SMPTE RP 431-2:2011
Revision of RP 431-2-2007

SMPTE RECOMMENDED PRACTICE

D-Cinema Quality — Reference Projector and Environment

Table of Contents **Page**

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MOTION PICTURE AND TELEVISION ENGINEERS
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Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

SMPTE RP 431-2 was prepared by SMPTE Technology Committee 21DC on Digital Cinema.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Standard. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

The creation and exhibition of a Digital Cinema Distribution Master (DCDM) requires the definition of a Reference Projector and controlled environment, as well as carefully calibrated projectors for Review Rooms and Theaters. This document defines the Reference Projector and specifies the tolerances around the critical image parameters for Review Rooms and Theaters so that consistent and repeatable color quality can be achieved.

After initial publication of this Recommended Practice, there was confusion concerning the alignment of the luminance at a given white point. Practice in the field made the assumption either that the *Mastering White* was *Calibration White* (48 cd/m^2 at x=0.314, y=0.351) or that projectors aligned to *Calibration White* would support other DCDM *Mastering Whites* properly without clipping. In the former case there was content being mastered at different white points and in the latter case both alignment procedures and internal test signals were incorrectly applied causing some projectors to clip the highlight portion of the content.

Recognizing this, SMPTE formed a White Gamut Practices Study Group which, upon concluding its work, recommended modifications to this Recommended Practice to include a *White Gamut* that incorporates the set of possible *Mastering Whites* that can be reproduced by the Reference Projector at a luminance of 48 cd/m^2. Along with this a new term was introduced, *Virtual White,* defined within Table A-1. *Virtual White* is only a mathematical result and is not intended for display or measurement because it might be clipped by a display system. *Virtual White* is used to define the relative balance of display primaries so that the *White Gamut* will be displayed with a luminance of 48 cd/m^2.

For more detail and explanation on this topic please refer to the White Gamut Practices Study Group Report.

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1 Scope

This document defines the Reference Projector and its controlled environment, along with the acceptable tolerances around critical image parameters for Review Room and Theatre applications. The goal is to provide a means for achieving consistent and repeatable color image quality. The Reference Projector is a practical device. The nominal (Reference Projector) parameters are based on industry experience and have been demonstrated by commercially available projectors in controlled environments. Two levels of tolerances are specified, a tighter tolerance for Review Rooms[1] where critical color judgments are made, and a wider tolerance for satisfactory reproduction in Theaters used for general public exhibition.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

Unless otherwise specified the order of precedence of the types of normative information in this document shall be as follows. Normative prose shall be the authoritative definition. Tables shall be next, followed by formal languages, then figures, and then any other language forms.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 428-1:2006) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 428-1-2006). Documents with the same root number (e.g. 428-1) and publication year (e.g. 2006) are functionally identical.

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

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

[1] The use of the term "Review Room" includes the mastering environment where creative color decisions are made on a projected image.

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

CIE Publication 15.2 (1986), Colorimetry

CIE Publication 15:2004, Colorimetry, 3rd Edition

4 Input Requirements

The Reference Projector shall support the DCDM image structures, and at a minimum, DCDM operational level 3, as defined in SMPTE ST 428-1.

5 Initial Conditions

The projector shall be turned on (including the lamp house) 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 projector shall be calibrated to the target image parameters in Table A.1 before final measurements are made.

6 Environment

6.1 Ambient Level

Stray light reflected from the screen should be minimized. Black, non-reflective finishes on all surfaces other than the screen, along with recessed lighting, should be used.

With the projector turned off (or with the lamp house doused), measure the luminance of the center of the screen. For Review Rooms, the ambient light level reflected by the screen should be less than 0.01 cd/m^2 (0.0029 ft L). For Exhibition Theaters, the ambient light level reflected by the screen should be less than 0.03 cd/m^2 (0.01 ft L). Safety regulations and the placement of exit lights or access lights may result in a higher ambient light level, but it should be noted that this will reduce the contrast of the projected image.

6.2 Screen Characteristics

The screen shall reflect energy uniformly across all angles, such that the color of the reflected light does not change with viewing angle. If the design of the room requires the placement of speakers behind the screen, it may be necessary to use perforations; however, care should be taken to ensure that the perforation structure does not beat against (alias with) the projector's display structure.

The screen shall have adjustable black masking that can be adjusted to tightly frame the projected image, for both 1.85:1 and 2.39:1 image formats.

6.3 Reference Viewing Position for Color Grading

The reference viewing position for color grading shall be at a viewing distance of 1.5 to 3.5 screen heights (for constant height presentation), or if constant width is used for both 2.39:1 and 1.85:1 aspect ratios, then this viewing distance refers to the height of the 1.85:1 picture. Lighting on work surfaces or consoles should be masked and filtered to eliminate any spill onto the screen.

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7 Image Parameters

All image parameters shall be measured as reflected light from the screen, with the measurements made from the reference viewing position in the Review Room, or from the center of the normal seating area in an Exhibition Theatre. The nominal (Reference Projector) parameters and the tolerances for Review Rooms and Exhibition Theaters are summarized in Table A.1.

7.1 7.1 Pixel Count

The sampling structure of the displayed picture (pixel count) shall be a minimum of 2048 (2k) horizontal and 1080 vertical pixels.

7.2 Luminance Uniformity

The lamp house shall be aligned such that the luminance fall-off from center to corners is within the specified tolerances. The measured luminance of the corners and sides in a 3 by 3 grid shall be within the tolerances specified by SMPTE ST 431-1.

7.3 Calibration White Point and Luminance

When the projector is sent a full frame *Reference White* image with the code values 3794 X' 3960 Y' 3890 Z'[2], the white point chromaticity coordinates of the center of the screen shall be specified by SMPTE ST 431-1. These code values shall produce a screen reflected luminance as specified by SMPTE ST 431-1 and SMPTE ST 428-1.

7.4 Color Uniformity of White Field

The chromaticities of the center points of a equally spaced 3x3 grid shall be within the tolerances specified in SMPTE ST 431-1.

7.5 Sequential Contrast

The sequential contrast ratio shall be computed by dividing the white luminance (of a peak white field as defined in Section 7.3) by the black luminance (of a code value zero black field), with the measurements made in-situ including the contributions of ambient light. It shall not be appropriate to subtract the room black (ambient light) when computing sequential contrast. The nominal value for the sequential contrast should be a least 2000:1 (in a darkened room). The tolerances for Review Rooms and Exhibition Theaters are shown in Table A.1. In order to eliminate unwanted detail or discoloration in near blacks, Review Rooms used for color grading should have an equal or higher sequential contrast than the best of Exhibition Theaters.

7.6 Intra-frame (Checkerboard) Contrast

Using a 4x4 checkerboard target, intra-frame contrast shall be computed by summing the luminances of the white patches and dividing by the sum of the luminances of the black patches. The nominal (Reference Projector) value for intra-frame contrast shall be minimum contrast of 150:1. The tolerances for Review Rooms and Exhibition Theaters are shown in Table A.1.

Note: Infra-frame contrast is reduced by many factors including projection lens flare, port glass flare, ambient light spilling on the screen and back-reflections from the room itself. This measurement is made with the projector "in situ", with the screening room or theatre in full operating mode.

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[2] At the time of the writing of this Recommended Practice, the X'Y'Z' code values specified are for the white point chromaticity coordinates of (0.314 x, 0.351 y. If this white point chromaticity is changed, the best practice is to change X'Y'Z' code values accordingly.

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7.7 Transfer Function

The encoding transfer function shall be defined in terms of output-referred CIE XYZ tristimulus values, as described in SMPTE Standard for D-Cinema Distribution Master- Image Structure. The projector transfer functions are:

$$X = P / L * \left(\frac{X'}{4095} \right)^{2.6}$$

$$Y = P / L * \left(\frac{Y'}{4095} \right)^{2.6}$$

$$Z = P / L * \left(\frac{Z'}{4095} \right)^{2.6}$$

where P = 52.37, and L shall be the Reference White Luminance. The peak luminance as shown in the transfer function equation shall be 52.37 cd/m^2 . The extra headroom is reserved to accommodate a range of white points including D_{55}, D_{61} and D_{65}, while still supporting the reference white luminance of 48 cd/m^2 as specified in SMPTE ST 431-1.

Note 1: In practice, Luminance at the bottom end of the transfer function is skewed by ambient light and finite projector sequential contrast. This transfer function does not attempt to correct for the resulting deviation from a pure power law., as tests have shown that corrections can produce undesirable clipping artefacts. Linearity and sensitivity of the photometer are critical for useful measurements.

Note 2: If the data is transported over SMPTE ST 372 (SDI dual link), code values 0-15 and 4080-4095 are reserved (illegal) code values and these code values will be clipped.

7.8 Color Gamut

In an additive display, the color gamut is a cuboid with vertices determined by the XYZ coordinates of the three primaries, the white point, and the black point. The color gamut primaries in Table A.1 define the minimum gamut for a Reference Projector. While *Virtual White* is necessary to specify the color gamut, it is not intended for reproduction, in the same sense that colors with a Y value above 48 cd/m^2 need not be reproduced. In practice, a projector may have a larger gamut.

7.9 Color Accuracy

Within the minimum color gamut, all colors shall be accurately reproduced. Table A.1 defines tolerances that can be used to verify the color primaries of the minimum gamut. Table A.4 provides exact chromaticities and luminances for a set of test code values that fall within these tolerances.

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Annex A Normative Tables

The Reference Projector image parameters and tolerances for the projected image in Review Rooms and Exhibition Theaters, as measured off the screen and including the room ambient light, are summarized in Table A.1. The nominal (Reference Projector) parameters are based on industry experience and have been demonstrated by commercially available projectors. Where the nominal parameters are specified as minimums, it is understood that these parameters shall not be constrained from future improvements as the technology improves.

Tolerances for Transfer Function – Least squares fit of slope of log/log plot of measured luminance vs. input code value, using a range from peak white luminance down to 5% of peak white.

Table A.1 – Reference Projector Image Parameters and Tolerances for Review Rooms and Theaters

Sec.	Image Parameters	Nominal (Reference Projector)	Tolerances (Review Rooms)	Tolerances (Theaters)
7.1	Pixel Count	2048*1080 or greater	2048*1080 or greater	2048*1080 or greater
7.2	Luminance Uniformity, corners and sides	These parameters are defined in: SMPTE ST 431-1		
7.3	CalibratedWhite Luminance, center			
7.3	Calibrated White Chromaticity, center from code values [3794, 3960, 3890]			
7.4	Color Uniformity of White Field, corners			
7.5	Sequential Contrast	2000:1 minimum	1500:1 minimum	1200:1 minimum
7.6	Intra-frame Contrast	150:1 minimum	100:1 mininum	100:1 mininum
7.7	Transfer Function	Gamma 2.6	± 2%	± 5% Best fit
7.8	Color Gamut	The cube in XYZ space defined by the black point [3] and the following points expressed in Y,x,y[4]. Reproduction of colors with a Y value above 48 cd/m^2 shall not be required. Red (11.90597, 0.6800, 0.3200) Green (34.63657, 0.2650, 0.6900) Blue (3.805772, 0.1500, 0.0600) Virtual White (50.34832, 0.3190, 0.3338)	Not applicable	Not applicable
7.9	Color Accuracy	The following points are expressed in x,y. Red (0.6800 ± .01 0.3200 ± .01) Green (0.2650 ± .02 0.6900 ± .02) Blue (0.1500 + 0.01/-0.03, 0.0600 + 0.02/-0.04)	(same)	(same)

[3] The luminance of the black point is limited by the sequential contrast ratio of the projector plus the ambient light falling on the screen.

[4] While the points are given for convenience in Y,x,y, the cube is defined in X,Y,Z. This cube is the result of the assumed additivity of the DCDM primary chromaticities and the adjusted gains to target the *Virtual White* which ensures enclosure of the desired *White Gamut.*

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Table A.2 – Black-to-white gray step-scale test pattern code values, luminance values, and chromaticity coordinates (all measurements are made in the center of the screen)

	Input Code Values[5]			Output Chromaticity Coordinates		Output Luminance[6]
Step Number	***X'***	***Y'***	***Z'***	**x**	**y**	**Y,** cd/m²
1	379	396	389	0.314	0.351	0.14
2	759	792	778	0.314	0.351	0.75
3	1138	1188	1167	0.314	0.351	2.12
4	1518	1584	1556	0.314	0.351	4.45
5	1897	1980	1945	0.314	0.351	7.94
6	2276	2376	2334	0.314	0.351	12.74
7	2656	2772	2723	0.314	0.351	19.01
8	3035	3168	3112	0.314	0.351	26.89
9	3415	3564	3501	0.314	0.351	36.52
10	3794	3960	3890	0.314	0.351	48.02

Table A.3 – Black-to-dark gray step-scale test pattern code values, luminance values, and chromaticity coordinates (all measurements are made in the center of the screen)

	Input Code Values[7]			Output Chromaticity Coordinates		Output Luminance[8]
Step Number	***X'***	***Y'***	***Z'***	**x**	**y**	**Y,** cd/m²
1	122	128	125	0.314	0.351	0.030
2	245	255	251	0.314	0.351	0.063
3	367	383	376	0.314	0.351	0.135
4	490	511	502	0.314	0.351	0.254
5	612	639	627	0.314	0.351	0.442
6	734	766	753	0.314	0.351	0.695
7	857	894	878	0.314	0.351	1.026
8	979	1022	1004	0.314	0.351	1.442
9	1101	1150	1129	0.314	0.351	1.950
10	1224	1277	1255	0.314	0.351	2.557

[5] *X'Y'Z'* code values specified are white point specific (0.314 x, 0.351 y). If the white point is changed, the *X'Y'Z'* code values will need to be rescaled accordingly.

[6] Output luminance includes 0.024 cd/m² screen black level (representing a 2000:1 contrast ratio).

[7] See note 4.

[8] See note 5.

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Table A.4 – Color Accuracy color patch code values, luminance values, and chromaticity coordinates. The accuracy with which these colors shall be displayed are shown in Table A.1 (all measurements are made in the center of the screen)

	Input Code Values*			**Output Chromaticity Coordinates**		**Output Luminance**
Patch	***X'***	***Y'***	***Z'***	**x**	**y**	**Y,** cd/m²
Red-1	2901	2171	100	0.6799	0.3200	10.06
Green-1	2417	3493	1222	0.2649	0.6901	34.64
Blue-1	2014	1416	3816	0.1500	0.0600	3.31
Cyan-1	2911	3618	3890	0.2047	0.3603	37.95
Magenta-1	3289	2421	3814	0.3424	0.1544	13.35
Yellow-1	3494	3853	1221	0.4247	0.5477	44.70
Red-2	2738	2171	1233	0.5979	0.3270	10.06
Green-2	2767	3493	2325	0.2883	0.5284	34.64
Blue-2	1800	1416	3203	0.1664	0.0892	3.31
Cyan-2	3085	3590	3756	0.2409	0.3573	37.19
Magenta-2	3062	2421	3497	0.3384	0.1837	13.35
Yellow-2	3461	3777	2065	0.3974	0.4988	42.44
White-1	3883	3960	4092	0.3127	0.3290	48.00
White-2	3794	3960	3890	0.3140	0.3510	48.00
White-3	3893	3960	3838	0.3323	0.3474	48.00

Note: Patches labelled -1 and -2 represent two levels of color saturation within the minimum color gamut of the Reference Projector, with the saturation of level -2 reduced so that it falls within the smaller Rec. 709 color gamut. White patches labelled -1, -2 and -3 represent three colors within the *White Gamut*.

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Annex B Subjective Parameters (Informative)

The following parameters are also important to picture quality, but because they are difficult to measure with today's readily available instrumentation, they are generally assessed subjectively.[9]

B.1 Grayscale Tracking

Using the black-to-white gray step-scale test pattern, the entire step-scale appears neutral without any visible color non-uniformity. The black-to-white gray step-scale test pattern is centered on the screen and occupies a rectangle sized 20% of the screen height by 80% of the screen width. The background is defined by code values [1565 1633 1604], which define a luminance of 4.80 cd/m^2 and chromaticity coordinates x = 0.314 y= 0.351. Each step is 8% of the screen width and is defined by the code values in Table A.2.

Using the black-to-dark gray step-scale test pattern, the entire step-scale appears neutral without any visible color non-uniformity. The black-to-dark gray step-scale test pattern is centered on the screen and occupy a rectangle sized 20% of the screen height by 80% of the screen width. The background is defined by code values [122 128 125], which define a luminance of 0.030 cd/m^2 and chromaticity coordinates x = 0.314 y= 0.351. Each step is 8% of the screen width and is defined by the code values in Table A.3.

B.2 Contouring

Contouring is the appearance of steps or bands where only a continuous or smooth gradient is expected. Because contouring is a function of many variables, it is important to look at a series of test patterns with shallow gradations to simulate naturally occurring gradations in images. Examples include horizons, particularly at sunset or sunrise, and the natural falloff around high intensity spotlights, particularly if diffused by atmosphere or lens filtration. These test pattern ramps have a step width of no less than 4 pixels with an increment of one code value per step and are placed on a background equal to the minimum value in the ramp, so that the eye is adapted for maximum sensitivity.

Since dynamic fades to black are widely used in real-world content, a dynamic test pattern that fades slowly to black is another useful approach.

Each image is viewed in the proper environment as defined in Section 6, and ought not exhibit any contouring (step in luminance), or color deviation from the neutral gray.

B.3 Temporal Artifacts

Temporal artifacts such as flicker and lag (on moving highlights) can significantly impair the quality of a projected image. Although it is difficult to measure and quantify these parameters, the goal should be to minimize the visibility of flicker and lag, such that they do not distract from the presentation.

[9] Instrumentation designers are encouraged to design and manufacture equipment that can be used to translate subjective parameters into objective performance characterization.

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Annex C Xenon Color Primaries, White Point and Color Conversions (Informative)

The color image encoding parameters for today's Xenon-based D-Cinema Reference Projectors and the corresponding color conversion steps to convert from native RGB to XYZ (and back) are shown here as an example for implementation.

C.1 Color Primaries

Table C.1 – Chromaticity Coordinates of Primaries

Encoding Primaries	x	y	u'	v'
R_{DC}	0.6800	0.3200	0.49635	0.52555
G_{DC}	0.2650	0.6900	0.09860	0.57767
B_{DC}	0.1500	0.0600	0.17544	0.15790

x, y, u', v' refers to the chromaticity coordinates defined by the CIE.

C.2 White Reference

Table C.2 – Chromaticity Coordinates of White Reference

	x	y	u'	v'
White Reference	0.3140	0.3510	0.2001	0.4730

x, y, u', v' refers to the chromaticity coordinates defined by the CIE.

C.3 Brightness

The Reference White Level is 48 cd/m^2 or 14.00 fL.

C.4 Color Conversion to *XYZ*

Color conversion from R'G'B' to *X'Y'Z'* requires a three-step process which involves linearizing the color-corrected R'G'B' signals (by applying a 2.6 gamma function), followed by their passage through a linear 3x3 transform matrix. The resultant linearized and coded XYZ signals are then given an inverse 2.6 gamma transfer characteristic whose output is quantized to 12 bits.

The transfer function of the Reference Projector is specified to be Gamma 2.6 (explicitly) and that the actual coefficients of the color transform matrices depend on the color primaries of the Mastering Projector (encoding side) and the Cinema Projector (decoding side), and their respective white points.

The processing steps for converting the R'G'B' code values (which range from 0 to 4095) of the color-graded master to device-independent *X'Y'Z'* are shown below. This color space conversion can be implemented within the color corrector or applied in a separate batch process. First, the R'G'B' data is linearized by applying a simple gamma 2.6 transfer function:

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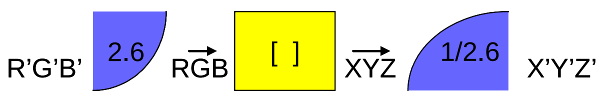
$$R = \left(\frac{R'}{4095} \right)^{2.6}$$, and likewise for G and B.

The output (RGB) of this linearization is a floating point number that ranges from 0 to 1.0. The 3x3 linear matrix is then applied to this signal, resulting in another linear XYZ signal with floating point values that range from 0 to 1.0. To minimize quantization errors, this matrix should be implemented as a floating point calculation. The matrix is shown here to 10 significant digits, as suggested by SMPTE RP 177.



$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{pmatrix} 0.4451698156 & 0.2771344092 & 0.1722826698 \\ 0.2094916779 & 0.7215952542 & 0.0689130679 \\ 0.0000000000 & 0.0470605601 & 0.9073553944 \end{pmatrix} * \begin{bmatrix} R_{DC} \\ G_{DC} \\ B_{DC} \end{bmatrix}$$

Finally, the *X'Y'Z'* encoding transfer function is defined by the following expression. This equation does not compensate for the screen black level, so it represents a relative encoding of the luminance values above the screen black level.[10] In this expression, X is a floating point number between 0 and 1.0, L is the Reference White Luminance and the output $CV_{X'}$ is an integer ranging between 0 and 4095[11].

$$CV_{X'} = INT\left[4095 * \left(\frac{X * L}{52.37} \right)^{1/2.6} \right]$$, and likewise for Y and Z

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[10] A more rigorous equation that describes the absolute on-screen luminance in the mastering environment is given by the following expression, where Screen Black Level (SBL) represents the black level measured off of the screen. In practice, this equation is only used if the exhibition projector wants to attempt tone mapping, and if the mastering screen black level is provided in metadata.

$$CV_{X'} = INT\left[4095 * \left(\frac{(X * L) - SBL_X}{52.37} \right)^{1/2.6} \right]$$, and likewise for Y and Z.

[11] The INT operator returns the value of 0 for fractional parts in the range of 0 to 0.4999... and +1 for fractional parts in the range 0.5 to 0.9999..., i.e. it rounds down fractions less than 0.5 and rounds up fractions at or above 0.5. L is the reference luminance of the projector white as defined by SMPTE 431-1 Standard for D-Cinema Exhibition -- Screen Luminance Level, Chromaticity and Uniformity. At the time of writing this Recommended Practice the value of L is 48."

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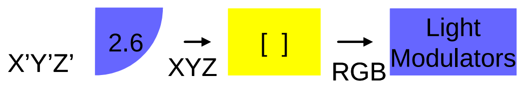
The inverse *X'Y'Z'*-to-RGB processing steps for a Digital Cinema Projector with the same color primaries as the Reference Projector (subscript DC) are shown below, where the projector transfer function is a pure 2.6 gamma power law as defined in Section 7.9.[12]



$$\begin{bmatrix} R_{DC} \\ G_{DC} \\ B_{DC} \end{bmatrix} = \begin{pmatrix} 2.7254 & -1.0180 & -0.4402 \\ -0.7952 & 1.6897 & 0.0226 \\ 0.0412 & -0.0876 & 1.1009 \end{pmatrix} * \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

[12] To rigorously reproduce the image as displayed in the mastering room, the best practice is that the exhibition projector compensate for the difference between the screen black level in mastering and its own screen black level. Initial testing has shown that this compensation can result in undesirable clipping of some black detail when pictures are displayed on a lower contrast exhibition projector, and that in fact, the simple power law provides a natural (and forgiving) result.

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Annex D   Bibliography (Informative)

SMPTE ST 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920 × 1080 and 2048 × 1080 Picture Formats

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