IEC 62341-6-4

Edition 1.0 2017-05

INTERNATIONAL STANDARD

colour inside

Organic light emitting diode (OLED) displays –
Part 6-4: Measuring methods of transparent properties

IEC 62341-6-4:2017-05(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.260

ISBN 978-2-8322-4297-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 6-4: Measuring methods of transparent properties

FOREWORD

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International Standard IEC 62341-6-4 has been prepared by IEC technical committee 110: Electronic display devices.

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

FDIS	Report on voting
110/843/FDIS	110/866/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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in 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 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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ORGANIC LIGHT EMITTING DIODE (OLED) DISPLAYS –

Part 6-4: Measuring methods of transparent properties

1 Scope

This part of IEC 62341 specifies the standard measurement conditions and measuring methods for determining the optical performance of transparent properties of organic light emitting diode (OLED) display panels and modules. This document includes the display performance under darkroom conditions, and front and back illumination.

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

IEC 62341-6-1, *Organic light emitting diode (OLED) displays – Part 6-1: Measuring methods of optical and electro-optical parameters*

IEC 62341-6-2, *Organic light emitting diode (OLED) displays – Part 6-2: Measuring methods of visual quality and ambient performance*

ISO 9241-307, *Ergonomics of human-system interaction – Part 307: Analysis and compliance test methods for electronic visual displays*

ISO 11664-2, *Colorimetry – Part 2: CIE standard illuminants*

CIE 15-2004, *Colorimetry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62341-1-2 and the following 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
transmittance factor
ratio of the radiant or luminous flux transmitted in the direction delimited by the given solid angle cone to that transmitted in the same direction and solid angle cone by a perfect transmitting diffuser identically irradiated or illuminated

Note 1 to entry: When the term transmittance factor is used in this document, it refers to the photopically-weighted luminous flux.

3.2
spectral transmittance factor
ratio of the spectral radiant flux transmitted in the direction delimited by the given solid angle cone to that transmitted in the same direction by a perfect transmitting diffuser identically irradiated

3.3
transmitted haze
percentage of transmitted luminance, passing through a specimen, which deviates from the incident light by no more than 0,044 rad (2,5°) by forward scattering

3.4
purity
ratio of the luminance measured in the 0,2° region to the luminance of the total transmitted light

Note 1 to entry: The purity is defined as how clearly the see-through image could be seen. The purity is derived from the measurement of distorted light due to diffraction or refraction.

3.5
on-screen performance
optical performance that can be measured on the transparent screen when viewing an image on the screen

4 Measuring conditions

4.1 Standard measuring environmental conditions

Measurements shall be carried out under the standard environmental 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 measurement report.

4.2 Standard lighting conditions

4.2.1 Darkroom conditions

The luminance contribution from the background illumination reflected off and/or transmitted through the test display shall be less than 0,01 cd/m^2 or 1/20 of 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 report. In addition, if the sensitivity of the light measuring device (LMD) is inadequate to measure at these low levels, then the lower limit of the LMD shall be noted in the measurement report.

4.2.2 Ambient illumination conditions

Ambient lighting conditions can make a large impact on the performance of a transparent display. For observers who will watch a transparent display, various ambient conditions shall be suggested based on previous research. Table 1 shows the standard indoor and daylight ambient illumination conditions.

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. The detail information to simulate those ambient conditions is described in IEC 62341-6-2 and IDMS [1][1].

Table 1 – Standard ambient conditions

Design screen illuminance	Indoor and daylight illumination environment	Recommended illumination geometry
Up to 200 lx	(mostly) General building areas (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
Up to 300 lx	(mostly) General machine work, rough assembly work, (general) museum (ISO 9241-307), office environment [8]	60 % hemispherical, 40 % directional at 45°
Up to 500 lx	Medium assembly and decorative work, simple inspection, counters, libraries, (mostly) educational areas, control rooms (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
Up to 750 lx	Fine work, technical drawing (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
Up to 1 000 lx	Precision work, quality control, inspection, medical examination and treatment (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
Up to 1 500 lx	High precision work (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
> 1 500 lx	Special workplaces in the medical area (ISO 9241-307)	60 % hemispherical, 40 % directional at 45°
80 000 lx	The daylight contrast ratio and colour shall be calculated using a combination of hemispherical diffuse illumination (with specular included) and directional illumination incident on a display surface in a vertical orientation [8][9]	15 000 lx hemispherical, 65 000 lx directional at 45°

4.2.3 Ambient illumination spectra

The ambient performance of the display can be significantly impacted by the spectral distribution of the illumination source. Unless it is specified otherwise, the source illumination shall closely approximate CIE Illuminant D65 (see CIE 15). The source illumination used for measuring the display reflection and transmission properties shall have a spectrally smooth and broadband emission. Spectral reflection and transmission measurements can then be used to predict the ambient display performance for any desired illumination spectra.

When evaluating the display's ambient indoor performance, it is recommended to use the same spectral distribution for the hemispherical and directional source illumination. Light source spectra approximating CIE Illuminant A, Illuminant D50, and Illuminant D65 are recommended for indoor applications. For simulating outdoor applications, Illuminant D50 is recommended for the directional illumination, and Illuminant D75 is recommended for hemispherical illumination.

4.3 Standard setup conditions

4.3.1 Starting conditions of measurements

Standard setup conditions are given below. Measurements shall be started after the transparent OLED display and measuring instruments achieve stability. Sufficient warm-up time has to be allowed for the transparent OLED display panels and modules to reach a

[1] Numbers in square brackets refer to the Bibliography.

luminance stability level of less than ±5 % over the entire measurement for a given display image.

4.3.2 Conditions of measuring equipment

The general conditions of this measurement shall be as follows.

1) The standard measurement setup is shown in Figure 1. The LMD shall be a luminance meter, colourimeter, or a spectroradiometer 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. For light sources that have sharp spectral features, like LEDs and fluorescent lamps, the spectroradiometer's maximum bandwidth shall be < 5 nm. The spectral bandwidth of the spectroradiometer shall be an integer multiple of the sampling interval. For example, a 5 nm sampling interval can be used for a 5 nm or 10 nm bandwidth. Care shall be taken to ensure that the device has enough sensitivity and dynamic range to perform the required task.
2) The light measuring device shall be focused on the image plane of the transparent display for on-screen performance and on the image plane of the background for transmission performance. The LMD will be aligned perpendicularly to its surface, unless stated otherwise.
3) The relative uncertainty and repeatability of all the measuring devices shall be maintained by following the instrument supplier's recommended calibration schedule.

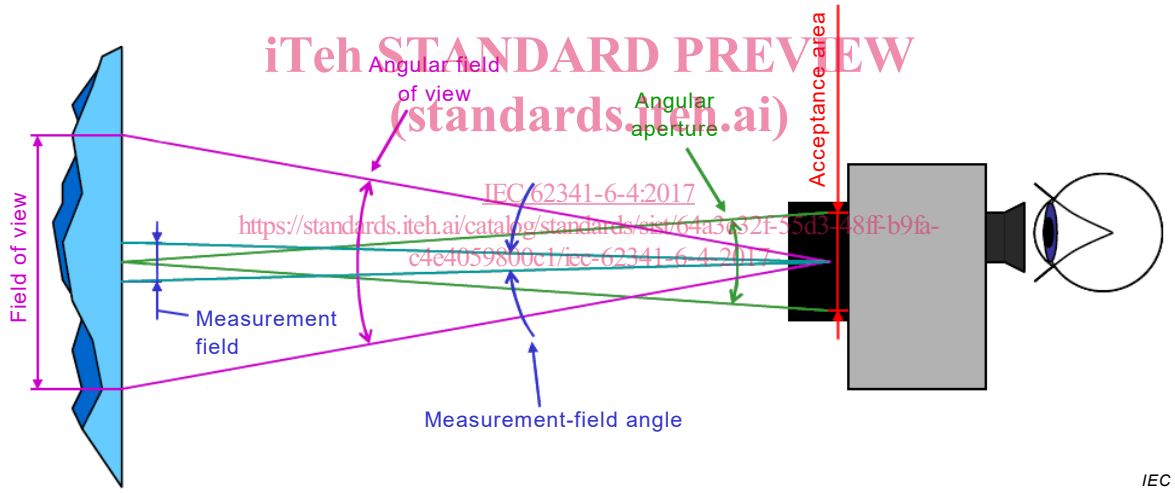

Figure 1 – Layout diagram of measurement setup

4) The LMD integration time shall be an integer number of frame periods, synchronized to the frame rate, or the integration time shall be greater than two hundred frame periods.
5) When measuring matrix displays, the light measuring devices shall be set to a measurement field that includes more than 500 pixels. If smaller measurement areas are necessary, equivalence to 500 pixels shall be confirmed.
6) The angular aperture shall be less than or equal to 5°, and measurement field angle shall be less than or equal to 2° (see Figure 1). The measuring distance and the measurement-field angle may be adjusted to achieve a measurement field greater than 500 pixels if setting the above measurement-field angle is difficult.
7) Display modules shall be operated at their design field frequency. When using separate driving signal equipment to operate a panel, the drive conditions shall be noted in the performance report.

Any deviations from these conditions shall be noted in the performance report.

5 Measuring methods of transparent properties

5.1 Measuring methods of transmission performance

5.1.1 Hemispherical transmittance factor with specular included

5.1.1.1 Purpose

The purpose of this method is to measure the transmitted light, including the specular component, through a transparent OLED display.

5.1.1.2 Measuring conditions

For this measurement, the following conditions shall be applied.

a) Apparatus:

1) light measuring device that can measure luminance or spectral radiance;
2) driving power source;
3) driving signal equipment;
4) integrating sphere with ports and a stabilized light source (see Figure 2), which shall be as follows:

i) The light source in the integrating sphere should have a smooth broadband spectrum approximating CIE standard Illuminant D65, as specified in ISO 11664-2. The integrating sphere should have a photopic optical detector which monitors the relative luminance level m inside the sphere. The monitor shall be fitted with baffles to prevent light from the light source or the sample port from falling on it directly. The spectral characteristics of the light source shall be kept constant during measurements on a transparent OLED display. The measurement conditions shall be such that the transparent OLED display temperature does not increase while measurements are made.

ii) The integrating sphere may be of any diameter as long as the total port area does not exceed 4,0 % of the internal area of the sphere. It is recommended that the diameter of the integrating sphere is not less than 150 mm so that specimens of a reasonable size can be used. When diameter of the integrating sphere is 150 mm and the diameters of the sample, compensation and light trap ports are 30 mm, the ratio of the total port area to the internal area of the sphere is 3,0 %. For specular included measurements, a port plug or diffuse white standard with similar reflectance to the inner wall can be used to fill the port. A sphere geometry may also be used instead for the configuration illustrated in Figure 2 (see Annex A). If the integrating sphere does not have a compensation port, and placing the OLED display at the sample port significantly changes the spectral distribution of the light in the sphere, the alternate sphere method in Annex A shall be used. In addition, if it is necessary to measure the hemispherical transmittance factor with the OLED display on, then the alternate sphere method shall be used.

iii) It is recommended to use a sample port between 30 mm to 75 mm. If a compensation port is used, the sample and compensation ports of the integrating sphere shall be circular and of the same size. The compensation port shall be positioned at an angle of less than 1,57 rad (90°) from the sample port. The sample port, compensation port and light trap port shall not lie on the great circle of the sphere. The ports shall be designed in such a way that samples placed at the port will lie at nearly the same surface as the inner sphere wall.

iv) The surfaces of the interior of the integrating sphere and the baffles shall be of substantially equal luminous reflectance which shall be 90 % or more and shall not vary by more than ±3 %. The sphere wall reflectance can be determined relative to a known reflection standard using the method described in Annex A.

- v) Using this instrument, the repeatability standard deviation shall be 0,2 % or less. The within-laboratory reproducibility over long time intervals shall not exceed the repeatability by a factor of more than 3.
- vi) The flat sample shall be held against the sample port so that the normal of the sample is within 2° of the normal of the sample port. The sphere interior should provide uniform illumination on the screen, with the screen receiving a constant luminance over its hemispherical inclination angles. This criterion is often satisfied when the sphere's internal light source dominates the illuminance inside the sphere compared to any sample contribution.
- vii) The LMD is aligned normal to the centre of the sample port at an approximate distance of 0,5 m. The measurement field shall be focused on the sample port plane.

b) Standard measuring environmental conditions:

   1) darkroom conditions;
   2) standard setup conditions.

5.1.1.3 Measuring method

The method is similar to ASTM D1003 [2], and analogous to ISO 13468-1 [3]. This method assumes that the transmission properties of the transparent OLED display are not affected by the illumination level on the display.

1) If the integrating sphere has a light trap port, place a port plug or diffuse white standard at the port. Turn on the integrating sphere light source and allow the light source and LMD to stabilize. The measurement configuration in Figure 2 shall be set up in a dark room, and ingress of external light into the integrating sphere shall be prevented.
2) If the integrating sphere has a compensation port, place the backside of the transparent OLED display against that port. The display is turned off.
3) Measure the luminance L_{ref} or spectral radiance at the sample port, and record the monitor detector value m_{ref}.
4) Place the backside of the transparent OLED display against the sample port. If the integrating sphere has a compensation port, place a light trap at that port. Measure the transmitted luminance (or spectral radiance) at the sample port $L_{di/0}$, and record the monitor detector value $m_{di/0}$.
5) Calculate the luminous hemispherical transmittance factor with specular included $T_{di/0}$ using Formula (1):

$$T_{di/0} = \frac{L_{di/0}}{L_{ref}} \cdot \frac{m_{di/0}}{m_{ref}} \quad (1)$$

6) Repeat the readings for L_{ref}, m_{ref}, $L_{di/0}$, and $m_{di/0}$, making additional readings with the specimen in positions selected to determine uniformity.
7) Carry out the procedure three times, and use the average of the three calculated results as the luminous hemispherical transmittance factor value.
8) All details are required to be recorded for identification of the test specimens and the source of the specimens (type of light source used, information of transparent OLED display).

If the transmission properties of the transparent OLED display are different in the off from the on state, then the alternate sphere method in Annex A shall be used.