

# SMPTE STANDARD

## for D-Cinema Quality — Screen Luminance Level, Chromaticity and Uniformity



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### 1 Scope

This standard specifies the absolute luminance level, white point chromaticity, and luminance uniformity of the reflected screen light for the presentation of motion pictures by projectors with digital light engines in review rooms and commercial cinemas. It is the purpose of this specification to achieve the tone scale and contrast in the projected image that will correspond to that intended during the mastering process.

### 2 Normative reference

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ISO/CIE 10527-1991, Colorimetric Observers

### 3 Performance classes

It should be recognized that different applications within the industry have varying requirements for tolerances, or the precision of the target specifications attained in any particular installation. For example, greater precision may be required for a system in a mastering suite than in a commercial cinema theatre. In order to simplify communication, two levels or classes of precision are defined herein as follows:

*Review Room*      intended as the highest practical precision, for the most critical colorimetry applications, recommended for the mastering activities of color timing and color matching.

*Theater*      intended as the minimum level for commercial cinema presentations.

Performance criteria for each class are defined in section 5.

### 4 Measurement criteria

#### 4.1 Projector conditions

Measurements shall be made with the projector in normal operation, with its lens(es) set at optimal focus position, set for the format covering the largest area of the screen, and a 100% white signal being displayed on the screen (either the entire screen or as a minimum the five zones consisting of the screen center and four corner locations defined in section 4.2). The 100% white signal is defined as the digital code values assigned to the maximum color-neutral white level allowed in the input signal standard of interest.

#### **4.2 Measurement locations on the screen**

Measurements of light levels shall be taken at screen locations consisting of the geometric center of the screen and the four sides in theaters, and those measurements with the addition of the four corners in review rooms. The side and corner locations are inset  $5\% \pm 1\%$  of the screen width from both of the adjacent screen edges.

#### **4.3 Measurement locations in the auditorium**

All screen measurements shall be performed at the center of the seating row closest to the geometric center of the seating area. All readings shall be taken at a height of approximately 1.1 m (43 in) above the floor to simulate the eye height of an audience member.

#### **4.4 Photometer type**

Screen luminance shall be measured with a spot photometer having the spectral luminance response of the standard observer (photopic vision), as defined in ISO/CIE 10527. The acceptance angle of the photometer shall be  $2^\circ$  or less. The photometer shall have an accuracy of  $\pm 0.5 \text{ cd/m}^2 (\pm 0.2 \text{ fL})$  or better. The photometer response to luminance variation over time shall be to properly integrate any such variation occurring at frequencies at or above 24 Hz and display the arithmetic mean value.

#### **4.5 Spectroradiometer type**

Screen chromaticity shall be measured with a spot spectroradiometer with an acceptance angle of  $2^\circ$  or less. It shall report values in CIE x, y coordinates, with an accuracy of  $\pm 0.002$  or better for both x and y.

NOTE – As there are meters available that measure both luminous flux and chromaticity, this may physically be the same meter defined in section 4.4.

### **5 Specifications**

Measurements taken from each location specified in section 4.3 shall be within the limits given in this section.

#### **5.1 Luminance, absolute**

The absolute luminance is that value measured at the screen center as taken with a meter meeting the criteria of section 4.4. The nominal value for screen luminance is  $48.0 \text{ cd/m}^2 (14.0 \text{ fL})$ . The allowable variation for each performance class is given in table 1.

#### **5.2 Luminance, uniformity**

The screen luminance shall be symmetrically distributed about the geometric center of the screen, and shall exhibit no abrupt changes. The luminance value at the sides and corners defined in section 4.2 is expressed as a percentage of the value at the screen center. The meter used shall meet the criteria of section 4.4. The allowable variation for each performance class is given in table 1.

#### **5.3 White point chromaticity**

The white point chromaticity is that value measured in the center of the screen as taken with a meter meeting the criteria of section 4.5. The white light reflected from the screen shall have a nominal chromaticity value of  $x = .314$ ,  $y = .351$ . The allowable variation for each performance class is given in table 1.

**Table 1 – Performance levels by class**

Section	Parameter	Reference	Review room	Theater
5.1	Luminance, center 100% white	48.0 cd/m <sup>2</sup> (14.0 fL)	± 3.5 cd/m <sup>2</sup> (± 1.00 fL)	± 10.2 cd/m <sup>2</sup> (± 3.00 fL)
5.2	Luminance sides	85% of center	80% to 90% of center	75% to 90% of center
5.2	Luminance corners	85% of center	80% to 90% of center	not specified
5.3	White chromaticity, center	x = .314 y = .351	± .002 x ± .002 y	± .006 x ± .006 y

**Annex A (informative)****Additional data****A.1 “Normal” release**

Standardized values for luminance and chromaticity are required in order to make images match the appearance intended by the creators of the content, and to facilitate interchangeability of the same content from one theatre to another as well as from one showing to the next within the same theatre. It is not possible to specify a “normal” digital release in terms of its optical density and other objective measurements due to its intangible nature and because of the difficulties of specifying artistic quality in scientific terms. Accordingly, the normal release is defined as that which conveys the desired artistic impression when projected as described by this standard.

**A.2 Acceptable luminance range**

The range of acceptable luminance levels is limited by a minimum value, below which the visual process becomes less efficient such that the dynamic range of scenes appears compressed, and by a maximum value, above which the black level becomes unnaturally elevated. The permissible luminance range is limited by the criterion that a digital release must provide acceptable quality when projected at any luminance within the specified range. Users are reminded that screen luminance decreases as a function of bulb age, dirt on optics, dirt on the screen, etc.

**A.3 Matching luminance of different formats**

It may be necessary to adjust projector light output to compensate for the different image sizes and magnification used when projecting different picture formats. The projector light source should be capable of achieving the specified screen luminance for the format with the *least* light efficiency. When projecting more light-efficient formats, adjustment may be made by reducing lamp current or by use of attenuators in the light beam to reduce the screen luminance to within the standardized range.

**A.4 Luminance distribution on gain screens**

The screen luminance should be symmetrically distributed about the geometric center of the screen. The luminance of any point on the screen between the center and the edges, as measured from any seat in the middle row, should not exceed the screen center reading. For screens with a gain factor of 1.1 or more, the screen should be curved for light uniformity as described in SMPTE RP 95. A more complete measurement of screen luminance distribution is described in SMPTE RP 98 and is recommended for new or revised installations.

**A.5 White chromaticity uniformity**

The white chromaticity should be symmetrically distributed about the geometric center of the screen, and should exhibit no abrupt changes. The value is measured at the four corners defined in section 4.2, and is computed separately for each location, as the x or y value for that location, minus the x or y value at the screen center. The identical meter used to measure white point chromaticity (section 5.3) should also be used to measure white chromaticity uniformity. While the goal of a good D-cinema presentation is review room quality, the allowable variation for each performance class is shown below:

Parameter	Reference	Review room	Theater
White chromaticity corners	within ± .000 x ± .000 y of center	within ±. 008 x ±. 008 y of center	within ± .015 x ± .015 y of center

**A.6 Incident vs. reflected light**

This standard is based upon measurement of an installed projection system, consisting of a projector, a room, and a screen, not merely a projector. Screen aging or yellowing may not be uniform across the screen surface and may result in luminance or chromaticity variation greater than expected. Likewise, misadjustment of the projector light source, optical system, or use of a non-optimum screen configuration may cause luminance readings taken at various locations in the

seating area and on various areas of the screen to exceed the screen center reading taken as described in section 5.1 (hot spots). In cases where excessive differences are measured across the image area, it may be helpful to identify the source of the problem by directly measuring the incident light from the projector. However this is understood to be a diagnostic aid only; readings taken this way are not in keeping with this standard. Generally speaking, in order for an installation in an auditorium to meet a specific performance level, the projector itself will likely have to meet a tighter performance specification to allow for the contributions of the port glass and screen (or provide the ability to compensate for these effects).

#### A.7 Stray light and contrast

Stray light from foot lights, exit signs, and the like causes a decrease in contrast and impairs the desired artistic impression. As a guideline, no illuminated area with a luminance greater than 3.4 cd/m<sup>2</sup> (1.0 fL) should be directly visible from the audience. Stray light reflected on to the screen from other surfaces or seats in the room will also reduce the image contrast on the screen. For review rooms, reflected stray light is expected to be less than that in theaters, and in either case should not be such that the image contrast is significantly compromised.

#### Annex B (informative)

#### Bibliography

The following references may contain useful information, but are intended for 35-mm film projection only:

SMPTE 196M-2003, Motion-Picture Film — Indoor Theater and Review Room Projection — Screen Luminance and Viewing Conditions

SMPTE RP 98-1995, Measurement of Screen Luminance in Theaters

#### Conversions used:

cd/m<sup>2</sup> (Candelas/sq meter) were converted to fL (foot-Lamberts) by multiplying by 0.292 and rounding to one decimal place.