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INTERNATIONAL STANDARD

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colour inside

Organic light emitting diode (OLED) displays –
Part 6-2: Measuring methods of visual quality and ambient performance

Afficheurs à diodes électroluminescentes organiques (OLED) –
Partie 6-2: Méthodes de mesure de la qualité visuelle et des caractéristiques de fonctionnement sous conditions ambiantes

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FOREWORD

International Standard IEC 62341-6-2 has been prepared by IEC technical committee 110: Electronic display devices.

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

FDIS	Report on voting
110/338/FDIS	110/353/RVD

Full information on the voting for the approval of this 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.

A list of all parts of the IEC 62341 series, published under the general title *Organic light emitting diode (OLED) displays,* can be found on the IEC website.

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

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- withdrawn,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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

Part 6-2: Measuring methods of visual quality and ambient performance

1 Scope

This part of IEC 62341 specifies the standard measurement conditions and measurement methods for determining the visual quality and ambient performance of organic light-emitting diode (OLED) display modules and panels. This document mainly applies to colour display modules.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary*
(available at <http://www.electropedia.org>)

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 61966-2-1, *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB*

IEC 62341-1-2, *Organic light emitting diode displays – Part 1-2: Terminology and letter symbols*

CIE 15:2004, *Colorimetry*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms, definitions and abbreviations given in IEC 62341-1-2 and IEC 60050-845:1987 as well as the following apply.

3.1 Terms and definitions

3.1.1
visual inspection
a means for checking image quality by human visual observation for classification and comparison against limit sample criteria

3.1.2
subpixel defect
for colour displays, all or part of a single subpixel, the minimum colour element, which is visibly brighter or darker than surrounding subpixels of the same colour. They are classified depending on the number and configuration of multiple subpixel defects within a region of the display

3.1.3
dot defect
for monochromatic displays, all or part of a single subpixel, the minimum dot element, which is visibly brighter or darker than surrounding dots. They are classified depending on the number and configuration of multiple subpixel defects within a region of the display

3.1.4
bright subpixel defect
subpixels or dots which are visibly brighter than surrounding subpixels of the same colour when addressed with a uniform dark or grey background

3.1.5
dark subpixel defect
subpixels or dots are visibly darker than surrounding subpixels of the same colour when addressed with a uniform bright background (e.g. > 50 % full screen luminance)

3.1.6
partial subpixel defect
subpixel or dot with part of the emission area obscured such that a visible difference in brightness is observed in comparison with neighbouring subpixels of the same colour

3.1.7
clustered subpixel defects
subpixel or dot defects gathered in specified area or within a specified distance. Also known as “close subpixel defect”

3.1.8
unstable subpixel
subpixel or dot that changes luminance in an uncontrollable way

3.1.9
pixel shrinkage
reduction in the active emissive area of one or more subpixels (or dots) over time

3.1.10
panel edge shrinkage
reduction in the active emissive area from the edges of the display area over time

3.1.11
line defect
vertical or horizontal bright or dark line parallel to a row or column observed against a dark or bright background, respectively

3.1.12
bright line defect
a line appearing bright on a screen displaying a uniform dark or grey pattern

3.1.13
dark line defect
a line appearing dark when displayed with a uniform bright or grey pattern

3.1.14
mura
region(s) of luminance and colour non-uniformity that generally vary more gradually than subpixel level defects. For classification, the maximum dimension should be less than one fourth of the display width or height

3.1.15
line mura
variation in luminance consisting of one or more lines extending horizontally or vertically across all or a portion of the display (such as may be caused by TFT threshold voltage variation from laser induced crystallization)

3.1.16
colour mura
mura that appears primarily in only one colour channel and results in a local variation of the white point (or CCT)

3.1.17
spot mura
region of luminance variation larger than a single pixel appearing as a localized slightly darker or brighter region with a smoothly varying edge

3.1.18
stain mura
region of luminance variation larger than a single pixel appearing as clearly defined edge bordering a region of brighter or darker luminance than surrounding regions

3.1.19
mechanical defects
image artefacts arising from defects in protective and contrast enhancement films, coatings, mechanical fixturing, or other elements within in the active area of the display

3.1.20
scratch defect
defect appearing as fine single or multiple lines or scratches, generally light in appearance on a dark background, and independent of display state

3.1.21
dent defect
localized spot generally white or grey in appearance on dark background and independent of display state

3.1.22
foreign material
defect caused by foreign material like dust or thread in between contrast enhancement films, protective films, or on emitting surface within the active area of the display

3.1.23
bubble
defect caused by a cavity in or between sealing materials, adhesives, contrast enhancement films, protective films, or any other films within the visible area of the display

3.1.24
ambient contrast ratio
contrast ratio of a display with external natural or artificial illumination incident onto its surface

NOTE Includes indoor illumination from luminaires, or outdoor daylight illumination.

3.1.25
colour gamut boundary
surface determined by a colour gamut's extremes

3.1.26
colour gamut volume
a single number for characterizing the colour response of a display device in a three-dimensional colour space

NOTE Typically the colour gamut volume is calculated in the CIELAB colour space.

3.1.27
ambient colour gamut volume
number for characterizing the colour response of a display device, under a defined ambient illumination condition, in a three-dimensional colour space

NOTE Typically the colour gamut volume is calculated in the CIELAB colour space.

3.2 Abbreviations

CCT	correlated colour temperature
CIE	International Commission on Illumination (Commission internationale de l'éclairage)
CIELAB	CIE 1976 (L*a*b*) colour space
DUT	device under test
HD	high definition
ISO	International Organization for Standardization
LED	light emitting diode
LMD	light measuring device
LTPS	low temperature polysilicon
OLED	organic light emitting diode
PL	photoluminescence
QVGA	quarter video graphics array
RGB	red, green, blue
SDCM	standard deviation of colour matching
sRGB	a standard RGB colour space as defined in IEC 61966-2-1
TFT	thin film transistor
TV	television
UV	ultraviolet

4 Structure of measuring equipment

The system diagrams and/or operating conditions of the measuring equipment shall comply with the structure specified in each item.

5 Standard measuring conditions

5.1 Standard measuring environmental conditions

Electro-optical measurements and visual inspection shall be carried out under the standard environmental conditions, using at a temperature of 25 °C ± 3 °C, a relative humidity of 25 % to 85 %, and pressure of 86 kPa to 106 kPa. When different environmental conditions are used, they shall be noted in the visual inspection or ambient performance report.

5.2 Standard lighting conditions

5.2.1 Dark-room conditions

The luminance contribution from the background illumination reflected off the test display shall be ≤ 0,01 cd/m^2 or less than 1/20 the display's black state luminance, whichever is lower. If these conditions are not satisfied, then background subtraction is required and it shall be noted in the ambient performance report. In addition, if the sensitivity of the LMD is inadequate to measure at these low levels, then the lower limit of the LMD shall be noted in the ambient performance report.

NOTE Unless stated otherwise, the standard lighting conditions shall be the dark-room conditions.

5.2.2 Ambient illumination conditions

5.2.2.1 Ambient illumination conditions for visual inspection

Ambient lighting conditions have a strong impact on the ability of the inspector to resolve defects and large variations of light intensity in the visual field can lead to inspector fatigue and a resulting loss of sensitivity to defects. Refer to ISO 9241-310 for general guidance on optimal illumination conditions for visual inspection of pixel defects [1][1].

For inspector comfort and consistency of inspection conditions an average ambient illuminance of between 50 lx and 150 lx is suggested in the inspector's work area. This ambient illuminance may be measured, for example, with an illuminance meter facing directly upward in a horizontal plane at the approximate eye level of the inspector. Care shall be taken to use diffuse illumination, and diffuse textures in the inspection environment, to avoid glare in the visual field of the inspector.

As shown in Figure 1, the display under test shall be placed to avoid direct illumination from ambient room light sources. In addition, dark light-absorbing materials shall be used to cover specular surfaces that may be viewed by the inspector in direct reflection from the display surface. In any case, to limit degradation of the display contrast from ambient light, the ambient illuminance incident from room light sources on the display surface measured with the display off shall be ≤ 20 lx. If ambient illuminance at the display surface is > 20 lx, it shall be noted in the visual inspection report.

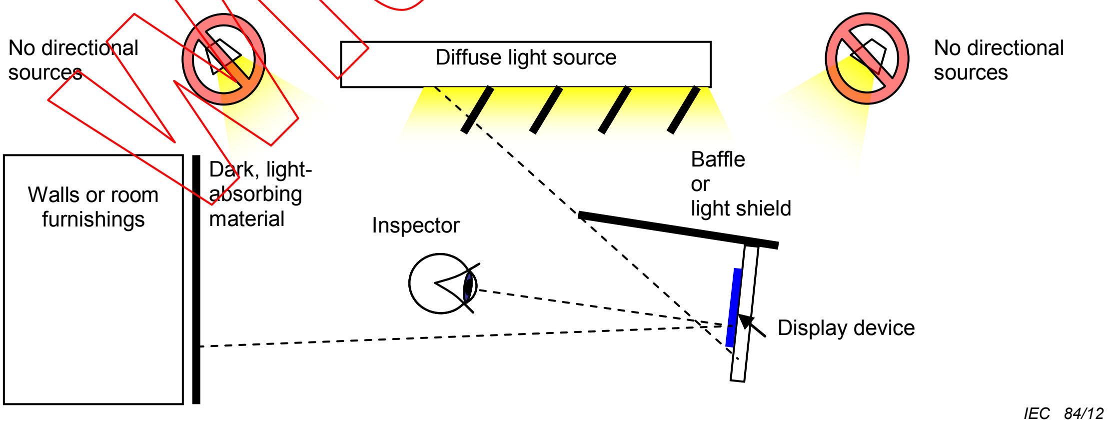

Figure 1 – Example of visual inspection room setup for control of ambient room lighting and reflections

1 Numbers in square brackets refer to the Bibliography.

5.2.2.2 Ambient illumination conditions for electro-optical measurements

The following illumination conditions are prescribed for electro-optical measurements of displays in ambient indoor or outdoor illumination conditions. Ambient indoor room illumination, and outdoor illumination of clear sky daylight, on a display shall be approximated by the combination of two illumination geometries [2]. Uniform hemispherical diffuse illumination will be used to simulate the background lighting in a room, or the hemispherical skylight incident on the display, with sun occluded. A directed source in a dark room will simulate the effect of directional illumination on a display by a luminaire in a room, or from direct sunlight.

Some displays can emit photoluminescence (PL) when exposed to certain light. The relative impact of PL on the reflection measurement can be determined, and is described in Annex A. An illumination condition that causes a significant reflection measurement error due to the presence of PL should be treated carefully. If the same illumination spectral distribution and illumination/detection geometry is used for the reflection measurements, and the calculation of ambient contrast ratio and colour, then the PL can be incorporated into the reflection coefficients. However, if the illumination spectra used in the calculations is significantly different, then the reflected component must be measured separately from the PL component. The latter case is not addressed in this document.

The following illumination conditions shall be used to simulate indoor and outdoor display viewing environments:

Indoor room illumination conditions:

- Uniform hemispherical diffuse illumination – Use a light source closely approximating CIE Standard Illuminant A, CIE Standard Illuminant D65, or fluorescent lamp FL1 as defined in CIE 15. The use of an infrared-blocking filter is also recommended to minimize sample heating from the illuminants. The UV region (< 380 nm) of all light sources shall be cut off. If FL1 is used as a light source, the chromaticity tolerance area of the lamp shall be less than 5 standard deviation of colour matching (SDCM, see IEC 60081). The fluorescent lamp shall be stabilized, for example, by ageing for 100 hours, and not used beyond 2 000 hours. Additional sources may also be used, depending on the intended application. For spectral measurements, if it can be demonstrated that the display does not exhibit significant PL (< 1 % PL, see Annex A) for the selected reference source spectra, then a spectrally smooth broadband source (such as an approximation to CIE Standard Illuminant A) may be used to measure the spectral reflectance factor. Without significant PL, a measurement of the spectral reflectance factor using a broad source (like Illuminant A) enables the ambient contrast ratio and colour to be calculated later for the desired reference spectra (for example D65). The indoor room contrast ratio shall be calculated using 60 lx of hemispherical diffuse illumination (with specular included) incident on the display surface for a typical TV viewing room, and 300 lx for an office environment [3]. The actual hemispherical diffuse reflectance factor measurement may require higher illumination levels for better measurement accuracy. The results are then scaled to the required illumination levels.

- Directional illumination- The same source spectra shall be used as with hemispherical diffuse illumination. If a different spectral source is used, it shall be noted in the ambient performance report. The presence of significant PL (see Annex A) shall also be determined for the measured source, and the preceding limitations be applied when PL is present. The indoor room contrast ratio or colour shall be calculated using directional illumination of 40 lx incident on the display surface for a typical TV viewing room, and 200 lx for an office environment with the display in the vertical orientation. The actual reflectance factor measurement may require higher illumination levels for better measurement accuracy. The directed source shall be 35 ° above the surface normal (θ_s=35 °, θ_d=0 °, see Figure 3) and have an angular subtense of no more than 8 °. The angular subtense is defined as the full angle span of the light source from the centre of the display's measurement area.

NOTE Other illumination levels may be used in addition to those defined above for calculating the ambient contrast ratio under indoor illumination conditions. However, approximately 60 % of the total illuminance should be hemispherical diffuse, and 40 % directional illumination.

Daylight illumination conditions:

- Uniform hemispherical diffuse illumination – Use a light source closely approximating skylight with the spectral distribution of CIE Illuminant D75 [4]. Additional CIE daylight illuminants) may also be used, depending on the intended application. An infrared-blocking filter is recommended to minimize sample heating. The UV region (< 380 nm) of the light source shall be cut off. For spectral measurements, if it can be demonstrated that the display does not exhibit significant PL for a 7 500 K correlated colour temperature (CCT) source, then spectral reflectance factor measurements can be made using a spectrally smooth broadband source (such as an approximation to CIE Standard Illuminant A). The contrast ratio or colour can be calculated later for the D75 Illuminant spectra. The daylight contrast ratio and colour shall be calculated using 15 000 lx of hemispherical diffuse illumination (with specular included) incident on a display surface in a vertical orientation [4, 5]. The actual hemispherical diffuse reflectance factor measurement may be taken at lower illumination levels.

- Directional illumination – The directional light source shall approximate CIE daylight Illuminant D50) [4]. Additional CIE daylight illuminants may also be used, depending on the intended application. The use of an infrared-blocking filter is recommended to minimize sample heating. The UV region (< 380 nm) of the light source shall be cut off. If it can be demonstrated that the display does not exhibit significant PL for a source approximating Illuminant D50, then a spectrally smooth broadband source (such as an approximation to CIE Standard Illuminant A) may be used for the reflectance factor measurement. The ambient contrast ratio or colour can be calculated later with the D50 Illuminant spectra. The daylight contrast ratio or colour shall be calculated using 65 000 lx for a directed source at an inclination angle of $\theta_s = 45°$ to the display surface (see Figure 3) [4][,5]. The actual reflectance factor measurement may be taken at lower illumination levels, and the contrast ratio and colour calculated for the correct illuminance. The directed source shall have an angular subtense of approximately 0,5 °.

For daylight contrast ratio and colour calculations from spectral reflectance factor measurements, the relative spectral distributions of CIE Illuminant A, lamp FL1, D65, D50 and D75 tabulated in CIE 15 shall be used. Additional CIE daylight illuminants shall be determined using the appropriate eigenfunctions, as defined in publication CIE 15.

5.2.2.3 Uniform hemispherical diffuse illumination

An integrating sphere, sampling sphere, or hemisphere shall be used to implement uniform hemispherical diffuse illumination conditions. Two possible examples of the measurement geometry are shown in Figure 2. If an integrating sphere that is at least seven times the physical outer diagonal of the display is available, the display can be mounted in the centre of the sphere (Figure 2, configuration A). For large displays, a sampling sphere (configuration B) or hemisphere would be more suitable. In all cases, the configuration shall follow the standard *d*i/8 ° to *d*i/10 ° illumination/detection geometry, where di is the standard notation for diffuse.

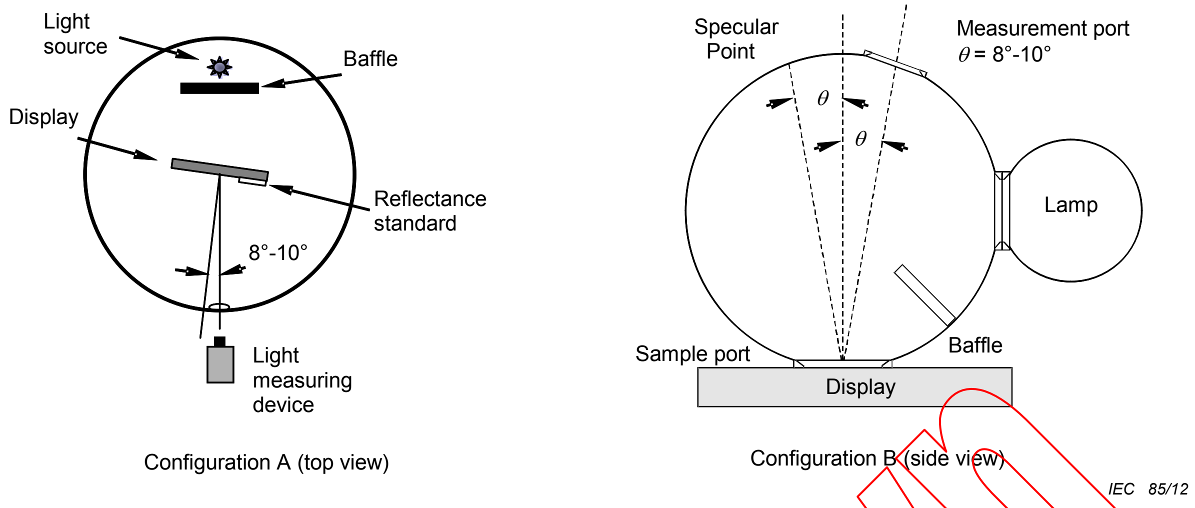

Figure 2 – Example of measurement geometries for diffuse illumination condition using an integrating sphere and sampling sphere

a) The display is placed in the centre of an integrating sphere/hemisphere, or against the sample port of a sampling sphere. The reflected luminance off the display from the sphere shall be much greater than the luminance from the display-generated light. For displays without significant PL, the reflected luminance from the sphere can be estimated with the display turned OFF.

b) For daylight measurements with an approximate 7 500 K CCT light source, an infrared-blocking filter is recommended to minimize sample heating. The colour temperature and illumination spectra can be measured from the reflected light of a white diffuse reflectance standard near the display measurement area (Figure 2, Configuration A), or the sampling sphere wall adjacent to the sample port (Figure 2, Configuration B.). The type of light source used, and its CCT, shall be noted in the ambient performance report.

c) The light measuring device (LMD) is aligned to view the centre of the display through a measurement port in the sphere wall at an 8 ° (−0 °, +2 °) angle from the display normal. The required LMD angle of inclination can also be realised by tilting the display within the integrating sphere. The LMD is focused on the display surface.

d) The measurement port diameter shall be 20 % to 30 % larger than the effective aperture of the LMD lens. Care needs to be taken to avoid any direct light from the sources, or any bright reflections off any surface (other than the screen itself), from hitting the lens of the LMD in order to minimise veiling glare contamination of the reflected luminance measurement. The LMD shall be moved back from the hole so that the bright walls of the sphere are not visible to the LMD. In addition, the sample port diameter will typically need to be larger than 25mm in order for the luminance meter's or spectroradiometer's field of view to be completely contained within the sample port.

e) The measurement port shall be bevelled away from the lens. The small diameter of the bevel is toward the LMD, and the large diameter on the inside of the sphere.

f) The spectral irradiance or illuminance on the display can be measured using a white diffuse reflectance standard with known hemispherical diffuse spectral reflectance factor $R(\lambda)$, or the photopically-weighted (or luminous) hemispherical diffuse reflectance factor R. The white diffuse reflectance standard must be calibrated under uniform hemispherical diffuse illumination in an integrating sphere. When an integrating sphere (configuration A) or hemisphere is used, the white diffuse reflectance standard shall be placed on the display surface. If t is the thickness of the white diffuse reflectance standard, then it shall be placed on the surface a distance of 5*t to 7*t from the measurement area. The white reflectance standard can also be placed adjacent and in the same plane as the display if the sphere illumination is uniform over that distance. In the case of the sampling sphere, the spectral irradiance can be determined by a measurement of the interior sphere wall adjacent to the sample port.[6] The hemispherical diffuse spectral reflectance factor, or