DRAFT Direct View Display

D-Cinema Addendum

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Digital Cinema Initiatives, LLC, Member Representatives Committee

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1 Introduction

D-Cinema Direct View Displays provide the potential for an improved high-quality image through significantly increased peak luminance and dynamic range, but may also be used to present legacy content. This specification defines performance requirements for such displays that are unique to D-Cinema Direct View Displays. These requirements will ensure interoperability and consistent quality of image content on the new generation of d-cinema displays.

Since these displays use emissive technology (often LED pixels) rather than a projected image, the image quality can be excellent, even in viewing environments with moderate ambient light, such as a dine-in theater. However emissive displays may potentially exhibit artifacts that are very different than those associated with projectors. For this reason, image quality metrics, performance requirements and metrology for Direct View Displays differ from those of D-Cinema projectors.

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2 Scope

This specification defines the image parameters applicable to D-Cinema Direct View Displays. Such displays are expected to be used for both legacy content and new high dynamic range content, so the requirements in this document are intended to apply to both modes of operation. Legacy operation refers to DCDM compositions containing Standard Dynamic Range (SDR) images conforming to the SMPTE D-Cinema document suites 428, 429, 430 and 431, including the color quality SMPTE ST 431-1 and Reference Projector RP 431-2 documents, with the Cinema Direct View Display operating in a mode that visually emulates projected images. This will ensure predictable and consistent exhibition quality for those DCDMs mastered using a reference projector.

High Dynamic Range (HDR) content refers to HDR DCDM compositions containing HDR images conforming to DCI's *High Dynamic Range D-Cinema Addendum*, with the D-Cinema Direct View Display operating in HDR mode.

This document shall be integrated into DCI's Digital Cinema System Specification.

3 Normative References

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

DCI High Dynamic Range D-Cinema Addendum

ISO 11664-1:2007, Colorimetry -- Part 1: CIE standard colorimetric observers

ISO/CIE 11664-5:2016, Colorimetry -- Part 5: CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram

ISO/CIE 11664-6:2014, Colorimetry -- Part 6: CIEDE2000 Colour-difference formula

SMPTE RP 431-2: 2011, Reference Projector and Environment for D-Cinema Quality

SMPTE ST 428-1:2006, D-Cinema Distribution Master (DCDM) — Image Characteristics

SMPTE ST 431-1:2006, Screen Luminance Level, Chromaticity and Uniformity for D-Cinema Quality

SMPTE ST 2084:2014, High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 Cinema Direct View Display

A display system intended for digital cinema applications and comprised of a combination of flat panel light-emitting display Cabinets conjoined so as to form a single large display. LED-based panels are typical, but the requirements herein apply to any image-forming display technology so comprised.

4.2 Screen

The complete Cinema Direct View Display system including all pixels sufficient to display the entire image, and typically comprised of a plurality of Cabinets with a supporting structure, associated electronics and cabling.

4.3 Cabinet

The physical structure and associated electronics which contains a portion of the image area of a Screen. The emissive surface area of a Cabinet is typically comprised of a plurality of Modules.

4.4 Module

A component including an array of Pixels physically positioned so as to form the front display surface of a Cabinet. The Module is typically the smallest field-serviceable light-emitting component of a Screen.

4.5 Display Pixel

The smallest grouping of light emitting elements within a Module, and capable of broad-spectrum (not monochromatic) light emissions. A Pixel is often comprised of a triplet of red, green and blue light emitting diodes, which may be considered Sub-Pixels.

4.6 Edit Unit

The smallest unit of D-Cinema content that can be successfully edited while maintaining the integrity of the content. The edit unit value must be an integer multiple of the duration of a single D-Cinema frame. In most cases, the edit unit value is the same as frame duration, but in certain applications, the value can be >1 (for example, stereoscopic D-Cinema requires an edit unit value twice that of the frame duration).

4.7 Minimum Active Black Level

The Minimum Active Black Level of a Cinema Direct View Display is the lowest luminance level above code value 0 reproduced within the specified uniformity tolerance.

5 Input Requirements

The Cinema Direct View Display operational modes and requirements are as follows:

5.1 Standard Dynamic Range Mode

The display shall have an SDR Mode. In this mode, the Direct View Display shall support DCDM image structures as defined in SMPTE ST 428-1, luminance, chromaticity and uniformity as defined in SMPTE ST 431-1, and display parameters as defined in SMPTE RP 431-2. RP 431-2 describes a Reference minimum sequential contrast ratio of 2000:1 with peak luminance 48.0 cd/m^2, which leads to a *maximum* screen black level of 48 cd/m^{2}2000=0.024 cd/m^2. EG 432-1 describes how higher performance projection with 5000:1 and 4000:1 sequential contrast ratios is supported with the DCDM's relative encoding above theater black. When the Cinema Direct View Display is operating in SDR Mode, the maximum sequential contrast ratio shall not exceed 5000:1, leading to a *minimum* screen black level of 48 cd/m^{2}5000=0.0096 cd/m^2.

5.2 High Dynamic Range Mode

HDR mode is optional. If implemented, the Cinema Direct View Display shall support HDR-DCDM (HDR Digital Cinema Distribution Master), as defined in DCI's *High Dynamic Range D-Cinema Addendum*.

5.3 Other Input Modes

The Cinema Direct View Display may support other image structures, aspect ratios, file formats and frame rates in order to support alternative content, or for other purposes.

5.4 Auxiliary Input Connection

It is highly desirable for the Cinema Direct View Display to have an Auxiliary Input connection capable of accepting an uncompressed image in the highest quality image format supported by the Media Block. For example, this could be a 4K, 4:4:4, 12-bit SMPTE ST 2084 encoded image at 60 fps. Such an auxiliary input is useful for display calibration and testing.

6 Frame Rates

The Cinema Direct View Display shall support the content frame rates in Table 1, expressed in Edit Units per second:

EU/sec	2K 2D	2K 3D[1]	4K 2D
24	Required	Required	Required
48	Required	Required	
60	Required	Required	
96	Required		
120	Required		

Table 1 *Edit units per second requirements for Cinema Direct View Displays*

7 Measurement Conditions

The following procedures and instrumentation shall be used for measurement of the Cinema Direct View Display.

7.1 Initial Conditions

The display shall be turned on and allowed to thermally stabilize for 20 to 30 minutes prior to all measurements. The room lights shall be turned off, with the exception of the minimal lighting provided for working or safety reasons. The display shall be calibrated to the target image parameters before final measurements are made.

7.2 Display Conditions

Measurements shall be made with the Cinema Direct View Display in normal operation, and set for the mode under test.

7.3 Photometer type

Screen luminance shall be measured with a spot photometer or spectroradiometer having the spectral luminance response of the standard observer (photopic vision), as defined in ISO/CIE 11664. The acceptance angle of the photometer shall be 2° or less. The photometer shall have a minimum luminance of 0.0005 cd/m², an accuracy of ± 2.0% and short-term repeatability of ±0.003 to 0.05 cd/m² . 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.

[1] Support for Stereoscopic 3D is optional; "Required" in this category applies only to displays in which 3D is implemented.

7.4 Imaging Colorimeter type

Screen luminance uniformity and color uniformity shall be measured with an imaging colorimeter having a minimum of 12 megapixels. It shall report values in CIE x, y coordinates with an accuracy of ± 0.003 and short term color repeatability of ± 0.00005.

7.5 Spectroradiometer Type

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

8 Image Parameters

8.1 Display Pixels

The number of display pixels and their visibility is defined below.

8.1.1 Display Pixel Count

The sampling structure of the displayed picture (pixel count) shall be at least 4096 (4K) horizontal and at least 2160 vertical pixels. Image scaling at non-integer values may be utilized if it is clearly demonstrable that no artifacts result.

8.1.2 Pixel Visibility

Since the Cinema Direct View Display utilizes individual light-emitting pixels, the visibility of pixel structure and the void between pixels (sometimes referred to as the “screen door effect”) is dependent on the optical design of the pixels. Factors affecting pixel visibility may include pixel pitch (space between adjacent pixels), pixel fill-factor, angular emission pattern, coatings and diffusion filters.

The pixel structure of the Cinema Direct View Display shall not be visible by an observer with normal visual acuity (e.g., 20/20 vision) when viewed from a distance equal to the image height.

8.1.3 Sub-pixel Spatial Coincidence

While the DCDM and HDR-DCDM image structures are defined with co-sited X’Y’Z’ pixel samples, the Cinema Direct View Display may not be built such that the color primaries are exactly co-sited at the same location. The spatial arrangement of the displayed color primary elements (likely composed of RGB subpixels corresponding to R, G and B LEDs) shall not introduce objectionable geometric anomalies such as fringing or checkerboard artifacts.

8.2 Calibration White Point and Luminance

The Calibration white point and luminance of Cinema Direct View Displays for each operational mode is as defined below. Measurements shall be taken with a meter meeting the criteria of Section 7.3.

8.2.1 Standard Dynamic Range Mode

In SDR mode, the Cinema Direct View Display shall conform to SMPTE ST 431-1.

8.2.2 High Dynamic Range Mode

In HDR mode, the Cinema Direct View Display shall conform to DCI's *High Dynamic Range D-Cinema Addendum.*

8.3 Minimum Active Black Level

The Minimum Active Black Level for each operational mode is defined below. Measurements shall be taken with a meter meeting the criteria of Section 7.3.

8.3.1 Standard Dynamic Range Mode

In SDR mode, the Cinema Direct View Display Minimum Active Black Level shall conform to SMPTE RP 431-2, with the exception that screen black level shall be displayed at luminance levels above 0.01 cd/m^2.

8.3.2 High Dynamic Range Mode

In HDR mode, the Cinema Direct View Display Minimum Active Black Level shall conform to DCI's *High Dynamic Range D-Cinema Addendum*.

8.4 Color Gamut and Accuracy

Color gamut and color accuracy for each operational mode is defined below. Measurements shall be taken with an instrument meeting the criteria of Section 7.5.

8.4.1 Standard Dynamic Range Mode

In SDR Mode, the Cinema Direct View Display color gamut and color accuracy shall conform to SMPTE ST 431-2.

8.4.2 High Dynamic Range Mode

In HDR mode, the Cinema Direct View Display gamut and color accuracy shall conform to DCI's *High Dynamic Range D-Cinema Addendum.*

8.5 Dithering

Dithering is an intentionally applied form of noise used to randomize quantization error. The following constraint on the use of dithering shall apply:

8.5.1 Spatial Dithering

Spatial dithering may be used to randomly "turn off" some pixels that would normally be illuminated at a given code value, in order to reduce the luminance level below that possible with all pixels on. This spatial dithering has the effect of reducing image resolution, and therefore, if used, it shall be only applied at luminance levels below 0.01 cd/m². Spatial dithering, if utilized, shall not be visible from a distance equal to the image height.

8.5.2 Temporal Dithering

Temporal dithering may be used to turn on and off pixels in a cycle similar to pulse-width modulation in order to reduce the luminance level below that possible with all pixels on continuously. Temporal dithering, if utilized, shall not be visible from a distance equal to the image height.

8.6 Luminance Uniformity

The luminance uniformity of a Cinema Direct View Display is affected by factors in the design and calibration of the display that are significantly different than those affecting the uniformity of a projector. In order to ensure an image free of distractingly visible non-uniformities, the following specifications shall be followed:

8.6.1 On-Axis Luminance Uniformity

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at horizontal screen center, as near vertical screen center as possible, and at a viewing angle directly perpendicular to the screen plane.

8.6.1.1 Full Screen Luminance Uniformity

Full Screen Luminance Uniformity is the measure of luminance variations present in low spatial frequencies – that is, when considering areas greater than 10% of the screen area. The full screen luminance shall be symmetrically distributed about the screen, and shall exhibit no abrupt changes. To eliminate moiré patterns in the test image, slightly de-focus the imaging colorimeter. The luminance variation on the screen, expressed as the average (mean) of any area of the screen exceeding 10% of the screen area compared to the average (mean) of the full screen, may not exceed the value specified in Table 2.

8.6.1.2 Inter-Module Luminance Uniformity

Inter-Module Luminance Uniformity is the measure of inconsistencies in luminance between adjacent Modules or Cabinets. These variances result in visible edges (transitions) between Modules, creating high-frequency fixed-pattern noise, which the human visual system is very sensitive to. To eliminate moiré patterns in the test image, slightly de-focus the imaging colorimeter. Because of electronic driver or optical performance of the display, this uniformity may vary at different luminance levels (e.g., look excellent at peak white, but inconsistent at mid-grey). Therefore, tests should be performed at various luminance levels. The luminance variation between adjacent Modules shall not exceed the value specified in Table 2.

8.6.1.3 Inter-Pixel Luminance Uniformity

Inter-Pixel Luminance Uniformity is the measure of inconsistencies in between adjacent pixels. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. These variances are often less perceptible than systematic fixed-pattern noise, and therefore may be allowed to have wider tolerances. Because of electronic driver or optical performance of the display, this uniformity may vary at different luminance levels (e.g., look excellent at peak white, but inconsistent at mid-grey).). Therefore, tests should be performed at various luminance levels. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The luminance variation between adjacent pixels shall not exceed the value specified in Table 2.

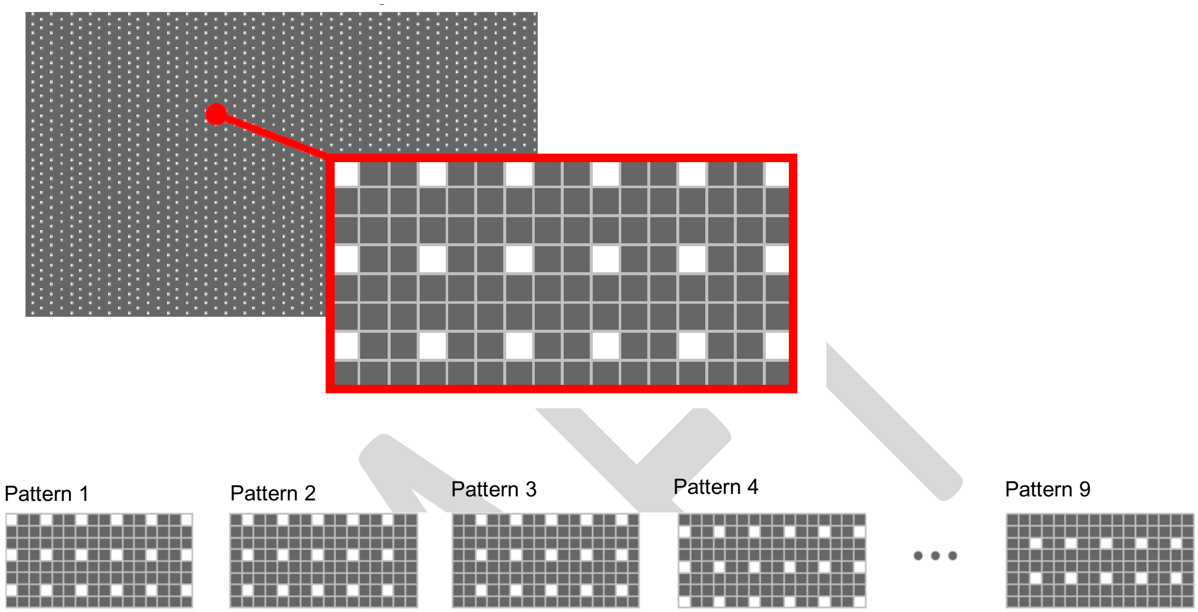

Figure 1 *Set of nine test images, each illuminating 1/9 of display pixels, for inter-pixel uniformity test*

8.6.1.4 Module Boundary Uniformity

Module Boundary Uniformity is the measure of the degree to which inconsistent mechanical spacing between Modules or Cabinets may be visible. These inconsistencies result in high-frequency fixed-pattern noise – typically vertical or horizontal lines representing transitions at certain Cabinet boundaries -- which the human visual system is very sensitive to. This defect is related to full-screen uniformity but may be caused by mechanical misalignment even in situations where the Modules themselves exhibit perfect uniformity. Misalignment may result from pixels at Cabinet boundaries being too far apart (gap; resulting in dark line) or too close together (overlap; resulting in bright line). Misalignment out of plane may be visible only from certain viewing angles, so the display should be inspected from all viewing angles to identify potential defects that should be measured.

Using the inter-pixel uniformity test data, process the data with a high-pass filter (3 x 3 Gaussian blur). The luminance variation at any Module boundary shall not exceed the value specified in Table 2.

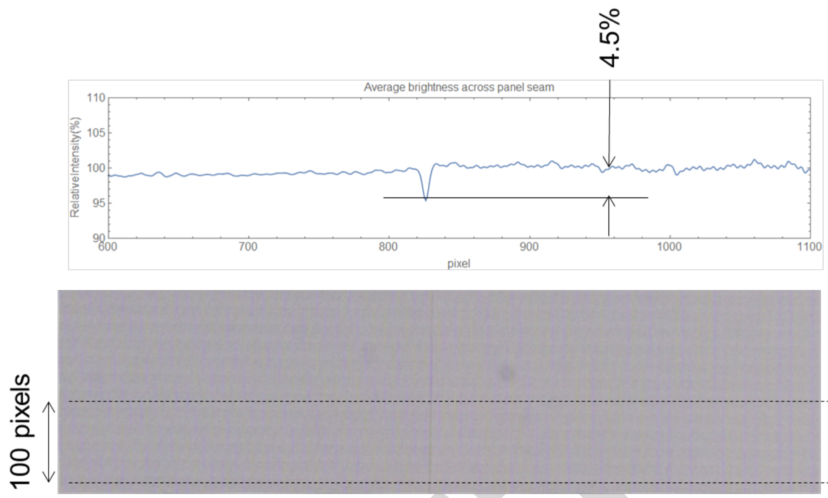

Figure 2 *Example of test result for Module boundary uniformity, with measured variance of 4.5%, exceeding permissible tolerance.*

8.6.2 Horizontal Off-Axis Luminance Uniformity

These tests are intended to quantify systemic inconsistencies in perceived luminance of the image when viewed from horizontally off-axis (not directly perpendicular to the screen plane). The primary cause for non-uniformity in off-axis viewing is the optical performance of the pixel emitters rather than electronics. Therefore, it is not necessary to perform tests at various luminance levels.

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at an acute horizontal angle to the screen plane. The angle(s) of measurement and distance to the screen are dependent on the specifications of the instrument being used.

8.6.3 Full Screen Off-Axis Luminance Uniformity

The luminance variation on the screen, when viewed from any angle up to ±60° horizontally from perpendicular to the screen plane, compared to the mean average of on-axis full screen luminance, shall not exceed the value specified in Table 2.

8.6.3.1 Inter-Pixel Off-Axis Luminance Uniformity

Inter-Pixel Off-Axis Luminance Uniformity is the measure of inconsistencies between adjacent pixels when viewed from positions not directly perpendicular to the screen plane. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The luminance variation between pixels, when viewed from any angle up to ±60° horizontally from perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.6.4 Vertical Off-Axis Luminance Uniformity

These tests are similar to the Horizontal Off-Axis Luminance Uniformity measurements, but are intended to characterize the image when viewed from a higher or lower angle. Due to the sub-pixel configuration in some Cinema Direct View Displays, there can be a luminance shift when viewed at these angles.

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at an acute vertical angle to the screen plane. The angle(s) of measurement and distance to the screen are dependent on the specifications of the instrument being used.

8.6.4.1 Vertical Full Screen Off-Axis Luminance Uniformity

The white chromaticity variation on the screen, when viewed from any angle between +10° and -35° from vertically perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.6.4.2 Vertical Inter-Pixel Off-Axis Luminance Uniformity

Inter-Pixel Off-Axis Luminance Uniformity is the measure of inconsistencies between adjacent pixels when viewed from positions not directly perpendicular to the screen plane. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The luminance variation between pixels, when viewed from any angle between +10° and -35° from vertically perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.7 White Chromaticity Uniformity

The White Chromaticity uniformity of a Cinema Direct View Displays is affected by factors in the design and calibration of the display that are significantly different than those affecting the uniformity of a projected image. In order to ensure an image free of distractingly visible non-uniformities, the following specifications shall be followed:

8.7.1 On-Axis White Chromaticity Uniformity

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at horizontal screen center, as near vertical screen center as possible, and at a viewing angle directly perpendicular to the screen plane.

8.7.1.1 Full Screen White Chromaticity Uniformity

Full Screen White Chromaticity Uniformity is the measure of color variation present in low spatial frequencies – that is, when considering areas greater than 10% of the screen area. The full screen luminance shall be symmetrically distributed about the screen, and shall exhibit no abrupt changes. To eliminate moiré patterns in the test image, slightly de-focus the imaging colorimeter. The white chromaticity variation on the screen, expressed as the mean average of any area of the screen exceeding 10% of the screen area compared to the screen center, when viewed from any angle up to ±60° from perpendicular to the screen plane, may not exceed the value specified in Table 2.

8.7.1.2 Inter-Module White Chromaticity Uniformity

Inter-Module White Chromaticity Uniformity is the measure of inconsistencies in color between adjacent Modules or Cabinets. These variances result in visible edges (transitions) between Modules, creating high-frequency fixed-pattern noise, which the human visual system is very sensitive to. To eliminate moiré patterns in the test image, slightly de-focus the imaging colorimeter. Because of electronic driver or optical performance of the display, this uniformity may vary at different luminance levels (e.g., look excellent at peak white, but inconsistent at mid-grey). Therefore, tests should be performed at various luminance levels. The color variation between adjacent Modules, when viewed from any angle up to ±60° from perpendicular to the screen plane shall not exceed the value specified in Table 2.

8.7.1.3 Inter-Pixel White Chromaticity Uniformity

Inter-Pixel White Chromaticity Uniformity is the measure of inconsistencies in between adjacent pixels. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. These variances are often less perceptible than systematic fixed-pattern noise, and therefore may be allowed to have wider tolerances. Because of electronic driver or optical performance of the display, this uniformity may vary at different luminance levels (e.g., look excellent at peak white, but inconsistent at mid-grey).). Therefore, tests should be performed at various luminance levels. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The color variation between adjacent pixels, when viewed from any angle up to ±60° from perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.7.1.4 Horizontal Off-Axis White Chromaticity Uniformity

These tests are intended to quantify systemic inconsistencies in perceived color of the image when viewed from horizontally off-axis (not directly perpendicular to the screen plane). The primary cause for non-uniformity in off-axis viewing is the optical performance of the pixel emitters rather than electronics. Therefore, it is not necessary to perform tests at various luminance levels.

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at an acute horizontal angle to the screen plane. The angle(s) of measurement and distance to the screen are dependent on the specifications of the instrument being used.

8.7.1.5 Horizontal Full Screen Off-Axis White Chromaticity Uniformity

The white chromaticity variation on the screen, when viewed from any angle up to ±60° horizontally from perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.7.1.6 Horizontal Inter-Pixel Off-Axis White Chromaticity Uniformity

Inter-Pixel Off-Axis White Chromaticity Uniformity is the measure of inconsistencies between adjacent pixels when viewed from positions not directly perpendicular to the screen plane. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The white chromaticity variation between pixels, when viewed from any angle up to ±60° horizontally from perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.7.2 Vertical Off-Axis White Chromaticity Uniformity

These tests are similar to the Horizontal Off-Axis White Chromaticity Uniformity measurements, but are intended to characterize the image when viewed from a higher or lower angle. Due to the sub-pixel configuration in some Cinema Direct View Displays, there can be a color shift when viewed at these angles.

The following measurements are made with the imaging colorimeter meeting the criteria of Section 7.4 placed at an acute vertical angle to the screen plane. The angle(s) of measurement and distance to the screen are dependent on the specifications of the instrument being used.

8.7.2.1 Vertical Full Screen Off-Axis White Chromaticity Uniformity

The white chromaticity variation on the screen, when viewed from any angle between +10° and -35° from vertically perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.7.2.2 Vertical Inter-Pixel Off-Axis White Chromaticity Uniformity

Inter-Pixel Off-Axis White Chromaticity Uniformity is the measure of inconsistencies between adjacent pixels when viewed from positions not directly perpendicular to the screen plane. These variances result in high-frequency fixed-pattern noise, which may appear as random noise to the human visual system. In order for the test instrument to distinguish individual pixels, the test pattern is divided into nine images, each with 1/9 of the screen pixels illuminated, as shown in Figure 1. The white chromaticity variation between pixels, when viewed from any angle between +10° and -35° from vertically perpendicular to the screen plane, shall not exceed the value specified in Table 2.

8.8 Surface Reflectivity

Since light reflecting from the auditorium off the screen will degrade the perceived contrast, a low reflectivity is required. The measurement shall be made using an imaging colorimeter meeting the criteria of Section 7.4. Since the screen surface may exhibit reflectivity with different optical characteristics, two measurements methods shall be utilized, as described here. The screen shall be turned off or input set to code value zero for this test to ensure that no light is emitted from the pixels.

8.8.1 Diffuse reflectivity

This test is intended to quantify Lambertian (diffused) light reflected off the surface of the screen in any direction. The measurement shall be made using a reference illuminant[2] as a light source. The colorimeter is positioned off-axis to the screen plane, such as both the reference illuminant and its reflection from the screen surface are within the field of view. The measurement of reflections from the screen shall be compared with those from a reference diffuse reflector[3] positioned over the screen surface, and used for calibration. The resulting data is analyzed to calculate the percentage of reflected luminance / calibration luminance, which shall not exceed the value in Table 2.

8.8.2 Specular reflectivity

This test is intended to quantify light reflected off the surface of the screen in a specular (mirror-like) manner. Such reflections from light sources in the auditorium, including safety footlights and exit signs, can be visually distracting to viewers in certain seats, so specular reflectivity should be minimized. The measurement shall be made using a reference illuminant as a light source. The colorimeter is positioned off-axis to the screen plane, such as both the reference illuminant and its reflection from the screen surface are within the field of view. The measurement of reflections from the screen shall be compared with those from a reference specular reflector[4] positioned over the screen surface, and used for calibration. The resulting data is analyzed to calculate the percentage of reflected luminance / calibration luminance, which shall not exceed the value in Table 2.

8.9 Stereoscopic Display Requirements

Support for Stereoscopic 3D in Cinema Direct View Displays is optional. There are no constraints in regard to the discriminator technology used, such as active shuttered eyewear, polarized passive eyewear or chromatic filtering eyewear, as long as the following specifications are met.

8.9.1 Stereoscopic Peak White Luminance

8.9.1.1 Standard Dynamic Range Mode

Given the increased light level capabilities of Cinema Direct View Displays, peak white luminance for such display systems should be as specified in Table 2 when measured through all filters and lenses, i.e., light level to the eye. Relative luminance uniformity should be consistent with Section 8.6 above.

[2] The reference illuminant may be an intenerating sphere, or a light bulb with uniform emission patterns and diffuse (frosted) surface. The luminance flux of the reference illuminant should be selected (or adjusted using a dimmer) so as to not exceed the measurement range of the imaging colorimeter.

[3] The reference diffuse reflector may be a projection screen with a matte (unity gain) surface.

[4] The reference specular reflector may be a piece of black, glossy, opaque acrylic.

8.9.1.2 High Dynamic Range Mode

Since stereoscopic discriminators may attenuate a significant portion of luminance from an emissive display. Therefore, it may not be practical to maintain the same peak white luminance as specified for 2D images while in the stereoscopic display mode. Peak white luminance for such display systems in the HDR 3D mode should be as specified in Table 2 when measured through all filters and lenses, i.e., light level to the eye. Relative luminance uniformity should be consistent with Section 8.6 above.

8.9.2 Stereoscopic Minimum Active Black Level

The Minimum Active Black Level for each operational mode is defined below. Measurements shall be taken with a meter meeting the criteria of Section 7.3 measured through all filters and lenses, i.e., light level to the eye.

8.9.2.1 Standard Dynamic Range Mode

In SDR Mode, the Cinema Direct View Display Minimum Active Black Level shall conform to SMPTE RP 431-2, with the exception that screen black level shall be displayed at luminance levels above 0.01 cd/m^2.

8.9.2.2 High Dynamic Range Mode

In HDR mode, the Cinema Direct View Display Minimum Active Black Level shall conform to DCI's *High Dynamic Range D-Cinema Addendum*.

8.9.3 Stereoscopic Color Gamut and Accuracy

Color gamut and color accuracy for each operational mode is defined below. Measurements shall be taken with an instrument meeting the criteria of Section 7.5 measured through all filters and lenses, i.e., light level to the eye.

8.9.3.1 Standard Dynamic Range Mode

In SDR Mode, the Cinema Direct View Display color gamut and color accuracy shall conform to SMPTE RP 431-2.

8.9.3.2 High Dynamic Range Mode

In HDR mode, the Cinema Direct View Display gamut and color accuracy shall conform to DCI's *High Dynamic Range D-Cinema Addendum*.

8.9.4 Stereo Contrast

Stereo contrast ratio is a measure of crosstalk between left eye and right eye images in a stereoscopic display, as measured through the appropriate eyewear. Low SCR measures result in "ghosting" of the image, where a low luminance right eye image is perceived in the left eye of the viewer (and vis versa). Stereo contrast ratio should be as specified in Table 2.

8.10 Spatio-Temporal Aliasing

Spatio-Temporal Aliasing refers to visible artifacts that result from pixel multiplexing or scanning, when viewed with eye movement such as saccades or gaze shift. Display multiplex scans may be horizontal, vertical or randomized, and may be synchronized across Modules or Cabinets, or unsynchronized. Spatio-Temporal aliasing artifacts can be distracting to the viewers and are therefore important to assessing image quality. However, because they are difficult to measure with today's readily available instrumentation, they are generally assessed subjectively. The Cinema Direct View Display shall not exhibit any such visible artifacts.

Table 2 Summary of Image Parameters for Cinema Direct View Displays

Sec	Image Parameter		Nominal	Tolerance
8.1.1	Pixel Count		4096 x 2160 or greater	
8.2	Luminance, screen average, 100% white	SDR Mode	As defined in SMPTE ST 431-1	
		HDR Mode	500 cd/m²	± 10 cd/m²
8.3	Minimum Active Black Level	SDR Mode	As defined in SMPTE ST 431-2	
		HDR Mode	0.005 cd/m²	< 0.0002 cd/m²
8.4	Color gamut and color accuracy	SDR Mode	As defined in SMPTE ST 431-1	
		HDR Mode	As defined in DCI High Dynamic Range Projector & Cinema Display Image Requirements	
8.5	Dithering	Spatial	Shall not be used above 0.01 cd/m²	
		Temporal	Not visible	
8.6.1	On-Axis Luminance Uniformity	Full Screen Uniformity	Any allowed lumiance level	± 10% of screen average
		Inter-Module Uniformity		± 0.50% between adjacent modules
		Inter-Pixel Uniformity		± 1.0% between adjacent pixels
		Module Boundary Uniformity		± 1.0% of screen average
8.6.2	Horizontal Off-Axis Luminance Uniformity	Full Screen Uniformity	D65 White Peak luminance	± 50% of on-axis luminance at ±60°
		Inter-Pixel Uniformity		± 1.0% between adjacent pixels at ±60° Horz
8.6.3	Vertical Off-Axis Luminance Uniformity	Full Screen Uniformity		± 50% of on-axis luminance at +10° to -35° Vert
		Inter-Pixel Uniformity		± 1.0% between adjacent pixels at at +10° to -35° Vert
8.7.1	On-Axis White Chromaticity Uniformity	Full Screen Uniformity	Any allowed lumiance level	Δ u'v' ± 0.007 from screen center
		Inter-Module Uniformity	D65 White Peak luminance	Δ u'v' ± 0.005 between adjacent modules
		Inter-Pixel Uniformity		Δ u'v' ± 0.007 between adjacent modules
8.7.2	Horizontal Off-Axis White Chromaticity Uniformity	Full Screen Uniformity		Δ u'v' ± 0.007 from screen center at ±60° Horz
		Inter-Pixel Uniformity		Δ u'v' ± 0.010 between adjacent pixels at ±60° Horz
8.7.3	Verical Off-Axis White Chromaticity Uniformity	Full Screen Uniformity		Δ u'v' ± 0.010 from screen center at +10° to -35° Vert
		Inter-Pixel Uniformity		Δ u'v' ± 0.015 between adjacent pixels at +10° to -35° Vert
8.8	Screen Surface Reflectivity	Diffuse Reflectivity	Less than 10%	
		Spectral Reflectivity	Less than 0.5%	
8.9.1	Stereoscopic Peak White Average Luminance	SDR Mode	48 cd/m²	± 4.8 cd/m²
		HDR Mode	300 cd/m²	± 6.0 cd/m²
8.9.2	Stereoscopic Minimum Active Black Level	SDR Mode	As defined in SMPTE ST 431-2	
		HDR Mode	0.005 cd/m²	< 0.0002 cd/m²
8.9.3	Stereoscopic Color gamut and color accuracy	SDR Mode	As defined in SMPTE ST 431-1	
		HDR Mode	As defined in DCI High Dynamic Range Projector & Cinema Display Image Requirements	
8.9.4	Stereo Contrast Ratio		200:1	Not less than 150:1