliptical or circular.

Note 2 to entry: The unqualified term "*polarizer*" is frequently used to describe a linear *polarizer*.

Note 3 to entry: Radiation with specific *polarization* will result from transmission through, for example, a *polarizing filter*.

[SOURCE: CIE S 017:2011, 17-966, modified — the word "optical" and Notes 2 and 3 to entry have been added.]

3.10.2.3
plane of oscillation
plane defined by the direction of oscillation of the electric vector and the direction of propagation of the *optical radiation* (3.2.1)

3.10.2.4
plane of transmission
<of a polarizing *lens* or *filter*> any plane intersecting the *lens* (3.5.1.3) or *filter* (3.10.1.1) that contains the axis of propagation of the transmitted radiation and is parallel to the orientation of maximal transmission of the electric vector of the transmitted radiation

3.10.2.5
polarizing filter
polarizer
element that produces *optical radiation* (3.2.1) of a specific *polarization* (3.10.2.1) condition regardless of the condition of the incident radiation

Note 1 to entry: There are linear, circular and elliptical *polarizing filters* but the term *polarizing filter* frequently implies a linear *polarizing filter*.

3.10.2.6
polarizing sunglare filter
sunglare filter (3.10.1.9) whose *transmittance* (3.10.1.18) is dependent on the orientation of the *plane of oscillation* (3.10.2.4) of the incident *optical radiation* (3.2.1)

Note 1 to entry: The major component of *light* reflected from (near) horizontal non-metallic surfaces has a horizontal electric vector. In a *polarizing filter* designed to reduce sunglare, the *plane of transmission* is usually orientated vertically to attenuate the reflected *light* as opposed to the non-reflected *light* (see Figure 7).

3.10.2.7
polarizing efficiency
P
parameter describing the performance of a *polarizing filter* (3.10.2.5), determined from the maximum and minimum *transmittance* (3.10.1.18) in 100 % linearly *polarized radiation* (3.10.2.2)

Note 1 to entry: The *polarizing efficiency* is usually expressed as a percentage and calculated from the following formula:

$$P = 100 \times \frac{\tau_{\mathrm{P\,max}} - \tau_{\mathrm{P\,min}}}{\tau_{\mathrm{P\,max}} + \tau_{\mathrm{P\,min}}}$$

where

$\tau_{\mathrm{P\,max}}$ is the maximum value of the *luminous transmittance* of the *polarizing filter* determined with linearly *polarized radiation*;

$\tau_{\mathrm{P\,min}}$ is the minimum value of the *luminous transmittance* of the *polarizing filter* determined with linearly *polarized radiation*.

Note 2 to entry: *Polarizing efficiency* can also be determined by measuring the *luminous transmittance* of two *polarizing filters* of the same type in series in unpolarized *light*, as:

$$P = 100 \times \sqrt{\frac{h(0) - h(\pi/2)}{h(0) + h(\pi/2)}}$$

where

$h(0)$ is the *transmittance* of two *polarizing filters* of the same type when they are orientated with their *planes of transmission* in alignment, and equals $0{,}5 \cdot (\tau_{\mathrm{P\,max}}^2 + \tau_{\mathrm{P\,min}}^2)$;

$h(\pi/2)$ is the *transmittance* of two *polarizing filters* of the same type when they are orientated with their *planes of transmission* perpendicular to each other, and equals $\tau_{\mathrm{P\,max}} \cdot \tau_{\mathrm{P\,min}}$.

Note 3 to entry: The *transmittance*, $h(\theta)$, of two *polarizing filters* of the same type, when set at a relative azimuth θ, is given by:

$$h(\theta) = h(0) \cdot \cos^2\theta + h(\pi/2) \cdot \sin^2\theta$$

3.10.2.8
polarizing ratio
R_{Pol}
ratio of maximum to minimum *luminous transmittances* (3.10.1.32) when measured with 100 % linearly *polarized radiation* (3.10.2.2)

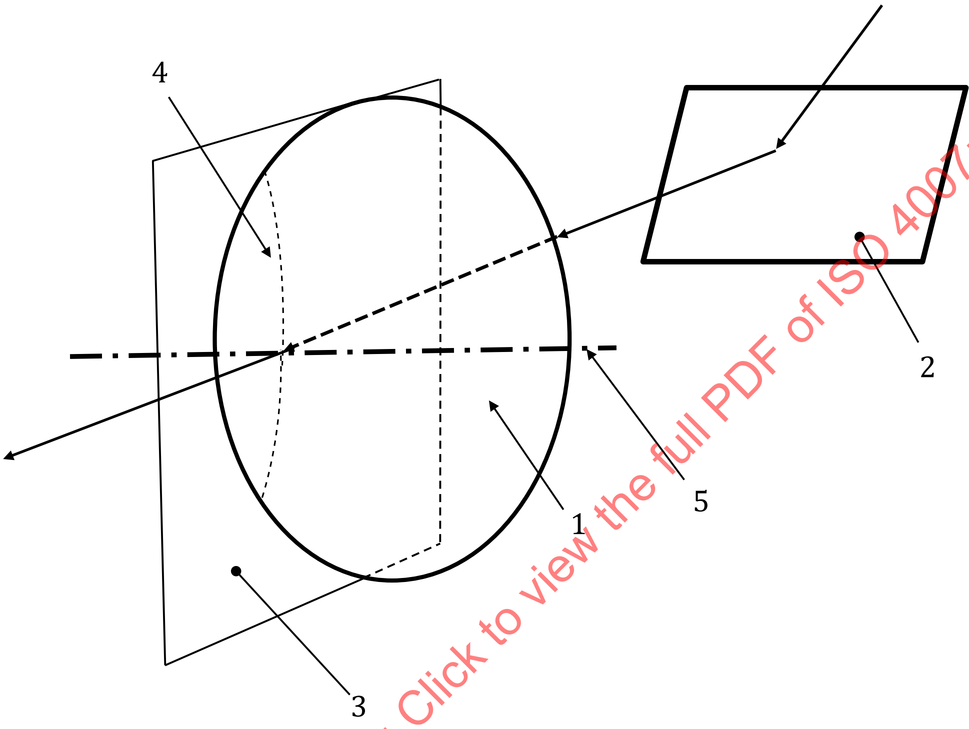
Note 1 to entry: The polarizing ratio is usually expressed as (the numerical value of $\tau_{\mathrm{P\,max}}/\tau_{\mathrm{P\,min}}$):1, where $\tau_{\mathrm{P\,max}}$ and $\tau_{\mathrm{P\,min}}$ are the maximum and minimum values respectively of the luminous transmittance of the polarizing filter determined with linearly polarized radiation.

Note 2 to entry: Polarizing ratios of 8:1 and 4:1 correspond to *polarizing efficiencies* of 78 % and 60 % respectively.

3.10.2.9
intended horizontal orientation
<of a *polarizing filter*> direction perpendicular to a *plane of transmission* (3.10.2.4) that passes through the optical centre of a *lens* (3.5.1.3) or *geometrical centre* of a plano *filter* (3.10.1.1)

Note 1 to entry: A *polarizing filter* is generally intended to be mounted with its *plane of transmission* vertical to reduce sun glare reflected from horizontal surfaces. The *intended horizontal orientation* should therefore be horizontal, hence the name.

Note 2 to entry: See Figure 7.



Key

1 lens or filter
2 horizontal reflecting surface
3 plane of transmission (vertical)
4 intersection of the plane with the lens or filter
5 direction of intended horizontal orientation of a polarizing filter

Figure 7 — Diagram illustrating some terms relating to *polarizing filters*

3.10.3 Welding filters

3.10.3.1
welding filter
filter (3.10.1.1) that provides protection against glare during welding and reduces the *ultraviolet radiation* (3.2.3) and *infrared radiation* (3.2.4) that are dangerous to the human eye

3.10.3.2
automatic welding filter
AWF
automatic darkening filter (3.10.1.49) used for welding that automatically switches its *shade number* (3.10.1.5) from a lower value [*light state shade number* (3.10.3.5)] to a higher value [*dark state shade number* (3.10.3.6)] when the welding arc is ignited and maintains this dark state while the arc is present

Note 1 to entry: An *automatic welding filter* combines an *automatic darkening filter* for *visible radiation* with passive *ultraviolet* and *infrared protective filters*.

3.10.3.3
automatic welding filter with automatic shade number setting
automatic welding filter (3.10.3.2) in which the dark state is variable and the *dark state shade number* (3.10.3.6) is automatically adjusted depending on the *irradiance* (3.4.2) generated by the welding arc

3.10.3.4
automatic welding filter with manual shade number setting
automatic welding filter (3.10.3.2) in which the dark state is variable and the *dark state shade number* (3.10.3.6) is manually adjusted

3.10.3.5
light state shade number
shade number (3.10.1.5) of an *automatic welding filter* (3.10.3.2) corresponding to the maximum value of its *luminous transmittance* (3.10.1.32)

Note 1 to entry: See Tables 3 and 4.

3.10.3.6
dark state shade number
shade number (3.10.1.5) corresponding to the value of the *luminous transmittance* (3.10.1.32) reached by an *automatic welding filter* (3.10.3.2) after ignition of the welding arc

Note 1 to entry: The *dark state shade number* applies to both the single possible dark state for an *automatic welding filter* having only two states, and to the multiple possible dark states for *welding filters* with variable dark states.

Note 2 to entry: The terminology here differs on purpose from the “faded” or “darkened” state, as applied to *photochromic sunglare filters*.

Note 3 to entry: See Tables 3 and 4.

Table 3 — Example showing the meaning of the terms for an *automatic welding filter* with a *light state shade number* of 5 and a *dark state shade number* of 14

Shade numbers	
5	14
Light state shade number	*Dark state shade number*

3.10.3.7
lightest dark state shade number
lowest *shade number* (3.10.1.5) claimed by the manufacturer corresponding to the maximum value of the *luminous transmittance* (3.10.1.32) within the dark state of an *automatic welding filter* (3.10.3.2)

Note 1 to entry: See Table 4.

Table 4 — Example showing the meaning of the terms for an *automatic welding filter* with a *light state shade number* of 5 and *dark state shade numbers* varying between the *lightest dark state number* of 10 and its *darkest dark state number* of 14

Shade numbers					
5	10	11	12	13	14
Light state shade number	*Lightest dark state shade number*				*Darkest dark state shade number*
	←------------variable dark states------------→				

3.10.3.8
darkest dark state shade number

highest *shade number* (3.10.1.5) claimed by the manufacturer corresponding to the minimum value of the *luminous transmittance* (3.10.1.32) of an *automatic welding filter* (3.10.3.2)

3.10.3.9
switching time

t_S

<for an *automatic welding filter*> response time of an *automatic welding filter* (3.10.3.2) to darken from its *light state shade number* (3.10.3.5) towards its *dark state shade number* (3.10.3.6) when triggered by a welding arc

Note 1 to entry: See *light state shade number, dark state shade number, lightest dark state shade number* and *darkest dark state shade number* for interpretation of *luminous transmittance* states for *automatic welding filters*.

Note 2 to entry: The *switching time* is a *transmittance* weighted measure of the time to switch from the *light state* to the *dark state* when a welding arc ignites, given by the integral of the ratio of the filter's *luminous transmittance* to its initial *light state*'s *luminous transmittance*, over the time taken from the arc's ignition to the time at which the *luminous transmittance* has fallen to three times that in its final *dark state* and is expressed by the following formula:

$$t_s = \frac{1}{\tau_{v0}} \int_{t=0}^{t=t\{\tau_v(t)=3\tau_{v1}\}} \tau_v(t)\cdot \mathrm{d}t$$

where

$t = 0$ is the time at which the arc ignites;

$\tau_v(t)$ is the *luminous transmittance* at a time t, after ignition of the welding arc;

$t = t\{\tau_v(t) = 3\tau_{v\,1}\}$ is the time at which the *luminous transmittance* falls to three times the *luminous transmittance* in the *dark state*;

$\tau_{v\,0}$ is the *luminous transmittance* in the *light state*;

$\tau_{v\,1}$ is the *luminous transmittance* in the *dark state*.

Note 3 to entry: In the case of short-term exposure to *light*, the glare is approximately proportional to the product of the *illuminance* at the eye and time. The time relationship of the darkening process can be very different depending on the construction of a *welding filter* with switchable *scale number*. It is therefore appropriate to define the *switching time* as an integral of the *luminous transmittance* over time and not merely by the initial and final *luminous transmittances*.

3.10.3.10
holding time

time taken by an *automatic welding filter* (3.10.3.2) to fade from its dark state to having a luminous transmittance 3 times the transmittance value in the dark state when the arc stops

Note 1 to entry: For an automatic welding filter with adjustable dark state, this test applies to the setting with the darkest dark state.

3.10.3.11
welding filter with dual scale number
welding filter (3.10.3.1) with two different *scale numbers* (3.10.1.3) (light and dark zones) that is divided into a maximum of three areas of the welding filter

Note 1 to entry: The light zone is used for brief viewing when setting the electrode to the weld and igniting it. The dark zone is used for viewing the welding process.

Note 2 to entry: If divided into two zones, one zone is light and the other is dark. If divided into three zones, then the central zone is generally dark, with the zones above and below being light.

3.10.3.12
peripheral awareness welding filter
additional protective *filters* (3.10.1.1), not intended for observing the welding arc, mounted in a *welding helmet* (3.5.4.7) or *welding face shield* (3.5.4.3) on either side of the main *welding filter* (3.10.3.1) that is intended for observing the welding arc

Note 1 to entry: The *shade number* of these *filters* is typically low enough to give peripheral vision when not welding (with the *automatic welding filter* in the *light state*) and high enough to avoid discomfort glare from the side when welding (with the *automatic welding filter* in the *dark state*).

3.10.3.13
optical sensitivity of welding detection
ability of an *automatic welding filter* (3.10.3.2) to detect and react to the *optical radiation* (3.2.1) from a welding arc and differentiate from ambient illumination

Note 1 to entry: Ambient illumination is typically indoor ambient *light* (i.e. a combination of daylight and artificial *light*) or outdoor ambient *light* (e.g. daylight).

Note 2 to entry: *Welding filters* need to be able to differentiate the welding arc from ambient *light*, especially from angularly small sources such as the sun, or artificial sources that flicker such as fluorescent and discharge lamps.

3.11 Test equipment

3.11.1
trained observer
person trained in testing of eye and face *protectors* (3.5.1.1) with a binocular decimal visual acuity of at least 1,0 (6/6 or 20/20) and wearing the appropriate refractive correction, if necessary, for the observation distance of the test

3.11.2
calibration lens
lens with values known to sufficiently small uncertainties of measurement that are used for adjusting or checking measuring and test equipment

Note 1 to entry: *Calibration lenses* are available with calibrations traceable to national standards.

3.11.3
headform
standard anatomical head with defined features suitable for use as a support for *protectors* (3.5.1.1) during testing

3.11.4
international rubber hardness degree scale
IRHD scale
hardness scale chosen so that 0 represents the hardness of material having a Young's modulus of zero and 100 represents the hardness of a material of infinite Young's modulus

Note 1 to entry: A Young's modulus of zero means "no measurable resistance to indentation"; a modulus of infinity means "no measurable indentation".

Note 2 to entry: Low hardness is 10 IRHD to 35 IRHD, medium hardness is 35 IRHD to 85 IRHD, high hardness is 85 IRHD to 100 IRHD.

[SOURCE: ISO 48: 2010, 3.1]

3.11.5
photocurrent
part of the output current of a *photoelectric detector* (3.11.6) that is caused by incident radiation

Note 1 to entry: *Photocurrent* is expressed in amperes (A).

Note 2 to entry: In photomultipliers, a distinction should be made between the cathode *photocurrent* and the anode *photocurrent*.

[SOURCE: CIE S 017:2011, 17-893, modified — the unit has been moved into Note 1 to entry.]

3.11.6
photoelectric detector
detector of *optical radiation* (3.2.1) that utilizes the interaction between radiation and matter resulting in the *absorption* (3.10.1.16) of photons and the consequent liberation of electrons from their equilibrium states, thereby generating an electric potential or current, or causing a change in electrical resistance, but excluding electrical phenomena caused by temperature changes

[SOURCE: CIE S 017:2011, 17-898]

3.11.7
radiation detector
device in which incident *optical radiation* (3.2.1) produces a measurable physical effect

Note 1 to entry: See also *photoelectric detector* (3.11.6).

[SOURCE: based on CIE S 017:2011, 17-1303, thermal detector of radiation: detector of *optical radiation*, in which a measurable physical effect is produced by the heating of the part that absorbs radiation, and the note to entry has been added.]

3.11.8
reflectometer
instrument for measuring quantities pertaining to *reflection* (3.10.1.19)

[SOURCE: CIE S 017:2011, 17-1068]

3.11.9
telescope method
optical test method using a telescope to determine the *power* (3.7.9) of *non-corrective lenses* (3.8.3)

3.11.10
thermocouple
thermal detector of *optical radiation* (3.2.1) in which the electromotive force produced in a single thermoelectric junction is used to measure the heating effect produced by the absorbed radiation

Note 1 to entry: A *thermocouple* usually consists of two different metal wires (e.g. NiCr-Ni) joined at one end, so that, as the temperature of the junction increases, the thermoelectric voltage at the open end increases.

[SOURCE: CIE S 017:2011, 17-309, modified — Note 1 to entry has been added.]

3.11.11
***V*(*λ*) detector**
radiation detector (3.11.7) with optical *filters* (3.10.1.1) that convert its relative spectral sensitivity to that of the *spectral luminous efficiency* (3.4.11) for photopic vision, $V(\lambda)$

4 Glossary of abbreviations and symbols

The main abbreviations and/or symbols for terms and their subscripts are given in Tables 5 and 6. Some of these, and others, are also listed in the main index.

Table 5 — Symbols and abbreviated terms

Abbreviation and/or symbol	Term	Term number
C	cylindrical power	3.7.4
D	optical density	3.10.1.21
D	dioptre	3.7.1
E_v; E	illuminance	3.4.1
E_e	irradiance	3.4.2
L_v; L	luminance	3.4.3
PD	interpupillary distance	3.9.1.
P	polarizing efficiency	3.10.2.7
Q	relative visual attenuation coefficient (quotient) for traffic signal light detection	3.10.1.34
S	spherical power	3.7.2
t	time	—
$V(\lambda)$	spectral luminous efficiency < for photopic vision >	3.4.11
$W(\lambda)$	weighting function	—
Φ_v; Φ	luminous flux	3.4.4
Φ_e; P	radiant flux	3.4.7
ρ	reflectance	3.10.1.20
τ	transmittance	3.10.1.18
Ω	solid angle, in steradians	3.4.13

Table 6 — Subscripts

Subscript	Meaning
380–400	the wavelength range 380 nm to 400 nm
1 900 K	Planckian black body radiator at 1 900 K
(λ)	spectral, at wavelength λ
A	quantities relating to CIE standard illuminant A
AOR	the spectral range 300 nm to 700 nm used for evaluating the *blue-light hazard* for sources of *artificial radiation*, sometimes referred to as the artificial optical radiation *hazard*
B	blue-light spectrum, 380 nm to 500 nm
D65	quantities relating to CIE standard illuminant D65
NIR	IR spectrum, 780 nm to 3 000 nm
IRA	IR spectrum, 780 nm to 1 400 nm
IRB	IR spectrum, 1 400 nm to 3 000 nm
s	Solar
SB	Solar blue-light spectrum, 380 nm to 500 nm
signal	relating to traffic signal colours
SIR	Solar IR spectrum, 780 nm to 2 000 nm
SUV	Solar UV spectrum, 280 nm to 380 nm or 400 nm, depending upon the application

Table 6 *(continued)*

Subscript	Meaning
SUVA	Solar UV-A spectrum, 315 nm to 380 nm or 400 nm, depending upon the application
SUVB	Solar UV-B spectrum, 280 nm to 315 nm
UV	UV spectrum, 280 nm to 380 or 400 nm
UVA	UV-A spectrum, 315 nm to 380 or 400 nm
UVB	UV-B spectrum, 280 nm to 315 nm
e	radiometric quantity.
v	photometric quantity indicating that the *radiant energy* equivalent has been adjusted to take into account the human eye's spectral sensitivity to visible radiation.

Annex A
(informative)

Spectral weighting functions and spectral distributions

This annex contains the spectral functions for the calculation of *solar UV-transmittance* values and *blue-light transmittance*.

For the spectral power distribution of solar radiation, $E_S(\lambda)$, the values are reproduced, from P. Moon[28]. These values extend to 295 nm and are interpolated where necessary. Between 280 nm and 290 nm, the *irradiance* values are so low that they can be set to 0 for all practical purposes.

The spectral distribution of the relative spectral effectiveness function for *UV radiation*, $S(\lambda)$, is taken from ICNIRP (2004)[25].

The complete weighting function for the calculation of the different *ultraviolet transmittance* values is the product of the relative spectral effectiveness function for *UV radiation*, $S(\lambda)$, and the solar spectral power distribution at sea level for *air mass* 2, $E_S(\lambda)$, as shown in Formula (A.1):

$$W(\lambda) = E_S(\lambda) \cdot S(\lambda) \quad \text{(A.1)}$$

This weighting function is also given in Table A.1.

The *blue-light hazard* function, $B(\lambda)$, is taken from ICNIRP (2013)[26]. Below 400 nm the *blue-light hazard* function, $B(\lambda)$, is extrapolated linearly on a logarithmic scale.

The complete weighting function for the calculation of the *blue-light transmittance* is the product of the *blue-light hazard* function, $B(\lambda)$, and the solar spectral power distribution at sea level for *air mass* 2 of solar radiation, $E_S(\lambda)$, as shown in Formula (A.2):

$$W_B(\lambda) = E_S(\lambda) \cdot B(\lambda) \quad \text{(A.2)}$$

This weighting function is also given in Table A.1.

Table A.1 — Spectral weighting functions for the calculation of *UV-transmittance* and *blue-light transmittance*

Wavelength λ nm	Solar spectral irradiance[a] $E_s(\lambda)$ $mW \cdot m^{-2} \cdot nm^{-1}$	Relative spectral effectiveness function $S(\lambda)$	Weighting function $W(\lambda) = E_s(\lambda) \cdot S(\lambda)$	Blue-light hazard function $B(\lambda)$	Weighting function $W_B(\lambda) = E_s(\lambda) \cdot B(\lambda)$
280	0	0,88	0		
285	0	0,77	0		
290	0	0,64	0		
295	$2{,}09 \cdot 10^{-4}$	0,54	0,000 11		
300	$8{,}10 \cdot 10^{-2}$	0,30	0,024 3	0,01 ‡	
305	1,91	0,060	0,115	0,01	
310	11,0	0,015	0,165	0,01	
315	30,0	0,003	0,090	0,01	
320	54,0	0,001 0	0,054	0,01	
325	79,2	0,000 50	0,040	0,01	
330	101	0,000 41	0,041	0,01	
335	128	0,000 34	0,044	0,01	
340	151	0,000 28	0,042	0,01	
345	170	0,000 24	0,041	0,01	
350	188	0,000 20	0,038	0,01	
355	210	0,000 16	0,034	0,01	
360	233	0,000 13	0,030	0,01	
365	253	0,000 11	0,028	0,01	
370	279	0,000 093	0,026	0,01	
375	306	0,000 077	0,024	0,01	
380	336	0,000 064	0,022	0,01	2
385	365	0,000 053†	0,019	0,013	4
390	397	0,000 044†	0,017	0,025	10
395	432	0,000 036†	0,016	0,05	22
400	470	0,000 030†	0,014	0,10	47
405	562			0,20	112
410	672			0,40	269
415	705			0,80	564
420	733			0,90	660
425	760			0,95	722
430	787			0,98	771
435	849			1,00	849

[a] This column as a whole is part of the solar spectral power distribution at sea level for *air mass* 2.

† The range of wavelengths has been extended to 400 nm for those applications where the upper limit of UV-A is taken as 400 nm.

‡ The range of wavelengths has been extended down to 300 nm and up to 700 nm for those applications where the limits *for blue-light transmittance* or *optical radiation transmittance* for artificial radiation source calculations are taken as 300 nm for the lower limit and 550 nm or 700 nm for the upper limit.

The *blue-light hazard function*, $B(\lambda)$, is reproduced from Reference [26].

Table A.1 *(continued)*

Wavelength λ nm	Solar spectral irradiance[a] $E_s(\lambda)$ $mW \cdot m^{-2} \cdot nm^{-1}$	Relative spectral effectiveness function $S(\lambda)$	Weighting function $W(\lambda) = E_s(\lambda) \cdot S(\lambda)$	Blue-light hazard function $B(\lambda)$	Weighting function $W_B(\lambda) = E_s(\lambda) \cdot B(\lambda)$
440	911			1,00	911
445	959			0,97	930
450	1 006			0,94	946
455	1 037			0,90	933
460	1 080			0,80	864
465	1 109			0,70	776
470	1 138			0,62	706
475	1 161			0,55	639
480	1 183			0,45	532
485	1 197			0,40	479
490	1 210			0,22	266
495	1 213			0,16	194
500	1 215			0,10 ‡	122
505	1 211			0,079	97
510	1 206			0,063	76
515	1 202			0,050	60
520	1 199			0,040	48
525	1 193			0,032	38
530	1 188			0,025	30
535	1 193			0,020	24
540	1 198			0,016	19
545	1 194			0,013	16
550	1 190			0,010	12
555				0,008	
560				0,006	
565				0,005	
570				0,004	
575				0,003	
580				0,002	
585				0,001	
590				0,001	
595				0,001	
600 – 700				0,001	

[a] This column as a whole is part of the solar spectral power distribution at sea level for *air mass* 2.

† The range of wavelengths has been extended to 400 nm for those applications where the upper limit of UV-A is taken as 400 nm.

‡ The range of wavelengths has been extended down to 300 nm and up to 700 nm for those applications where the limits *for blue-light transmittance* or *optical radiation transmittance* for artificial radiation source calculations are taken as 300 nm for the lower limit and 550 nm or 700 nm for the upper limit.

The *blue-light hazard function*, $B(\lambda)$, is reproduced from Reference [26].

