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TECHNICAL REPORT

colour inside

Electronic display devices – Part 2-5: Transparent displays – Measurements of optical characteristics

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 2-5: Transparent displays – Measurements of optical characteristics

FOREWORD

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IEC TR 62977-2-5, which is a technical report, has been prepared by IEC technical committee 110: Electronic display devices.

The text of this technical report is based on the following documents:

Draft TR	Report on voting
110/919/DTR	110/935B/RVDTR

Full information on the voting for the approval of this technical report 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 62977 series, published under the general title *Electronic display devices*, 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- withdrawn,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.

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ELECTRONIC DISPLAY DEVICES –

Part 2-5: Transparent displays – Measurements of optical characteristics

1 Scope

This part of IEC 62977 describes the conditions and measuring methods for determining the displayed properties (on-screen) and the through-screen properties of transparent direct-view-type liquid crystal displays (LCDs) and those of organic light emitting diode (OLED) displays.

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 62341-6-4:2017, *Organic light emitting diode (OLED) displays – Part 6-4: Measuring methods of transparent properties*

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

3 Terms and definitions

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

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

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

3.1
transparent display module
display module which can show the information on the screen and allow objects behind the display to be viewed through the screen

3.2
on-screen property
image quality attributes when the intended information is on the display panel

3.3
through-screen property
image quality attributes when the intended information is behind the display panel and is viewed through it

3.4
transmittance
ratio of the transmitted radiant or luminous flux to the incident flux in the given conditions

3.5
transmitted haze
percent of transmitted light that is scattered more than 2,5° from the direction of the incident beam

3.6
clarity
measure based on luminance modulations from stripe patterns to represent the degree of clear distinction of see-through objects

3.7
purity
ratio of luminance which is measured in a 0,2° region to luminance of total transmitted light in a transparent display panel to represent the degree of clear distinction of see-through objects

3.8
colour shift
change in chromaticity of the reference object when viewed through a transparent display device

3.9
contrast ratio offset
change in contrast ratio of the reference object when viewed through a transparent display device

4 Measuring conditions

4.1 Standard measuring environmental conditions

Measurements are carried out under the standard environmental conditions:

– temperature: 25 °C ± 3 °C,
– relative humidity: 25 % to 85 %,
– atmospheric pressure: 86 kPa to 106 kPa.

When different environmental conditions are used, they are noted in the measurement report.

4.2 Standard lighting conditions

4.2.1 Darkroom conditions

The luminance contribution from unwanted background illumination reflected off the test display shall be less than 1/20 of the display's black state luminance. If this condition is not satisfied, then background subtraction is required and it shall be noted in the test 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 test report.

4.2.2 Ambient illumination conditions

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

Uniform hemispherical diffuse illumination is used to simulate the background lighting in a room or the hemispherical skylight incident on the display, with sun occluded. The detailed information to simulate those ambient conditions is described in IEC 62341-6-2 [1][1] and in IDMS [2].

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 [3])	60 % hemispherical, 40 % directional at 45°
Up to 300 lx	(mostly) General machine work, rough assembly work, (general) museum (ISO 9241-307), office environment	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 is calculated using a combination of hemispherical diffuse illumination (with specular included) and directional illumination incident on a display surface in a vertical orientation	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 closely approximates CIE Illuminant D65 [4]. The source illumination used for measuring the display reflection and transmission properties has 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. In order to simulate outdoor applications, Illuminant D50 is recommended for the directional illumination, and Illuminant D75 is recommended for hemispherical illumination.

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

4.3 Standard setup conditions

4.3.1 Starting conditions of measurements

Measurements will be started after the displays and measuring instruments achieve stability. The display under test (DUT) will be turned on first and operated for at least 30 min 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 for a given display image.

4.3.2 Standard measuring positions

Luminance, radiance distribution and/or tristimulus values may be measured at several specified positions on the DUT surface; see Figure 1. Unless otherwise specified, measurements are carried out in the centre of each circle. Care is taken that the measuring spots on the display do not overlap.

Any deviation from the above-described standard positions is added to the detail specification.

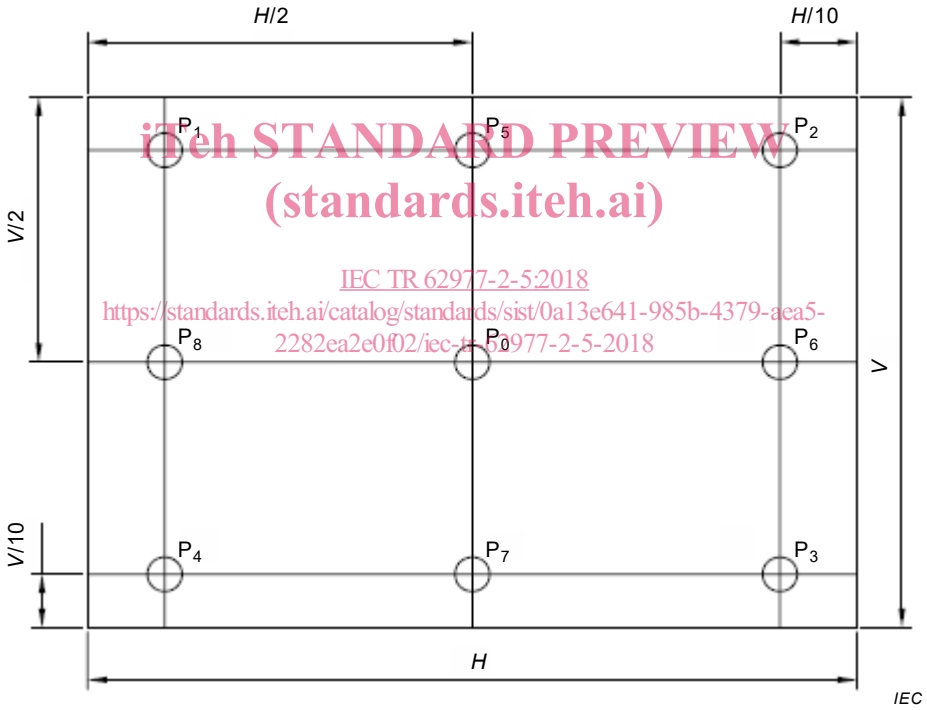

Figure 1 – Measurement points

4.3.3 Conditions of measuring equipment

General conditions of the measuring equipment specified in IEC 62341-6-2 are adopted. Three different LMDs may be applied to the measurements of the light transmitted and/or reflected by the DUT: a luminance meter, a colorimeter or a spectroradiometer. If measuring segmented displays, the measurement field area is located completely inside a single segment, and does not include any of its surroundings.

For DUT which is not equipped with its own source of illumination, an external light source which has the same size as that of the DUT is used. Assemble the back light source with the transparent display module to ensure that there is no light leakage.

Measure the following parameters of the light source in the plane of the DUT at P_0 and other relevant positions from P_1 to P_8 (Figure 1); measure and specify:

a) spectrum of emission;

b) luminance L;

c) temporal stability of the luminance $L(t)$.

The general conditions of the measurement are as follows:

1) The standard measurement setup is shown in Figure 2. The LMD is 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 is less than 5 nm. The spectral bandwidth of the spectroradiometer is 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 is taken to ensure that the device has enough sensitivity and dynamic range to perform the required task.

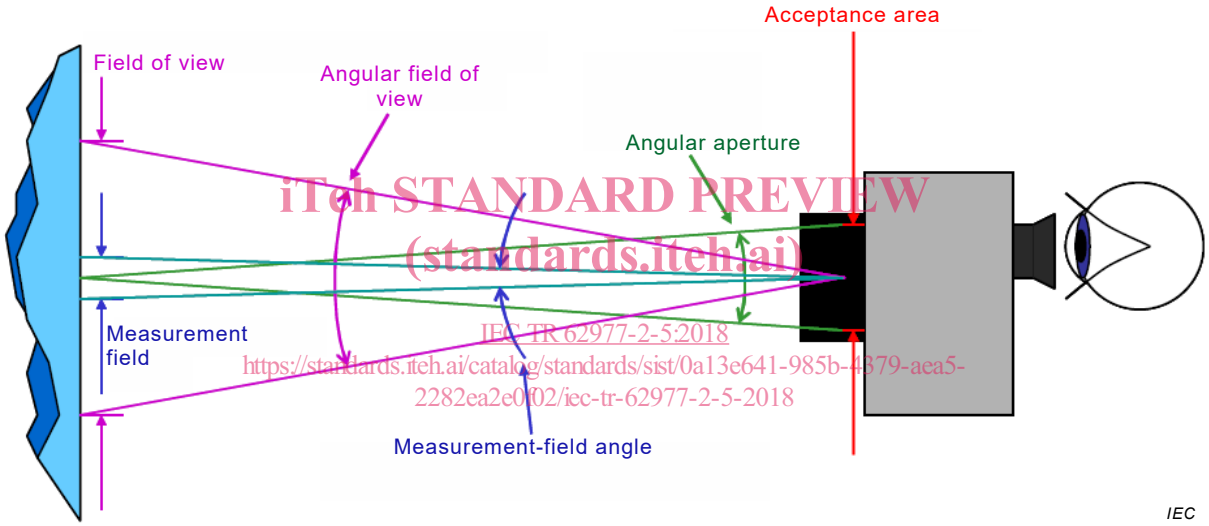

Figure 2 – Layout diagram of measurement setup

2) The LMD is 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 is aligned perpendicularly to its surface, unless stated otherwise.

3) The relative uncertainty and repeatability of all the measuring devices is maintained by following the instrument supplier's recommended calibration schedule.

4) The LMD integration time is an integer number of frame periods, synchronized to the frame rate, or the integration time is greater than 200 frame periods.

5) When measuring matrix displays, the LMDs are set to a measurement field that includes more than 500 pixels. If smaller measurement areas are necessary, equivalence to 500 pixels is confirmed.

6) The angular aperture is less than or equal to 5°, and the measurement field angle is less than or equal to 2° (see Figure 2). The measuring distance and the aperture angle may be adjusted to achieve a measuring field greater than 500 pixels if setting the above aperture angle is difficult.

7) Display modules are operated at their design field frequency. When using separate driving signal equipment to operate a panel, the drive conditions are noted in the performance report.

Any deviations from these conditions are noted in the performance report.

5 Measuring methods of transparent properties

5.1 Hemispherical transmittance factor with specular included

5.1.1 Purpose

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

NOTE This method was originally specified for transparent OLED displays.

5.1.2 Measuring conditions

For this measurement, the following conditions are 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 3), which is as follows:

i) The light source in the integrating sphere has a smooth broadband spectrum approximating CIE standard illuminant D65 [4]. The integrating sphere has a photopic optical detector which monitors the relative luminance level m inside the sphere. The monitor is 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 are kept constant during measurements on a transparent display. The measurement conditions are such that the transparent 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 be not less than 150 mm so that specimens of a reasonable size can be used. When the 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 of the configuration illustrated in Figure 3 (see IEC 62341-6-4:2017, Annex A). If the integrating sphere does not have a compensation port, and placing the display at the sample port significantly changes the spectral distribution of the light in the sphere, the alternate sphere method in IEC 62341-6-4:2017, Annex A shall be used. In addition, if it is necessary to measure the hemispherical transmittance factor with the display on, then the alternate sphere method is used.

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

iv) The surfaces of the interior of the integrating sphere and the baffles are of substantially equal luminous reflectance which is 90 % or more and does not vary by more than ±3 %. The sphere wall reflectance can be determined relative to a known reflection standard using the method described in IEC 62341-6-4:2017, Annex A.