Adobe® RGB (1998) Color Image Encoding

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Specification of the Adobe® RGB (1998) color image encoding

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Introduction

The Adobe® RGB (1998) color image encoding is defined by Adobe Systems to meet the demands for an RGB working space suited for print production.

This document has been developed in response to industry needs for a specification of the Adobe RGB (1998) color image encoding. With the Adobe RGB (1998) color image encoding, users can represent digital images in a color space larger than typical CRT monitors, without using overranged RGB values. This color space is well suited for professional and consumer digital photography applications.

The Adobe RGB (1998) color image encoding was first introduced with Adobe Photoshop® 5.0.2 in November 1998. The Adobe RGB (1998) color image encoding has a color gamut that is larger than sRGB (IEC 61966–2.1) and encompasses typical press gamuts. The Adobe RGB (1998) color image encoding is designed to be suited for display and print production with a broad range of colors.

This version of Adobe RGB (1998) captures previously undocumented details of the Adobe RGB (1998) color image encoding that were evident only in implementations made by Adobe Systems. The specification is in response to growing adoption and inquiries and is presented in an effort to insure broad interoperability. It is fully backwards compatible with earlier implementations and ICC profiles for the Adobe RGB (1998) color image encoding.

The Adobe RGB (1998) Color Image Encoding

1 Scope

This document specifies an output-referred RGB color encoding named Adobe RGB (1998) to be used for digital exchange of Adobe RGB (1998)-encoded color data.

2 References

The following standards and specifications are referenced in this text.

ANSI C78.376-2001 Specifications for the chromaticity of fluorescent lamps

BBC RD 1995/10, Roberts, Eng: A method for the calculation of tolerances for display primary chromaticity coordinates

CIE Publication 15.2-1986, Colorimetry, Second Edition

EBU Tech. 3213-E: EBU standard for chromaticity tolerances for studio monitors

ICC Profile Format Specification, Version 3.4,1997

ICC.1:2001-04, File Format for Color Profiles

ICC.1:2004-10, File Format for Color Profiles

IEC 61966-2-1, Multimedia systems and equipment - Colour measurement and management - Part 2.1: Colour management in multimedia systems - Default RGB colour space - sRGB

ISO 22028-1:2004, Photography and graphic technology – Extended colour encodings for digital image storage, manipulation and interchange

ISO 3664:2000, Viewing conditions – Graphic technology and photography

PDF Reference: Adobe Portable Document Format

3 Terms and definitions

The following terms and definitions are used in this document.

NOTE Most terms are derived from ISO 22028-1 or ISO 3664.

3.1 adapted white

Color stimulus that an observer who is adapted to the viewing environment would judge to be perfectly achromatic and to have a luminance factor of unity; i.e., absolute colorimetric coordinates that an observer would consider to be a perfect white diffuser

NOTE The adapted white may vary within a scene.

3.2 additive RGB color space

A colorimetric color space having three color primaries (generally red, green and blue) such that CIE XYZ tristimulus values can be determined from the RGB color space values by forming a weighted combination of the CIE XYZ tristimulus values for the individual color primaries, where the weights are proportional to the radiometrically linear color space values for the corresponding color primaries

3.3 color component transfer function

Single variable, monotonic mathematical function applied individually to one or more color channels of a color space

3.4 color encoding

A generic term for a quantized digital encoding of a color space, encompassing both color space encodings and color image encodings

3.5 color gamut

Solid in a color space, consisting of all those colors that are either: present in a specific scene, artwork, photograph, photomechanical, or other reproduction; or capable of being created using a particular output device and/or medium

3.6 color image encoding

Digital encoding of the color values for a digital image, including the specification of a color space encoding, together with any information necessary to properly interpret the color values such as the image state, the intended image viewing environment and the reference medium

3.7 color space

Geometric representation of colors in space, usually of three dimensions

[CIE Publication 17.4, 845-03-25]

3.8 color space encoding

Digital encoding of a color space, including the specification of a digital encoding method, and a color space value range

3.9 color space white point

Color stimulus to which color space values are normalized

NOTE The color space white point may or may not correspond to the assumed adapted white point and/or the reference medium white point for a color image encoding.

3.10 ICC profile

International Color Consortium's file format, used to store transforms from one color encoding to another, e.g. from device color coordinates to profile connection space, as part of a color management system

3.11 image state

Attribute of a color image encoding indicating the rendering state of the image data

3.12 International Color Consortium profile connection space (ICC PCS)

Standard color image encoding defined by the International Color Consortium providing a standard connection point for combining ICC profiles

3.13 medium black point

Neutral color with the lowest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

3.14 medium white point

Neutral color with the highest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

3.15 output-referred image state

Image state associated with image data that represents the color-space coordinates of the elements of an image that has undergone color rendering appropriate for a specified real or virtual output device and viewing conditions

NOTE 1 When the phrase "output-referred" is used as a qualifier to an object, it implies that the object is in an output-referred image state. For example, output-referred image data is image data in an output-referred image state.

NOTE 2 Output referred image data is referred to the specified output device and viewing conditions. A single scene can be color rendered to a variety of output-referred representations depending on the anticipated output viewing conditions, media limitations, and/or artistic intents.

NOTE 3 Output-referred image data may become the starting point for a subsequent reproduction process. For example, sRGB output-referred image data is frequently considered the starting point for the color re-rendering performed by a printer designed to receive sRGB image data.

3.16 surround

Area adjacent to the border of an image, which, upon viewing the image, may affect the local state of adaptation of the eye

3.17 tristimulus value

Amounts of the three reference color stimuli, in a given trichromatic system, required to match the color of the stimulus considered

[CIE Publication 17.4, 845-03-22]

3.18 veiling glare

Light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

NOTE 1 Veiling glare lightens and reduces the contrast of the darker parts of an image.

NOTE 2 In CIE 122, the veiling glare of a CRT display is referred to as ambient flare.

3.19 viewing flare

Veiling glare that is observed in a viewing environment but not accounted for in radiometric measurements made using a prescribed measurement geometry

NOTE The viewing flare is expressed as a percentage of the luminance of adapted white.

4 Requirements

4.1 General

The Adobe RGB (1998) color image encoding is defined as an encoding of the color *appearance* of an image that is being displayed on a *reference* color monitor in a *reference* viewing environment.

NOTE The intended color appearance can be reproduced exactly on a physical device in an actual viewing environment, only when the actual viewing environment exactly matches the reference viewing environment. See Annex B for recommended tolerances for viewing Adobe RGB (1998)-encoded data in an actual viewing environment.

4.2 Reference Viewing Environment

The following reference viewing conditions define the reference viewing environment for the Adobe RGB (1998) color image encoding. They are based on conditions for appraisal of images displayed on color monitors as specified in section 4.5 in ISO 3664:2000. These specifications are applicable for images viewed independently of any form of hardcopy; they are not designed for direct comparison between hardcopy and softcopy.

4.2.1 Reference Display White Point

The chromaticity coordinates of white displayed on the reference color monitor shall be x=0.3127, y=0.3290.

NOTE The chromaticity coordinates correspond to CIE Standard Illuminant D65.

The luminance level of white displayed on the reference color monitor shall be 160.00 cd/m^2

The corresponding absolute XYZ_W tristimulus values for the reference display white point are X_W = 152.07, Y_W = 160.00, Z_W = 174.25.

4.2.2 Reference Display Black Point

The reference display black point shall have the same chromaticity as the reference display white point, and a luminance equal to 0.34731% of the reference display white point luminance.

The corresponding luminance of the reference display black point is 0.5557 cd/m^2.

The corresponding absolute XYZ_K tristimulus values for the reference display black point are X_K = 0.5282, Y_K = 0.5557, Z_K=0.6052.

Residual monitor emissions and veiling glare in the reference viewing environment are included in the reference display black point luminance value, while viewing flare is not included.

4.2.3 Contrast Ratio

The contrast ratio shall be the ratio of reference display white point luminance over reference display black point luminance, (Y_W / Y_K), which is 287.9.

NOTE The ratio Y_W / Y_K of 287.9 matches the linear dynamic range specified for the reference medium in ICC.1:2004-10, section D.1.5.

4.2.4 Adapted White Point

The adapted white point is assumed equal to the reference display white point.

4.2.5 Ambient Illumination

When measured, with the monitor turned off, at the monitor faceplate, the ambient illumination level shall be equal to 32 lx. When measured, with the monitor turned off, in any plane between the monitor and the observer, the ambient illumination level shall be within the range of 16 to 64 lx. The ambient illumination shall have the same chromaticity as the white point of the display.

4.2.6 Reference Display Surround

The area immediately surrounding the displayed image may affect the local state of adaptation of the eye upon viewing the image. This surround shall be a neutral gray, of the same chromaticity as the reference display white point. The surround shall extend at least two degrees from the edge of the image in all directions. Its luminance shall be 20% of the reference display white point, that is, 32.00 cd/m^2.

NOTE A surround level of 20% of display white cannot be achieved solely using the ambient illumination specified above. The surround near the image needs to be emissive. If the monitor is equipped with a hood, the ambient illumination of the extended surround outside the hood can be kept higher than the ambient illumination at the monitor faceplate, possibly enabling the use of a reflective extended surround.

4.2.7 Image Size and Viewing Distance

The normal to the center of the display faceplate shall be the viewer's direction of gaze.

The viewing distance shall be equal to the image diagonal, or longest chord.

NOTE From the viewer's position, the image extends 27 degrees from the normal to the display faceplate.

4.2.8 Glare

The veiling glare in the reference viewing environment shall be included in the display black point, as would result from measurement of the display from the viewer position in the reference viewing environment. Viewing flare that may result in viewing conditions different from the reference viewing conditions shall not be included.

NOTE When positioning a display in a viewing environment, it is important to arrange the ambient lighting so that specular reflections off the display faceplate, as seen from the viewer position, are avoided. This can usually be achieved by placing ambient light sources at an angle of at least 45 degrees relative to the normal to the display faceplate, which is assumed to be the viewer's direction of gaze.

4.2.9 Measurements

All illuminance or luminance measurements shall be made with a photometer having the spectral sensitivity of the CIE standard photopic photometric observer, $V(\lambda)$, and measuring an area having a diameter no greater than 1/20 of the shortest linear dimension of the illuminated surface area.

All chromaticity values shall be based on the CIE 1931 two-degree standard observer. See CIE Publication 15.2

Display measurements shall be performed in the reference viewing environment.

The use of telespectroradiometers or telecolorimeters for display measurement from the viewer position is recommended, as they include allowance for any veiling glare present, and therefore provide an accurate representation of the color as perceived by the viewer. Where such instruments are not available, and measurements are made in contact with the face of the display, the veiling glare should be measured from the viewer position and used to correct the measurement data obtained.

NOTE 1 Care should be taken when making measurements of displays to ensure that the sampling frequency, or integration time, of the instrument used is synchronized with the frequency of scanning of the display. If not, at least 10 measurements should be taken and averaged.

NOTE 2 Since the prescribed display measurement conditions are the reference viewing conditions, any veiling glare present will be included in the measurements, while viewing flare (additional veiling glare) is not included in measurements or the reference viewing conditions.

4.3 Adobe RGB (1998) Color Image Encoding

4.3.1 The Adobe RGB (1998) Color Space And Color Image Encoding

The Adobe RGB (1998) color space is an additive RGB color space defined by a set of additive primaries, a white point, a black point, and a color component transfer function.

NOTE The reference color monitor is not required to be an additive RGB device.

4.3.1.1 Color space chromaticities and luminance

The chromaticity coordinates for the color space primaries and white point shall be as follows:

Red	x=0.6400, y=0.3300
Green	x=0.2100, y=0.7100
Blue	x=0.1500, y=0.0600
White	x=0.3127, y=0.3290

The color space white point shall be equal to the reference display white point.

The color space black point shall be equal to the reference display black point.

4.3.1.2 The inverse color component transfer function

The inverse color component transfer function defines the conversion from color component values to radiometrically linear values.

The inverse color component transfer function shall be a simple power-law function using a gamma value of 2.19921875, defined as follows:

$$R = R'^{\,2.19921875},\ G = G'^{\,2.19921875},\ B = B'^{\,2.19921875} \qquad (1)$$

The value 2.19921875 is obtained from $2\frac{51}{256}$, or hexadecimal 02.33

NOTE The transfer function does not include a linear segment.

4.3.1.3 Color Space Encodings

The value range for Adobe RGB (1998) color space component values shall be [0, 1].

The color component values shall be encoded using integer or floating-point encodings.

Integer encodings shall be unsigned with 8 or 16 bits per component with the same number of bits for all three components. The R', G', B' component value range [0, 1] shall be encoded over the code value range [0, max integer value]. R', G', B' code values of 0, 0, 0 shall represent the color space black point, and max integer code values shall represent the color space white point.

For integer encodings, all code values shall be within the color space gamut.

Floating-point encodings shall be 32 bit per component using the floating point encoding defined for the applicable image format. If no such encoding format is defined, then use IEEE 754-1985. In floating-point encodings, a component value and its encoding value are the same. Code values 0.0, 0.0, 0.0 shall represent the color space black point, and code values 1.0, 1.0, 1.0 shall represent the color space white point. Component values outside the range [0, 1] are not allowed for floating-point encodings.

4.3.1.4 Image state

The image state of the Adobe RGB (1998) color image encoding shall be output-referred as defined in ISO 22028-1:2004.

4.3.2 Normalizing absolute XYZ tristimulus values

4.3.2.1 Obtaining tristimulus values

The CIE XYZ tristimulus values shall be those of the image as viewed on the reference display by the reference observer in the reference viewing environment.

Absolute luminance $X_aY_aZ_a$ tristimulus values shall be obtained as specified in section 4.2.9 Measurements

4.3.2.2 Normalizing absolute XYZ tristimulus values

Normalized XYZ image tristimulus values shall be obtained from absolute luminance $X_aY_aZ_a$ tristimulus values as follows, using the reference display white point and black point values.

$$X = \frac{(X_a - X_K)}{(X_W - X_K)} \frac{X_W}{Y_W}$$

$$Y = \frac{(Y_a - Y_K)}{(Y_W - Y_K)}$$

$$Z = \frac{(Z_a - Z_K)}{(Z_W - Z_K)} \frac{Z_W}{Y_W}$$

The normalized XYZ tristimulus values 0.0000, 0.0000, 0.0000 correspond to the reference display black point. The normalized XYZ tristimulus values 0.9505, 1.0000, 1.0891 correspond to the reference display white point.

4.3.3 Converting from normalized XYZ to absolute XYZ tristimulus values

The normalized XYZ tristimulus values 0.0000, 0.0000, 0.0000 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0.9505, 1.0000, 1.0891 shall correspond to the reference display white point.

4.3.3.1 Obtaining absolute XYZ tristimulus values

Absolute luminance $X_aY_aZ_a$ tristimulus values shall be obtained from normalized XYZ tristimulus values as follows, using the reference display white point and black point values.

$$X_a = X(X_W - X_K)\frac{Y_W}{X_W} + X_K$$

$$Y_a = Y(Y_W - Y_K) + Y_K$$

$$Z_a = Z(Z_W - Z_K)\frac{Y_W}{Z_W} + Z_K$$

The absolute XYZ tristimulus values $X_aY_aZ_a$ are those of the image as viewed on the reference display by the reference observer in the reference viewing environment.

4.3.4 Encoding an image in 24-bit Adobe RGB (1998) color image encoding

An image's normalized XYZ tristimulus values shall be encoded in 24-bit Adobe RGB (1998) color image encoding as specified in this section 4.3.4.

The normalized XYZ tristimulus values 0.0000, 0.0000, 0.0000 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0.9505, 1.0000, 1.0891 shall correspond to the reference display white point.

4.3.4.1 Converting normalized XYZ to RGB tristimulus values

The normalized XYZ tristimulus values shall be converted to R, G, B tristimulus values as follows:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 2.04159 & -0.56501 & -0.34473 \\ -0.96924 & 1.87597 & 0.04156 \\ 0.01344 & -0.11836 & 1.01517 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

R, G, B tristimulus values with all component values within the range [0, 1] shall be within the color gamut of the Adobe RGB (1998) color image encoding.

NOTE The above matrix is derived from the color space chromaticity coordinates.

4.3.4.2 Applying the color component transfer function

The R, G, B tristimulus values shall be converted to Adobe RGB (1998) component values R', G', B' as follows:

$$R' = R^{\frac{1}{2.19921875}},\ G' = G^{\frac{1}{2.19921875}},\ B' = B^{\frac{1}{2.19921875}}$$

The resulting Adobe RGB (1998) component values R', G', B' shall be represented in floating point encodings or integer encodings.

4.3.4.3 Encoding Adobe RGB (1998) component values as integers

Adobe RGB (1998) component values may be encoded in integer encodings, using 8 or 16 bits per component.

When such encodings are used, the Adobe RGB (1998) component values R', G', B' shall be encoded as R'_8, G'_8, B'_8 8-bit channels in 24-bit Adobe RGB (1998) color image encoding as follows:

$$R'_8 = Round(255R')$$
$$G'_8 = Round(255G')$$
$$B'_8 = Round(255B')$$

For Adobe RGB (1998) color image encodings using integer encodings with number of bits per component (N) other than eight, 255 in above formulas shall be replaced with (2^N-1).

4.3.5 Decoding 24-bit Adobe RGB (1998) to XYZ (D65) values

An image encoded in 24-bit Adobe RGB (1998) color image encoding shall be decoded into normalized XYZ tristimulus values as specified in this section 4.3.5.

The conversion from Adobe RGB (1998) color image encoding to normalized XYZ shall be the inverse of the conversion from normalized XYZ to Adobe RGB (1998) color image encoding that was given in section 4.3.4.

4.3.5.1 Decoding integers to Adobe RGB (1998) component values

The three R'_8, G'_8, B'_8 8-bit channel values in 24-bit Adobe RGB (1998) color image encoding shall be assumed to be unsigned integers and shall be converted to Adobe RGB (1998) component values R', G', B' as follows:

$$R' = \frac{R'_8}{255},\ G' = \frac{G'_8}{255},\ B' = \frac{B'_8}{255}$$

For Adobe RGB (1998) color image encodings using integer encodings with number of bits per component (N) other than eight, 255 in above formulas shall be replaced with (2^N-1).

4.3.5.2 Inverting the color component transfer function

Adobe RGB (1998) component values R', G', B' of range [0, 1] shall be converted to R, G, B tristimulus values of range [0, 1] as follows:

$$R = R'^{\,2.19921875},\ G = G'^{\,2.19921875},\ B = B'^{\,2.19921875}$$

4.3.5.3 Converting RGB to normalized XYZ values

The R, G, B tristimulus values shall be converted to XYZ tristimulus values as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.57667 & 0.18556 & 0.18823 \\ 0.29734 & 0.62736 & 0.07529 \\ 0.02703 & 0.07069 & 0.99134 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

NOTE The matrix is derived from the color space chromaticity coordinates.

The normalized XYZ tristimulus values 0.0000, 0.0000, 0.0000 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0.9505, 1.0000, 1.0891 shall correspond to the reference display white point.

4.3.6 Encoding ICC PCS Version 2 values in 24-bit Adobe RGB (1998)

An image in the ICC Profile Connection Space defined in ICC.1:2001-04 (Profile version 2.4) shall be encoded in 24-bit Adobe RGB (1998) color image encoding as specified in this section 4.3.6.

The ICC profile specification ICC.1:2001-04 (Profile version 2.4) defines a Profile Connection Space (PCS). This space is the interface, which provides an unambiguous connection between input and output profiles. The profile connection space is based on the CIE 1931 standard observer. The profile connection space is defined as the CIE colorimetry, which will produce the desired color appearance if rendered on a reference imaging media and viewed in a reference viewing environment. This reference corresponds to an ideal reflection print viewed in an ANSI standard viewing booth. The default measurement parameters for the profile connection space are based on the ANSI CGATS.5-1993 standard, “Graphic technology - Spectral measurement and colorimetric computation for graphic arts images.” Essentially this defines a standard illuminant of D50, the 1931 CIE standard observer, and 0/45 or 45/0 reflectance measurement geometry. The reference viewing condition is ISO 3664 viewing condition P2 using the recommended 20% surround reflectance. This is a graphics arts and photography print viewing environment with a D50 illumination level of 500 lux.

It is necessary to adapt the measured colorimetry to that appropriate for the profile connection space. These adaptations account for such differences as white point chromaticity and luminance relative to an ideal reflector, maximum density, viewing surround, viewing illuminant, and flare.

No re-rendering or brightness adaptation color appearance transform is used in the conversion between Adobe RGB (1998) and the above ICC Profile Connection Space.

NOTE This section does not cover conversion to or from the Profile Connection Space (PCS) defined in ICC profile specification ICC.1:2004 (Profile version 4.2), as this differs from specification ICC.1:2001-04. See section 4.3.8.

4.3.6.1 Converting XYZ to RGB tristimulus values

The XYZ tristimulus values 0.0000, 0.0000, 0.0000 in the Profile Connection Space ($XYZ_{PCS\ v2}$) shall correspond to the reference display black point. The XYZ tristimulus values 0.9642, 1.000, 0.8249 shall correspond to the reference display white point.

The XYZ tristimulus values shall be converted to R, G, B tristimulus values as follows:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.96253 & -0.61068 & -0.34137 \\ -0.97876 & 1.91615 & 0.03342 \\ 0.02869 & -0.14067 & 1.34926 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

The component values of the R, G, B tristimulus values shall be clipped to the range [0, 1].

NOTE The above matrix is derived from the color space chromaticity coordinates, and a chromatic adaptation to CIE Standard Illuminant D50, using the Bradford matrix as specified in the ICC.1 specification, rounded off to the s15.16 binary format used in ICC profiles, then inverted.

4.3.6.2 Applying the color component transfer function

The R, G, B tristimulus values shall be converted to Adobe RGB (1998) component values R', G', B' as follows:

$$R' = R^{\frac{1}{2.19921875}},\ G' = G^{\frac{1}{2.19921875}},\ B' = B^{\frac{1}{2.19921875}}$$

The Adobe RGB (1998) component values R', G', B' may be represented in floating point encodings or integer encodings.

4.3.6.3 Encoding Adobe RGB (1998) component values as integers

Adobe RGB (1998) component values may be encoded in integer encodings, using 8 or 16 bits per component.

When such encodings are used, the Adobe RGB (1998) component values R', G', B' shall be encoded as R'_8, G'_8, B'_8 8-bit channels in 24-bit Adobe RGB (1998) color image encoding as follows:

$$R'_8 = Round(255R')$$
$$G'_8 = Round(255G')$$
$$B'_8 = Round(255B')$$

For Adobe RGB (1998) color image encodings using integer encodings with number of bits per component (N) other than eight, 255 in above formulas shall be replaced with (2^N-1).

4.3.7 Decoding 24-bit Adobe RGB (1998) to ICC PCS Version 2 values

An image encoded in 24-bit Adobe RGB (1998) color image encoding shall be decoded into the ICC Profile Connection Space as specified in this section 4.3.7.

The decoding from Adobe RGB (1998) color image encoding to the Profile Connection Space shall be the inverse of the encoding of the Profile Connection Space in Adobe RGB (1998) that was given in 4.3.6.

4.3.7.1 Decoding integers to Adobe RGB (1998) component values

The three R'_8, G'_8, B'_8 8-bit channel values in 24-bit Adobe RGB (1998) color image encoding shall be assumed to be unsigned integers and shall be converted to Adobe RGB (1998) component values R', G', B' as follows:

$$R' = \frac{R'_8}{255},\ G' = \frac{G'_8}{255},\ B' = \frac{B'_8}{255}$$

For Adobe RGB (1998) color image encodings using integer encodings with number of bits per component (N) other than eight, 255 in above formulas shall be replaced with (2^N-1).

4.3.7.2 Inverting the color component transfer function

Adobe RGB (1998) component values R', G', B' of range [0, 1] shall be converted to R, G, B tristimulus values of range [0, 1] as follows:

$$R = R'^{\ 2.19921875},\ G = G'^{\ 2.19921875},\ B = B'^{\ 2.19921875}$$

4.3.7.3 Converting to ICC CIEXYZ PCS values

The R, G, B tristimulus values shall be converted to $XYZ_{PCS\ v2}$ tristimulus values as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.60974 & 0.20528 & 0.14919 \\ 0.31111 & 0.62567 & 0.06322 \\ 0.01947 & 0.06087 & 0.74457 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The resulting $XYZ_{PCS\ v2}$ tristimulus values 0.0000, 0.0000, 0.0000 shall correspond to the reference display black point. The $XYZ_{PCS\ v2}$ tristimulus values 0.9642, 1.000, 0.8249 shall correspond to the reference display white point.

NOTE The above matrix is as defined in the Adobe RGB (1998) profile created in 1998. It was derived from the color space chromaticity coordinates, and a chromatic adaptation to CIE Standard Illuminant D50, using the Bradford matrix as specified in the ICC.1 specification, rounded off to the s15.16 binary format used in ICC profiles.

4.3.8 Encoding and decoding ICC PCS Version 4 values

An image in the ICC Profile Connection Space defined in ICC.1:2004 (Profile version 4.2) using the media-relative colorimetric rendering intent shall be encoded in 24-bit Adobe RGB (1998) color image encoding as specified in this section 4.3.8.

4.3.8.1 Encoding PCS Version 4 in 24-bit Adobe RGB (1998)

The XYZ_{P4} tristimulus values 0.0033488, 0.0034731, 0.0028650 in the Profile Connection Space ($XYZ_{PCS\ v4}$) shall correspond to the reference display black point.

The XYZ_{P4} tristimulus values 0.9642, 1.000, 0.8249 shall correspond to the reference display white point.

NOTE 1 / 0.0034731 is equal to the Contrast Ratio specified in 4.2.3

The XYZ_{P4} tristimulus values shall be normalized, such that the normalized XYZ tristimulus values 0.0000, 0.0000, 0.0000 shall correspond to the reference display black point, as follows:

$$X = \frac{(X_{P4} - X_{PK})}{(X_{PW} - X_{PK})} X_{PW}$$

$$Y = \frac{(Y_{P4} - Y_{PK})}{(Y_{PW} - Y_{PK})} Y_{PW}$$

$$Z = \frac{(Z_{P4} - Z_{PK})}{(Z_{PW} - Z_{PK})} Z_{PW}$$

where XYZ_{PK} = 0.0033488, 0.0034731, 0.0028650 and XYZ_{PW} = 0.9642, 1.000, 0.8249.

The normalized XYZ tristimulus values shall be converted to 24-bit Adobe RGB (1998) values as specified in section 4.3.6 Encoding ICC PCS Version 2 values in 24-bit Adobe RGB (1998).

4.3.8.2 Decoding 24-bit Adobe RGB (1998) to PCS Version 4

24-bit Adobe RGB (1998) values shall be converted to normalized XYZ tristimulus values as specified in section 4.3.7 Decoding 24-bit Adobe RGB (1998) to ICC PCS Version 2 values.

The normalized XYZ tristimulus values shall be converted to XYZ_{P4} tristimulus values as follows:

$$X_{P4} = X\left(1 - \frac{X_{PK}}{X_{PW}}\right) + X_{PK}$$

$$Y_{P4} = Y\left(1 - \frac{Y_{PK}}{Y_{PW}}\right) + Y_{PK}$$

$$Z_{P4} = Z\left(1 - \frac{Z_{PK}}{Z_{PW}}\right) + Z_{PK}$$

where XYZ_{PK} = 0.0033488, 0.0034731, 0.0028650 and XYZ_{PW} = 0.9642, 1.000, 0.8249.

The XYZ_{P4} tristimulus values 0.0033488, 0.0034731, 0.0028650 in the Profile Connection Space ($XYZ_{PCS\ v4}$) shall correspond to the reference display black point. The XYZ_{P4} tristimulus values 0.9642, 1.000, 0.8249 shall correspond to the reference display white point.

5 Indicating the use of Adobe RGB (1998) color image encoding

For compliance with this specification the use of the Adobe RGB (1998) color image encoding shall be specified by using the Adobe RGB (1998) ICC profile.

Many image file formats include means to indicate the method used for encoding an image. The Adobe RGB (1998) ICC profile, specified in Annex A, shall be used to indicate the use of the Adobe RGB (1998) color image encoding. For this purpose, the Adobe RGB (1998) ICC profile shall be embedded in PDF, PICT, EPS, TIFF, JFIF, JPEG, and GIF files.

ICC.1:2004-10 specifies how to embed ICC profiles in PICT, EPS, TIFF, JFIF (and JPEG) and GIF files.

The PDF Reference, version 1.3 or later, specifies how to use ICCBased Color Spaces to embed ICC profiles. In addition, when the Output Intent of a PDF file is the Adobe RGB (1998) color image encoding, the OutputConditionIdentifier shall be Adobe RGB (1998) including spaces and parentheses. CalRGB Color Spaces should not be used for Adobe RGB (1998) color image encodings in PDF files, as CalRGB cannot store a name for the color image encoding.

Annex A. The Adobe RGB (1998) ICC profile (Informative)

The Adobe RGB (1998) ICC profile from Adobe Systems is an instance of the Adobe RGB (1998) color image encoding. It is included with several applications from Adobe Systems. The profile and a license agreement can also be downloaded from http://www.adobe.com/support/downloads/main.html

The Adobe RGB (1998) ICC profile is constructed as follows, using the ICC Profile Format Specification, Version 3.4,1997.

Specific header fields shall be set as follows:

Preferred CMM = ADBE

Specification version = 2.1.0

Profile class = mntr

Color space = RGB

PCS space = XYZ

PCS Illuminant = f6d6, 10000, d32d (all values are hexadecimal)

The ASCII part of the desc tag shall be set to Adobe RGB (1998)

The cprt tag shall include Copyright Adobe Systems

The rXYZ tag shall be set to 9c18, 348d, 2631

The gXYZ tag shall be set to 4fa5, a02c, 102f

The bXYZ tag shall be set to 04fc, 0f95, be9c

The wtpt tag shall be set to f351, 10000, 116cc

The rTRC, gTRC, bTRC tags shall specify a gamma curve using a gamma value of 0233

Other required fields shall be set according to the ICC profile specification.

Annex B. Practical tolerances for viewing Adobe RGB (1998)-encoded data (Informative)

No tolerances are specified in Adobe RGB (1998) Color Image Encoding, Section 4, as Section 4 defines the reference conditions for Adobe RGB (1998). This informative section provides tolerances for practical construction of display systems.

It is important to make a distinction between the Adobe RGB (1998) Color Image Encoding as a reference encoding and any physical device approximating this encoding. As a reference encoding, the Adobe RGB (1998) Color Image Encoding is exact, with no tolerances or variations in color appearance. However, physical devices will usually exhibit variations from an ideal design specification for any number of reasons. Thus, an Adobe RGB (1998)-compatible device is one that sufficiently approximates the reference Adobe RGB (1998) Color Image Encoding within acceptable tolerances so that users may approximate an accurate view of Adobe RGB (1998) encoded images. Given this, an Adobe RGB (1998) encoded image when viewed across a range of devices, all within accepted tolerances, may appear slightly different on each device. Of course, the most accurate color reproduction occurs when devices exactly match the reference. The below information is provided as guidance to device manufacturers by specifying tolerances that should provide users with acceptable views. Manufacturers are encouraged to match the reference as closely as possible.

The recommended tolerances in this section are applicable to real display systems to be used for evaluation of the color quality of Adobe RGB (1998) encoded digital files. A display system includes a display and optionally a graphics card, a software driver, or other support systems. If these tolerances are met by a display system and its viewing environment, the color appearance of Adobe RGB (1998) encoded images appropriately presented and viewed on the display should be sufficiently accurate to allow for evaluation of their quality for most applications. However, it should be noted that the user ultimately judges the acceptability of an image for a specific use. For some cases, these tolerances will be either insufficiently or overly restrictive. Many practical workflows utilize previews on displays that do not meet these tolerances, but are nevertheless adequate for the use case. It is also possible, if the desired end result is reflection hardcopy, that no display preview will be sufficient for critical evaluation. In this case, a hardcopy proof should be produced.

The tolerance values below assume that the display system has been color calibrated for the actual viewing environment.

Parameter	***Tolerances for viewing Adobe RGB (1998)-encoded data on a calibrated display system***
Display White Point	The white point luminance should be within the range 125 to 200 cd/m^2. It is assumed that rerendering will be required for luminance levels outside this range. The white point chromaticity should have u', v' chromaticity coordinates within the radius of 0.005 of the reference display white point in the CIE 1976 u' v' Uniform Chromaticity Scale (UCS) diagram. This is slightly larger than the 4-step MacAdam ellipse specified in ANSI C78.376-2001 Specifications for the chromaticity of fluorescent lamps.
Contrast Ratio	The contrast ratio should be within the range 230 : 1 to 400 : 1.
Display Black Point	The black point luminance level is limited only by the above restrictions on the display white point luminance and contrast ratio. The black point chromaticity should not be noticeably different from the white point chromaticity.
Color space chromaticities	The chromaticity coordinates for the display primaries should be within the limits specified in E.B.U. Standard for Chromaticity Tolerances for Studio Monitors, Tech. 3213-E, amended as follows: The limits for the green primary shall be transposed by the coordinate difference between the Adobe RGB (1998) green primary and the EBU green primary. Alternately, the chromaticity coordinates for the display primaries should be within the limits proposed in BBC RD 1995/10, Roberts, Eng, A method for the calculation of tolerances for display primary chromaticity coordinates, amended as above.
Gamma of the inverse color component transfer function	The gamma value should be within the range 2.190 to 2.210 for the individual color components and for the neutral axis.
Ambient Illumination Level	The ambient illuminance level should be limited by the above restrictions on the black point luminance level. The level of ambient illumination needs to be significantly lower than the luminance level of the monitor white point. This is partly to ensure that the observer is reasonably adapted to the monitor but primarily to ensure that the effects of veiling glare do not significantly reduce the full contrast range of the monitor. An illuminance level higher than the reference level can be used with a display with lower residual emission and/or lower faceplate reflectance than implied in the reference conditions.
Ambient Illumination Chromaticity	The ambient illuminance chromaticity should be limited by the above tolerances for the black point chromaticity. The ambient illumination chromaticity may be D65 to D50, if the black point chromaticity is kept within above tolerances. The chromaticity of the ambient illumination affects the chromaticity of the black point through veiling glare.
Display Surround	The luminance of the border can be lower than 20% when this does not measurably affect the viewer's adapted state.

Annex C. Implementation notes (Informative)

Slope limits in a color converter

Many color converters and products impose slope limits on gamma curves found in the rTRC, gTRC, and bTRC tags of ICC profiles. For an arbitrary slope limit of x (where $x < 1$), the effective gamma curve as used in the color converter has a slope of x or greater.

When used with the Adobe RGB (1998) ICC profile, the slope limit should not be greater than 1/32. A slope limit of 1/32 affects 8-bit integer values 1 to 14.

At the time of writing, the Adobe color conversion engine, ACE, included with Adobe Photoshop and other products from Adobe Systems, imposes a slope limit of 1/32. The effective inverse transfer function for Adobe RGB (1998) when used with ACE thus becomes:

$$C = Max\left(C'^{\,2.19921875},\ \frac{C'}{32}\right) \text{ for C' in the range } [0, 1]$$

Note that the above slope limit is an implementation aspect, not an attribute of the Adobe RGB (1998) color space encoding. Different implementations may use different slope limits.