
**Ergonomics of human-system
interaction —**

**Part 333:
Stereoscopic displays using glasses**

Ergonomie de l'interaction homme-système —

Partie 333: Écrans stéréoscopiques utilisant des lunettes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

A list of all parts in the ISO 9241 series can be found on the ISO website.

Introduction

Recently, due to the improvement of display technologies, users can easily experience stereoscopic displays using glasses, such as TVs with large screen, personal computers, etc. The displays are used not only in the field of leisure, but also in business, education and medical applications.

This document presents the requirements for visual display units (VDUs) with stereoscopic displays using glasses.

ISO 9241-303 covers the display hardware aspect and gives basic requirements for head-mounted displays (HMDs). ISO/TR 9241-331 presents the optical characteristics of autostereoscopic displays. These other documents are closely related to stereoscopic displays using glasses, but are not directly applicable to them, because the need for special glasses or its absence is an important factor in ergonomics. The visual factors of HMDs are also ergonomically different from those of other displays.

This document is not included in the current ISO 9241-300 subseries for 2D displays because stereoscopic displays have unique features. The development of a separate document to cover stereoscopic displays offers better understanding of its unique features. For an overview of the entire ISO 9241 series, see [Annex A](#).

Moreover, IWA 3:2005^[19] was published (since withdrawn) to discuss the image contents aspect. This ISO International Workshop Agreement described image safety issues and means of reducing the incidence of undesirable biomedical effects caused by visual image sequences. Visual fatigue caused by stereoscopic images (VFSI) is one of these undesirable effects.

With this document and the related International Standards, the purpose is to develop guidelines for image content where activities are closely related to the use of stereoscopic displays with glasses.

To ensure effective and comfortable viewing, and to reduce VFSI, the standards will need to address both display hardware and the displayed contents. However, as the first step, this document focuses on the display hardware aspect in order to simplify the discussions.

Ergonomics of human-system interaction —

Part 333:

Stereoscopic displays using glasses

1 Scope

This document specifies ergonomic requirements for stereoscopic displays using glasses designed to produce or facilitate binocular parallax. These requirements are stated as performance specifications, aimed at ensuring effective and comfortable viewing conditions for users, and at reducing visual fatigue caused by stereoscopic images on stereoscopic display using glasses. Test methods and metrology, yielding conformance measurements and criteria, are provided for design evaluation. See [Annex B](#) for measurement procedures.

This document is applicable to temporally or spatially interlaced types of display. These are implemented by flat-panel displays, projection displays, etc.

Stereoscopic displays using glasses can be applied to many contexts of use. However, this document focuses on business and home leisure applications (i.e. observing moving images, games, etc.). Only dark environments are specified in this document.

For technical explanation of display technologies, see [Annex C](#).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1 General terms

3.1.1

stereoscopic display

3D display where depth perception is induced by *binocular parallax* ([3.2.1](#))

[SOURCE: ISO/TR 9241-331:2012, 2.1]

3.1.2

temporally interlaced type

temporally multiplexed type

temporally multiplexed display

temporally multiplexed stereoscopic display

stereoscopic display ([3.1.1](#)) that shows each of stereoscopic images sequentially

3.1.3

spatially interlaced type

spatially multiplexed type

spatially multiplexed display

spatially multiplexed stereoscopic display

stereoscopic display (3.1.1) that shows each of stereoscopic images divided in the screen

Note 1 to entry: As a result, each of stereoscopic images is shown simultaneously.

3.1.4

glasses

eye attachment for dividing stereoscopic images into each eye from a *stereoscopic display* (3.1.1) not mounted on the user

3.1.5

active glasses

glasses (3.1.4) where the lenses differently change their optical properties synchronizing with the *stereoscopic display* (3.1.1)

Note 1 to entry: Usually left and right images are displayed alternately on a screen. When a left image is displayed, the left lens of active glasses is turned on to transmit the image and the right lens is turned off to cut off the image.

3.1.6

passive glasses

glasses (3.1.4) where the lenses have differently fixed optical properties

3.1.7

stereoscopic images

set of images with parallax shown on a *stereoscopic display* (3.1.1).

[SOURCE: ISO/TR 9241-331:2012, 2.1.7]

3.1.8

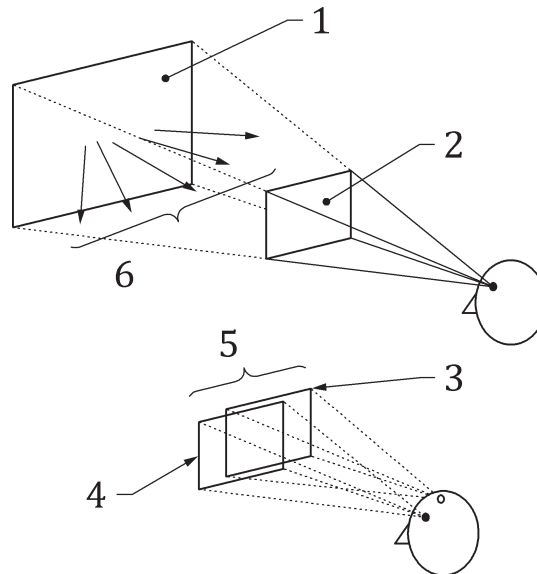
stereoscopic views

pair of sights provided by a *stereoscopic display* (3.1.1), which induce stereopsis

Note 1 to entry: See [Figure 1](#).

Note 2 to entry: Oxford Dictionary defines stereopsis as “the perception of depth produced by the reception in the brain of visual stimuli from both eyes in combination”.

[SOURCE: ISO/TR 9241-331:2012, 2.1.8]

**Key**

- | | | | |
|---|----------------------------|---|---------------------------|
| 1 | autostereoscopic display | 4 | monocular view (left eye) |
| 2 | monocular view (left eye) | 5 | stereoscopic views |
| 3 | monocular view (right eye) | 6 | stereoscopic images |

Figure 1 — Relationship between stereoscopic images, stereoscopic views and monocular view

3.1.9**monocular view**

one *stereoscopic view* ([3.1.8](#))

[SOURCE: ISO/TR 9241-331:2012, 2.1.9]

3.2 Human factors**3.2.1****binocular parallax**

apparent difference in the direction of a point as seen separately by one eye and the other, while the head remains in a fixed position

Note 1 to entry: Binocular parallax is equivalent to the optic angle between the visual axes of both eyes, when they are fixated to a single point.

[SOURCE: ISO/IWA 3:2005, 2.15 — modified.]

3.2.2**visual fatigue**

eyestrain or asthenopia, which shows a wide range of visual symptoms, including tiredness, headache, and soreness of the eyes, caused by watching images in a visual display

Note 1 to entry: See ISO 9241-302:2008, 3.5.3 for the definition of “asthenopia”.

[SOURCE: ISO/IWA 3:2005, 2.13 — modified.]

3.3 Performance characteristics

3.3.1

interocular crosstalk

leakage of the *stereoscopic images* (3.1.7) from one eye to the other

Note 1 to entry: In some cases, interocular crosstalk is referred to as “3D crosstalk”. In *stereoscopic display* (3.1.1) using *glasses* (3.1.4), the crosstalk means interocular effect and therefore this document uses “interocular” instead of “3D”.

3.3.2

interocular luminance difference

difference between the luminance values of the left and right views of a stereoscopic presentation

[SOURCE: ISO 9241-392:2014, 3.16]

3.3.3

pseudoscopic images

pseudostereoscopic images

set of images with inverted parallax shown on a *stereoscopic display* (3.1.1)

4 Display technologies and their guiding principles

For a satisfying human–display interaction, a number of different requirements have to be met at the same time in an appropriate balance. These requirements have been grouped into the following subjects:

- viewing conditions; see 5.1;
- luminance; see 5.2;
- visual artefacts and fidelity; see 5.3.

Each subject includes the related performance characteristics (see Table 1) and the display performance. This document focuses on the significant performance characteristics for stereoscopic display using glasses, which are marked with an asterisk in Table 1. Other performance characteristics, such as “gaze and head tilt angles”, “luminance adjustment”, etc. are common to the ordinary 2D display, and ISO 9241-303 should be applied.

Table 1 — Performance characteristics by subject

Subject	Performance characteristic
Viewing conditions	Design viewing distance ^a
	Design viewing direction ^a
	Gaze and head tilt angles
Luminance	Illuminance ^a
	Display luminance ^a
	Luminance balance
	Luminance adjustment
^a This performance characteristic is a focus of this document.	

Table 1 (continued)

Subject	Performance characteristic
Visual artefacts	Luminance non-uniformity ^a
	Colour non-uniformity
	Contrast uniformity
	Geometric distortions
	Screen and faceplate defects
	Temporal instability (flicker)
	Spatial instability (jitter)
	Moiré effects
	Other instabilities
	Unwanted reflections
	Unwanted depth effects
	Unwanted velocity and acceleration effects
	Interocular luminance difference ^a
	Interocular chromaticity difference
	Interocular contrast difference
	Interocular crosstalk ^a
Fidelity	Colour gamut and reference white
	Gamma and grey scale
	Rendering of moving images
	Image formation time
	Spatial resolution
	Raster modulation or fill factor
	Pixel density
^a This performance characteristic is a focus of this document.	

5 Ergonomic requirements

5.1 Viewing conditions

5.1.1 General

When viewing the stereoscopic display using glasses, conditions such as design viewing distance, design viewing direction and head rotation (in-plain rotation) angles affect the viewer. In order to achieve a comfortable viewing condition, the design viewing distance and direction need to be determined properly.

NOTE When the viewer rotates his/her head, stereopsis is affected due to the mismatch of displayed parallax. In this case, the effect of the displayed contents is evaluated first, and therefore the detailed requirements are omitted from this document.

5.1.2 Design viewing distance

The design viewing distance is dependent on the application and the display hardware, such as the display area size and the screen resolution. Therefore, the supplier of the display shall specify the design viewing distance. If it is not specified, $1,3D_{\text{view}}$ should be applied, where D_{view} is the diagonal

of the active display area. Shorter viewing distances can be used in the smaller display (smaller than 9 inches diagonal).

NOTE In stereoscopic displays, the depth sensation is affected by the viewing distance. Many contents for stereoscopic display using glasses assume the viewing distance to be $3H_{\text{view}}$. $3H_{\text{view}}$ is equivalent to $1,3D_{\text{view}}$, and $1,3D_{\text{view}}$ is better for various aspect ratios of the active display area. When the viewing distance is shorter, the perceived parallax is larger. This condition may increase discomfort and visual fatigue caused by stereoscopic images (VFSI) and therefore needs to be avoided.

5.1.3 Design viewing direction

For general use, the stereoscopic display using glasses should be viewed from any angle of inclination up to at least 40° from the normal to the surface of the display, measured in any plane. For personal use, the display area as a whole should be viewed from at least the design viewing position determined by the design viewing distance and direction. Therefore, the supplier of the display shall specify the design viewing direction, and the specified value shall be applied. If it is not specified, the above requirements should be applied.

5.2 Luminance

5.2.1 General

In order to obtain information from the display, sufficient display luminance is necessary. In addition, a luminous environment to the screen contributes to the display luminance. When the stereoscopic display using glasses is used, the display area and also the environment is viewed through the glasses. Therefore, the display luminance shall be checked through the glasses.

NOTE With the glasses, both the display luminance and the screen illuminance are generally reduced.

5.2.2 Illuminance

The supplier shall specify the design screen illuminance, E_s .

5.2.3 Display luminance

In the ambient illumination for which the display is designed, the display luminance through glasses shall exceed the minimum value for obtaining a sufficient recognizability of the displayed information over the design viewing range and the intended lifetime of the visual display unit.

NOTE In the stereoscopic display using glasses, the display luminance through glasses is checked, because the glasses transmittance affects the display luminance.

5.3 Visual artefacts and fidelity

5.3.1 General

When the display technology is not ideal, the viewer will perceive visual artefacts. In the stereoscopic display using glasses, the visual artefacts are classified into monocular artefacts and binocular artefacts. The monocular artefacts are perceived by one eye and contain screen non-uniformity in luminance, temporal instability (flicker), etc. The binocular artefacts are typical of the stereoscopic display using glasses, and interocular difference in luminance and interocular crosstalk are included.

In this document, the performance characteristics selected are those that are strongly related to stereopsis. Performance characteristics where the current display technology can easily fulfil the requirements (e.g. colour non-uniformity and contrast uniformity) are omitted. For example, the requirements for colour non-uniformity for 2D display are described in ISO 9241-303. However, in some cases the requirements cannot be directly applied to the stereoscopic display using glasses, because the stereoscopic display is viewed through glasses. The effect of glasses should be taken into account.

Moiré effects are also omitted because it is not peculiar to the stereoscopic display using glasses. In the patterned retarder-type display, the moiré phenomenon can sometimes occur. However, this can be evaluated from the luminance non-uniformity. In temporally or spatially interlaced types, interocular chromaticity difference and interocular contrast difference can be omitted because the difference is generally small.

In this document, the temporally instability (flicker) is not applied.

NOTE 1 The display flicker causes discomfort in general and therefore it needs to be avoided. However, in order to establish the requirements, more investigations are necessary. For example, some academic papers have described an asynchronous flicker effect with shutter glasses. If the flicker between both eyes is not synchronized, it is said that the flicker perception can be reduced[6][7].

NOTE 2 See ISO 9241-305: 2008, P15.3 and P15.3A for the measurement method of flicker for 2D displays.

NOTE 3 When a non-inverter type of environmental illumination is observed through the shutter glasses, the viewer sometimes perceives the flicker. In this case, the environmental illumination can be off or darkened. The viewer needs to pay attention to the illumination.

Fidelity is an attribute for indicating the correspondence between displayed images and their original images, and includes colour gamut, reference white, gamma, grey scale, resolution, rendering of moving images, etc. In this document, fidelity is not applied for the same reasons as for visual artefacts.

NOTE 4 ISO 9241-303 suggests that it is uncertain whether images with the highest fidelity will be those preferred by the viewers. The requirements in ISO 9241-303 cannot be directly applied to the stereoscopic display using glasses, because the effect of glasses needs to be considered. For example, the glasses may affect the colour gamut and reference white.

5.3.2 Luminance non-uniformity

For an intended uniform display luminance, the luminance non-uniformity, either step-wise or smooth, in ambient illumination shall not exceed the threshold for reduced visual performance, with a maximum of 1,4:1.

5.3.3 Interocular luminance difference

The luminance differences in the left- and right-eye views should not exceed 25 % and shall not exceed 40 %.

NOTE In the stereoscopic display using glasses, the interocular luminance difference is caused by the glasses influence. For example, in the shutter glasses type, the difference occurs if the shutter timing is not appropriate, because the transmittance between both lenses will be different. Generally, the limit of interocular luminance difference is around 50 %[8][9].

5.3.4 Interocular crosstalk

The interocular crosstalk of each eye should not exceed 5 % and shall not exceed 10 %.

NOTE 1 Interocular crosstalk is the leakage of the stereoscopic images from one eye to the other. When interocular crosstalk occurs a double image can be viewed. It is generally said that 1 % to 2 % crosstalk can be perceived, and therefore the perception limit is around 2 %[10]. When crosstalk increases, stereopsis is disturbed, and then it causes discomfort and VFSI. Generally, the tolerance limit is around 10 %[11] and less than 5 % is recommended[12]. Using the current display technology, in the perpendicular direction the stereoscopic display has lower crosstalk but angular dependence exists. Therefore, the interocular crosstalk is checked across the design viewing angles.

NOTE 2 The displayed contents are strongly related to the perception of interocular crosstalk. Generally, white-and-black interocular crosstalk is used, because its influence is large. However, many kinds of grey level crosstalk measurement are recently proposed[13][14][15][16][17][18]. When the measurement is applied, the relation between the grey level crosstalk level and its influence is evaluated.

NOTE 3 Pseudostereoscopy can be regarded as the state where interocular crosstalk is over 100 %, because visual images to be presented to the right and left eyes for stereopsis are presented to the left and right eyes, respectively. This means that reducing interocular crosstalk can prevent pseudostereoscopy.

6 Optical laboratory test methods

6.1 General

6.1.1 Basic measurements and derived procedures

The optical laboratory test methods in this document adopt the same format as that of ISO 9241-305. The collection of optical measurements necessary for the compliance evaluations is divided into basic measurements, identified by M and a measurement number, and measurement procedures, identified by P and a procedure number (and letter in the case of supplementary procedures), as described in [6.1.1.1](#) and [6.1.1.2](#).

6.1.1.1 Basic measurements (or evaluation): method M

Basic measurements should describe a fundamental method as simply as possible. Most of the essential measurement parameters (such as screen location, viewing direction, test pattern, etc.) are not specified. The specified result is a physical quantity or some other directly measured property, and does not involve any processing of the collected data. These results are usually not directly used in a compliance procedure, as specified in [Clause 7](#). Instead, following a compound measurement procedure (see [6.1.1.2](#)), a basic measurement will be used to achieve sets or collections of data.

These basic measurements define the types of meters acceptable for use, meter parameters, and any default parameters ("fixed measurement conditions"), and list the parameters that are to be varied by the compound measurement procedure ("configurable measurement conditions"). These latter parameters are often defined by the compliance procedure (see [Clause 7](#)).

6.1.1.2 Compound measurement procedures: procedure P

Compound measurement procedures are methods that collect and evaluate physical quantities that were measured using a basic method (see [6.1.1.1](#)). These procedures reference basic measurements, and may specify the specific requirements for the "configurable measurement conditions". They also include any special preparation procedures. The result of a procedure is a collection of basic quantities (e.g. area or angular distribution of luminance), or derived quantities (e.g. crosstalk, interocular difference). In many cases, the measurement procedures could have some of the configurable measurement conditions defined by the compliance procedure (see [Clause 7](#)).

6.1.2 Structure

The measurement methods given in this clause are structured as follows:

- a) objective: describes the purpose and quantities measured;
- b) applicability: describes the type of displays (or applications) in which the particular measurement is relevant;
- c) preparation and set-up: describes fixed and configurable measurement conditions, optional accessory equipment and any special preliminary requirements;
- d) procedure: describes the measurement or references basic measurement method;
- e) analysis: describes calculation of the measured data with mathematical models;
- f) reporting: describes the form of reporting, including the number of significant digits, where appropriate;

g) comments: describes any special concerns or relevant information not contained elsewhere.

6.2 Measurement conditions

6.2.1 Preparations and procedures

6.2.1.1 Display warm-up

Allow sufficient time for the display luminance to stabilize, with a minimum of 20 min. When indicated by the manufacturer, the display should be warmed up for the specified time (not to exceed 1 h).

6.2.1.2 Technology dependent parameters

Testing should be conducted under normal user conditions for power supply. The bias settings (if any) of the display should be set to those expected under typical use.

One adjustment setting shall be used for each complete test sequence. If multiple settings are provided, this implies multiple complete test sequences.

6.2.1.3 Cleaning

Ensure that the display is clean.

6.2.1.4 Alignment

The display screen should be aligned such that a plane tangential to the screen centre is parallel to the axes of the measurement system(s). The alignment tolerance should be within 1°.

For tilt, the active display area shall be aligned such that a horizontal line through the screen centre is parallel to the horizontal axis of the measurement instrument and/or of the measurement instrument travel.

6.2.1.5 Brightness and contrast control settings

The display should be adjusted to its default or preset brightness and contrast. The controls should remain at these settings for all measurements.

NOTE The default or preset mode is most likely to be used.

6.2.1.6 Image size

Use the factory setting or the default, if available. Otherwise, adjust to a specified size.

6.2.1.7 Video drive levels

A digital interface is applied. If the display only uses an analogue interface, then the drive level(s) should be specified for video signal lines. The value used should be specified.

6.2.1.8 Display resolution

The display should be tested in its natural resolution if not otherwise specified by the supplier.

6.2.2 Test accessories

6.2.2.1 Mirror standards

Mirror standards are mainly used for checking the geometrical alignment and for redirecting light from a source into a light-measuring device (LMD).

6.2.2.2 Data acquisition

LMD samples as a function of time are typically collected, stored, processed and displayed by a storage device such as a computer or storage oscilloscope.

6.2.2.3 Ruler

Use of a steel ruler (mm resolution) or equivalent linear or digital micrometre can be used for small measurements. For large measurements, such as a steel tape measure (with mm resolution) can be used for determining large area dimensions, such as the size of a projected image.

6.2.2.4 Graduated scales

Linear and rotational scales are recommended for achieving accurate alignment.

6.2.3 Test patterns

The test patterns that are used by the measurement procedures are described below.

- All pixels are white (all white).
- All pixels are black (all black).
- One of stereoscopic images is white, others are black.
- One of stereoscopic images is grey, others are grey in a different level.
- Colour test images (red, green, blue).
- Grey and colour levels will be expressed accordingly.

Box (window) patterns are also used in some measurements.

EXAMPLE 1 For RGB, red is $R = 100\%$, $G = 0\%$, $B = 0\%$.

EXAMPLE 2 50 %, grey is $R = 50\%$, $G = 50\%$, $B = 50\%$.

NOTE 1 In some cases, grey patterns are used.

NOTE 2 For preparing the test patterns, the supplier specifies which pixels are used for measurement. Or alternatively, the supplier can prepare the test patterns.

6.2.4 Alignment: measurement location and meter position

6.2.4.1 Standard five locations

Five standard measurement locations are defined for making measurements of various types (see [Figure 2](#)).

The locations are at

- a) the centre (i.e. at the intersection of the two diagonals of the addressable area), and

- b) the locations on the diagonals that are 10 % of the diagonal length in from the corners of the addressable area of the display.

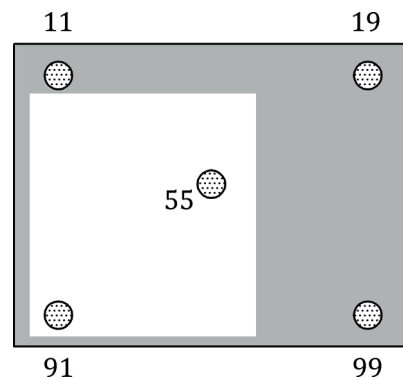


Figure 2 — Standard five locations

6.2.4.2 Standard nine locations

The standard nine locations are shown in Figure 3.

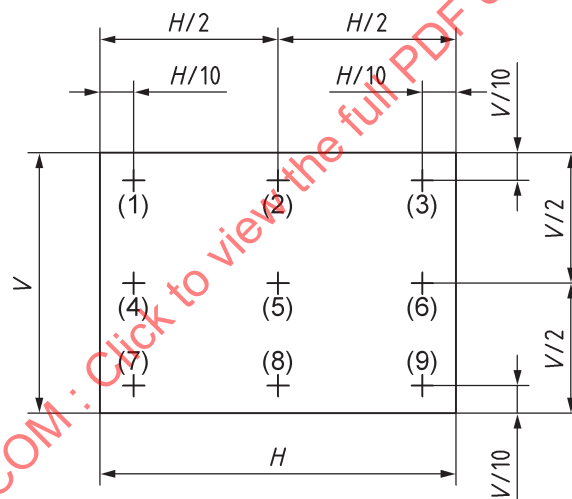


Figure 3 — Standard nine locations

6.2.5 Light measuring device (LMD)

6.2.5.1 Spot meter

The spot meter creates an image of the object on a photodetector using a lens and the sample part of that image is measured. Many of these LMDs have a viewing port or viewfinder (either optical or video) such that the lens focuses the image of the object to be measured onto the detection aperture. It is always important to properly focus the device so that the image lies essentially in the plane of the measurement aperture.

Any instrument with a lens is sensitive to stray light and thus to methods taken to minimize any corruption.

The aperture of the LMD (usually the diameter of the object lens of the LMD) shall be smaller than the lens of glasses in standard measuring layout. When no LMD having a small aperture is available and a larger aperture LMD is used, the distant LMD or near-screen layouts of glasses can be applied.

6.2.5.2 Array devices

In addition to the spot meter, there are array detectors such as charge-coupled devices (CCD).

When the array devices are applied, the measurement results shall be confirmed to be the same as that measured by the spot meter.

Several sources of errors are associated with array detector imaging systems. For example, a calibrated CCD can have exactly the same response for each array pixel. However, when it is put into a system with a lens, it is likely that the entire imaging system will no longer preserve that uniformity because of the performance of the lens, reflections, etc. Therefore, there are several factors that should be considered when using an array photodetector; see ISO 9241-305.

NOTE The imaging system includes the lens.

6.2.6 Measurement field

The LMD shall measure an area of at least 500 pixels that has an extent of less than 10 % of the screen height. The area should be centred round the measurement locations. If the variation is 1 % or more, then any spatial non-uniformity is insignificant and the smaller measurement field can be used.

6.2.7 Angular aperture

The angular aperture of LMD shall be 2° or less.

6.2.8 Meter time response

The measurement time interval should be long enough so that the standard deviation of 10 or more luminance measurements is no greater than 1 %. The instrument can be time-synchronised to trigger a measurement with the refresh rate of the display. Measurement interval should be a multiple of the refresh rate.

6.2.9 Test illumination

6.2.9.1 Darkroom

Ensure not only that all room lights are turned off, but also that light from equipment in the room and reflections from surrounding objects back to the screen are controlled such that they are at a negligible level. Illuminance, E , on the screen should be 1 lx or less. This is equivalent to stating that the luminance of a diffuse white surface at the position of the screen should have a luminance of less than 0,32 cd/m². However, in some cases this specification is insufficient. In general, the goal is to avoid corruption of measured dark colours due to ambient light or reflections. Avoid measuring as screen luminance reflections off the screen from clothing and equipment lights. Ambient lighting, both direct (instrumentation, room lighting, windows, and other sources) and indirect (walls, tables, equipment, lab personnel clothing, and other surfaces), should be controlled to avoid errors caused by reflections from the display screen. Additional errors can be contributed by lens flare or veiling glare from the rest of the screen.

6.2.10 Other ambient test conditions

Normal lab conditions assume an environment similar to normal office conditions. If the equipment under test (EUT) should be operated beyond the conditions described, use the conditions recommended by the manufacturer and agreed upon by all interested parties. Report compliance with conditions. Any deviation from the following limits should be reported.

- Temperature: 20 °C ± 5 °C.
- Humidity: 25 % to 85 % relative humidity, non-condensing.

— Barometric pressure: 86 kPa to 106 kPa (approximate sea level to 1 400 m).

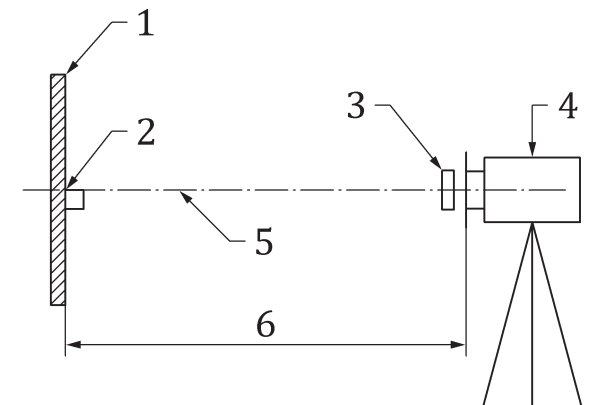
6.3 Measurement methods

6.3.1 Basic light measurements

6.3.1.1 M 331.1: Basic spot measurement

- a) Objective: Measure the photometric and/or spectral properties of the display at the specified parameters.
- b) Applicability: All displays.
- c) Preparation and set-up:
 - 1) fixed measurement conditions:
 - i) measurement field; see [6.2.6](#), measurement field;
 - ii) meter angular aperture; see [6.2.7](#), angular aperture;
 - iii) meter response time; see [6.2.8](#), time-averaging meter;
 - 2) configurable measurement conditions:
 - i) test patterns;
 - ii) measurement locations;
 - iii) meter direction;
 - iv) test illumination;
 - v) spectral characteristics.
- d) Procedure:
 - 1) generate a specified pattern on the EUT screen;
 - 2) measure the luminance and/or the chromaticity coordinates and/or spectral power distribution for each of the specified measurement location(s) at the specified direction(s);
 - 3) change the lens of glasses to another side and repeat for additional patterns.
- e) Analysis: None.
- f) Reporting: Report luminance in cd/m^2 , chromaticity spectral power distribution in $\text{W}/(\text{sr nm m}^2)$.
- g) Comments: The measurement of the black luminance is particularly susceptible to errors caused by the room ambient lighting conditions (see [6.2.9.1](#) for more details).

Automatically focusing instruments should be focused on the screen and not on the lens.



Key

- | | |
|------------------------|-------------------------------|
| 1 stereoscopic display | 4 light-measuring device |
| 2 screen centre | 5 centre line |
| 3 a lens of glasses | 6 standard measuring distance |

Figure 4 — Measuring layout (side view)

6.3.1.2 M 332.1: Standard measurement locations

- a) Objective: Measure the full screen luminance at predefined positions based on screen size, and report the minimum, maximum and centre screen luminances.

NOTE This procedure is based on [6.3.1.1](#).

- b) Applicability: All displays.

- c) Preparation and set-up:

- 1) fixed measurement conditions:
 - i) measurement field; see [6.2.6](#), measurement field;
 - ii) meter angular aperture; see [6.2.7](#), angular aperture;
 - iii) meter response time; see [6.2.8](#), time-averaging meter;
- 2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see [6.2.3](#), full screen 100 % white or box patterns;
 - ii) measurement locations; see [6.2.4.2](#), standard nine locations;
 - iii) meter direction;
 - iv) test illumination; see [6.2.9.1](#), darkroom.
 - v) spectral characteristics, only luminance required.
- d) Procedure: Perform luminance measurement at each specified location; see [6.3.1.1](#).
- e) Analysis: None.
- f) Reporting: Report the maximum, minimum and centre screen luminances along with their respective screen positions.

g) Comments: See [6.3.1.1](#).

6.3.2 P 333.1: Luminance angular distribution

- a) Objective: Determine luminance characteristics for a set number of viewing directions by taking full screen luminance measurements at the locations of the screen.
- b) Applicability: All displays.
- c) Preparation and set-up:

- 1) fixed measurement conditions:
 - i) measurement field; see [6.2.6](#), measurement field;
 - ii) meter angular aperture; see [6.2.7](#), angular aperture;
 - iii) meter response time; see [6.2.8](#), time-averaging meter;
- 2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see [6.2.3](#), full screen or box patterns at specified colours;
- ii) measurement locations; see [6.2.4.2](#), standard nine locations;
- iii) meter direction, normal to display screen at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see [6.2.9.1](#), darkroom.
- v) spectral characteristics, spectral distribution, luminance.
- d) Procedure: Take the required goniometric measurements of luminance L_θ , φ and the chromaticity coordinates of the required patterns with the meter positioned at each of the appropriate viewing angles; see [6.3.1.1](#).
- e) Analysis: None.
- f) Reporting: Data should be presented in tabular or graphic form showing no more than three significant figures.
- g) Comments: See [6.3.1.1](#).

6.3.3 P 334.1: Luminance angular uniformity

- a) Objective: Measure the full screen luminance uniformity for different angles at specified locations.
- b) Applicability: All displays.
- c) Preparation and set-up:

- 1) fixed measurement conditions:
 - i) measurement field; see [6.2.6](#), measurement field;
 - ii) meter angular aperture; see [6.2.7](#), angular aperture;
 - iii) meter response time; see [6.2.8](#), time-averaging meter;
- 2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see 6.2.3, full screen or box patterns at specified colours;
- ii) measurement locations; see 6.2.4.2, standard nine locations;
- iii) meter direction, normal to display screen: at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see 6.2.9.1, darkroom.
- v) spectral characteristics, only luminance required.

d) Procedure: See 6.3.2.

e) Analysis: Calculate the luminance uniformity, at each test position, using Formula (1):

$$\text{Uniformity} = 100 \% (L_{\min}/L_{\max}) \quad (1)$$

where

$L_{\max}$ is the maximum measured display luminance of the sampled display luminance set, L_i , and where $i = 1, \dots, n$, for each test direction;

$L_{\min}$ is the minimum measured display luminance of the sampled display luminance set: L_i , and where $i = 1, \dots, n$, for each test direction.

- f) Reporting: Data should be presented in tabular or graphic form showing no more than three significant figures.
- g) Comments: See 6.3.1.1.

6.3.4 Luminance analysis

6.3.4.1 P 335.1: Area average luminance

- a) Objective: Measure the average of the display luminance at the defined locations of the screen.
- b) Applicability: All displays.
- c) Preparation and set-up:

1) fixed measurement conditions:

- i) measurement field; see 6.2.6, measurement field;
- ii) meter angular aperture; see 6.2.7, angular aperture;
- iii) meter response time; see 6.2.8, time-averaging meter;

2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see 6.2.3, full screen or box patterns at specified colours;
- ii) measurement locations; see 6.2.4.2, standard nine locations;
- iii) meter direction, normal to display screen: at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see 6.2.9.1, darkroom.

- v) spectral characteristics, only luminance required.
- d) Procedure: See [6.3.1.1](#).
- e) Analysis: Calculate the average luminance of the display using [Formula \(2\)](#):

$$L_{\text{ave}} = \frac{1}{n} \sum_{i=1}^n L_i \quad (2)$$

where

L_i is the luminance of the display at the i th position;

n is the number of measurement locations.

- f) Reporting: Report the average luminance in cd/m².
- g) Comments: See [6.3.1.1](#).

6.3.4.2 P 336.2: Lateral luminance uniformity

- a) Objective: ensure luminance of full-screen white at the dimmest (darkest) and the brightest areas (spots) and calculate the uniformity.
- b) Applicability: All displays.
- c) Preparation and set-up:

- 1) fixed measurement conditions:
 - i) measurement field; see [6.2.6](#), measurement field;
 - ii) meter angular aperture; see [6.2.7](#), angular aperture;
 - iii) meter response time; see [6.2.8](#), time-averaging meter;

- 2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see [6.2.3](#), full screen or box patterns at specified colours;
- ii) measurement locations; see [6.2.4.2](#), standard nine locations;
- iii) meter direction, normal to display screen: at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see [6.2.9.1](#), darkroom.
- v) spectral characteristics, only luminance required.
- d) Procedure: Measure the luminance of the centre of the brightest spot, L_{max} , and then of the centre of the darkest or dimmest spot, L_{min} , subject to above set-up conditions.

- e) Analysis: Calculate the luminance uniformity, at each test position using [Formula \(3\)](#):

$$\text{Uniformity} = 100 \% (L_{\text{min}}/L_{\text{max}}) \quad (3)$$

where L_{max} and L_{min} are the maximum and minimum measured display luminances.

- f) Reporting: Data should be presented in tabular or graphic form showing no more than three significant figures.

g) Comments: See [6.3.1.1](#).

6.3.5 P 337.1: Interocular luminance difference

a) Objective: Ensure interocular luminance difference of full-screen white.

b) Applicability: All displays.

c) Preparation and set-up:

1) fixed measurement conditions:

- i) measurement field; see [6.2.6](#), measurement field;
- ii) meter angular aperture; see [6.2.7](#), angular aperture;
- iii) meter response time; see [6.2.8](#), time-averaging meter;

2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see [6.2.3](#), full screen or box patterns at specified colours;
- ii) measurement locations; see [6.2.4.2](#), standard nine locations;
- iii) meter direction, normal to display screen: at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see [6.2.9.1](#), darkroom.
- v) spectral characteristics, only luminance required.

d) Procedure:

- 1) apply a full screen white signal to left and right signal inputs;
- 2) set a lens of the glasses on the LMD, measure the luminance at each selected point and record the luminance values as full screen white luminance;
- 3) change the lens of glasses to another side and measure the luminance values similarly.

e) Analysis: Calculate the interocular luminance difference (ILD), at each test position, using [Formula \(4\)](#):

$$ILD = 100 \% \left(\frac{2 \times |L_L - L_R|}{L_L + L_R} \right) \quad (4)$$

where

L_L is the luminance when the left lens of glasses is set on the LMD;

L_R is the luminance when the right lens of glasses is set on the LMD.

f) Reporting: Data should be presented in tabular or graphic form showing no more than three significant figures.

g) Comments: See [6.3.1.1](#).

6.3.6 P 338.1: Interocular crosstalk

a) Objective: Ensure interocular crosstalk of white-and-black.

b) Applicability: All displays.

c) Preparation and set-up:

- 1) fixed measurement conditions:
 - i) measurement field; see 6.2.6, measurement field;
 - ii) meter angular aperture; see 6.2.7, angular aperture;
 - iii) meter response time; see 6.2.8, time-averaging meter;
- 2) configurable measurement conditions:

NOTE Use the parameters as described unless otherwise specified.

- i) test patterns; see 6.2.3, full screen or box patterns at specified colours;
- ii) measurement locations; see 6.2.4.2, standard nine locations;
- iii) meter direction, normal to display screen: at specified values of θ and φ (10° steps or less within specified viewing region);
- iv) test illumination; see 6.2.9.1, darkroom.
- v) spectral characteristics, only luminance required.

d) Procedure:

- 1) apply full screen white to left image and full screen black to right image;
- 2) set the left lens of glasses on the LMD, measure the luminance and record the luminance values as the left eye luminance with the input signals of white and black $L_{L, WB}$;
- 3) change the lens to the right one and measure the luminance and record the luminance values as the right eye luminance with the input signals of black and white $L_{R, BW}$;
- 4) change the input signals as full screen black to left image and a full screen white to right image;
- 5) measure the luminance and record the right eye luminance with the input signals of white and black $L_{R, WB}$;
- 6) change the lens to the left one, measure the luminance and record the left eye luminance with the input signals of black and white $L_{L, BW}$;
- 7) change the input signal as full screen black signal to both left and right images;
- 8) measure the luminance and record the left eye luminance with the input signals of both black $L_{L, BB}$;
- 9) change the lens to the right one, measure the luminance and record the right eye luminance with the input signals of both black $L_{R, BB}$.

e) Analysis: Calculate the interocular crosstalk of the left view $X_{R \text{ to } L}$ using Formula (5) and the right view $X_{L \text{ to } R}$ using Formula (6):

$$X_{R \text{ to } L} = 100 \% \left(\frac{L_{L, BW} - L_{L, BB}}{L_{L, WB} - L_{L, BB}} \right) \quad (5)$$

$$X_{L \text{ to } R} = 100 \% \left(\frac{L_{R, WB} - L_{R, BB}}{L_{R, BW} - L_{R, BB}} \right) \quad (6)$$

where

$L_{L, WB}$ is the luminance when the left lens of glasses is set on the LMD and full screen white to left image and full screen black to right image;

$L_{R, BW}$ is the luminance when the right lens of glasses is set on the LMD and full screen white to left image and full screen black to right image;

$L_{R, WB}$ is the luminance when the right lens of glasses is set on the LMD and full screen black to left image and a full screen white to right image;

$L_{L, BW}$ is the luminance when the left lens of glasses is set on the LMD and full screen black to left image and a full screen white to right image;

$L_{L, BB}$ is the luminance when the left lens of glasses is set on the LMD and the input signal as full screen black signal to both left and right images;

$L_{R, BB}$ is the luminance when the right lens of glasses is set on the LMD and the input signal as full screen black signal to both left and right images.

f) Reporting: Data should be presented in tabular or graphic form showing no more than three significant figures.

g) Comments: See [6.3.1.1](#).

7 Analysis and compliance test methods

7.1 Compliance routes

7.1.1 Intended context of use

The attributes of the user, environment, tasks and use of display are summarized in [Table 2](#). Attributes are derived from analysis of the intended context of use and are an essential prerequisite for the compliance assessment. The supplier shall specify the intended context of use as well as the value or value range of an attribute. The values specified shall match the intended context of use. The intended context of use is part of the compliance report.

Table 2 — Intended context of use

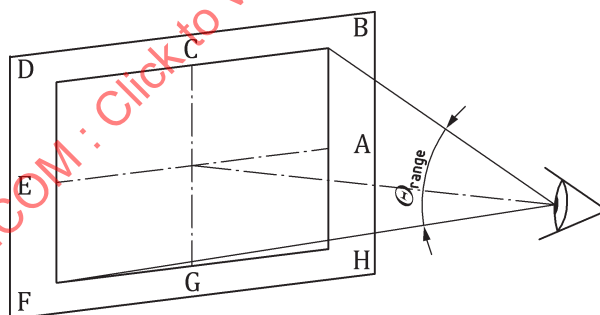
Element	Attribute	Quantification
User	Vision	User with normal or corrected to normal vision of any age, 7 years or older (any literate user).
Environment	Design screen illuminance, E_s	Darkroom environment: up to 1 lx.
	Typical components of the illumination	Not applied (Dark environment).
	Illuminant	Not applied (Dark environment).
	Ambient temperature	For this compliance route, an ambient temperature of approximately 15 °C to 35 °C is considered, if not otherwise specified by the supplier.

Table 2 (continued)

Element	Attribute	Quantification
Contexts of use	Content and perception	Stereoscopic image of objects and scenes that have existing originals in the real world, e.g. faces, people, landscapes, etc.
	Amount of information	Preferred screen size for sufficient amount of information with appropriate object size and resolution.
	Image type	For this compliance route, still, quasi-static or moving images are considered, if not otherwise specified by the supplier.
	Design viewing distance, $D_{\text{design, view}}$	The supplier shall specify the design viewing distance depending on the predominant information. If it is not specified, $1.3D_{\text{view}}$ should be applied, where $1.3D_{\text{view}}$ is the diagonal of the active display area.
	Design viewing direction	Perpendicular viewing direction is assumed, if not otherwise specified by the supplier.
	Design viewing direction range (angle of inclination and azimuth)	The supplier shall specify the design viewing direction range. If not, one of the cases presented in 7.1.2 should be applied.
	Eye and head position	From fixed to moving.
	Number of users	Typically single or multiple.
	Glasses	The display supplier shall specify the glasses.
Usage	Display handling	For this compliance route, stationary display handling is considered, if not otherwise specified by the supplier.

7.1.2 Design viewing direction range (angle of inclination and azimuth)

See [Figure 5](#).



Viewing cone for a single user to view the whole area of a single visual display at the design viewing distance from at least one fixed location. Provides uniformity over the whole screen.

The maximum inclination angle range, θ_{range} , is:

$$\theta_{\text{range}} = 2 \times \arctan(D_{\text{active}} / 2 \times D_{\text{design, view}})$$

where

D_{active} is the diagonal of the active display area;

$D_{\text{design, view}}$ is the design viewing distance.

The design inclination angle is within $0^\circ \leq \theta_D \leq 40^\circ - \theta_{\text{range}}/2$.

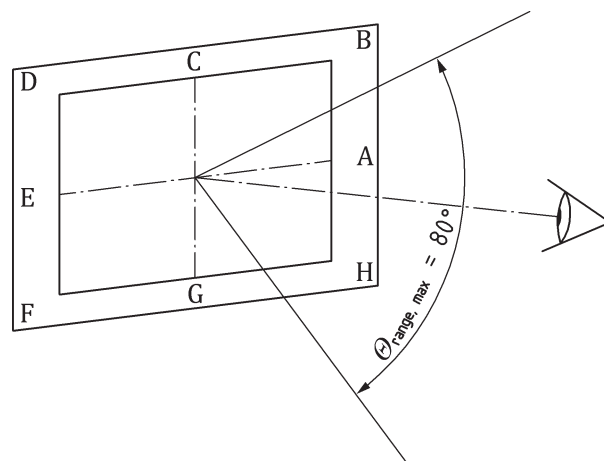
The azimuth angle ϕ is 0° to 360° .

NOTE 1 This definition corresponds to viewing direction range class, ClassviewingIII.

NOTE 2 Sourced from ISO 9241-307:2008, Table 39 b).

Figure 5 — Viewing cone with limited viewing location

See [Figure 6](#).



Viewing cone for multiple users to view the whole area of the display at the design viewing distance from any viewing direction within an 80° viewing cone without reduced visual performance. Allows movement of the head. Provides uniformity over the whole screen.

For this compliance route, a maximum inclination angle range of $\theta_{range, max} = 80^\circ$ is considered, if not otherwise specified by the supplier. Therefore, the maximum angle of inclination, θ , is 40°. The azimuth angle, ϕ , is 0° to 360°.

NOTE Sourced from ISO 9241-307:2008, Table 39 e).

Figure 6 — Viewing cone with unlimited viewing location

7.1.3 Information about the technology

The supplier shall submit a detailed technical specification, including rated voltage, rated frequency, rated current, rated power consumption, display panel specification, horizontal/vertical pixel size, original resolution, sub-pixel drawing, display type, vertical frequency bandwidth, horizontal frequency bandwidth, maximum video bandwidth, video/computer compatibilities, prepared gamma value, factory setting of “brightness”, “contrast”, “colour” control, reference colour gamut. For example, as defined by the International Telecommunication Union (ITU), etc.

7.1.4 Compliance assessment

The compliance assessment shall be made in accordance with [Tables 3](#) to [4](#).

Table 3 — Viewing conditions

Attribute	Pass/fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Design viewing distance	The supplier shall specify the design viewing distance depending on the predominant information. If it is not specified, $1.3D_{\text{view}}$ should be applied, where $1.3D_{\text{view}}$ is the diagonal of the active display area.	Supplier specification, intended context of use	Use supplier specified value or value obtained from intended context of use. Report the resulting value.
Design viewing direction	The visual display shall conform to all optical requirements over a relevant range of viewing directions. The design viewing direction, $(\theta D, \phi D)$, as well as the design viewing direction range shall be specified by the supplier. If not, Table 4 should be applied.		Use supplier specified value or see Table 4 .

Table 4 — Assessment and reporting for design viewing direction

According to Table 3	Assessment and reporting
	Measure the display luminance, L_{ill}, where — illumination condition: darkroom; — object: full-screen test pattern with maximum grey level for monochrome visual displays or combination $R = G = B = 100\%$ for multicolour visual displays; — measurement locations: the measurement locations 1 to 9 as shown in Figure 3; — measurement directions: nine measurements directions are defined as follows: — measurement direction A: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 0^\circ$; — measurement direction B: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = \arctan(H_{\text{view}}/W_{\text{view}})$; — measurement direction C: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 90^\circ$; — measurement direction D: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 90^\circ + \arctan(W_{\text{view}}/H_{\text{view}})$; — measurement direction E: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 180^\circ$; — measurement direction F: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 180^\circ + \arctan(H_{\text{view}}/W_{\text{view}})$; — measurement direction G: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 270^\circ$; — measurement direction H: $\theta = 0,5 \cdot \theta_{\text{range}}, \phi = 270^\circ + \arctan(W_{\text{view}}/H_{\text{view}})$; — measurement direction I: $\theta = \theta D = 0^\circ, \phi = \phi D = \text{not applicable (perpendicular, design viewing direction)}$; where H_{view} is the height of the active display area; W_{view} is the width of the active display area. Report the resulting value. To reduce the number of measurements, it is possible to choose three final measurement locations from the nine measurement locations by following the procedure. Select the site that has the lowest measured luminance (called LL for “low location”) and the site that has the highest measured luminance (called HL for “high location”). The centre site (called CL for “centre location”) is always selected.

Table 5 — Luminance

Attribute	Pass/fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Illuminance	The supplier shall specify the maximum design screen illuminance, E_s , as well as the illuminant.	Supplier specification, intended context of use	Use supplier specified value or value obtained from intended context of use. Report the resulting value.
Display luminance	The display shall fulfil the following requirements. 1) Under darkroom conditions, the visual display shall have a minimum display luminance of 20 cd/m ² over all relevant viewing directions through glasses (see design viewing direction). 2) Under darkroom conditions, the visual display should have a minimum display luminance of 50 cd/m ² over all relevant viewing directions through glasses (see design viewing direction).	P 333.1 M 331.1	See Table 6 .

Table 6 — Assessment and reporting for display luminance

According to Table 5	Assessment and reporting
	Measure the display luminance, L_{ill} , where — illumination condition: darkroom; — object: full-screen test pattern with combination R = G = B = 100 %; — measurement location: 1, 3, 5, 7 and 9 (centre and four corners); — measurement direction: A to L. Report the resulting values for passed or failed.

Table 7 — Luminance non-uniformity

Attribute	Pass/fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance non-uniformity	The visual display shall fulfil the following requirements. 1) Lateral uniformity criterion: Depending on the angular distance of test object separation at the design viewing distance, the luminance non-uniformity shall not exceed the following luminance ratio: 1,1° to < 2°:1,1:1 ≥2° to < 4°:1,2:1 ≥4° to < 5°:1,3:1 ≥5° to < 7°:1,35:1 ≥7°:1,4:1 2) Directional uniformity criterion: Within the design viewing direction range, the luminance non-uniformity shall not exceed a maximum luminance ratio of 1,4:1	P 336.1 P 336.2 P 335.1	See Table 8 .

Table 8 — Assessment and reporting for luminance non-uniformity

According to Table 7	Assessment and reporting
1)	Step 1 Measure the display luminance, L_{ill}, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100 \%$; — measurement locations: 1 to 9; — measurement direction: I (design viewing direction). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, using the centre location as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
2)	Step 1 Measure the display luminance, L_{ill}, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100 \%$; — measurement location: 5; — measurement direction: in steps of 1° within maximum inclination angle range, θ_{range}, in horizontal and vertical direction. Report the resulting values. Step 2 Evaluate the directional uniformity criterion. If the requirement is not fulfilled within θ_{range}, specify the maximum inclination angle for which the maximum luminance ratio is reached.

Table 9 — Interocular luminance difference

Attribute	Pass/fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Interocular luminance difference	1) Lateral uniformity criterion The interocular luminance difference should not exceed 25 %, and shall not exceed 40 %. 2) Directional uniformity criterion Within the design viewing direction range, the interocular luminance difference should not exceed 25 %, and shall not exceed 40 %.	P 337.1	See Table 10 .

Table 10 — Assessment and reporting for interocular luminance difference

According to Table 9	Assessment and reporting
1)	Estimate the interocular luminance difference, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100\%$; — measurement locations: 1 to 9; — measurement direction: I (design viewing direction). Report the resulting values for passed or failed.
2)	Estimate the interocular luminance difference, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100\%$; — measurement location: 5; — measurement direction: in steps of 1° within maximum inclination angle range, θ_{range}, in horizontal and vertical direction. Report the resulting values for passed or failed. If the requirement is not fulfilled within θ_{range}, specify the maximum inclination angle for which the maximum difference is reached.

Table 11 — Interocular crosstalk

Attribute	Pass/fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Interocular crosstalk	1) Lateral uniformity criterion The interocular crosstalk should not exceed 5 %, and shall not exceed 10 %. 2) Directional uniformity criterion Within the design viewing direction range, the interocular crosstalk should not exceed 5 %, and shall not exceed 10 %.	P 338.1	See Table 12 .

Table 12 — Assessment and reporting for interocular crosstalk

According to Table 11	Assessment and reporting
1)	Estimate the interocular crosstalk, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100\%$; — measurement locations: 1 to 9; — measurement direction: I (design viewing direction). Report the resulting values for passed or failed.
2)	Estimate the interocular crosstalk, where: — illumination condition: darkroom; — object: full-screen test pattern with combination $R = G = B = 100\%$; — measurement location: 5; — measurement direction: in steps of 1° within maximum inclination angle range, θ_{range}, in horizontal and vertical direction. Report the resulting values for passed or failed. If the requirement is not fulfilled within θ_{range}, specify the maximum inclination angle for which the maximum crosstalk is reached.