IEC 62595-2-5

Edition 1.0 2021-05

# INTERNATIONAL STANDARD

colour inside

## Display lighting unit –
## Part 2-5: Measurement method for optical quantities of non-planar light sources



IEC 62595-2-5:2021-05(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.120; 31.260

ISBN 978-2-8322-9771-1

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# DISPLAY LIGHTING UNIT –

## Part 2-5: Measurement method for optical quantities of non-planar light sources

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International Standard IEC 62595-2-5 has been prepared by IEC technical committee 110: Electronic displays.

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

| FDIS | Report on voting |
|---|---|
| 110/1296/FDIS | 110/1320/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 62595 series, published under the general title *Display lighting unit*, 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- withdrawn,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
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# INTRODUCTION

The recent introduction of curved OLED TVs, and the expected rapid spread of flexible displays in portable devices, highlights the necessity of new measurement methods. In recent years flexible displays have been integrated into products such as cellular phones and wearable devices [1] to [5][1]. Development and integration of flexible displays have increased the application of curved devices, for example distinct or curved-back large-size wall displays, foldable signage displays, and commercial wearable or handheld devices. The measurement of optical characteristics of displays with radii larger than 35 mm has been documented.

Recently flexible light sources (LSs) have been used for general lighting applications and as light source for flexible non-emissive displays. Since bending a planar lighting unit alters the optical properties of the unit, assessment of the optical performance of the lighting units in a curved state, i.e., concave or convex condition, is indispensable for manufacturing companies.

A light source can be a planar or non-planar (continuous multiple curvatures), i.e., convex (outer light emitting surface of a curvature), or concave light source (inner light emitting surface of a curvature). When a light source is bent the LS is under strain, i.e., tension or depression, the optical characteristics differ from that of a planar LS. A non-planar LS may have local curvatures on its surface with different surface normal from position to position. Such an LS can be a semiconductor light-emitting diode (LED, OLED, polymer LED (PLED)) or a phosphor excited type using a pump source. An LS can have a narrow-band radiation or more than one narrow band emission.



Issues concerning flexible light sources with surface curvatures, which are different from those issues concerning displays (e.g., resolution, contrast, lateral and directional characteristics or directions of viewing), hitherto have not been documented.



Since the characteristics of a non-planar light source (NPLS) change with the decreasing radius of the curvature, the optical characteristics of LS such as lateral and directional luminance and luminance variations, lateral and directional chromaticity distributions and their variations, luminous intensity distribution, and luminous flux, will be measured and evaluated.

This document establishes the measurement methods for cylindrical light sources that can be a base for the study of non-planar LS, which is assumed to be an integration of small areas. The fundamental element of such a surface can be a convex or a concave curvature with a first order of radius, i.e., a cylindrical shape, which is worth considering in this document.

In addition, a curved light source is used in a variety of conditions. Therefore, the optical measurements of an LS will be performed in a darkroom.

As in the measurement of planar LSs the following measurements are used for convex and concave LS measurements: 1) a lateral scanning measurement and 2) a directional scanning measurement. In the case of lateral scanning, the surface normal coincides with the optical axis of the light measurement device. In the case of directional scanning the local surface normal makes an angle with the optical axis of the measurement device.

Since the aperture of a light measurement device is not zero (non-zero aperture), there exist an optimized measurement distance and angle (i.e., 0,1°, 0,2°, 1°, and 2°) for the measurements. In the measurement of a cylindrical LS, a light measurement device which has sufficient depth-of-field or depth-of-focus is selected, because the measurement field on the LS has a three-dimensional geometry and is different from that of a plane.

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1 Numbers in square brackets refer to the Bibliography.

**DISPLAY LIGHTING UNIT –**

**Part 2-5: Measurement method for optical quantities of non-planar light sources**

## 1 Scope

This part of IEC 62595 specifies the measurement methods for measuring the optical characteristics of convex and concave cylindrical light sources. These non-planar light sources (NPLSs) can have either a continuous, distinct, segmented or block-wised light radiating surface, for example OLED panels, integrated LEDs, integrated mini-LEDs, micro-LEDs, laser diodes, each being either monochromatic or polychromatic.

## 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 61747-6-2, *Liquid crystal display devices – Part 6-2: Measuring methods for liquid crystal display modules – Reflective type*

IEC 62595-2-1, *Display lighting unit – Part 2-1: Electro-optical measuring methods of LED backlight unit*



IEC 62595-2-3, *Display lighting unit – Part 2-3: Electro-optical measuring methods for LED frontlight unit*

IEC 62679-3-3, *Electronic paper displays – Part 3-3: Optical measuring methods for displays with integrated lighting units*

IEC 62922, *Organic light emitting diode (OLED) panels for general lighting – Performance requirements*

ISO/CIE 11664-3*, Colorimetry – Part 3: CIE tristimulus values*

ISO/CIE 19476, *Characterization of the performance of illuminance meters and luminance meters*

CIE S 017/E:2020, *International Lighting Vocabulary*

CIE 1931, *Colour space*

# 3 Terms, definitions, abbreviated terms and letter symbols

## 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**
**planar light source**
light source with a nearly infinite radius of curvature

**3.1.2**
**non-planar light source**
light source having continuous multiple curvatures

**3.1.3**
**convex light source**
light source defined by the outer light emitting surface of a curvature



**3.1.4**
**concave light source**
light source defined by the inner light emitting surface of a curvature



**3.1.5**
**flexible light source**
light source capable of bending or being bent or to endure strain without being destroyed

**3.1.6**
**single-curvature surface emission light source**
**cylindrical light source**
light source that possesses one radius of curvature whether negative (concave) or positive (convex), along its length, width or diagonal

**3.1.7**
**multiple-curvature surface light source**
light source that possesses multiple radii of curvatures whether negative (concave) or positive (convex), along any dimension such as length, width or diagonal

**3.1.8**
**phosphor converted emission light source**
light source with a pump source that is used to excite a phosphor or any phosphor-like material that radiates light of wavelengths longer than the pump source

## 3.2 Abbreviated terms

| | |
|---|---|
| CCT | Correlated colour temperature |
| COC | Circle of confusion |
| DC | Direct current |
| DoF | Depth-of-field |
| dof | Depth-of-focus |
| DUT | Device under test |

| | |
|---|---|
| LED | Light emitting diode |
| LMD | Light measurement device |
| LS | Light source |
| MF | Masurement field |
| NPLS | Non-planar light source |
| OLED | Organic light emitting diode |
| PLS | Panar light source |
| SLMD | Spot-type light measuring device |

NOTE The measurement field is an area on the DUT viewed through the LMD lens within a cone limited by the measurement field angle.

### 3.3 Letter symbols (quantity symbols/unit symbols)

The letter symbols for NPLS are shown in Table 1.

**Table 1 – Letter symbols (quantity symbols/unit symbols)**

| Definition | Symbol | Unit |
|---|---|---|
| Luminance of an arbitrary area centred at point ($x_i$, $y_i$) on an NPLS | $L_{\mathrm{v}i}$ ($x_i$, $y_i$, $\theta_0$, $\phi_0$) | cd/m$^2$ |
| Maximum luminance on an NPLS | $L_{\mathrm{vM}}$ | cd/m$^2$ |
| Minimum luminance on an NPLS | $L_{\mathrm{vm}}$ | cd/m$^2$ |
| Directional average luminance on an NPLS | $L_{\mathrm{va}}$ | cd/m$^2$ |
| Centre luminance on NPLS (in case of definition for an NPLS) | $L_{\mathrm{vc}}$ | cd/m$^2$ |
| Lateral luminance uniformity | $U_{\mathrm{lat}}$ | % |
| Directional luminance uniformity | $U_{\mathrm{dir}}$ | % |
| Directional luminance viewed from an arbitrary direction | $L_{\mathrm{v}}(x, y, z, \theta, \phi)$ | cd/m$^2$ |
| Chromaticity difference (chromaticity difference, CIE 1976) | $\Delta u'v'$ | |
| Directional chromaticity difference | $\Delta u'v'$ ($\theta$, $\phi$, $x_i$, $y_i$, $z_i$) | |
| Uniformity in chromaticity | $U_{\mathrm{c}}$ | |
| Depth-of-field | $\Delta L$ | mm |
| Depth-of-focus | $\Delta l$ | mm |
| Direct current | $I_{\mathrm{DC}}$ | mA |
| Peak value of an alternating current | $I_{\mathrm{peak}}$ | mA |
| RMS of an alternating current | $I_{\mathrm{rms}}$ | mA |
| Effective value of an alternating current | $I_{\mathrm{eff}}$ | mA |
| DC voltage | $V_{\mathrm{DC}}$ | V |
| Peak value of an alternating voltage | $V_{\mathrm{peak}}$ | V |
| RMS of an alternating voltage | $V_{\mathrm{rms}}$ | V |
| Effective value of an alternating voltage | $V_{\mathrm{eff}}$ | V |
| Correlated colour temperature for lateral measurement | $CCT_{\mathrm{lat}}$ | K |
| Correlated colour temperature for directional measurement | $CCT_{\mathrm{dir}}$ | K |
| Luminous flux of a standard LS | $\Phi_{\mathrm{vstd}}$ | lm |
| Luminous flux of a DUT | $\Phi_{\mathrm{vDUT}}$ | lm |
| Chromaticity coordinates | $x_{\mathrm{ca}}, y_{\mathrm{ca}}$ | |

NOTE Directional luminance distribution, $L_{Vi}$ ($x_i$, $y_i$, $\theta$, $\phi$) , is measured for an area centred at point ($x_i$, $y_i$, $z_i$), along the zenith angle ($\theta$) and an intended azimuth angle ($\phi$).

# 4 Measurement devices

## 4.1 General

In 4.1 to 4.5 a light measurement device, such as a spectrometer, an integrating sphere and a goniometer with LMD are used. In addition, three axial stages for fixing the device under test are used.

For an evaluation of the measurement results, the Cartesian and the spherical coordinate systems are used as shown in Figure 1.

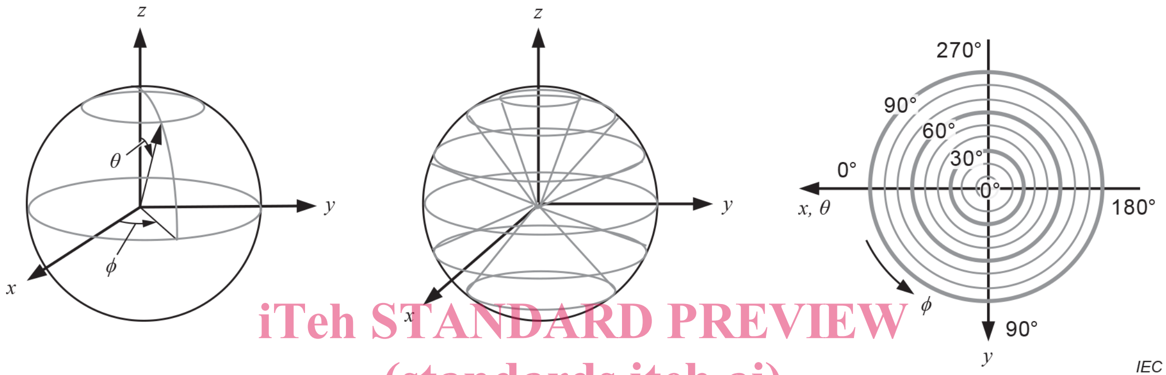




**Figure 1 – Cartesian and spherical coordinate systems for NPLS measurement**



## 4.2 Spot-type light measuring device

The spot LMD (SLMD) shall be equipped with a view finder (see Figure 2). The position of the entrance pupil (aperture) of the LMD shall be provided by the manufacturer or the supplier. The size of the entrance pupil of the LMD should be set between 2 mm and 5 mm, and shall be smaller than the output light field of the DUT [1] to [6].

NOTE 1 The terms used in Figure 2 correspond to ISO/CIE 19476.

The optics of an SLMD shall be equivalent to the spectral luminous efficiency function (CIE S 017/E:2020) $V(\lambda)$. The LMD to measure the optical characteristics such as luminance and chromaticity shall be calibrated with the appropriate photometric or spectrometric standards. When a filter-type LMD such as a luminance meter is used to ensure the luminance accuracy for the intended DUT light sources, its responsivity should comply with the spectral luminous efficiency for CIE photopic vision or it should be compared with a calibrated spectrometer. The spectral mismatch correction factor can be specified (see NOTE 2).

NOTE 2 ISO/CIE 19476 indicates the spectral mismatch factor between the spectral responsivity of the filter-type LMD and the CIE spectral luminous efficiency function. Details of the spectral mismatch correction factor are given in ISO/CIE 19476.

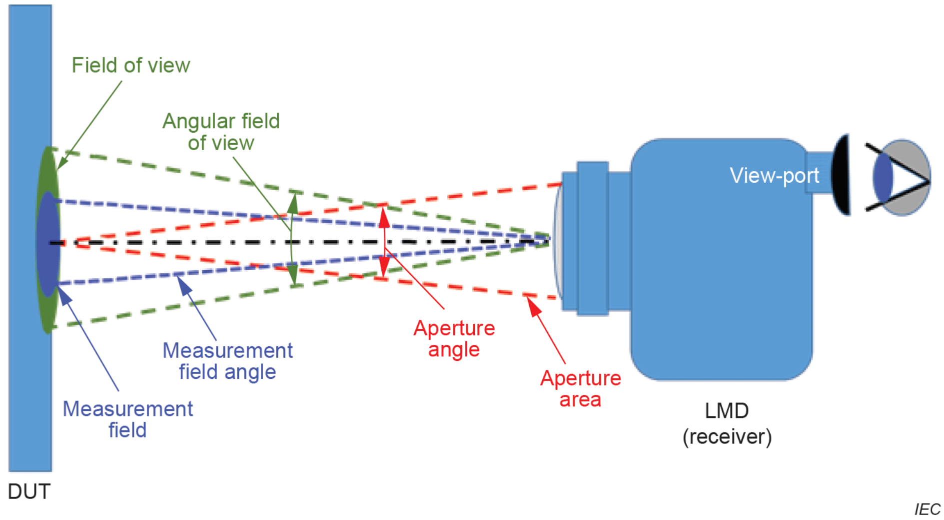


**Figure 2 – Example of LMD with the viewing area surrounding the measurement field**

To ensure accurate measurements, the following requirements shall be applied. Otherwise, the differences shall be noted in the report. More information on LMD evaluation can be found in ISO/CIE 19476.

The LMD should be carefully checked before measurements, considering the following points:



– sensitivity of the LMD to measuring light (i.e., to cover the spectrum of the DUT);
– errors caused by the veiling glare and lens flare (i.e. stray light in the optical system);
– timing of data-acquisition, low-pass filtering (noise reduction);
– linearity of detection and data conversion;
– measurement field size.



In addition, the LMD shall be calibrated in accordance with ISO/CIE 19476. All devices shall be checked for sufficient depth-of-field (DoF). Ensure that the LMD measures the DUT on the intended curvature area. The depth-of-focus in the LMD's optical detector, ($\Delta l_r$ + $\Delta l_f$), is proportional to the depth-of-field. The depth-of-focus is explained in Annex A.

### 4.3 Spectroradiometer (spectral radiance-meter)

The wavelength range shall be at least 380 nm to 780 nm and the spectral bandwidth shall be 5 nm or less. The wavelength deviation shall be between -0,3 nm and +0,3 nm. The equipment shall be calibrated with the spectral radiance standard. The performance should be carefully checked before measurement, considering the same elements as in 4.2.

### 4.4 Electrical measurement devices

#### 4.4.1 Current meter

In the measurement of a DUT, a DC drive or signal driving can be required. In case of direct current, an ammeter (current meter) shall be between points C and D (see IEC 62595-2-1 and IEC 62595-2-3), as shown in Figure 3**.**

In case of signal driving of the DUT, the peak value ($I_{peak}$) and effective current ($I_{eff}$, i.e., the $I_{rms}$ value) should be recorded as in Figure 3.

#### 4.4.2 Voltage meter

The measurement of input voltage should be performed under standard measurement conditions using the voltage meter (voltmeter) between points A and B in as shown in Figure 3 (see IEC 62595-2-1 and IEC 62595-2-3).

In case of DC driving of the DUT, the voltage ($V_{DC}$) should be recorded by using a voltmeter between A and B in Figure 3.

In case of signal driving of the DUT, the peak value ($V_{peak}$) and effective voltage ($V_{eff}$ i.e., the $V_{rms}$ value) should be recorded.

The measurement of input voltage should be performed under standard measurement conditions using the voltage meter (voltmeter) between points A and B as shown in Figure 3.

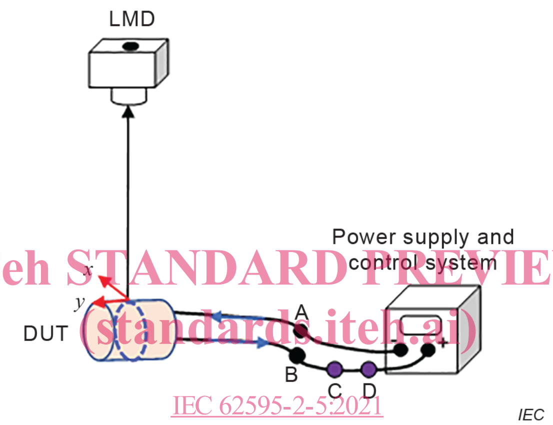




**Figure 3 – Current and voltage measurements using an ammeter between points C and D and a voltage meter between points A and B**

### 4.5 Luminous flux measurement devices

#### 4.5.1 General

There are two typical methods of measuring luminous flux:

1) a spherical photometer method with an integrating sphere, and
2) a light distribution measurement method with a goniophotometer of any type for measurement of the luminous intensity from which the luminous flux is calculated.

#### 4.5.2 Luminous flux

##### 4.5.2.1 Integrating sphere method and installation position

An integrating sphere can perform luminous flux measurement with reasonable accuracy. The size of an integrating sphere is important in the measurement of a DUT. The larger integrating sphere exhibits less throughput than the smaller spheres and thus higher optical attenuation, thereby eventually introducing a lower signal-to-noise ratio. One of the points that shall be considered is the effect of self-absorption and its correction. This means that the percentage of flux absorbed by installations and by the DUT itself inside the integrating sphere shall be taken into account. Therefore, prior to measurement, the self-absorption correction factor shall be measured (6.6.9.4).

This factor shall be used for correcting the real amount of the luminous flux that is emitted by the LS (removing the effect of the jigs and the DUT itself). In addition, a standard LS with a