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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex **(e.g. 3.1)**	Paragraph/Figure/ Table/Note	**Type of comment**	**Commend (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations on each comment submitted**
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

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110/1089/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: **IEC 62977-3-4 ED1**	
DATE OF CIRCULATION: **2019-03-08**	CLOSING DATE FOR COMMENTS: **2019-05-03**
SUPERSEDES DOCUMENTS: **110/1006/CD,110/1037A/CC**	

IEC TC 110 : ELECTRONIC DISPLAYS	
SECRETARIAT: Japan	SECRETARY: Mr Yoshi SHIBAHARA
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 100	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	

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TITLE:

Electronic displays – Part 3-4: Evaluation of optical performances – High dynamic range displays

NOTE FROM TC/SC OFFICERS:

Some national committee comments are still open due to lack of consensus in WG 13 as shown in 110/1037A/CC. However, TC 110/WG 13 has requested TC 110 Secretary to circulate the 3rd CD for discussion during the next meeting to be held at San Jose, USA on 2019-05-11~12.

The discussions in WG 13 are also shown in the notes of the observation column of 110/1037A/CC. NCs are invited to indicate their position especially on those discussions.

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ELECTRONIC DISPLAYS – Part 3-4: Evaluation of optical performances – High Dynamic Range displays

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The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

The National Committees are requested to note that for this publication the stability date is 2024.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

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INTRODUCTION

This document is intended to describe the measurement and evaluation of optical performances of High Dynamic Range (HDR) displays as a reference for forthcoming standards to make the work of the involved experts more efficient and to avoid duplication of efforts.

Introduction of the Optical Measurements of Electronic Displays (OPT) is also related to a structure where each kind of optical measurement finds its unambiguous position for identification of similarities to other methods or for clarification of distinctions. This structural classification together with a general taxonomy is supposed to make the process of standards production easier, faster and thus more effective.

HDR is the ability to render bright and dark portions of the image with a higher and lower luminance, respectively, compared to SDR displays. HDR content preserves details in the darkest and brightest areas of a picture that are lost when using Standard Dynamic Range (SDR) standards such as Rec.BT.709. It also allows for more natural, true-to-life colours that are closer to how we see them in real life.

For measurements of HDR displays, many levels of considerations are required in order to do the measurements in a proper manner. For example,

1) Very low level of luminance should be measured, which requires a careful treatment of stray light from the emission from the display and from the ambient light. Subtle colour change can be problematic especially observing the dark area. The viewing direction dependency should be also measured in addition to the measurement from the normal direction.

2) The HDR content consists of 10 bits or more. The measurement of resolution of luminance level, especially resolution of luminance of dark black is essential.

3) HDR TVs have some very unique modes of operation that we have never seen on displays before. There are also some very unique content/commands/performance information contained in the source material. HDR displays also have limited ways in how they can be driven. All of these are intrinsically tied together. Plus the modes and adjustments in HDR TVs or monitors are depending on the maker's intention. Getting them correct is an important part of getting the HDR metrology correct and achieving meaningful results from the measurements. For instance, they may have Colour Space settings which have to be matched to the expectations of the source material. Or they might have a contrast setting that is a hidden Electro-Optical Transfer Function (EOTF) setting.

4) Measurements generally can be the same between HDR and SDR, but HDR will require some new test patterns and methods that go beyond what is meaningful for SDR. For instance, the EOTF for HDR (which we used to call the gamma curve for SDR) is entirely different for HDR than for SDR and requires assessment in a way that will not work for SDR.

5) Actually, for HDR, colour and tone mapping are a product of a) the content of the HDR pattern, b) the metadata contained in the HDR signal, c) the colour mapping method of the display (mainly the contrast/colour mode setup). The colour management tends to be a result of b) and c) above. The content, mainly provides the intent of the HDR to be reproduced. In Hollywood terms, that is the Director's artistic intent of the scene.

Proper source content is critical to evaluating HDR performance material including the driver (and interface). In SDR displays, it may be possible to separate these issues with evaluation of "panels", but for HDR displays, we cannot easily separate them, nor avoid new areas.

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ELECTRONIC DISPLAYS –

Part 3-4: Evaluation of optical performances – High Dynamic Range displays

1 Scope

This part of IEC 62977 specifies the standard measurements of optical characteristics of electronic display system including drivers or EOTF controllers for HDR content in the darkroom and bright room conditions. Display modules for HDR by themselves are excluded from the scope of this document. This document is applicable to non-portable and stationary display systems for indoor use such as TVs or monitors to render HDR images effectively. The measuring methods stipulated in this document are in order to evaluate HDR display system at the reference master mode that complies with the HDR standards by ITU-R BT.2100 and ITU-R BT.2390.

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 62341-6-2:2015, *Organic Light Emitting Diode (OLED) Displays – Part 6-2: Measuring methods of visual quality and ambient performance*

IEC 62341-6-3 Ed.2:2018, *Organic Light Emitting Diode (OLED) Displays – Part 6-3: Measuring methods of image quality*

IEC TS 62341-6-5:2018, *Organic Light Emitting Diode (OLED) Displays – Part 6-5: Measuring methods of dynamic range properties*

IEC 62977-2-1, *Electronic displays – Part 2-1: Measurement of optical characteristics – Fundamental measurements (5CD)*

IEC 62977-2-2, *Electronic displays – Part 2-2: Measurement of optical characteristics – Ambient performance (CD)*

IEC TS 62977-3-1, *Electronic displays – Part 3-1: Evaluation of Optical performances – Colour difference based viewing direction dependence*

Recommendation ITU-R BT.2020-2: *Parameter values for the ultra-high definition television systems for production and international programme exchange, 2015*

Recommendation ITU-R BT.2100-2: *Image parameter values for high dynamic range television for use in production and international programme exchange, 2018*

Report ITU-R BT.2390-0: *High dynamic range television for production and international programme exchange, 2016*

CIE 015:2004, *Colorimetry, 3rd Edition*

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3 Terms, definitions and abbreviated terms

3.1 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:

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

3.1.1
peak luminance
maximum measured display luminance at the centre of the screen for a specific input signal in the required measuring condition

Note 1 to entry The peak luminance should be measured among the maximum luminance at white input with a specific input APL during the stable luminance condition.

Note 2 to entry If the peak luminance is different between full range and narrow range inputs (refer to Rec. ITU-R BT.2100), the higher luminance shall be selected.

Note 3 to entry The peak luminance in multi-primary (or called multi-chromatic) displays can be independent from colour signal white due to the white boosting which can be treated as a function of tone management to enhance dynamic range, while the chromaticity is maintained.

3.1.2
dynamic range
luminance range or span expressed as a ratio of peak luminance to the lowest luminance that the display can render by non-zero value in a single scene

Note to entry The unit of dynamic range can be expressed in terms of the number of stops using the formula Log_2[dynamic range].

3.1.3
high dynamic range
span of image luminance and contrast that is larger than normally possible in standard dynamic range (SDR) image and SDR content [20]

Note 1 to entry In this document, high dynamic range is used as a proper noun HDR such as HDR display that is capable to render HDR content.

Note 2 to entry In case of Recommendation ITU-R BT.2100, the dynamic range of HDR display is recommended from ≤0,005 to ≥1 000 cd/m^2 for reference viewing environment.

3.1.4
standard dynamic range
span of image luminance that is normally possible for the conventional video display against high dynamic range video

Note 1 to entry SDR displays have a reference reproduction using a luminance range constrained by Recommendation ITU-R BT.2035 § 3.2 for video applications, or SMPTE RP 431 for cinema applications.

Note 2 to entry SDR is defined and constrained by ITU-R BT.601 or ITU-R BT.709 or ITU-R BT.2020, and SMPTE ST 2036-1.

3.1.5
average picture level

APL

average of input signal pixel values in RGB or average level percentage of display pixels after EOTF of input signals expressed as a percentage of the range based on a white input

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Note 1 to entry Pre-gamma APL is calculated by averaging of signal pixels (non-linear code values) which is equal or greater than post-gamma APL.

Note 2 to entry Post-gamma APL is calculated by averaging of post-gamma signal pixels (linear code values), but APL loading depends on the power consumption logic of the display according as pixel configuration.

Note 3 to entry APL loading means the percentage of average power loading to display subpixels in self-emissive displays when signal inputs.

3.1.6
code value
digital value of an image signal component consisting signal pixel expressed as a specified format such as RGB or YC_bC_r

3.1.7
opto-electrical transfer function

OETF

mathematical function usually used for image acquisition devices such as digital cameras that maps scene luminance (light from a scene) to digital code value that can be transmitted or compressed

Note to entry If OETF and EOTF consist of a power function, the function is called gamma correction and inverse gamma correction respectively where its exponent is called gamma.

3.1.8
electro-optical transfer function

EOTF

mathematical function of inverse OETF and system gamma by optical-to-optical transfer function usually used for display systems such as TV and monitors that maps digital code values to displayed luminance

3.1.9
optical-to-optical transfer function

OOTF

mathematical function that maps captured luminance by a camera to displayed luminance by a display device according to rendering intent or peak luminance of the display

Note to entry OOTF for PQ HDR adopts BT.1886 and BT.709 gamma like conventional SDR display gamma, and OOTF for HLG HDR adopts the system gamma defined in BT.2100.

3.1.10
wide colour gamut
wider range of colours in 2 dimensional colour coordinates such as xy and $u'v'$ than conventional colour gamut such as ITU-R BT.709 or sRGB colour gamut

Note 1 to entry The colour gamut for BT.709 shows 52,89% coverage of BT.2020 colour gamut in *xy* colour coordinate, and 58,03% coverage of BT.2020 in *u'v'* colour coordinate. The gamut rendering over 52,89% of BT.2020 in *xy* and 58,03% of BT.2020 in *u'v'* can be called the wide colour gamut.

Note 2 to entry Adobe RGB and DCI-P3 are also called wide colour gamut which render 134,90% and 135,65% of BT.709 respectively in *xy*, and 116,7% and 125,6% of BT.709 respectively in *u'v'* colour coordinate.

Note 3 to entry In this document, the colour gamut is used for 2D colour range except colour gamut volume while the term of colour gamut mean 2D or 3D colour range.

3.1.11
colour reproduction accuracy
capability to render target colours to within a certain level of accuracy

Note to entry In order to reproduce target colours of a large colour space such as BT.2020 to within the third or fourth decimal place in chromaticity, the display would need enough colour gamut coverage and may need the display bit depth of 10 to 14 bits.

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3.1.12
white boosting
luminance boosting enhanced according as the colour saturation decreases from the full saturated colour to achromatic colour by optional power distribution management of the display, while maintaining its chromaticity

3.1.13
colour saturation gamma
gamma value of EOTF according as the colour saturation decreases from RGB primary colours to white in SDR display or in SDR equivalent conversion of HDR display

Note to entry Colour saturation gamma is approximately evaluated with an assumed power function if the luminance varies according to colour saturation.

3.1.14
HDR display
display rendering with EOTF and OOTF which accommodates to HDR content

Note to entry HDR display can also display SDR content by changing EOTF and its related functions such as tone mapping and system gamma.

3.1.15
HDR content
image content mastering with OETF which is described in Rec. ITU-R BT.2100

Note to entry The colour distribution container of HDR content should comply with BT.2020.

3.1.16
tone mapping
image processing technique of display system to map one set of tone range to another to approximate the appearance of HDR content that requires wider dynamic range than the display that is inadequate to reproduce the full range of light intensities and dark areas in the content

Note to entry Tone mapping should preserve the chromaticity of original image.

3.1.17
inverse tone mapping

re-mastering or image processing technique to convert SDR content to the image with HDR effect matching an HDR display's capabilities while preserving the original content's creative intent

3.2 Abbreviated terms

For the purposes of this document, the following abbreviations apply.

APL	average picture level
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	device under test
HDR	high dynamic range
SDR	standard dynamic range
OETF	opto-electrical transfer function
EOTF	electro-optical transfer function
OOTF	optical-to-optical transfer function
PQ	perceptual quantizer (PQ tone curve as defined in SMPTE ST 2084)
HLG	hybrid log-gamma
OLED	organic light emitting diode

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WCG wide colour gamut

RGBCMY red, green, blue, cyan, magenta and yellow

RGBW red, green, blue and white (4 subpixels per pixel, or 3 subpixels per pixel with subpixel rendering)

RGBY red, green, blue and yellow

VCRC volume colour reproduction capability

4 Standard measuring equipment

4.1 Video signal generator

A digital video signal generator is used. The DUT should support 10 bit or over 10 bit signal and colour range signal input of ITU-R BT.2020. It shall be reported by “Supported” or ”Not supported” in the test report of chapter 7. The signal characteristics shall match with HDR signal, but signals with metadata for dynamic and static operation are excluded. Input signal or input data, in this document, means the transferred code values by the OETF of PQ HDR or HLG HDR (refer to Rec. ITU-R BT.2100 and Rep. ITU-R BT.2390).

Note For the HDR displays, the video signal shall comply with HDR content, 10 bit or over 10 bit with high dynamic range.

4.2 Measuring equipment

Optical properties of displays shall generally be expressed in photometric or colorimetric units using the CIE 1931 standard colorimetric 2-degree observer (see ISO 11664-1). Luminance can be measured by a photometer, and CIE tristimulus values (X, Y, Z) or CIE chromaticity coordinates by a colorimeter. A spectroradiometer may also obtain photometric and colorimetric values through a numerical conversion of the measured spectral radiance data. The following requirements are given for these instruments:

The LMD shall be a luminance meter, colorimeter, or a spectroradiometer. For DUTs that have sharp spectral peak full-width-at-half-maximums (FWHMs) smaller than 20 nm, such as laser displays, LCDs with fluorescent lamp backlights or LED with narrow-peak phosphors, quantum-dot phosphors, or narrow-spectrum OLEDs, a spectroradiometer should be used. A filter colorimeter should generally not be used for light sources with sharp spectral peaks. If they are used, the colorimeter must be calibrated with a narrow bandwidth spectroradiometer to give the same results for the specific spectrum. Report the spectroradiometer characteristics of spectroradiometer which is used for calibration. For light sources with sharp spectral peaks, the maximum bandwidth of the spectroradiometer shall be ≤ 5 nm. The higher resolution spectrometer produces a more accurate colour measurement, especially for lasers sources. The spectroradiometer shall be capable of measuring spectral radiance over at least the 380 nm to 780 nm wavelength range, with a maximum bandwidth of 10 nm for smooth broadband spectra (i.e. broad spectrum with no sharp spikes).

The following additional best practices shall be followed:

1) The LMD shall be focused on the image plane of the display and generally aligned perpendicularly to the display surface at the centre of the active display area, unless stated otherwise.
2) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier’s recommended calibration schedule
3) If the light level of the display is temporally modulated, then the LMD integration time shall be synchronized with the modulation frequency. If the LMD is not capable of synchronizing, then the LMD integration time shall be at least 200 cycles of the fundamental Fourier Transform frequency light of the modulated light in order to measure the luminance to better than 5 %.
4) If LMD measurements are taken for displays with temporal light modulation (including LCD backlights), the temporal high peak luminance of these displays can cause detector saturation errors. The accuracy of these measurements can be checked by attenuating

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the light with a neutral density filter with known characteristics. If the change in signal amplitude of the detector is proportional to the transmittance of the neutral density filter, then there are no detector saturation errors. This method can be used for measuring the time-averaged screen luminance.

5) If the LMD is to measure a dim measurement area, the LMD field of view should avoid containing a bright background. If this is not possible, then a frustum or stray-light-elimination tube (SLET) shall be used (see ISO 9241-305 [23]).

6) Response meter: The Response meter should be capable of producing a linear response to rapid changes in luminance. The Response Meter's response time TLMD and sample time should be less than one tenth the minimum transition time. The Response meter need not be dark field corrected, and does not require photopic correction unless the colour of the test pattern changes significantly as it changes between L_W (full white) and L_K (full black).

Additional conditions of measurement equipment are given in IEC 62977-2-1. Generally, HDR's black luminance is lower than SDR's one and the HDR's gamut is larger than SDR's one. Care shall be taken to ensure that the LMD has enough sensitivity and dynamic range to perform the required task. Care shall be taken to ensure that the LMD has enough chromaticity accuracy to perform required task. Before measuring the DUT, LMD specification shall be checked. Other than these, there is no special points. Light measurements shall generally be measured in terms of photometric or colorimetric unis for a CIE 1931 standard colorimetric observer.

4.3 Test equipment block diagram

There is no need to add any special requirements to the test equipment and layout of HDR display measurement. The followings show the fundamental block diagram which is commonly applied to HDR display measurement. Please refer to IEC 62977-2-1. An example of the block diagram is shown in Figure 1. Optical axis of the optical test equipment shall be centered on the screen and perpendicular to the plane of the display screen. The directional measurement can be also performed horizontally and vertically in case of viewing directional measurement. Generally, the measuring distance should be specified by the manufacturer of the display. Otherwise, the measuring distance of the test should be the reference viewindg distance [21], [22].

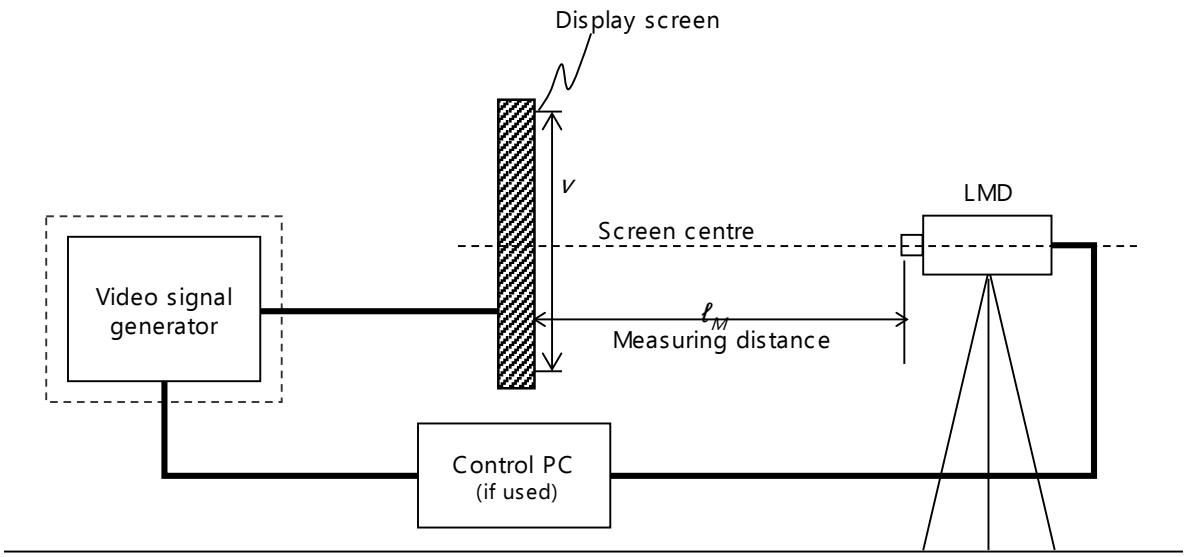

Figure 1 – Measuring layout for non-contact measurement

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5 Standard measuring conditions

5.1 Standard measuring environmental conditions

Measurement shall be carried out under following conditions.

Temperature: 25 °C ± 3°C

Relative humidity: 25 % RH to 85 % RH

Atmospheric pressure: 86 kPa to 106 kPa

When different environmental conditions are used, they shall be noted in the report. There is no specific point with HDR. The following 5.2 through 5.4 show the measuring conditions identical to the fundamental one. They are for reference. Please also refer to IEC 62977-2-1 and IEC 62977-2-2.

5.2 Power supply

The power supply for driving the DUT shall be adjusted to the rated voltage ± 2 %. In addition, the frequency of the power supply shall provide the rated frequency ± 1 %.

5.3 Warm-up time

Measurements shall be started after the displays and measuring instruments achieve stability. The DUT shall be turned on first and operated for at least 30 minutes prior to the measurement. Some display technologies may need a loop of colour patterns rendered on the screen during the warm-up period. Sufficient warm-up time has been achieved when the luminance of the test feature to be measured varies by less than ± 3 % over the entire measurement period (e.g. uniformity measurements) for a given display image.

5.4 Standard measuring room conditions

5.4.1 Darkroom conditions

The luminance contribution from the background illumination reflected the test display shall be below 0,0005 cd/m^2 while the display is off in the darkroom under the illumination below 0,01 lx. In this document, if there is no comment for ambient lighting, it is measured in darkroom. If the test pattern generates stray lights, the stray light elimination methods such as frustum or stray light elimination tubes should be used. The LMD has sufficient signal-to-noise ratio suitable to measure the low luminance of black. If there is significant background illumination influencing more than 10 % of the measured black luminance, the off-state luminance by background illumination (also called background black) should be subtracted from the measured black luminance of on-state.

5.4.2 Bright room illumination conditions

5.4.2.1 General

The following illumination conditions are specified for the reflectance measurements of displays. Display luminance is calculated from the measured reflectance and assumed ambient illumination mentioned below. More detail information about measuring reflectance properties are stipulated in Clause 4 and Clause 5 of IEC 62977-2-2. The bright room shall simulate indoor directional illumination conditions under 200 lx with D65 (refer to BT.2022 [21]) which is measured in normal direction on the screen centre. A directed source in a darkroom will simulate the effect of directional illumination on a display by a luminaire in a room (refer to IEC 62977-2-2, IEC 62715-5-1, IEC 62341-6-2).

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