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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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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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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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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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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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.

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.

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.

180

INTRODUCTION

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

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

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

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

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

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

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

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

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

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

227

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*

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 $\text{Log}_2[\text{dynamic range}]$.

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 $\leq 0,005$ to $\geq 1\,000$ cd/m² 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

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

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

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

317 **3.1.6**

318 **code value**

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

321 **3.1.7**

322 **opto-electrical transfer function**

323 **OETF**

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

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

329 **3.1.8**

330 **electro-optical transfer function**

331 **EOTF**

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

335 **3.1.9**

336 **optical-to-optical transfer function**

337 **OOTF**

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

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

342 **3.1.10**

343 **wide colour gamut**

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

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

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

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

353 **3.1.11**

354 **colour reproduction accuracy**

355 capability to render target colours to within a certain level of accuracy

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

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

404	WCG	wide colour gamut
405	RGBCMY	red, green, blue, cyan, magenta and yellow
406	RGBW	red, green, blue and white (4 subpixels per pixel, or 3 subpixels per pixel with subpixel rendering)
407		
408	RGBY	red, green, blue and yellow
409	VCRC	volume colour reproduction capability

410 **4 Standard measuring equipment**

411 **4.1 Video signal generator**

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

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

419 **4.2 Measuring equipment**

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

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

439 The following additional best practices shall be followed:

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

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 units 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 viewing distance^[21].

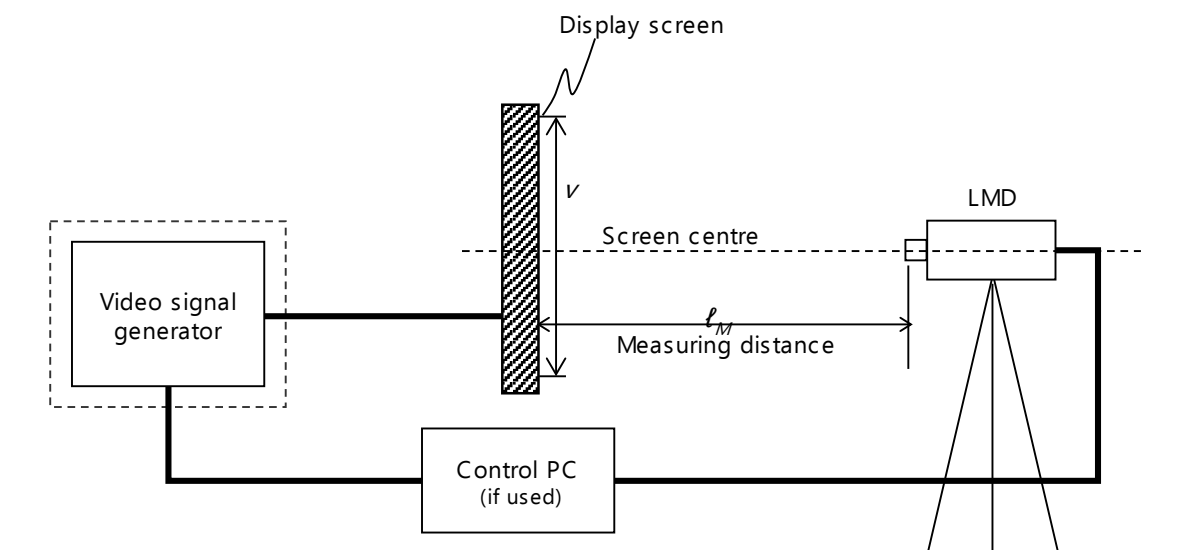


Figure 1 – Measuring layout for non-contact measurement

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/m² 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).