

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic projection – Measurement and documentation of key performance criteria

Part 1: Fixed resolution projectors

Projection électronique – Mesure et documentation des critères principaux de performance –
Partie 1: Projecteurs à résolution fixe



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MEASUREMENT AND DOCUMENTATION OF
KEY PERFORMANCE CRITERIA****Part 1: Fixed resolution projectors****FOREWORD**

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International Standard IEC 61947-1 was prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

This bilingual version (2013-03) corresponds to the monolingual English version, published in 2002-08.

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

FDIS	Report on voting
100/501/FDIS	100/537/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.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2004. At that date, the publication will be

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- withdrawn;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

INTRODUCTION

This standard was developed to ensure a common, meaningful description of key performance parameters for fixed resolution projectors. The measurement methods and test signals correlate closely to typical uses involving computer-generated text and graphics displays. These measurements evaluate the actual viewable image that emanates from fixed resolution projectors. The resulting performance specifications are conservative in nature and allow any display device to be used beyond its rated specifications with degraded performance. The point at which this degraded performance is no longer useful is highly subjective and strongly affected by the environment and the application.

This standard is designed to specify a means of measuring and quantifying the performance of fixed resolution projectors and is not intended to provide design goals for manufacturers of such equipment.

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ELECTRONIC PROJECTION – MEASUREMENT AND DOCUMENTATION OF KEY PERFORMANCE CRITERIA

Part 1: Fixed resolution projectors

1 Scope

This part of IEC 61947 specifies requirements for measuring and documenting key performance parameters for electronic projection systems with fixed resolution projectors in which the light source and projection/magnification optics are an integral part of the system (i.e. individual pixel light sources or matrix displays such as liquid crystal, DMD, plasma, or electroluminescent panels). It also applies to LCD panels or other fixed resolution imaging devices themselves that are used with overhead projectors.

The provisions of this standard are designed to codify the measurement of the performance of variable resolution projectors and are not intended to provide design goals for manufacturers of such equipment.

This standard is intended for fixed resolution projectors that are primarily designed for use with discrete colour (RGB) raster-scanned video, text, and graphics signals generated by computer equipment.

NOTE These devices may also accept composite or component television video signals encoded in ITU/R publications, which are not within the scope of this standard. In this standard, all of these signals are referred to as television video (TV video).

Projectors and projection systems with multiple variable resolutions, such as cathode-ray tubes and laser projectors, are not fully addressed by this standard, and reference should be made to IEC 61947-2.

A discussion of considerations taken into account in the development of this standard appears in Annex C.

2 Normative references

The following referenced documents are indispensable for the application 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 61947-2, *Electronic projection – Measurement and documentation of key performance criteria – Part 2: Variable resolution projectors*

IEC 61966-4, *Multimedia systems and equipment – Colour measurement and management – Part 4: Equipment using liquid crystal display panels*

IEC 61966-5, *Multimedia systems and equipment – Colour measurement and management – Part 5: Equipment using plasma display panels*

ISO 3741, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for reverberation rooms*

ISO 7779, *Acoustics – Measurement of airborne noise emitted by information technology and telecommunication equipment*

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1

active matrix display

display that uses switches at each pixel to select those pixels to which a voltage will be applied

3.2

active viewing area

horizontal and vertical dimensions in millimetres (inches) of the boundary of the array of pixels. It may also be expressed in square millimetres or square inches

3.3

aperture ratio (fill factor)

light transmitting/reflecting area of a pixel times the number of pixels divided by the active viewing area (light transmitting area and light blocking area)

3.4

aspect ratio

proportions of a projected picture area, for example, the width compared to the height

NOTE It is usually expressed in standard ratios such as 4:3, 16:9, or others.

3.5

blanking

process of the beam turning off (blanking) which occurs during horizontal and vertical retrace (flyback)

3.6

CIE

Commission Internationale de l'Eclairage, the international commission on illumination

NOTE The CIE is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the art and science of lighting.

3.7

CIE chromaticity values

Cartesian coordinates used to define a colour in CIE colour space

NOTE The 1931 chromaticity values are designated x and y . In 1976, the CIE defined a more uniform colour space. The 1976 CIE chromaticity values are u' and v' .

3.8

colour mapping

means for accurately displaying colour signals or altering sets of colour signals in a controlled manner

3.9

contrast ratio

luminance or illuminance ratio of a light area of the image to the dark area of the same image

3.10

correlated colour temperature (CCT) of the white-point

temperature, in kelvins, of the black-body radiator the chromaticity of which is closest to the chromaticity of a particular light, for example, from a display screen, as measured in the 1960 CIE (u , v) uniform chromaticity space

NOTE An algorithm for computing CCT of the white-point, either from 1931 CIE (x , y) coordinates or from 1960 (u , v) coordinates, appears in Wyszecki and Stiles [1]. A graphical nomogram also appears in this work.

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Alternatively, a successful numerical approximation has been derived by C. S. McCamy [2]. Given CIE 1931 coordinates (x, y) , McCamy's approximation is $\text{CCT} = 437 n^3 + 3601 n^2 + 6831 n + 5517$ where $n = (x - 0,3320)/(0,1858 - y)$. This approximation, the second of three proposed, is close enough for any practical use between 2000 K and 10 000 K. In units of 1960 u, v chromaticity, it is agreed that the concept of CCT of the white-point has little meaning beyond the distance of 0,01 from the Planckian locus (see Robinson et al [3]), where the distance is specified by:

$$\Delta uv = \sqrt{(u_1 - u_2)^2 + (v_1 - v_2)^2}$$

Most commercial colorimeters will report CCT of the white-point from 0,0175 u, v units above the Planckian locus to 0,014 u, v units below this locus.

3.11

digital micromirror device (DMD)

semiconductor light micromirror array. The DMD can switch incident light on or off in discrete pixels within microseconds to produce projection display systems

3.12

optical distortion

situation in which an image is not a true-to-scale reproduction of an object due to the optics of the system

NOTE There are many types of distortion, such as anamorphic, barrel, curvilinear, geometric, keystone, panoramic, perspective, radial, stereoscopic, tangential, and wide-angle.

3.13

f/number

stop number

the reciprocal value of the relative aperture

NOTE Relative aperture of a photographic lens: twice the numerical aperture where the numerical aperture is the sine of the semi-angle subtended by the exit pupil at the focal plane. For photographic applications, the aperture is equivalent (within a 1/3 stop) to the ratio of the diameter of the entrance pupil to the focal length. (See ISO 517: 1996(E) *Photography – Apertures and related properties pertaining to photographic lenses – Designations and measurements*.)

3.14

fall time

time, in milliseconds, for the image brightness to change from 90 % of its maximum value to 10 % of its maximum value

3.15

focal length

distance between the centre of the focusing lens or mirror and the focal spot.

NOTE Shorter focal length projection lenses produce larger screen images for a given distance from the screen

3.16

focus

adjustment of an optical system to achieve the greatest possible sharpness

3.17

four corners

centres of the four corner points (see Figure A.2), located at 10 % of the distance from the corners to the centre of point 5

3.18

front screen projection

image projected on the audience side of a light-reflecting screen

3.19

illuminance

quotient of a luminous flux incident on an element of the surface containing the point by the area of that element

Unit: lux (lx)

3.20

light source life expectancy

time that the light source can keep its projected light output as measured in this standard, higher than 50 % of the initial value when tested with a duty cycle of 2 h on and 15 min off

3.21

liquid-crystal display (LCD)

display made of material the reflectance or transmittance of which changes when an electric field is applied

3.22

luminance

L

luminance in a given direction is the luminous intensity per unit of projected area of any surface, as viewed for that direction

Unit: candela per square metre (cd/m²).

3.23

luminous flux

quantity derived from radiant flux by evaluating the radiation according to its action upon a selective receptor, the spectral sensitivity of which is defined by the standard 1931 CIE spectral luminance efficiency function for the photopic $V(\lambda)$ function

NOTE Quantity of light expressed in lumens, and directed in a given direction.

3.24

luminous intensity

luminous flux per unit solid angle emitted or reflected from a point source

Unit: candela

3.25

object

slide or transmissive/reflective image forming panel, such as an LCD, that is illuminated and imaged by the optics onto a viewing screen

3.26

peak angle

angle at which maximum luminance is observed

3.27

photometric units

units of light measurement based on the response of the average human observer. The response of the average human observer is defined by the 1931 CIE spectral luminance efficiency function for the photopic $V(\lambda)$ function

3.28

pixel

smallest element of a display space that can be independently assigned a colour or intensity

3.29**projection distance**

distance between the projector and the screen measured in linear units (i.e. metres, feet, or inches). This distance is considered to be the distance from the image displayed on the screen to the outermost element of the projection lens

3.30**rear screen projection**

image projected through a light transmitting screen to the audience side of the screen

3.31**response time**

sum of the rise and fall times divided by 2. It is measured at $(23 \pm 5) ^\circ\text{C}$ ambient temperature after 15 min in operation:

$$t_{\text{res}} = \frac{t_r + t_f}{2}$$

3.32**rise time**

time, in milliseconds, for the image brightness to change from 10 % of its maximum value to 90 % of its maximum value

3.33**Scan rate**

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3.33.1**vertical scanning**

rate (hertz) at which one complete image (frame) is drawn

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3.33.2**horizontal scanning**

rate (kilohertz) at which each line of the display is scanned

3.34**screen gain**

measure of the projector screen luminance as compared to the luminance of a block of a perfect reflecting diffuser, (preferably a calibrated tablet of pressed barium sulfate, as specified in CIE 38: 1977, Section 12.2.5 or pressed polytetrafluoroethylene (PTFE) powder, see CIE 135/6: 1999) illuminated with the same projection source, which serves as the standard for a gain of 1,0

NOTE Gains are typically measured perpendicular to the centre of the screen.

3.35**standard viewing position**

for display devices the screen of which is an integral part of the projection device, the standard viewing position is the reference position for measurements, and is specified by the standard viewing distance measured from the horizontal plane on which the display under test is placed

3.36**steradian**

SI unit of solid angle: solid angle that, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere

[IEV 845-01-20 (ISO 31/1-2.1,1978)]

3.37

transmission

measure of the amount of light that is transmitted by an optical medium relative to the total amount of incident light

3.38

vertical lines

number of active lines in a picture

3.39

viewing angle/half gain

angle between the direction of maximal reflection and the direction where the luminance drops to 50 % of its value

NOTE This quantity should be measured in the centre of the viewing screen.

3.40

visible light

electromagnetic radiation to which the human observer is sensitive through the visual sensations that arise from the stimulation of the retina of the eye

NOTE The spectral range is typically considered to have a range of 380 nm to 780 nm (3 800 Å to 7 800 Å).

3.41

zoom lens

focusing lens that has a second, primary adjustment for focal length

NOTE This capability allows smaller or larger image sizes from a fixed projection distance. The zoom ratio is typically stated in a range of screen width/projection distance ratios, for example a 1:2 to 1:4 zoom lens could focus a 10 m or a 5 m wide image from a 20 m throw distance.

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4 General requirements

This part of IEC 61947 is intended to specify a complete description of the product. In accordance with these intentions, a complete specification (see example in Annex D) shall be used in product descriptions. If a particular specified measurement was not performed, the complete specification shall include the text “not measured” or “data not available” under that measurement section.

NOTE The use of partial specifications in product descriptions is not recommended since many of the specified measurements are interrelated (e.g. resolution and light output).

All measurements and specifications shall conform to the following:

- the measurements of light output, visual resolution, and blanking found in this standard are interrelated and shall be measured and specified as a set;
- the parameters and measurement criteria specified in this document allow for a wide variety of equipment performance. Secondary, non-conforming specifications are permitted to allow flexibility for special features of various products and technologies, but shall be displayed in the same type face font and density at least 25 % smaller in size;
- a sample from normal production runs shall be used to establish the specifications. Results from measurements of pre-production and prototype units shall be identified as preliminary specifications;
- the sample units shall not be adjusted or enhanced beyond normal production parameters, especially in a way that would reduce the normal operating life of any component or of the entire display;
- all optical, electrical focus, and convergence controls shall be adjusted for the sharpest display over the largest possible percentage of the illuminated area, using appropriate patterns from an internal or external test generator as needed;

- the equipment shall be allowed to stabilize without further adjustment for a minimum of 15 min, at a nominal ambient room temperature of $(23 \pm 5) ^\circ\text{C}$, before taking measurements;

NOTE Measurement could also be taken after 1 h of operation with all covers in place, white raster, as intended for normal use.

- measurements shall take place in a lightproof room where the only source of illumination is the projector. Less than 1 % of the light on the screen shall be from any source other than the projector. The projector should be operated with all covers in place as in normal operation;
- for contrast ratio measurement, less than 10 % of the light on the screen where a black image is projected shall be from any source other than the projector;
- the display device shall be adjusted for a 4:3 (horizontal:vertical) aspect ratio, if it is capable of it. The horizontal and vertical size of the scanned area shall be adjusted to the maximum usable diagonal size of the light modulator or source, such as a light valve or CRT, with the specified aspect ratio;
- displays designed for only one aspect ratio shall be adjusted to, and measured at, the design aspect ratio that shall be specified with the light output;
- devices that use a separate screen shall be positioned relative to the screen in accordance with the angle, height, and distance specified in the manufacturer's set-up instructions;
- displays with integral screens shall be adjusted so as exactly to fill their viewing screens. The displays shall not delete nor hide any data in the corners or edges in the horizontal dimension. The vertical dimension shall then be adjusted to achieve a 4 H:3 V aspect ratio, if applicable;
- all measurements shall be taken with no adjustments made between measurements;
- measurements shall be specified in international units, or both international and national units, with international units listed first.

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5 Light output measurement and specification

The light output specification shall be stated in lumens for projectors with separate screens, and in candela per square metre (nits) for displays with self-contained screens.

The following conditions shall be met:

- input signals shall be supplied by a standard test signal source, as specified in Annex B;
- the light meter shall be photopically and cosine corrected, calibrated, and traceable to a national standard;
- a special test pattern (see Figure A.1) shall be used to set the controls for making measurements. The black level (or brightness control) shall be set to the point where the maximum number of signal level blocks on the top line, representing 0 %, 5 %, 10 % and 15 % signal levels, are visible and distinct from the adjacent signal level blocks.

The video gain (contrast or picture control) shall be advanced from minimum until the maximum number of signal level blocks in the lower line of the pattern, representing the 85 %, 90 %, 95 %, and 100 % signal levels, are visible and distinct from the adjacent signal level blocks, or until the picture no longer increases in brightness as limited by automatic brightness circuitry.

In the event of controls interacting, they shall be readjusted in sequence in order to achieve the described conditions on the screen. The controls shall remain at these settings for all measurements. The total number of signal level blocks distinguishable in this pattern shall be stated in the specification.

A 100 % full-white image shall be used for the correlated colour temperature (CCT) and screen illuminance measurements.

For display devices where the screen is not an integral part of the viewing system, the CCT shall be measured by placing a cosine corrected colorimeter in the plane of the focused image.

For display devices the screen of which is an integral part of the projection device, the CCT shall be measured by focusing a colorimeter at the centre of the screen. The measurement field shall be at least 3 pixels by 3 pixels. The projection system shall be adjusted until the desired CCT is obtained.

The equipment shall be stabilized without further adjustment for at least 15 min before making any colour or other measurement. All measurements shall be made in a darkened room.

Light from the projector shall be measured with a photopically corrected, cosine corrected light-meter, the calibration of which is traceable to a national standard.

NOTE Meters may suffer from errors due to such problems as spectral mismatch of tristimulus filters. Also, scanning or pulsed source displays may saturate the meter. For diagnostics, solutions, and further information concerning light meters, see Annex H.

For display devices where the screen is not an integral part of the viewing system, the screen illuminance shall be measured with a light meter, the sensor of which is placed in and parallel to the plane of the focused image at the centre of each of nine equal rectangles and four corners (see Figure A.2) or the detector can be placed at the viewing space design centre.

The measurement field shall be at least 3 pixels by 3 pixels. The average of the nine readings in lux (lumens per square metre) shall be multiplied by the number of square metres covered by the image at the plane of the meter readings. The result shall be taken as the light output of the projector, in lumens.

The light output specification shall also state the aspect ratio of the display, horizontal and vertical scan rates, CCT and the lens throw distance ratio and type.

For display devices where the screen is an integral part of the projection device, the luminance of the screen is measured in candela per square metre (nits) at the centre of each of the nine equal rectangles (see Figure A.2) or the detector can be placed at the designed viewing distance.

The standard viewing distance shall be four times the screen height and the standard viewing angle shall be selected as the peak angle in order to obtain the maximum luminance of the white picture at the centre of the screen.

Luminance shall be measured for nine zones. The measurements shall be made and specified at the maximum horizontal and minimum vertical rate, and the minimum horizontal and maximum vertical rate within the capability of the equipment. The measurement field shall be at least 3 pixels by 3 pixels. An average of the nine readings shall be taken in order to calculate the light output specification, in candela per square metre (nits).

5.1 Light output specifications

5.1.1 Light output specification for projectors with a separate screen

EXAMPLE

Light output measurement conditions: 6 500 K CCT, 4:3 aspect ratio, and a 2:1 HD6 lens;

- 180 lm at 15,75 kHz horizontal and 90 Hz vertical;
- 220 lm at 36 kHz horizontal and 40 Hz vertical.

5.1.2 Full black light level specification

Measurements shall be made at the same signal as the black rectangles for contrast ratio measurement (see Figure A.3).

EXAMPLE

- Full black light level: 1,2 lm at 15,75 kHz horizontal and 90 Hz vertical.

5.1.3 Luminance specification for devices with an integral screen

EXAMPLE

Luminance measurement conditions: 9 300 K CCT, 4:3 aspect ratio, and a total screen viewing angle of 60° horizontal, 20° vertical (higher luminance values are better):

- 27 cd/m² (nits) at 15,75 kHz horizontal and 70 Hz vertical;
- 31 cd/m² at 33 kHz horizontal and 57 Hz vertical.

NOTE Direct comparisons can be made between displays with and without integral screens using candela per square metre, if both screens have the same horizontal and vertical angles of view. If this is not the case, mathematical conversions may be made, but will result in unreliable data of questionable value.

5.2 Light output uniformity

The average of nine readings, used in the light output measurement, shall be taken as the reference for the light output uniformity measurement. An additional four points, as in Figure A.2, shall be measured, with the maximum deviation of the resulting 13 measurements stated as a percentage as in the following example. The measuring field shall be at least 3 pixels by 3 pixels.

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NOTE See Annex C for further information on light output measurement.

EXAMPLE

- Brightest measurement locations: 10 % greater than the average;
- Dimmest measurement locations: 5 % less than the average.

5.3 Contrast ratio

The contrast ratio shall be determined from illuminance values, or luminance for devices with an integral screen, obtained from a black-and-white “chessboard” pattern consisting of sixteen equal rectangles (see Figure A.3). The white rectangles shall be at full specified light output, as previously measured, with all controls at the same settings.

Illuminance measurements in lux (candela per square metre with internal screen units) shall be made at the centre of each of the bright (white) rectangles and the dark (black) rectangles. The average illuminance or luminance value of the bright rectangles shall be divided by the average illuminance or luminance value of the dark rectangles. The contrast ratio shall then be expressed as this ratio:1 (e.g. bright rectangles with an average value of 15 lx and dark rectangles with an average value of 0,10 lx provide a contrast ratio of 150:1).

5.4 Light transmission for fixed resolution projection systems: liquid-crystal imaging devices (LCD) used with an overhead projector (OHP)

Light transmission is the percentage of the light transmitted by the LCD. The light output of the projection system shall be measured in lumens.

The LCD shall be removed from the OHP and replaced with a test mask that is opaque except for an area equal to the active viewing area of the LCD. It shall be positioned at the same