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Eyewear display – Part 10: Specifications

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Part 10: Specifications

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FOREWORD

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IEC 63145-10 has been prepared by IEC technical committee 110: Electronic displays. It is an International Standard.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
110/1539/FDIS	110/1560/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 63145 series, published under the general title *Eyewear display*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

EYEWEAR DISPLAY –

Part 10: Specifications

1 Scope

This part of IEC 63145 establishes specifications and requirements for eyewear displays. This document is applicable to virtual reality (VR)-type (non-see-through) and augmented reality (AR)-type (see-through) eyewear displays using virtual image optics. The specifications and requirements for prescription lenses are out of the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 63145-1-2, *Eyewear display – Part 1-2: Generic – Terminology*

IEC 63145-20-10:2019, *Eyewear display – Part 20-10: Fundamental measurement methods – Optical properties*

IEC 63145-20-20:2019, *Eyewear display – Part 20-20: Fundamental measurement methods – Image quality*

IEC 63145-22-10:2020, *Eyewear display – Part 22-10: Specific measurement methods for AR type – Optical properties*

IEC 63145-22-20[1], *Eyewear display – Part 22-20: Specific measurement methods for AR type – Image quality*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 63145-1-2 and the following apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

[1] Under preparation. Stage at the time of publication: IEC AFDIS 63145-22-20:2023.

3.1.1
number of electrically addressable pixels
total number of physical pixels which are electrically accessible and constitute the micro display that is used to display the image

Note 1 to entry: It is described by $H \times V$, where H and V are the numbers of horizontal and vertical pixels, respectively.

Note 2 to entry: This term does not consider the kind of sub-pixel arrangement.

3.2 Abbreviated terms

AR augmented reality

DUT device under test

FOV field of view

LCD liquid crystal display

LMD light measuring device

VR virtual reality

4 Specification tables

4.1 Generic specification tables

Table 1 and Table 2 shall be applied as the generic specification tables of optical characteristics of eyewear displays. These tables show the list of items which specifies the optical characteristics of eyewear displays.

Table 1 – Blank detail specification table of optical characteristics (applicable to AR and VR)

Characteristics	Symbol	Unit	VR		AR		Measurement methods
			Min.	Max.	Min.	Max.	
Monocular characteristics							
Maximum centre luminance	L_{vCM}	cd/m^2	-		-		IEC 63145-20-10:2019, 6.3
Minimum centre luminance	L_{vCm}	cd/m^2		-		-	IEC 63145-20-10:2019, 6.3
Nine-point luminance	L_{vi} (i = 0 to 8)	cd/m^2					IEC 63145-20-10:2019, 6.3
Average luminance	L_{va}	cd/m^2					IEC 63145-20-10:2019, 6.3
Luminance uniformity	U	%					IEC 63145-20-10:2019, 6.3
Luminance non-uniformity	NU	%					IEC 63145-20-10:2019, 6.3
Chromaticity of white at the centre	(x_W, y_W), (u'_W, v'_W)						IEC 63145-20-10:2019, 6.4
Chromaticity of red at the centre	(x_R, y_R), (u_R', v'_R)						IEC 63145-20-10:2019, 6.4
Chromaticity of green at the centre	(x_G, y_G), (u'_G, v'_G)						IEC 63145-20-10:2019, 6.4
Chromaticity of blue at the centre	(x_B, y_B), (u'_B, v'_B)						IEC 63145-20-10:2019, 6.4

Characteristics	Symbol	Unit	VR		AR		Measurement methods
			Min.	Max.	Min.	Max.	
Chromaticity gamut	$GA_{u'v'}$	%					IEC 63145-20-10:2019, 6.4
Chromaticity uniformity	$(\Delta u'v')_{\mathrm{max}}$						IEC 63145-20-10:2019, 6.5
Centre contrast ratio	CR_{C}						IEC 63145-20-10:2019, 6.6
Nine-point contrast ratio	Cr_i (i = 0 to 8)						IEC 63145-20-10:2019, 6.6
Averaged contrast ratio	CR_{a}						IEC 63145-20-10:2019, 6.6
Contrast non-uniformity	NU_{CR}	%					IEC 63145-20-10:2019, 6.6
Diagonal FOV based on luminance	$A_{\mathrm{d,\ l}}$	degree					IEC 63145-20-10:2019, 6.7
Diagonal FOV based on Michelson contrast	$A_{\mathrm{d,\ MC}}$	degree					IEC 63145-20-20:2019, 6.7
Horizontal, vertical FOV based on luminance	$A_{\mathrm{H,\ l}}$, $A_{\mathrm{V,\ l}}$	degree					IEC 63145-20-10:2019, 6.7
Horizontal, vertical FOV based on Michelson contrast	$A_{\mathrm{H,\ MC}}$, $A_{\mathrm{V,\ MC}}$	degree					IEC 63145-20-20:2019, 6.7
Eye-box width, height based on luminance	$W_{\mathrm{BOX,\ l}}$, $H_{\mathrm{BOX,\ l}}$	mm					IEC 63145-20-10:2019, 6.8
Eye-box width, height based on Michelson contrast	$W_{\mathrm{BOX,\ MC}}$, $H_{\mathrm{BOX,\ MC}}$	mm					IEC 63145-20-20:2019, 6.8
Distortion[a]	δ_{vh}	%					IEC 63145-20-20:2019, 6.3
Colour registration error (red-green)	$\varepsilon_{\mathrm{vh,\ red}}$	degree					IEC 63145-20-20:2019, 6.4
Colour registration error (blue-green)	$\varepsilon_{\mathrm{vh,\ blue}}$	degree					IEC 63145-20-20:2019, 6.4
Michelson contrast	$C_{\mathrm{M},i,\ \mathrm{freq}}$ (i =0 to 8)	lp/degree[b]					IEC 63145-20-20:2019, 6.5
Centre focal distance (dioptre)	D_0	m^{-1}					IEC 63145-20-20:2019, 6.6
Number of electrically addressable pixels	R_{H}, R_{V}	pixel					
Eye relief	ER	mm					

a "Distortion" is referred to as "geometrical distortion" in ISO 9241-305 [1][2].

b "lp" stands for "line pair".

NOTE "Number of electrically addressable pixels" and "Eye relief" are specified by the manufacturer or the supplier.

For multi-point measurement such as that of nine-point luminance, the positions of measurement points shall be reported.

2 Numbers in square brackets refer to the Bibliography.

For FOV measurements, several measurement methods based on luminance (see IEC 63145-20-10:2019, 6.7), chromaticity (see IEC 63145-20-10:2019, 6.7), contrast ratio (see IEC 63145-20-10:2019, 6.7) and Michelson contrast (see IEC 63145-20-20:2019, 6.7) are proposed. The type of FOV measurement method which was used for evaluation shall be reported.

For eye-box measurements, several measurement methods based on luminance (IEC 63145-20-10:2019, 6.8) and Michelson contrast (IEC 63145-20-20:2019, 6.8) are proposed. The type of eye-box measurement method which was used for evaluation shall be reported.

NOTE 1 Table 1 and Table 2 show the list of optical characteristics of eyewear displays. For example, when presenting product specifications in a catalogue, etc., one or more items in Table 1 and Table 2 will be filled. Not necessarily all items will be shown in the product specifications. The table shows the range of performance of characteristic items for multiple eyewear displays with a specific model number.

NOTE 2 For characterizing and reporting characteristics of eyewear display devices, it is useful to consider that performance can be affected by body temperature as well as ambient conditions.

Table 2 – Blank detail specification table of optical characteristics (applicable to AR)

Characteristics	Symbol	Unit	AR		Measurement methods
			Min.	Max.	
Monocular characteristics					
Directional transmittance	$T_{0/0}$	%			IEC 63145-22-10:2020, 6.1
Chromaticity difference through DUT	$\Delta u'v'_{0/0}$				IEC 63145-22-10:2020, 6.2
Front side stray light	$H_{de/0}$	%			IEC 63145-22-10:2020, 6.3
Contrast modulation (Michelson contrast) through DUT	C_{CM}	%			IEC 63145-22-10:2020, 6.4

4.2 Basic specification tables

Subclause 4.2 contains requirements for style and layout of basic specification tables. These requirements are applicable when the detail specification is published.

Table 3 and Table 4, which are subsets of Table 1 and Table 2, shall be applied as the basic specification tables of AR-type and VR-type eyewear displays, respectively. These tables show the minimum required optical items for users to know the basic characteristics of AR-type and VR-type eyewear displays. When presenting product specifications in a catalogue, etc., all items should be filled.

All of the parameters in Table 3 or Table 4 shall be shown in the detail specification. Any additional values shall be given at the appropriate place, but without subclause number(s).

For FOV measurements, several measurement methods based on luminance (see IEC 63145-20-10:2019, 6.7), chromaticity (see IEC 63145-20-10:2019, 6.7), contrast ratio (see IEC 63145-20-10:2019, 6.7) and Michelson contrast (see IEC 63145-20-20:2019, 6.7) are proposed. The supplier or the manufacturer can pick either method. The type of FOV measurement method which was used for evaluation shall be reported.

For eye-box measurements, several measurement methods based on luminance (IEC 63145-20-10:2019, 6.8) and Michelson contrast (IEC 63145-20-20:2019, 6.8) are proposed. The supplier or the manufacturer can pick either method. The type of eye-box measurement method which was used for evaluation shall be reported.

NOTE Table 3 and Table 4 show the list of basic optical characteristics of eyewear displays. For example, when presenting product specifications in a catalogue, etc., all items in Table 3 and Table 4 will be filled.

Table 3 – Blank basic specification table (AR-type)

Subclause	Parameters	Symbol	Unit	Value	Measurement methods
5.2	Directional transmittance	$T_{0/0}$	%		IEC 63145-22-10:2020, 6.1
5.3	Maximum centre luminance (full-screen white)	L_{vCM}	cd/m²		IEC 63145-20-10:2019, 6.3
5.4	Minimum centre luminance (full-screen white)	L_{vCm}	cd/m²		IEC 63145-20-10:2019, 6.3
5.5	Luminance uniformity (full-screen white)	U	%		IEC 63145-20-10:2019, 6.3
5.6	Centre contrast ratio	CR_0			IEC 63145-20-10:2019, 6.6
5.7	Diagonal FOV	A_d	degree		IEC 63145-20-10:2019, 6.7 IEC 63145-20-20:2019, 6.7
5.8	Number of electrically addressable pixels	R_H, R_V	pixel		
5.9	Eye-box width and height	W_{BOX}, H_{BOX}	mm		IEC 63145-20-10:2019, 6.8 IEC 63145-20-20:2019, 6.8

Table 4 – Blank basic specification table (VR-type)

Subclause	Parameters	Symbol	Unit	Value	Measurement methods
5.3	Maximum centre luminance (full-screen white)	L_{vCM}	cd/m²		IEC 63145-20-10:2019, 6.3
5.4	Minimum centre luminance (full-screen white)	L_{vCm}	cd/m²		IEC 63145-20-10:2019, 6.3
5.5	Luminance uniformity (full-screen white)	U	%		IEC 63145-20-10:2019, 6.3
5.6	Centre contrast ratio	CR_0			IEC 63145-20-10:2019, 6.6
5.7	Diagonal FOV	A_d	degree		IEC 63145-20-10:2019, 6.7 IEC 63145-20-20:2019, 6.7
5.8	Number of electrically addressable pixels	R_H, R_V	pixel		
5.9	Eye-box width and height	W_{BOX}, H_{BOX}	mm		IEC 63145-20-10:2019, 6.8 IEC 63145-20-20:2019, 6.8

5 Common conditions for basic specifications

5.1 General

Clause 5 provides the common conditions for basic specifications defined in 4.2. When presenting product specifications in a catalogue, etc., all items shall follow the conditions specified in Clause 5.

NOTE When a user compares different products, an accurate comparison cannot be achieved unless the specifications are described under unified conditions. In Clause 5, the unified conditions are defined for users' convenience.

5.2 Spectral directional transmittance

5.2.1 Measurement methods

The measurement methods specified in IEC 63145-22-10:2020, 6.1, shall be applied.

5.2.2 Measurement conditions

The measurement conditions specified in IEC 63145-22-10:2020, 6.1, shall be applied.

5.2.3 Calculation conditions

The definition of transmittance $T_{0/0}$ specified by Formula (1) in IEC 63145-22-10:2020, 6.1.4, shall be applied.

The following calculation conditions shall be applied: the wavelength range shall be at least from 380 nm to 780 nm.

NOTE The integral range is not determined in IEC 63145-22-10:2020, 6.1. In order to evaluate transmittance in the visible spectrum range, the integral is carried out for sufficient wavelength range.

5.3 Maximum centre luminance (full-screen white)

5.3.1 Measurement methods

The measurement method specified in IEC 63145-20-10:2019, 6.3, shall be applied.

5.3.2 Measurement conditions

The following measurement conditions based on IEC 63145-20-10:2019, 6.3, shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its maximum level.
– The display image is the full-screen white pattern.
– The measuring point of the image is P_0.

NOTE The multi-point luminance measurement method is specified in IEC 63145-20-10. The centre point P_0 is utilized as the representative point for the centre of the virtual image.

5.4 Minimum centre luminance (full-screen white)

5.4.1 Measurement methods

The measurement methods specified in IEC 63145-20-10:2019, 6.3, shall be applied.

5.4.2 Measurement conditions

The following measurement conditions based on IEC 63145-20-10:2019, 6.3, shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its minimum level but not zero.
– The display image is the full-screen white pattern.
– The measuring point of image is P_0.

NOTE In some displays, it can be possible to change the luminance even if the RGB signals are the same, for example by changing the current to the backlight. The item in 5.4.2 is the minimum centre luminance with full-screen white input signal. Thus, reducing the luminance adjustment setting of the DUT with full white image at maximum signal input is intended. Tonal adjustments of RGB signals, such as setting them to the minimum level, are not intended.

5.5 Luminance uniformity (full-screen white)

5.5.1 Measurement methods

The measurement methods specified in IEC 63145-20-10:2019, 6.3, shall be applied.

5.5.2 Measurement conditions

The following measurement conditions based on IEC 63145-20-10:2019, 6.3, shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its maximum level.
– The display image is the full-screen white pattern.

5.5.3 Calculation conditions

The uniformity U is defined as

$$U = \frac{\min\left\{L_{vi} \middle| i = 0 \text{ to } 8\right\}}{\max\left\{L_{vi} \middle| i = 0 \text{ to } 8\right\}} \times 100 \qquad (1)$$

where

U is the uniformity, expressed in %;

L_{vi} is the luminance value of the measurement at the position P_i (i = 0 to 8) specified in IEC 63145-20-10:2019, 5.4, expressed in cd/m^2.

NOTE The definition of uniformity U, whose range is 0 % ≤ U ≤ 100 %, and which is specified in IEC 62977-2-1:2021, [2], 6.5 is applied.

5.6 Centre contrast ratio

5.6.1 Measurement methods

The measurement methods specified in IEC 63145-20-10:2019, 6.6, shall be applied.

5.6.2 Measurement conditions

The following measurement conditions based on IEC 63145-20-10:2019, 6.6, shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its maximum level.
– The measuring point of the image is P_0.

5.6.3 Calculation conditions

The definition of contrast ratio CR_0 specified by Formula (7) in IEC 63145-20-10:2019, 6.6,shall be applied as the centre contrast ratio.

5.7 Diagonal FOV

5.7.1 Measurement methods

For FOV measurements, several measurement methods based on luminance (see IEC 63145-20-10:2019, 6.7), chromaticity (see IEC 63145-20-10:2019, 6.7), contrast ratio (see IEC 63145-20-10:2019, 6.7) and Michelson contrast (see IEC 63145-20-20:2019, 6.7) are proposed. The supplier or the manufacturer can pick either method. One of the measurement methods above shall be applied. The type of FOV measurement method which was used for evaluation shall be reported.

5.7.2 Measurement conditions

The following measurement conditions shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its maximum level.

NOTE FOV is mainly determined by luminance (edge of bright image) in the industry. FOV can also be determined in terms of contrast modulation and spatial resolution.

5.8 Number of electrically addressable pixels

The number of electrically addressable physical pixels of the micro display of the eyewear display shall be reported by the supplier or the manufacturer. If just part of the display pixels is being used to show a virtual image, the number of pixels which are used to show the virtual image shall be reported. If the eyewear display is binocular or biocular, the addressable number of pixels for each eye shall be reported.

NOTE The number of pixels used to show a virtual image can be the same as, or less than, that of the physical display (if just part of the display pixels is used or is being imaged optically towards the virtual image).

5.9 Eye-box width and height

5.9.1 Measurement method

The measurement method specified in IEC 63145-20-10:2019, 6.8, for eye-box based on luminance or IEC 63145-20-20:2019, 6.8, for eye-box based on Michelson contrast, shall be applied.

5.9.2 Measurement conditions

The following measurement conditions shall be applied.

– If the DUT has a functionality to adjust luminance, it shall be set to its maximum level.

NOTE Eye-box is mainly determined by luminance in the industry. Eye-box can also be determined in terms of contrast modulation and spatial resolution.

6 Specifications for AR displays

6.1 General

Clause 6 provides the specifications for AR displays. Due to the nature of AR displays, which are highly dependent on background lighting, a specific specification is introduced. In Clause 6, only the minimum number of items are taken up which are necessary to avoid undesirable situations for eyewear display applications that the user cannot be able to see the surroundings or the eyewear display images. Clause 6 provides specifications for the user to determine if an eyewear display is actually applicable to each user's application.

6.2 Specification tables of transmittance and luminance (AR-type)

Table 5, which is a subset of Table 3, shows a specification table of transmittance and luminance for AR-type eyewear displays. Table 5 provides the essential optical properties of AR-type eyewear displays that enable the user to see both the eyewear display image and real scene around the user (environment).

When utilizing an eyewear display, the user should be able to see both the image of the eyewear display and the surrounding scene clearly. The ability to see the surrounding scene and the image of the eyewear display can be specified by the transmittance of the device and the ratio of the luminance of the image of the eyewear display relative to the luminance of the surrounding scene. If the transmittance of the device is low when considering related basic ambient use case conditions, the user might not be able to see the surrounding scene. Thus, the transmittance of the device shall be higher than a minimum criterion under these basic ambient use case conditions. If the luminance of the image is too low compared to the surrounding scene, the user might not be able to see the image. On the other hand, if the luminance of the image is too high compared to the surrounding scene, the user might be dazzled by the bright image. Thus, the ratio of the luminance of the image of the eyewear display relative to the luminance of the surrounding scene shall be within a minimum and maximum criterion.

NOTE 1 In some eyewear displays, transmittance can depend on the area of the combiner. In Clause 6, the transmittance of the area of the combiner where the image is superimposed is discussed. For example, in the case of an eyewear display with a waveguide, the transmittance at the diffraction grating regions can be different from the transmittance at the rest of the area. In this case, the transmittance at the diffraction grating regions is discussed.

NOTE 2 The difference of chromaticity between an eyewear display image and a real scene image can improve image visibility even if the white luminance ratio is low.

Table 5 – Specification table of transmittance and luminance (AR-type)

Characteristics	Symbol	Unit	Value	Measurement methods
Directional transmittance	$T_{0/0}$	%		IEC 63145-22-10:2020, 6.1
Maximum centre luminance	L_{vCM}	cd/m^2		IEC 63145-20-10:2019, 6.3
Minimum centre luminance	L_{vCm}	cd/m^2		IEC 63145-20-10:2019, 6.3

6.3 Classification and applicable cases

6.3.1 Spectral directional transmittance

6.3.1.1 Classifications

Table 6 shall be used for the transmittance classifications of the eyewear display [3],[5].

Table 6 – Classifications of transmittance

Class	Transmittance $T_{0/0}$ %
Clear	100 > $T_{0/0}$ ≥ 85
A	85 > $T_{0/0}$ ≥ 75
B	75 > $T_{0/0}$ ≥ 55
C	55 > $T_{0/0}$ ≥ 43
D	43 > $T_{0/0}$ ≥ 29
E	29 > $T_{0/0}$ ≥ 18
F	18 > $T_{0/0}$ ≥ 8
G	8 > $T_{0/0}$ ≥ 3
H	3 > $T_{0/0}$ ≥ 0,008 5
I	0,008 5 > $T_{0/0}$ ≥ 0,000 023

NOTE In some eyewear displays with diffractive elements such as gratings or holograms, the measurement results can be affected by the difference of these measurement methods due to scattering or diffraction on the diffractive elements. The transmission measurement can be sensitive to the DUT structure, the light source size, and the LMD collection optics. The measurement variation is expected to be within the relative error allowed for this measurement. IEC 63145-22-10 specifies that the source angular subtense is less than 3° in half angle, while smaller angles lead to errors in transmittance measurement. A light source with half angle of 1° to 3° works well for transmission measurement when diffractive elements are being measured.

6.3.1.2 Level of spectral directional transmittance for applicable use cases and illuminance

Table 7 should be the table of transmittance level categories and basic ambient use case conditions [3] to [16]. As for detail of illuminance in several environments, refer to Annex A.

Table 7 – Level of transmittance for applicable use cases and illuminance

Case No.	Transmittance level	Basic ambient use case conditions
1	Included in category “Clear”	Cases requiring high see-through property (optical clear) in both indoor and outdoor applications [3],[4].
2	Included in categories “Clear” to “A”	Cases requiring high see-through property under twilight or at night [5],[6].
3	Included in categories “Clear” to “C”	Cases requiring high see-through property (optical clear) in both indoor and outdoor applications, with some dimming necessary in case of strong ambient illumination.
4	Included in categories “Clear” to “D”	Case where a certain level of transmittance is necessary; however, the change of luminance through the combiner does not interfere with work in an environment with a certain illuminance (both indoor and outdoor applications) [7].
5	Included in categories “Clear” to “F”	Cases requiring high see-through property (optical clear) in outdoor applications, with dimming necessary in case of strong ambient illumination due to high chance of sun light [5],[6].
6	Included in categories “Clear” to “H”	Usage when users are not required to see the environment or their hands carefully.
7	Included in categories “A” to “G”	Cases mainly targeting dimming in outdoor applications for protection against sun glare.
8	Included in category “G”	Cases targeting strong dimming in outdoor applications for protection against extreme sun glare and UV (e.g., including side protection).
9	Included in categories “Clear” to “I”	Extreme light conditions due to welding, “Clear” or “A” to “H” required in case of switchable eye protection devices.

The case No.1 refers to eyewear display applications where high transmittance is necessary and the dimming effect is not intended in a dark environment. It is not indicated whether the eyewear display is used outside or inside. An example is a working supporting system where the dimming effect is not preferred in order to prevent degradation of the environment recognition. In applications where high transmittance is necessary even in a bright environment, it is preferable to apply the same condition as No.1. This level is based on that of safety glasses [3],[4].

Case No.2 and case No.5 refer to the cases where the eyewear display is used outside [6]. These levels are based on that of spectacle lenses [5].

Case No.4 refers to eyewear display applications where a certain level of transmittance is necessary; however, the change of illuminance through the combiner does not interfere with work in an environment with a certain illuminance [7].

Some eyewear devices have variable transmittance (or use a dimming device) for external scenes, such as an adjustable filter (electro-optical device or photochromic filter) or a series of fixed tint filters. In this case, transmittance shall be measured and reported at least in the two conditions where the transmittance is highest and lowest.

The following shows examples of use cases.

a) Included in category “Clear”:
   – indoor shop floor manual work;
   – indoor operation of hand-held tools;
   – indoor desktop work;
   – outdoor operation of hand-held tools in dark daylight (e.g., forestry);
   – working in a dark control room.
b) Included in categories “Clear” to “A”:
   – motorcycle visor;
   – indoor squash goggles;
   – E-sports (indoor);
   – driving and road use in twilight or at night [5].
c) Included in categories “Clear” to “B”:
   – indoor shop floor equipment monitoring.
d) Included in categories “Clear” to “C”:
   – indoor shop floor logistics.
e) Included in categories “Clear” to “D”:
   – sunglasses for cloudy weather;
   – ski goggles, snowmobile goggles for cloudy weather;
   – office work while sitting on a chair.
f) Included in categories “Clear” to “E”:
   – outdoor yard bulk works (e.g., loading or unloading);
   – outdoor shaft works;
   – motorcycle goggles (sports).

g) Included in categories “Clear” to “F”:
   - outdoor marine works;
   - surface mining;
   - outdoor facility maintenance in winter;
   - surface swimming goggles;
   - outdoor squash goggles;
   - other outdoor sports (hiking,...);
   - driving and road use during daylight [5].

h) Included in categories “Clear” to “H”:
   - activities that do not require to see the environment while sitting on a chair.

i) Included in categories “Clear” to “I”:
   - welding eye protectors.

j) Included in categories “A” to “F”:
   - common sunglasses.

k) Included in categories “A” to “G”:
   - ski and snowmobile goggles.

l) Included in category “G”:
   - very dark sunglasses (for snowfields, at sea…).

NOTE 1 Annex A shows some examples of illuminance of environments.

NOTE 2 Eyewear displays that show images to users by blocking out part of the peripheral field of view are excluded from 6.3.1.2.

6.3.2 Luminance ratio of virtual image versus background

6.3.2.1 General

In 6.3.2, the brightness of the available surrounding scene according to the luminance of eyewear displays shall be specified.

Subclause 6.3.2 shall be applied to use cases where the virtual image of the eyewear display is shown in the line of sight, and the user should recognize both the virtual image and real scene image overlapping one another. Subclause 6.3.2 shall be applied in moderate (≥ 100 lx) and high illumination conditions.

NOTE In 6.3.2, it is discussed whether the user can see the virtual image of eyewear displays (visibility) under ambient illumination. For legibility and readability, it might require higher luminance ratio than that discussed in 6.3.2 (C_{vb} ≥ 1,15). For more detail, see [17].

6.3.2.2 Definition of luminance ratio of virtual image versus background C_{vb}

An eyewear display is equipped with a device which overlaps the image from the image source, to the partial or full view of the scene. In 6.3.2, this device is called a “combiner”. The light from the surrounding scene is partially coupled in, transmit. and coupled out the combiner. When the combiner is a half mirror prism for example, the image light from the image source is partially reflected on the combiner. When the combiner is a waveguide for example, the image light from the image source is coupled in, transmit, and coupled out the combiner. As a result, the combiner overlaps the image from the image source to the view of the scene. In 6.3.2, ambient illumination with a diffuse profile is considered. In addition to a Lambertian diffuse profile, diffuse profiles with different weights for different directions are also considered.

The measurement methods, measurement conditions, and calculation conditions of the luminance ratio of the virtual image versus background C_{vb} specified in IEC 63145-22-20 shall be applied.

The luminance ratio of the virtual image versus background C_{vb} is defined as

$$C_{vb} = \frac{L_{vE} + L_{vI}}{L_{vE}} \tag{2}$$

where

L_{vI} is the luminance of the eyewear display image, expressed in cd/m^2;

L_{vE} is the luminance of the surrounding scene through the combiner (behind the eyewear display image) [18],[19],[20] , expressed in cd/m^2.

NOTE When the background luminance dominates relative to the luminance of the black image L_{vB}, the black and white contrast under ambient light, C_{bw} = (L_{vE} + L_{vI}) / (L_{vE} + L_{vB}), asymptotically approaches to Formula (2).

EXAMPLE An example of C_{vb} and C_{bw} under a bright environment is given as L_{vE} = 1 000 cd/m^2 (for example, E_E = 10 000 lx, R_{obj} = 0,65 and $T_{0/0}$ = 0,5 for Formula (3)), L_{vI} = 150 cd/m^2, black and white contrast in a dark room is CR = 100; then L_{vB} = 1,5 cd/m^2, C_{vb} = 1,15 (C_{vb} is set to the minimum in Table 8), and C_{bw} = 1,148, and thus C_{vb} / C_{bw} = 1,001 5. The second example under a moderate luminance environment is given as: L_{vE} = 10 cd/m^2 (for example, E_E = 100 lx, R_{obj} = 0,65 and $T_{0/0}$ = 0,5 for Formula (3)), L_{vI} = 1,5 cd/m^2, black and white contrast in a dark room is CR = 100 (assuming that the same eyewear display is utilized by reducing illumination on the micro display); then L_{vB} = 0,015 cd/m^2, C_{vb} = 1,15 (assuming C_{vb} is kept), and C_{bw} = 1,148, and thus C_{vb} / C_{bw} = 1,001 5. Another example under a moderate luminance environment is given as: L_{vE} = 10 cd/m^2, L_{vI} = 30 cd/m^2, black and white contrast in a dark room is CR = 100 (assuming that the same eyewear display is utilized by reducing illumination on the micro display); then L_{vB} = 0,3 cd/m^2, C_{vb} = 4 (C_{vb} is set to maximum in Table 8), and C_{bw} = 3,9, and thus C_{vb} / C_{bw} = 1,03.

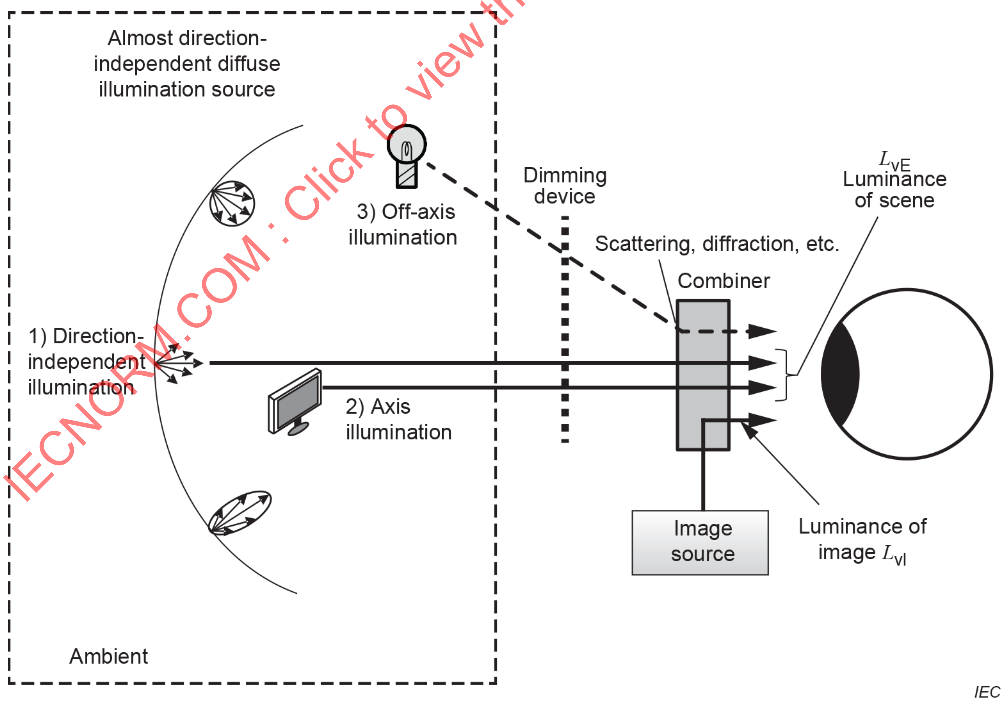

Figure 1 – Examples of ambient illuminations

The eyewear display can be equipped with one or more adjustable shaders (electronic shading devices) or shading plates to reduce the luminance of environment light. The luminance of the surrounding scene L_{vE} shows the luminance after shading by shading element(s). The identifiability of the virtual image can depend on transmittance of the adjustable shader. In order to evaluate the luminance ratio of the virtual image versus background C_{vb}, transmittance of the adjustable shader should be fixed.

There are several types of background illumination [21]. In 6.3.2, the following two types of transmitting environmental illumination are considered as sources for the luminance of surrounding scene L_{vE} (see Figure 1):

1) transmitted, almost direction-independent (diffuse) illumination: ambient illumination with diffuse profile which is almost independent of its direction in front of the combiner (e.g., background room light or day light);
2) transmitted on-axis diffuse illumination: illumination from a diffuse illumination source on the axis of the virtual image behind the combiner (e.g., light from an LCD monitor).

NOTE 1 A surface light source illumination with diffuse profile is considered as the item 2) transmitting axis diffuse illumination. Light from a point light source on the axis of the virtual image in the rear of the combiner has a possibility to affect the identifiability of the eyewear display image.

NOTE 2 Transmitted off-axis illumination is illumination from an illumination source off the axis of the virtual image behind the combiner (e.g. luminaires or the sun), and has the possibility to affect the identifiability of the eyewear display image if it is observed within sight by scattering or diffraction on the combiner.

NOTE 3 Back side stray light has the possibility to affect the identifiability of the eyewear display image. For more detail, see Annex B.

6.3.2.3 Luminance of available surrounding scene

In order to make the image visible for the user, the C_{vb} should be 1,15 or larger to the minimum luminance ratio [18], but a C_{vb} of 1,3 is preferable [19]. In order to avoid dazzling, the C_{vb} should be 4 or less (Table 8) [20]. These specifications show that the eyewear display with image luminance L_{vI} can be utilized under luminance of the surrounding scene between L_{vI} / 3 and L_{vI} / 0,15.

Table 8 – Range of luminance ratio

	Range of luminance ratio
Minimum	$C_{vb} \geq 1,15$
Maximum	$C_{vb} \leq 4$

NOTE 1 For legibility and readability, a luminance ratio of more than 1,15 can be used. For more detail, see [17].

NOTE 2 Since the application is intended for AR, the surrounding environment is assumed to have a certain level of brightness, and the user is expected to be able to see the surroundings. Specifically, it is assumed that the ambient light is brighter than one-third of the luminance emitted by the eyewear display, and it is discussed whether images can be seen when the luminance of the ambient light becomes brighter. If the ambient light is very dark compared to that of the eyewear display image, the ambient light is brightened by turning on a lighting device such as a light bulb or torch to make it easier to see the surrounding environment, or the luminance of the eyewear display is lowered to prevent dazzling.

NOTE 3 Although discussion on the ratio of virtual image luminance and scene luminance has been historically prevalent in head-up displays such as in [18],[19],[20], eyewear displays and head-up displays have in common that they superimpose images onto the real scene. Luminance ratio has been discussed for head-up displays so that both the environment and images can be seen without causing accidents, and this can be applied to eyewear displays. Especially in Chapter 5 of [19], luminance ratio in head-mounted displays is discussed and a luminance ratio of 1,3 is referred to as a “desired” ratio”.

NOTE 4 Table 8 shows the range of luminance ratio for users to be able to see both surrounding and the virtual image of eyewear displays in order to avoid undesirable situations that the user is dazzled by the eyewear display image or the user is not able to see the eyewear display image. In some applications, the luminance of eyewear display image is set to C_{vb} > 4 in order to get the users’ attention, for example.

6.3.2.4 Illuminance of available surrounding scene

Let E_E be the illuminance of the surrounding scene. The luminance of the surrounding scene shall be evaluated with a virtual object located at the background of the image, which has the Lambertian diffusion profile or an approximately Lambertian diffusion profile with a reflectance factor R_{obj}. For example, the value close to 65 % should be used as the reflectance factor R_{obj} for evaluation so that the virtual image is able to be recognizable under severe conditions such as against a white wall. The value of R_{obj} shall be reported. The luminance of the surrounding scene through the combiner L_{vE} is given by

$$L_{vE} = \frac{E_E}{\pi} R_{obj} T_{0/0} \quad (3)$$

where

E_E is the illuminance of the surrounding scene, expressed in lx;

R_{obj} is the luminous reflectance factor of the virtual object, expressed in %;

$T_{0/0}$ is the luminous transmittance of the combiner, expressed in %.

The luminance ratio of the virtual image versus background C_{vb} is given by Formula (2).

In order to make the image visible for the user, the C_{vb} should be 1,15 or larger to the minimum luminance ratio [18], but a C_{vb} of 1,3 is preferable [19]. In order to avoid dazzling, the C_{vb} should be 4 or less (see Table 8) [20].

6.3.2.5 Automatic and manual luminance adjustment

Table 9 shall be the direction to automatic and manual luminance adjustments.

Table 9 – Direction to automatic and manual luminance adjustments

No.	Case	Direction
1	Automatic luminance adjustment is on.	Luminance adjustment should be carried out by considering luminance ratio C_{vb}. The supplier should notify the user of the recommended operating environment.
2	Luminance is adjusted manually by the user.	The supplier should notify the user that luminance is adjusted properly by including it in the instructions, for example. The supplier should notify the user of the recommended operating environment.
3	Luminance is fixed.	The supplier should notify the user of the recommended operating environment.

1) If the DUT has a functionality to adjust the luminance of the virtual image automatically depending on the luminance or illuminance of the surrounding scene, and if its functionality is activated, the luminance adjustment should be carried out by considering the luminance ratio C_{vb}, and the supplier should notify the user of the recommended operating environment.

2) If the DUT is set to a mode in which the luminance of the virtual image is adjustable manually by the user, the supplier should notify the user of the recommended operating environment and that the luminance is adjusted properly.

3) If the DUT does not have a functionality to adjust the luminance of the virtual image either automatically or manually, that is, the luminance is fixed, the supplier should notify the user of the recommended operating environment.

If the luminance of the DUT is fixed, it can be possible to evaluate the luminance ratio by measuring more than two different environment conditions such as a dark and bright environment by considering the recommended operating environment.

If the DUT has a functionality to adjust the luminance automatically or manually, or both, the evaluation of the luminance ratio shall be carried out at multiple and reasonable illuminance or luminance environment conditions by considering the dynamic range of the virtual image luminance, the dynamic range of the environment illuminance or luminance, and the functionality of the automatic luminance adjustment.

7 Specifications for video see-through eyewear displays

7.1 General

Clause 7 provides the specifications for eyewear displays excluding optically see-through displays. Video see-through and VR displays are included.

7.2 Specification table to see the image

Table 10 shows the essential specification table for eyewear displays excluding optically see-through displays. This specification table provides the essential optical properties of eyewear displays excluding optically see-through displays to see the image.

Table 10 – Specification table of luminance (for eyewear displays excluding optically see-through displays)

Characteristics	Symbol	Unit	Value	Measurement methods
Maximum centre luminance	L_{vCM}	cd/m^2		IEC 63145-20-10:2019, 6.3
Minimum centre luminance	L_{vCm}	cd/m^2		IEC 63145-20-10:2019, 6.3

7.3 Video see-through eyewear display – Luminance ratio

In 7.3, the luminance of the background and superimposed image in video see-through eyewear displays shall be specified.

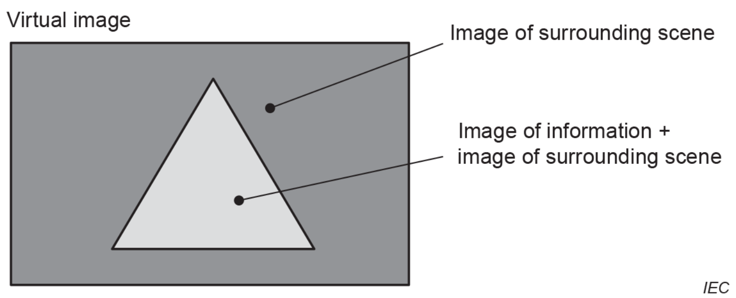

Figure 2 – Image in video see-through eyewear display

Figure 2 shows a virtual image in a video see-through eyewear display. The image of the information which is generated by the eyewear display is superimposed on the image of the surrounding scene. In 7.3, the image of the information is simply superimposed on the image of the surrounding scene without dimming of the image of the surrounding scene and without any frame around the information to make it easier to read.

NOTE 1 In terms of image tonal levels in RGB display devices, $R_A \geq R_B$, $G_A \geq G_B$, and $B_A \geq B_B$, where R_A, G_A, and B_A are the red, green, and blue tonal levels of pixel A; R_B, G_B, and B_B are the red, green, and blue tonal levels of pixel B; pixel A is a pixel where the image of the information is superimposed; pixel B is a pixel where the image of the information is not superimposed, and pixel A is close to pixel B.

The luminance ratio of the image of the information versus the image of the surrounding scene C_{vb} is defined as

$$C_{vb} = \frac{L_{vE} + L_{vI}}{L_{vE}} \quad (4)$$

where

$L_{vE} + L_{vI}$ is the luminance of a pixel when the image of the information is superimposed on the image of the surrounding scene, expressed in cd/m^2;

L_{vE} is the luminance of a pixel when the image of the information is not superimposed on the image of the surrounding scene, expressed in cd/m^2.

In order to make the information visible for the user, C_{vb} should be larger than, or equal to, the minimum luminance ratio 1,15 [18], but a C_{vb} of 1,3 is preferable [19].

NOTE 2 The luminance of the image of the surrounding scene and information is set under maximum luminance. In almost all cases, it is independent of the luminance of the surrounding scene.