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INTERNATIONAL STANDARD

colour inside

Laser displays –
Part 5-1: Measurement of optical performance for laser front projection

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FOREWORD

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IEC 62906-5-1 has been prepared by IEC technical committee 110: Electronic displays. It is an International Standard.

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

Draft	Report on voting
110/1351/FDIS	110/1367/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62906 series, published under the general title *Laser displays*, can be found on the IEC website.

Future documents in this series will carry the new general title as cited above. Titles of existing documents in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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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LASER DISPLAYS –

Part 5-1: Measurement of optical performance for laser front projection

1 Scope

This part of IEC 62906 specifies the standard measurement conditions and measurement methods for front projection displays without screen which use lasers or laser hybrids as light sources. The hybrid light sources can use both lasers and spontaneous emission-based light sources. This document covers optical performance measurements for full-frame projection technologies such as digital micro-mirror devices (DMDs), liquid crystal on silicon (LCOS), and liquid crystal display (LCD) projectors. Other displays, such as raster-scanned (flying spot) projection displays, are not included.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content shall constitute 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 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61947-1:2002, *Electronic projection – Measurement and documentation of key performance criteria – Part 1: Fixed resolution projectors*

IEC 62471-5, *Photobiological safety of lamps and lamp systems- Part 5: Image projectors*

IEC TR 62977-2-3, *Electronic display devices – Part 2-3: Measurements of optical properties – Multi-colour test patterns*

ISO/CIE 11664-4, *Colorimetry – Part 4: CIE 1976 L*a*b* colour space*

ISO 15076-1:2010, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:2010*

CIE 15, *Colorimetry*

CIE 168-2005, *Criteria for the evaluation of extended-gamut colour encoding*

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

NOTE Most definitions and units are in accordance with the naming methods used in ISO 11145 and IEC 62906-1-2

3.1.1
chromaticity difference
geometric distance $\Delta u'v'$ between two colours in the CIE 1976 $u'v'$ chromaticity diagram

3.1.2
white light output (WLO) method
method that estimates total luminous flux measured from the average of nine points for a full white screen or for a sequence of white tiles that total the area of the full screen

3.1.3
colour-signal white (CSW) method
method that estimates total luminous flux from the sum of the input-referred red, green, and blue tile sequence

Note 1 to entry: The area of all colour tiles totals the area of the full screen.

3.2 Abbreviated terms

APL	average picture level
CAT	chromatic adaptation transform
CCT	correlated colour temperature
CGV	colour gamut volume
CIE	International Commission on Illumination
CIELAB	CIE 1976 (L*a*b*) colour space
CSW	colour signal white
CT	colour tile
DMD	digital micro-mirror device
DUT	device under test
EOTF	electro-optical transfer function
ISO	International Organization for Standardization
LCD	liquid crystal display
LCOS	liquid crystal on silicon
LDD	laser display device
LED	light emitting diode
LMD	light measuring device
RGB	red, green, blue
RGBCMY	red, green, blue, cyan, magenta, yellow
SDR	standard dynamic range
sRGB	standard RGB colour space as defined in IEC 61966-2-1
WLO	white light output

4 Standard measuring conditions

4.1 General

Unless stated otherwise, the following standard measuring conditions shall be used. When carrying out optical measurements of the laser projector, the measuring environment, equipment, and methods shall comply with IEC 60825-1 and IEC 62471-5 for human safety.

4.2 Standard measuring environmental conditions

All the tests and measurements shall be made under the following standard environmental conditions:

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

If other conditions are used, they shall be noted in the report.

NOTE For temperature sensitive cases, 25 °C ± 2 °C is used.

4.3 Standard dark room conditions

The laser projectors are intended to be measured under dark room conditions. The illuminance contribution from unwanted background illumination shall be less than 1 / 20 of the projector's lowest illuminance in a given test pattern. The room background illuminance can be estimated by using a projection mask (see section 15.1.4 in [1][1]). For the determination of the colorimetric values, the background tri-stimuli shall be applied.

When it is not possible to achieve the background illuminance conditions, then background subtraction by using the projection mask for the same test pattern shall be used in the measurement. If the luminance measurement with a reflectance standard is applied to determine the illuminance, the dimension of the projection mask has to take into account the measurement area of the reflectance standard instead of the measurement area of the illuminance meter.

In the case of direct illuminance measurement, a stray light elimination tube (see section 15.1.5 in [1]) can be used with the illuminance meters to minimize the contribution of the background illumination. A stray light elimination tube is required if for a given test pattern, the background illuminance measured with a projection mask is more than 67 % of the illuminance measured on the same location in the test pattern without the projection mask.

It should be noted that the reflections from the mask, projector shell, LMD and their frames in the front of the detection area can produce significant background illuminance, especially in the case of a luminance measurement. It is recommended to absorb the direct projection beam by applying light traps behind the virtual screen. Blackout curtains and black room surface (such as walls, ceiling, floor, etc.) with a reflectance less than 3 % are valuable for reducing the background illumination.

4.4 Standard conditions of measuring equipment

Standard equipment conditions are described in 4.5. Any deviations from these conditions shall be noted in the report.

Measurements shall be started after the laser projector, the light source, and measuring instruments achieve stability. The illuminance originating from the projector shall not vary by more than ±2 % over the entire measurement duration.

1 Numbers in square brackets refer to the Bibliography.

4.5 Conditions of measuring equipment

4.5.1 General conditions

The measuring equipment shall be as follows:

a) The laser projector is to be characterized by focusing a test pattern on a projected image plane at a defined distance from the projector. This image plane is the location where a projection screen would be placed. The image plane for projector measurements shall be set up in accordance with the angle, height, and distance specified in the manufacturer's set-up instructions (Figure 1). The projector's optical axis shall lie in the vertical plane perpendicular to the image plane and intersect the centre of the screen. The measurement configuration shall be reported.

b) Unless stated otherwise, the measurement area of the LMD shall be at the centre of the image area to be measured.

c) The measurement area at the image plane shall be at least 1 cm in diameter and contain at least 10 pixels × 10 pixels. It shall be confirmed that this number of pixels is sufficient by shifting the LMD over a lateral distance of 20 % of the measurement area diameter and by verifying that the illuminance changes by less than 2 % and the colour by less than 0,003 in (x, y) chromaticity values, for a full white screen as test pattern. A large enough measurement area is needed to average out speckle-induced non-uniformity.

d) Illuminance shall be determined by using direct illuminance measurement with an illuminance (or spectral irradiance) meter with a cosine-corrected transmission diffuser or an integrating sphere as LMD (Figure 1a), or the measurement be made using a reflectance standard and a luminance (or spectral radiance) meter as LMD (Figure 1b). The optical properties of these devices are generally dependent on the inclination angle of the light. The measurements shall compensate for any light incidence angle dependence of these items. This is especially important for short-focus (short-throw) projectors where the inclination angle can be large. In that case, the integrating sphere with a thin edge at the entrance port is preferred. Both the integrating sphere and reflectance standard method can be used but they will need to be calibrated for the illumination inclination angle used in the measurement. The image plane can be established through use of a virtual screen where the image is focused in the x–y coordinate plane. The virtual screen can be set up with the LMD (Figure 1a) or reflectance standard (Figure 1b). The front surface of the diffuser or reflectance standard, or the entrance port of the integrating sphere should be placed at the projector image plane. The measurement area shall lie within the plane of this virtual screen. The screen can be constructed with a black frame, with millimetre grids placed at the corners of the frame. The frame shall be sufficiently large so that the specified image area is contained within the four corner grids. The spacing between the corner grids shall be calibrated to an accuracy of ±0,2 % of the minimum vertical or horizontal dimension of the projected image. The millimetre grids need to be covered with matte black materials to avoid causing stray light when performing sensitive dark level measurements.

e) Spectrally integrated light measurements shall be measured in terms of calibrated photometric or colorimetric units traceable to a recognized national metrology institute, illuminance for an illuminance meter, or CIE 1931 tristimulus values (X, Y, Z) and chromaticity coordinates (x, y) for a colorimeter.

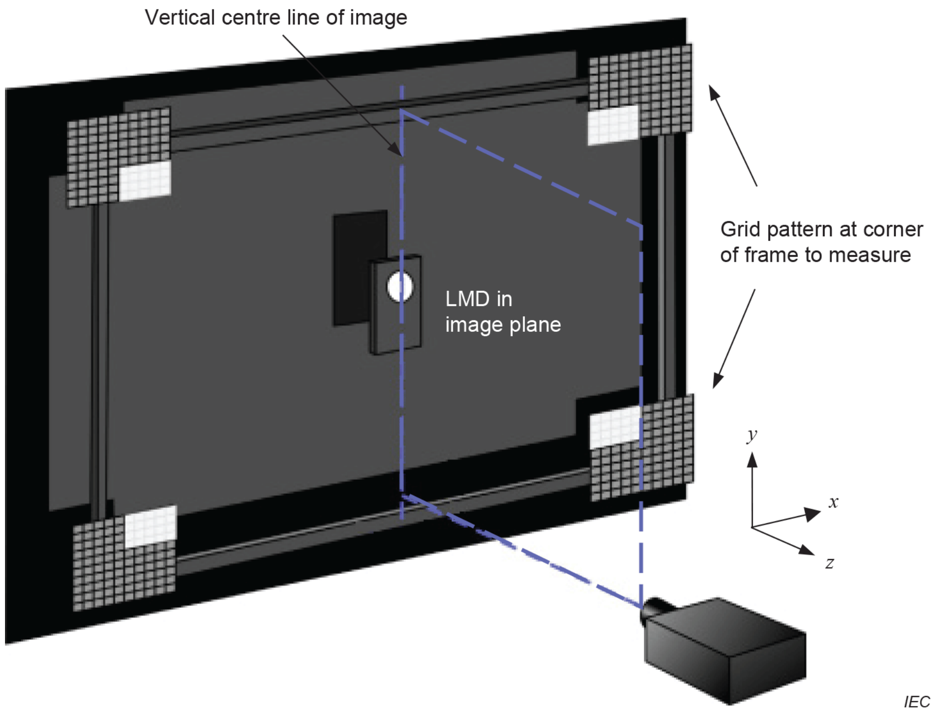
f) Photometric and colorimetric data shall be calculated for a CIE 2° standard colorimetric observer, as specified in CIE 15.

g) The light measuring device (LMD) shall have enough sensitivity and dynamic range to perform the required task. The measured LMD signal in the lowest illuminance measurement shall be at least ten times greater than the dark level (noise floor) of the LMD, and no greater than 85 % of the saturation level in the highest illuminance measurement. The LMDs are especially prone to saturation with laser sources, and calibrated neutral density filters are generally applied. Detector saturation can be diagnosed by using a calibrated neutral density filter in front of the projector.

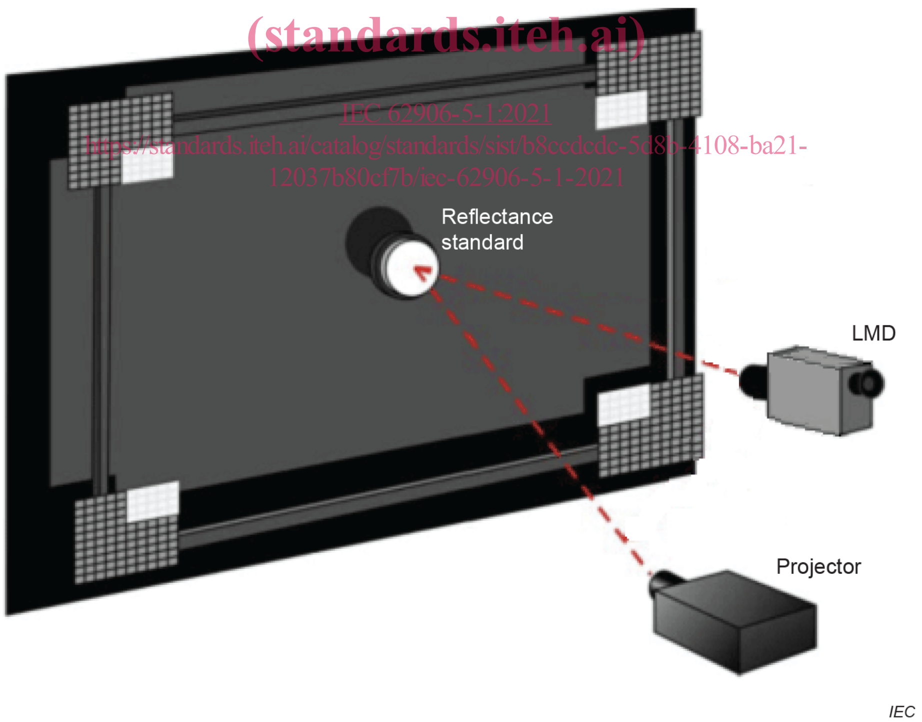
h) If the laser projector light is polarized, the polarization dependence of the LMD shall be less than 1 %.

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

j) If temporal synchronization with the projector or video source is possible, the LMD shall be synchronized with the frame synchronization signal, and the LMD integration time shall be an integer number of frame periods. If synchronization is not possible, the LMD integration time shall be larger than two hundred frame periods.



a) Virtual screen setup with the illuminance LMD



b) Virtual screen setup with the reflectance standard and luminance meter

Figure 1 – Virtual screen setup with (a) the illuminance LMD or (b) reflectance standard placed at the projector image plane for standard measurements

4.5.2 Measurement coordinate system

The measurement angular positioning is referred to by the coordinate system illustrated in Figure 2. The projected image is focused on the x-y plane of the coordinate system. The projector's optical axis can be described by two angles. The inclination angle θ increases relative to the surface normal of the image plane (z-axis). The angle of rotation, or azimuthal angle ϕ, increases from the x-axis in the x-y plane. This corresponds to the counter clockwise rotation of a clock dial, where ϕ = 0° when the dial is at 3 o'clock and ϕ = 90° when the dial is at 12 o'clock.

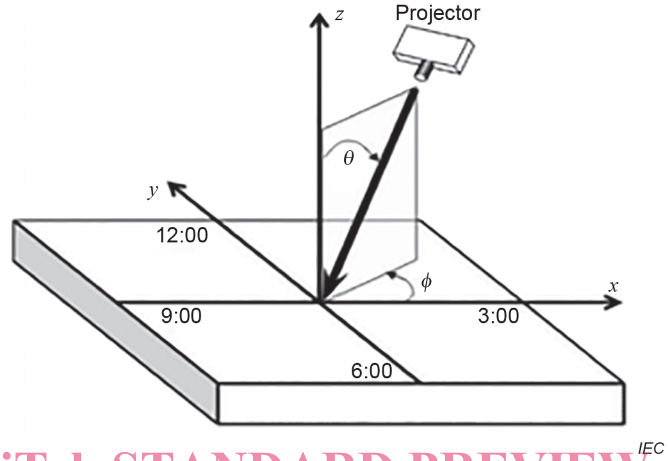


Figure 2 – Polar coordinate system used to describe the inclination and azimuthal angle of the projector

4.5.3 Diffuse reflectance standard

The illuminance or spectral irradiance can be measured directly, or by measuring the luminance or spectral radiance from a diffuse reflectance standard placed at the desired location in the image plane. Diffuse reflectance standards can be obtained with a diffuse reflectance of 98 % or more. A luminance L_{std} measurement from a spectrally flat diffuse reflectance standard can be used to determine the illuminance E,

$$E = \frac{\pi L_{\text{std}}}{R_{\text{std}}} \tag{1}$$

where

R_{std} is the calibrated luminous reflectance factor for that measurement configuration. The calibration of R_{std} shall be traceable to a national metrology institute.

The spectral irradiance $E(\lambda)$ can follow the same form as Formula (1), where L_{std} then denotes the spectral radiance $L_{\text{std}}(\lambda)$ and where R_{std} denotes the calibrated spectral reflectance factor $R_{\text{std}}(\lambda)$, which will have to be known and available in the visible wavelength range.

The white reflectance standard shall be calibrated for the same illumination and detection geometry as will be used in the measurement.