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**Electronic projection –
Measurement and documentation
of key performance criteria –**

**Part 1:
Fixed resolution projectors**



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Part 1: Fixed resolution projectors

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRONIC PROJECTION –
MEASUREMENT AND DOCUMENTATION OF
KEY PERFORMANCE CRITERIA****Part 1: Fixed resolution projectors**

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61947-1 was prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

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.

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- withdrawn;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.

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.

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****3.33.1****vertical scanning**

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

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.

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.

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.

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

height above the OHP as was the plane of the LCD pixels, so that the test pattern is placed at the same viewing screen location and area.

Light transmission shall be expressed as the ratio of two measurements of the luminous flux; one with the imaging device (LCD) and one with the imaging device replaced by the test mask. (100 % full white image):

$$T = \frac{L \times 100}{F}$$

where

T is the light transmission;

L is the luminous flux with LCD;

F is the luminous flux without LCD.

The type of the light source shall also be stated with the results.

EXAMPLE

Light transmission: 5 % with metal-halide OHP, 6 500 K.

5.5 Small area contrast ratio for alternating black and white pixel lines

The small area contrast ratio is a measure of the capability of the projection system to reproduce fine detail on the screen. This can be compromised by many mechanisms; the bandwidth of the analogue signal electronics, the driver circuitry for the display cell, and the optical quality of the projection optics.

Both vertical and horizontal patterns (as illustrated in Figures A.4 and A.5 respectively) shall be measured. For each measurement, the light sensor array shall be perpendicular to the parallel lines being measured. The ratio of the light and dark lines (L_{on}/L_{off}) is the small area contrast ratio (SACR):

$$SACR = \frac{L_{on}}{L_{off}}$$

Measure the average light output (L_{on} and L_{off}) of at least 5 line pairs at the screen centre and at each of the four corners of the display, and calculate the SACR for both vertical and horizontal lines. Report the SACR of the corner where the performance is worst.

For display devices where the screen is not an integral part of the viewing system, set up the vertical and horizontal patterns on the screen, and adjust the distance between the screen and the detector so that at least 5 detector pixels fall within each pixel line imaged on the screen. At least 5 white and 5 black lines (5 line pairs) falling on the screen shall be imaged onto the detector. Measure the average of the white and black lines ($L_{on}:L_{off}$) and report the SACR of the centre.

Move the detector to each of the corners and repeat the measurements for all four corners. Report the contrast ratio of the corner where the performance is worst.

The horizontal small area contrast ratio shall be obtained by measuring the vertical parallel lines. The vertical small area contrast ratio shall be obtained by measuring the horizontal parallel lines.

EXAMPLE

Small-area contrast ratio:

Vertical pattern – centre	10:1
Vertical pattern – corner	8:1
Horizontal pattern – centre	4.5:1
Horizontal pattern – corner	5:1

6 Fixed resolution projectors characteristics**6.1 Displayable format (IEC resolution)**

The displayable format describes the physical array of picture elements that is imaged onto the screen in terms of:

- the number of overlaid partial images, for example “three panel overlaid”, “single panel”, etc.;
- the width of the picture in units of the picture element width;
- the number of horizontal “rows” of picture elements;
- the picture element pattern, expressed as:
 - 1) the position of bordering picture elements in adjacent rows relative to each other as described by:

orthogonal array: a format in which the centres of the picture elements in adjacent lines are on a straight line in a direction perpendicular to the direction of the row;

staggered array: a format in which the centres of the picture elements in odd and even rows do not form an orthogonal array; that is, every other row is displaced sideways by some fraction of the width of a picture element with respect to the other rows;
 - 2) the colour capability of the picture elements per superimposed partial image as described by:

sequential colour: an orthogonal or staggered type panel with colours superimposed through a common aperture in serial time.

EXAMPLES

- single panel, 640×480 , stripe colour;
- single panel, 1068×480 , staggered array;
- three panel overlaid, 644×484 , orthogonal array;
- three panel overlaid, 1068×480 , staggered array;
- 640×480 monochrome;
- single panel, 640×480 , orthogonal array, sequential colour.

6.2 Aspect ratio

The aspect ratio of a display can be described as follows:

for 640×480 resolution and a square pixel (1:1), the aspect ratio is 1.33:1 (4:3).

6.3 Viewing angle (half/gain) specification for devices with an integral screen

This is the angle between the normal or peak angle perpendicular to the centre of the viewing screen and the observer in the horizontal (left and right) and vertical (up and down) direction where the intensity of luminance drops to 50 % of its value, for example, total screen viewing angle of 60° horizontal and 20° vertical (full angle at 1/2 intensity).

6.4 Input signal format compatibility

Manufacturers shall supply customers with a list of compatible modes, video standards and, if necessary, hardware description.

If input signals formats are different from the displayable format acceptable by the projector, the method of converting the input signal format to the displayable format shall be specified, for example, scaling down the input EWS format to displayable XGA format.

6.5 Response time

The response time shall be specified by the light valve manufacturer, for example, less than 50 ms for the LCD light valve.

6.6 Colour measurements

6.6.1 General

Colour measurements shall be made either:

- a) in accordance with IEC 61966-4 or IEC 61966-5, as appropriate according to the type of projection device; or,
- b) in accordance with the following conditions, together with those specified in 6.6.2 and 6.6.3:
 - the colour-measuring instrument shall have a photometric accuracy of $\pm 5\%$ and a colour accuracy of $\pm 0,008$ in 1931 CIE chromaticity values (x and y) for all colours. It shall also be able to measure the CCT and the 1976 CIE chromaticity values u' and v' . Colorimeters shall be calibrated for the particular light source measured. All filter-based instruments shall be evaluated for sensitivity to saturated colours (or monochromatic light sources) if the projector uses narrow band primaries (see clause F.2 and Annex H for details);
 - for display devices where the screen is not an integral part of the viewing system, the CCT shall be measured by placing appropriate equipment in the plane of the focused image at the spot where the centre of the screen would be located. The measuring field shall be at least 3 pixels by 3 pixels;
 - for display devices the screen of which is an integral part of the projection device, the CCT is measured by using the appropriate equipment at the centre of the screen. Adjust the projection system until the desired CCT is obtained;
 - the CCT at which colour measurements are performed shall always be specified.

6.6.2 Colour chromaticity

Set up a white screen at the desired CCT. The u' , v' chromaticity of the nine zones of the screen, as shown in Figure A.2, is measured using the procedure described for measuring light output in clause 5.

Similarly, set up a screen with the primary colours red, blue, and green and measure the u' , v' chromaticity of the centre of the screen.

A colour chromaticity example for a CCT of 6 500 K is as follows:

white: $u' = 0,198$, $v' = 0,468$

red: $u' = 0,477$, $v' = 0,528$

green: $u' = 0,076$, $v' = 0,576$

blue: $u' = 0,175$, $v' = 0,158$

Given the u' , v' coordinates of each of the primaries, a colour gamut "efficiency" can be defined as the area of the triangle of the primaries in u' , v' space, divided by the area subtended by the spectrum locus in that space (see Annex I for details).

For fixed resolution projection systems, also measure the u' , v' coordinates without the LCD.

EXAMPLE

OHP white: $u' = 0.162$, $v' = 0.461$

6.6.3 Colour uniformity

Set up white, red, green, and blue colours on the screen and for each colour measure the u' , v' chromaticity at the centre of each of the nine equal rectangles described in Figure A.2. Calculate the arithmetic average chromaticity value (u'_0 and v'_0) of the nine measurements for each colour. Also measure the u' , v' chromaticity at the four corners of the screen.

Record the maximum deviation in u' and v' of the 13 measurements from the average value for each colour. If u'_1 , v'_1 represent the spots with maximum deviation from the average values u'_0 , v'_0 , a measure of the colour uniformity for each colour is given by:

$$\Delta u'v' = [(u'_1 - u'_0)^2 + (v'_1 - v'_0)^2]^{1/2}$$

6.7 Number of colours

State whether this is for an analogue or digital light valve. For digital, describe the number of bits using the number of colours for the light valve and the control electronics. For example:

colour LCD RGB panel with 512 colours (3 bit drivers) and controller colour enhancement to 2,1 million colours;

colour LCD RGB panel with 8 bit drivers – 16,8 million colours;

monochrome LCD panel with 8 bit drivers – 256 grey levels.

6.8 Keystone correction

Keystone correction is the specification of the angular tilt range in degrees (between the centre ray of the projected beam and a line orthogonal to the screen), with the same zoom setting as used during light output measurements, over which the projector can display a rectangular image with equal length top and bottom edges and equal length right and left edges.

Positive angles indicate that the screen centre line orthogonal is above the projector, (projection is *up*). Negative angles indicate that the screen centre line orthogonal is below the projector (projection is *down*).

EXAMPLE

Keystone correction: $+15^\circ$, -5°

7 Range of focus and image size

This comprises the minimum and maximum distances from the screen at which a sharp focus and image size (diagonal) can be obtained.

EXAMPLE

Range of focus is 1,2 m to 4,5 m, with a diagonal image size of 1,8 m to 3,0 m (4:3 aspect ratio)

8 Audio characteristics

Describe the number and each type of audio input and output connections including impedance, signal level, and type of connector. If multiple audio-with-video inputs are available, report the method of selection between them and the signal separation in dB. Report any special audio features such as stereo.

Report the power output per channel and the frequency response in accordance with ISO 3741.

EXAMPLE

Output power when driving into an $8\ \Omega$ load is 5 W rms. Total harmonic distortion for the frequency range 20 Hz to 20 kHz is less than 1 %.

9 Light source specification.

If a lamp is used, the following information shall be reported:

- lamp type, identification code;
- lamp wattage, CCT, and life expectancy (50 % or shutdown: see 3.20);
- user or dealer serviceable lamp;
- any special handling requirements for safety.

EXAMPLE

Metal-halide lamp, 400 W, 500 h

10 Maximum acoustical noise level

Make the measurement in accordance with ISO 7779 and report the result.

EXAMPLE

Less than 45 dBA

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

11 Power consumption

The projector shall be connected to a regulated power source, with voltage held constant to within $\pm 0,5\%$ of the nominal voltage. Report the power, in watts, drawn by the projector when operating with all function controls set to, or operating in, their highest power consuming mode. Also report the input voltage.

EXAMPLE

250 W at 220 V a.c.

12 Weight

The weight (including that of the a.c. power supply and specified lenses) shall be given in kilograms and/or pounds.

13 Dimensions

Length, width, and height shall be given in metres and/or inches.

14 Sync hierarchy – Recommended practice

If the display device accepts more than one sync source, the following hierarchical preference should be used even if sync signals are present at more than one input:

- separate horizontal and vertical sync (<1,0 V to >5,0 V peak-to-peak video into 75 Ω);
- separate composite horizontal and vertical sync (<1,0 V to >5,0 V peak-to-peak video into 75 Ω);
- composite sync mixed with the monochrome or green video (<0,2 V to >0,5 V peak-to-peak sync plus 0 V to 1,0 V peak-to-peak video into 75 Ω).

Annex A
(normative)

Figures



0 % = BLACK 100 % = WHITE

IEC 1945/02

Figure A.1 – Test patterns/measurements set-up

The pattern in Figure A.1 is a fully illuminating white pattern. The height of each small rectangle is equal to 10 % of the height of the image area; the width of each small rectangle is equal to 5 % of the width of the image area; and the distance between two patterns is equal to 5 % of the height of the image area.

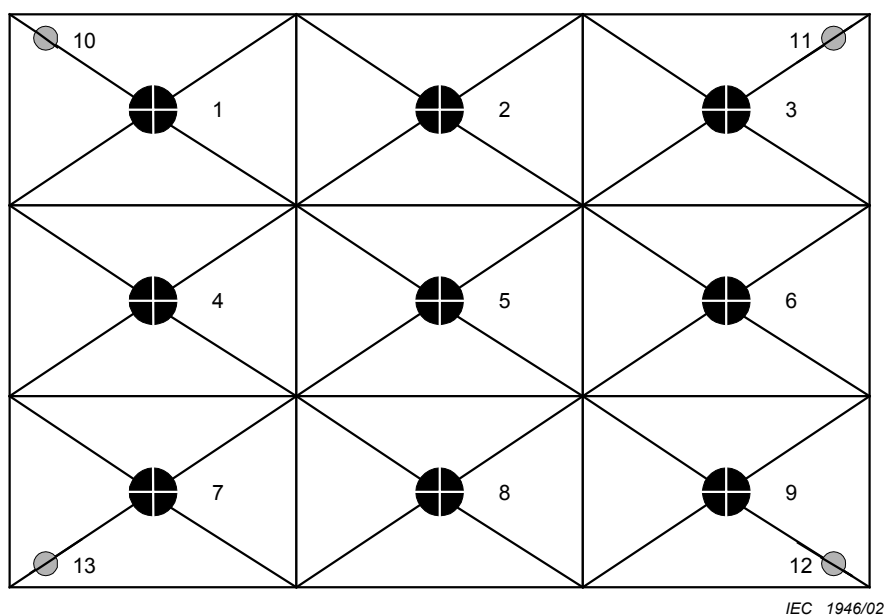
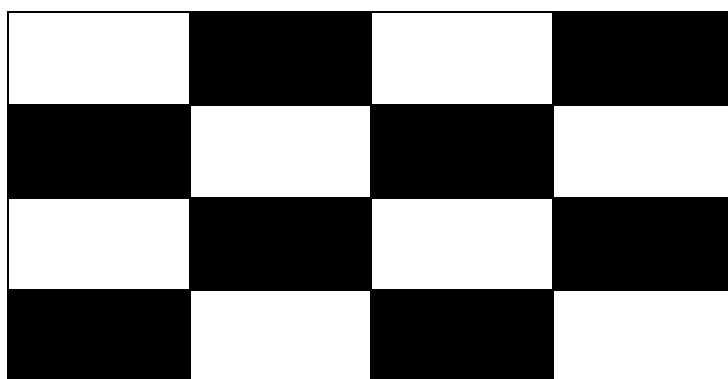


Figure A.2 – Thirteen point measuring grid

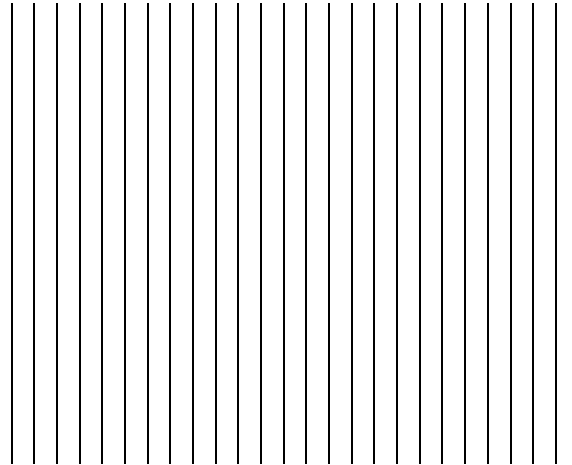
Figure A.2 is an example of the nine zones to be established for measurement. The centre of each zone is to be used for light output and visual resolution measurements. The four corner points 10, 11, 12 and 13 are located at 10 % of the distance from the corner itself to the centre of point 5.



IEC 1947/02

Figure A.3 – Contrast measurement

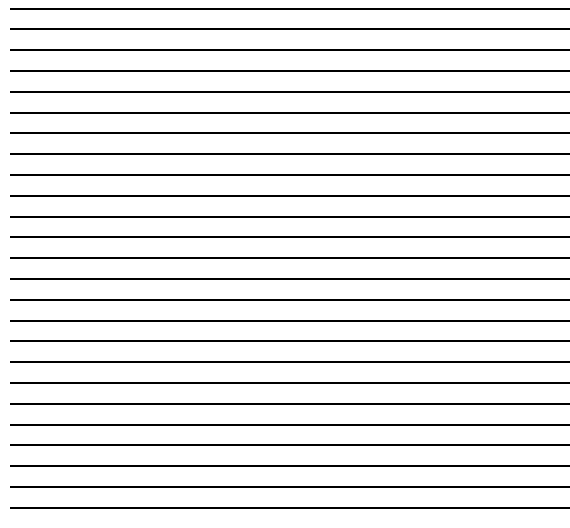
Figure A.3 is a pattern of 16 rectangles of alternating white and black used to measure the large area contrast ratio.



IEC 1948/02

Figure A.4 – Vertical alternating lines

Figure A.4 is a pixel width pattern with alternating white and black vertical lines used for making the small area contrast ratio measurement.



IEC 1949/02

Figure A.5 – Horizontal alternating lines

Figure A.5 is a pixel width pattern with alternating white and black horizontal lines used for making the small area contrast ratio measurement.

Annex B (normative)

Pattern generator specifications

The pattern generator needed for these measurements shall have as a minimum the following specifications:

- the ability to maintain output levels within 1 % when switching from pattern to pattern and during 8 h of operation;
- three identical red, green, and blue outputs at 700 mV (± 1 %), 75 Ω ;
- an easy method for entry of the horizontal and vertical scan rates as independent frequencies. The device shall also have automatic internal rounding to the nearest even vertical divisor and a readout in microseconds (μ s);
- continuously adjustable video pixel rates of 50 % on and 50 % off (± 1 %) with pixel widths from greater than 250 ns to less than 5 ns. Rise and fall times shall be less than 20 % of the minimum pixel size at any desired combination of scan rates with a readout in nanoseconds (see Figures A.4 and A.5);
- a pattern generator, the video pixel rate of which exceeds the specified capability of the projector under test, can be used. If the pattern generator does not meet the above specification, the pattern generator used should be described in the complete sample specification.
- adjustable horizontal and vertical blanking and centring with readout in microseconds. Resolution of the adjustments for blanking shall be at least as fine as 0,1 μ s of a microsecond (see Figure A.1).

Annex C (informative)

Considerations in formulating this standard

C.1 General

The intent of this standard is to codify the creation uniform specifications that are useful to the non-expert user in the evaluation of large screen displays.

NOTE This concept correlates to the U.S. Federal Trade Commission's (FTC) high fidelity power and distortion measurement standards for the audio industry.

C.2 Light output measurement

The purpose of measuring the total luminous flux of a projector, as reported in lumens, is to allow users to calculate the illuminance of a projector and screen combination in an installation given that the screen is a variable in each application.

Screens are available with gains from less than 1 to over 20 and viewing angles from 180° to less than 20°. The ultimate aim of an installation is to provide a given amount of luminosity and contrast, both of which depend on factors beyond the luminous flux of the projector.

Illuminance (expressed in lux) is the luminous flux (expressed in lumens) from the projector incident on the surface per unit area (e.g. square metre) of a projection screen. Luminance (expressed in candela per square metre), which quantifies the light intensity from a surface, is the luminous flux (e.g. lumens) per unit solid angle (expressed in steradians) subtended by the light-measurement device per unit area (expressed in square metres) of the emitter, measured about a given direction relative to a projection screen (e.g. perpendicular to the screen).

EXAMPLE

A projector illuminance of 300 lx will lead to a screen luminance of $300/\pi$ or 95,5 cd/m², assuming the screen scatters light uniformly in all directions and does not absorb any light, i.e. screen gain = 1. Assuming, for this example, a 1,8 m² image area is projected onto a lambertian screen of gain = 1, the light output (computed from the 300 lx illuminance of the projector) is 300 lx × 1,8 m² or 540 lm, and is equal to the light output computed using the screen luminance, 95,5 cd/m² × π × 1,8 m² = 540 lm. (Here, π is the half-space-integrated beam pattern of a lambertian screen.)

In general, the light output for a lambertian screen having a gain of 1 may be computed as follows:

$$\Phi = \pi L A$$

where:

Φ is the luminous flux, in lumens;

L is the luminance, in candela per square metre;

A is the area of image, in square metres.

The pattern chosen (see Annex A, Figure A.1) is a typical representation of contemporary workstations that have black characters on a white background. It is important to have the entire screen fully illuminated and the 5 % and 95 % illuminated rectangles clearly discernible.

C.3 Possible causes for measurement errors

Assuming that the measurement and display conditions have been set up carefully in accordance with this standard, there are still several factors that can lead to measurement errors and widely varying results when performing light measurements on a projection system. Issues to be watchful of are briefly discussed in Clause 5 and in Annexes F and G.

C.4 Input signal levels

Analogue input signal levels for R, G, and B should be 0,7 V.

Annex D (normative)

Complete sample specification

XYZ (brand), Model 123 data projector

Light output: 480 lumens

CCT: 6 500 K

Light uniformity: +10 %, –5 %

(4 lowest signal levels and 4 highest signal levels visible)

Contrast ratio: 100:1

Displayable format: 1 024 × 768, RGB panels overlaid, orthogonal array

Number of colours: 16,8 million colours, 8 bit drivers

Colour chromaticity:

White: $u' = 0,198$

$v' = 0,468$

Red: $u' = 0,477$

$v' = 0,528$

Green: $u' = 0,076$

$v' = 0,576$

Blue: $u' = 0,175$

$v' = 0,158$

Aspect ratio: 4:3

Focus range: 1,2 m – 4,5 m with an image size of 1,2 m to 3,0 m (diagonal)

Four audio inputs; Two stereo speakers with output power (8 Ω load) 5 W continuous, with less than 1 % total harmonic distortion, 20 Hz to 20 kHz.

Lamp: 575 W metal-halide, 500 h

Audible noise: 40 dB A-weighted

Total power consumption: 700 W

Mass: less than 10 kg

Dimensions: 0,43 m × 0,36 m × 0,15 m

Annex E

(informative)

Conversion equations

Conversion from (x,y) colour co-ordinates to (u',v') co-ordinates and vice-versa.

$$u' = \frac{4x}{(-2x + 12y + 3)}$$

$$v' = \frac{9y}{(-2x + 12y + 3)}$$

$$x = \frac{9u'}{(6u' - 16v' + 12)}$$

$$y = \frac{4v'}{(6u' - 16v' + 12)}$$

Annex F (informative)

Possible causes of photometric measurement errors

F.1 Size of measured spot

When measuring the luminance of a projection system with an integral display, the minimum number of pixels that has to be measured to make an accurate luminance measurement depends on the pixel fill factor of the display. When the fill factor is below 100 % and the measuring field of view (FOV) of the photometer is very small, the number of display pixels in that spot may change as the photometer is moved to different regions of the display. It is a good practice to have a measurement FOV that covers at least 25 to 50 display pixels.

F.2 Colour measurement

Filter colorimeters are typically accurate for measuring colour only when used to measure broadband sources that are spectrally similar to the light source used to calibrate the colorimeter. Most manufacturers use an Illuminant A incandescent source at 2 856 K to calibrate their filter colorimeters and therefore specify colour accuracy only for that source. The main drawback of filter colorimeters is the error introduced by the spectral mismatch of the instrument's filters from the theoretical CIE colour matching functions. Although the integrated error may be within 1 % or 2 %, it is typical to find much higher mismatches in narrow regions of the spectrum. This makes filter colorimeters unsuitable for measuring sources (such as the red phosphor of CRTs, LCDs backlit by triphosphor fluorescent lamps and laser-based projection) that have sharp spectral peaks that may fall in a region of spectral mismatch of the colorimeter's filters. Since colour is being analyzed using three or four filters, this error can be compounded when the source's peak energy falls in the region of greatest mismatch of two or more filters.

Spectroradiometry is the most accurate method of measuring colour. The complete spectral power distribution of a source is measured, and tristimulus values X, Y, and Z are obtained by integrating the spectral data mathematically with the CIE colour matching functions. The calculated tristimulus values are then used to compute CIE chromaticity coordinates and luminance, which provide a complete description of the colour of the source. As long as the spectral accuracy is known, it is possible to specify the colour accuracy of a spectroradiometer for different sources.

Annex G (informative)

Photometer precision and veiling glare

Assuming that the measurement and display conditions have been set up carefully in accordance with this standard, there are still several factors which can lead to measurement errors and widely varying results when performing light measurements on a projection system. A brief listing of issues to which to be watchful are listed below.

G.1 Photometer precision

Apart from the photometric accuracy of 10 % specified in this standard, it is also important to check the precision of the photometer. The precision of a photometer is a good measure of the repeatability of a measurement. A good diagnostic procedure is to wait for the projection system to be stable and then measure the centre of a white screen ten or more times over a 5 min interval. If the standard deviation of the measurements is more than 2 % of the average illuminance (or the luminance if the display is integral to the system) level, the photometer may not be useful to make repeatable measurements.

G.2 Integration time

If the integration time taken by the photometer to make a measurement is too short, then the refresh rate of the projection display can affect the measurement. For example, when the refresh rate is 80 Hz and the integration time of the photometer is 0,0925 s, a single measurement could be performed on 7 or 8 refresh cycles depending on when it is initiated and this can introduce a variance of 15 % in the measured value. If the integration time of the photometer is fixed, this problem also contributes to the imprecision of the photometer. However, if it is possible to vary the integration time, the user should choose it so that the integration time is a multiple of the refresh rate of the display. Some photometers automatically measure the refresh rate and change the integration time accordingly.

G.3 Veiling glare

Contrast measurements are typically made by measuring white and black rectangles on a checkerboard pattern displayed on the projection system. When the luminance of a projection system with an integral display is measured using a spot photometer, a phenomenon called lens flare or “veiling glare” can greatly influence the black measurement. Any light-measuring device (LMD) that employs a lens is susceptible to veiling glare. Veiling glare results from light outside the aperture field of view of the LMD scattering and reflecting at the lens surfaces, imperfections in the glass and dirt on the glass, barrel, iris, and other mechanical parts of the lens. This results in a corrupted measurement. Thus an LMD measuring the luminance of a black rectangle on a white background could result in a falsely higher luminance measurement, or a reduced contrast ratio measurement.

There are at least two methods to indicate the sensitivity to veiling glare of the light-measuring device. Both involve measuring the luminance level of a black rectangle (patch) on a white background, varying the patch to cover from 5 % of the total screen size to 100 % of total screen size.

Place a black mask (made from glossy black plastic) across the patch, tilting it slightly to eliminate specular reflections from the projector. Be sure the mask is displaying only reflections from a dark area of the room, or from a light trap (such as a glossy black cone).

Alternatively, a glossy black cone with an apex of 45° can be used (see [6]). The cone is placed in front of the LMD so that the outer (larger) diameter faces the LMD and prevents any light from the display from reaching the LMD lens. The inner diameter (aperture) should be small enough to keep out stray light but large enough to prevent vignetting between the LMD aperture and the aperture of the cone. Using either one of the masks mentioned above would provide a quick indication of the sensitivity of the LMD to veiling glare.

Be aware of the back-reflections from walls and objects in the room, i.e. reflections due to the screen being illuminated. Such reflections can also corrupt luminance measurements. Care has to be taken to account for this effect. Methods are currently being investigated [2]. Performing luminance measurements by projecting the image on to a black felt screen with a diffuse white standard as the target would minimize both reflections and veiling glare. Note that if it is possible to avoid veiling glare in the LMD, back-reflections and ambient illumination, any observed halation probably arises from veiling glare in the projection lens or halation in the source.

Either of the above methods can be used for large area measurements. However, for small-area contrast ratios (SACR) the cone may not be effective (especially for black targets 5 mm in diameter or smaller). One solution would be to use a replica mask. Use a glossy black target, the same width as the SACR pattern. Place the mask over the pattern and use similar procedures to those described above to determine the luminance without LMD glare. A piece of calibrated neutral-density filter film can be used to verify the measurement. Measure the white luminance and the filter luminance. How closely this measured transmission compares to the calibrated transmission can serve as a check. Precautions should be taken when performing these measurements. Attaching a mask to the screen assumes that the screen surface is designed to be treated roughly. Some screen surfaces can be damaged by such a procedure.

Annex H

(informative)

Light measuring devices

There several light-measuring device technologies that may be appropriate for a particular measurement task. For an overview of these technologies, see references [4] [5] [6] [7] [8]. It should be remembered that even if an instrument is calibrated and is specified to measure a particular photometric or colorimetric quantity, it may not provide the results intended. Accuracy and reproducibility should be verified by means of redundant equipment and diagnostics.

Annex I (informative)

Figure of merit for projection display colour gamut

This annex describes a metric for the colour gamut of a three-primary projector system, developed at the US National Information Display Laboratories (NIDL). An argument from first principles might conclude that a proper gamut metric would be a volume in a CIE uniform colour space, in which equal distances correspond approximately to equal colour differences. However, such a volume would depend on the gains of the primaries, and on the white of the display. These quantities are not subject to rigorous control in a projector system, and thus cannot be used in a metric that usefully characterizes the system. Another possible metric might involve colorimetric purity of the primaries, but again this metric is not useful because it depends on the white point.

On the other hand, the chromaticities of the projector primaries are stable enough to characterize a projector system, so these chromaticities can be the basis of a metric. The metric should reside in a chromaticity space for which uniformity is attributed. One uniform-colour space, CIELUV [9], has embedded in it a chromaticity space (u', v') that is used widely in the display industry for such metrics as screen uniformity [10] [11]. Also, there are ANSI standards that specify measurement of chromaticities in (u', v') coordinates [12]. Furthermore, the area in a uniform chromaticity space has long been regarded as a reasonable Figure-of-merit for colour gamut [13]. Therefore, the metric advanced in this annex is the area of the triangle subtended by the primaries (r,g,b) in the chromaticity space the coordinates of which are (u', v') .

To give meaning to a single value of the area metric, it is expressed as a percentage of the area subtended by the entire spectrum locus in (u', v') space, which is the maximum gamut of any projector system, no matter how many primaries are used in the system.

NOTE The area of the spectrum locus is computed as the area of the polygon the vertices of which are the chromaticities of spectral lights from 380 nm to 700 nm in increments of 1 nm. The computed value of this area is 0,1952.

The gamut-area metric for a three-primary system is derived as follows:

If the measurement device measures CIE (x, y) values but not (u', v') values, then:

- a) Measure CIE (x, y) values for each primary at full-on (with the other primaries turned off). Denote the (x, y) values as (x_r, y_r) for the red primary, (x_g, y_g) for the green primary, and (x_b, y_b) for the blue primary.
- b) Transform each of the (x, y) pairs defined above to the CIE 1976 (u', v') coordinate system, using the following equations:

$$u' = 4x/(3 + 12y - 2x)$$

$$v' = 9y/(3 + 12y - 2x)$$

- c) Compute the area of the projector gamut (for 3 primaries, the rgb triangle) in (u', v') space, divide by 0,1952, and multiply by 100 % to obtain percentage of gamut coverage, G_p .

$$G_p = 100(1/0,1952)\{\text{Area of the gamut}\}$$

For the case of a three primary system, the area of the rgb triangle can be computed with the following formula:

$$\text{Area of rgb triangle} = 1/2 \{ (u'_r - u'_b)(v'_g - v'_b) - (u'_g - u'_b)(v'_r - v'_b) \}$$

Alternatively, if the coordinates (u', v') are directly available from the measurement instrument, it is possible to omit steps a) and b) and to proceed directly to step c).

EXAMPLE CALCULATION

The following coordinates were measured on a particular projector:

Red: $u'_r = 0,443$, $v'_r = 0,529$

Green: $u'_g = 0,124$, $v'_g = 0,567$

Blue: $u'_b = 0,186$, $v'_b = 0,120$

From these coordinates, the gamut-area metric (percentage of gamut coverage) is $G_p = 36$ as computed from the equation in step c). That means the projector has access to 36 % of the area inside the spectrum locus.

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 product design/development ☐
 specifications ☐
 tenders ☐
 quality assessment ☐
 certification ☐
 technical documentation ☐
 thesis ☐
 manufacturing ☐
 other.....

Q5 This standard meets my needs:
(tick one)

- not at all ☐
 nearly ☐
 fairly well ☐
 exactly ☐

Q6 If you ticked NOT AT ALL in Question 5 the reason is: (tick all that apply)

- standard is out of date ☐
 standard is incomplete ☐
 standard is too academic ☐
 standard is too superficial ☐
 title is misleading ☐
 I made the wrong choice ☐
 other

Q7 Please assess the standard in the following categories, using the numbers:

- (1) unacceptable,
 (2) below average,
 (3) average,
 (4) above average,
 (5) exceptional,
 (6) not applicable

- timeliness.....
 quality of writing.....
 technical contents.....
 logic of arrangement of contents
 tables, charts, graphs, figures.....
 other

Q8 I read/use the: (tick one)

- French text only ☐
 English text only ☐
 both English and French texts ☐

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

.....



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