TECHNICAL SPECIFICATION

ISO/TS 22028-4

First edition
2012-11-01

Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 4: European Colour Initiative RGB colour image encoding [eciRGB (2008)]

Photographie et technologie graphique — Codages par couleurs étendues pour stockage, manipulation et échange d'image numérique —

Partie 4: Codage d'image en couleurs RGB par initiative de couleur européenne [eciRGB(2008)]

Reference number
ISO/TS 22028-4:2012(E)

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Published in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 22028-4 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO/TS 22028 consists of the following parts, under the general title *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange*:

— *Part 1: Architecture and requirements*

— *Part 2: Reference output medium metric RGB colour image encoding (ROMM RGB)*

— *Part 3: Reference input medium metric RGB colour image encoding (RIMM RGB)* [Technical Specification]

— *Part 4: European Colour Initiative RGB colour image encoding [eciRGB (2008)]* [Technical Specification]

Introduction

This Technical Specification has been developed in order to meet the industry need for a complete, fully documented, publicly available definition of an output-referred extended gamut RGB colour image encoding which is optimized for an 8-bit encoding and the conversion of RGB images into offset print colour spaces. Since users have also asked for a 16-bit encoding it has been added to this Technical Specification as well. This colour image encoding provides a way to represent output-referred images that does not limit the colour gamut to those colours capable of being displayed on a CRT monitor, such as that represented by the sRGB colour encoding, or require the use of negative RGB colorimetry coordinates, such as with extended sRGB colour encodings like bg-sRGB.

An extended colour-gamut colour encoding is particularly desirable for professional photography applications. For example, colours used for company logos may be outside a monitor gamut and would therefore need to be clipped or compressed to a less saturated colour. Similarly, scanned photographic prints that are to be duplicated may contain colours outside a monitor RGB colour-gamut. By using a standard output-referred extended gamut colour image encoding, images containing such colours can be stored, interchanged, manipulated, and later printed, without limiting or distorting the colours of the final output.

The European Colour Initiative (ECI) RGB colour image encoding [eciRGB (2008)] specified in this international standard meets the needs of these types of applications.

The primaries of eciRGB (2008) are between Reference Output Medium Metric RGB (ROMM RGB) and sRGB, thereby providing a larger gamut than sRGB, together with lower quantization errors than ROMM RGB. The tone curve has an encoding linear to the L* axis defined in the CIE 1976 (L*, a*, b*) colour space (CIELAB 1976).

This Technical Specification has been prepared to provide sufficient documentation, consistent with the definitions of ISO 22028-1, to allow the imaging community adequate opportunity for implementation and evaluation of this colour image encoding. It is anticipated that, when there is sufficient implementation of, and practical experience in the use of, eciRGB (2008), this Technical Specification can be revised as an International Standard.

The European Colour Initiative owns the copyright on the name eciRGB (2008) and has granted ISO the irrevocable non-exclusive right to use the name for the purpose of this Technical Specification. A colour encoding named eciRGB was initiated by ECI in 2004. A second version of this encoding with a modified tonal curve was defined in 2008. Because of its importance to the European photographers and graphic arts industry, this Technical Specification was prepared in order to fully define eciRGB according to ISO 22028-1.

Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange —

Part 4: European Colour Initiative RGB colour image encoding [eciRGB (2008)]

1 Scope

This Technical Specification defines an extended colour-gamut output-referred RGB colour image encoding designated as European Colour Initiative RGB [eciRGB (2008)]. Digital images encoded using eciRGB (2008) can be manipulated, stored, transmitted, displayed, or printed by digital still picture imaging systems. Two precision levels are defined, using 8 bits/channel and 16 bits/channel.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3664:2009, *Graphic technology and photography — Viewing conditions*

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

ISO 22028-1, *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange — Part 1: Architecture and requirements*

CIE Publication 15, *Colorimetry*

3 Terms and definitions

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

3.1
adapted white
colour 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 can vary within a scene.

3.2
additive RGB colour space
a colorimetric colour space having three colour primaries (generally red, green and blue) such that CIE XYZ tristimulus values can be determined from the RGB colour space values by forming a weighted combination of the CIE XYZ tristimulus values for the individual colour primaries, where the weights are proportional to the radiometrically linear colour space values for the corresponding colour primaries

NOTE 1 A simple linear 3 × 3 matrix transformation can be used to transform between CIE XYZ tristimulus values and the radiometrically linear colour space values for an additive RGB colour space.

NOTE 2 Additive RGB colour spaces are defined by specifying the CIE chromaticity values for a set of additive RGB primaries and a colour space white point, together with a colour component transfer function

3.3
colorimetric colour space
a colour space having an exact and simple relationship to CIE colorimetric values

NOTE Colorimetric colour spaces include those defined by CIE (e.g. CIE XYZ, CIELAB, CIELUV, etc.), as well as colour spaces that are simple transformations of those colour spaces (e.g. additive RGB colour spaces).

3.4
colour component transfer function
single variable, monotonic mathematical function applied individually to one or more colour channels of a colour space

NOTE 1 Colour component transfer functions are frequently used to account for the nonlinear response of a reference device and/or to improve the visual uniformity of a colour space.

NOTE 2 Generally, colour component transfer functions will be nonlinear functions such as a power-law (i.e. "gamma") function or a logarithmic function. However, in some cases a linear colour component transfer function can be used.

3.5
colour encoding
a generic term for a quantized digital encoding of a colour space, encompassing both colour space encodings and colour image encodings

3.6
colour gamut
solid in a colour space, consisting of all those colours 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

3.7
colour image encoding
digital encoding of the colour values for a digital image, including the specification of a colour space encoding, together with any information necessary to properly interpret the colour values such as the image state, the intended image viewing environment and the reference medium

NOTE 1 In some cases the intended image viewing environment will be explicitly defined for the colour image encoding. In other cases, the intended image viewing environment can be specified on an image-by-image basis using metadata associated with the digital image.

NOTE 2 Some colour image encodings will indicate particular reference medium characteristics, such as a reflection print with a specified density range. In other cases the reference medium will be not applicable, such as with a scene-referred colour image encoding, or will be specified using image metadata.

NOTE 3 Colour image encodings are not limited to pictorial digital images that originate from an original scene, but are also applicable to digital images with content such as text, line art, vector graphics and other forms of original artwork.

3.8
colour rendering
mapping of image data representing the colour-space coordinates of the elements of a scene to output-referred image data representing the colour-space coordinates of the elements of a reproduction

NOTE Colour rendering generally consists of one or more of the following: compensating for differences in the input and output viewing conditions; tone scale and gamut mapping to map the scene colours onto the dynamic range and colour gamut of the reproduction; and applying preference adjustments.

3.9
colour space
geometric representation of colours in space, usually of three dimensions

[CIE Publication 17.4, 845-03-25]

3.10
colour space encoding
digital encoding of a colour space, including the specification of a digital encoding method, and a colour space value range

NOTE Multiple colour space encodings can be defined based on a single colour space where the different colour space encodings have different digital encoding methods and/or colour space value ranges. (For example, 8-bit sRGB and 10-bit e-sRGB are different colour space encodings based on a particular RGB colour space.)

3.11
colour space white point
colour stimulus to which colour space values are normalized

NOTE It is not necessary that the colour space white point correspond to the assumed adapted white point and/or the reference medium white point for a colour image encoding.

3.12
extended gamut
colour gamut extending outside that of the standard sRGB CRT display as defined by IEC 61966-2-1

3.13
gamut mapping
mapping of the colour-space coordinates of the elements of a source image to colour-space coordinates of the elements of a reproduction to compensate for differences in the source and output medium colour gamut capability

NOTE The term "gamut mapping" is somewhat more restrictive than the term "colour rendering" because gamut mapping is performed on colorimetry that has already been adjusted to compensate for viewing condition differences and viewer preferences, although these processing operations are frequently combined in reproduction and preferred reproduction models.

3.14
ICC profile
International Colour Consortium file format, used to store transforms from one colour encoding to another, e.g. from device colour coordinates to profile connection space, as part of a colour management system

3.15
image state
attribute of a colour image encoding indicating the rendering state of the image data

NOTE The primary image states defined in this document are the scene-referred image state, the original-referred image state and the output-referred image state.

3.16
luminance factor
ratio of the luminance of the surface element in the given direction to that of a perfect reflecting or transmitting diffuser identically illuminated

[CIE Publication 17.4, 845-04-69]

3.17
medium black point
neutral colour with the lowest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

NOTE It is generally desirable to specify a medium black point that has the same chromaticity as the medium white point.

3.18
medium white point
neutral colour with the highest luminance that can be produced by an imaging medium in normal use, measured using the specified measurement geometry

3.19
output-referred image state
image state associated with image data that represents the colour-space coordinates of the elements of an image that has undergone colour 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 are image data in an output-referred image state.

NOTE 2 Output-referred image data are referred to the specified output device and viewing conditions. A single scene can be colour 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 can become the starting point for a subsequent reproduction process. For example, sRGB output-referred image data are frequently considered to be the starting point for the colour re-rendering performed by a printer designed to receive sRGB image data.

3.20
tristimulus values
amounts of the three reference colour stimuli, in a given trichromatic system, required to match the colour of the stimulus considered

[CIE Publication 17.4, 845-03-22]

3.21
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.

3.22
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

European Colour Initiative RGB [eciRGB (2008)] is an extended gamut RGB colour image encoding for representing the colorimetry of display-referred image data in a display-referred image. The output-referred image data has the intended colour appearance when viewed on a reference colour monitor in

a reference viewing environment. The image colorimetry is encoded in terms of an additive RGB colour space associated with a hypothetical additive colour device having a specified set of primaries, no cross-talk between the colour channels and a luminance dynamic range defined by an associated medium black point and medium white point.

The encoding can either be in 8 bits/channel or 16 bits/channel (24 bits/pixel or 48 bits/pixel).

The image colorimetry shall be based on flareless (or instrument flare corrected) colorimetric measurements as described in CIE Publication 15 using the CIE 1931 Standard Colorimetric Observer defined in ISO 11664-1.

NOTE The intended colour appearance can be reproduced on a physical device in an actual viewing environment, only when the actual viewing environment matches the reference viewing environment. See Annex B for recommended tolerances for viewing eciRGB (2008)-encoded data in an actual viewing environment.

The colour image encoding defined in this Technical Specification conforms to the requirements defined in ISO 22028-1:2004, Clause 5.

4.2 Reference viewing environment

4.2.1 General

The following reference viewing conditions define the reference viewing environment for the eciRGB (2008) colour image encoding. They are based on conditions for appraisal of images displayed on colour monitors as specified in ISO 3664:2009, 4.5. These specifications are applicable for images viewed independently of any form of hardcopy; they are not designed for direct comparison between hardcopy and softcopy.

4.2.2 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 lx to 64 lx. The ambient illumination shall have the same chromaticity as the white point of the display.

4.2.3 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 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.

4.2.4 Image size and viewing distance

The normal to the centre 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.

4.2.5 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° relative to the normal to the display faceplate, which is assumed to be the viewer's direction of gaze.

4.2.6 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 other tristimulus and chromaticity values shall be measured using the same geometry with a spectroradiometer or colorimeter based on the CIE 1931 two-degree standard observer. See CIE Publication 15.

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 colour 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 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.

4.3 Reference display

4.3.1 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 320.

4.3.2 Reference display white point and luminance

The reference display white point shall be such that the adapted white has the chromaticity values of CIE Illuminant D50 (x_0 = 0,345 7, y_0 = 0,358 5).

The absolute luminance level of the adapted white on the reference display shall be 160 cd/m^2.

NOTE This absolute luminance level is equivalent to that of a perfect white Lambertian reflector illuminated with 500 lx as specified in ISO 3664 for the practical appraisal of prints.

4.3.3 Reference display black point and luminance

The reference display shall have a reference display black point with the chromaticity values of CIE Illuminant D50 (x_0 = 0,345 7, y_0 = 0,358 5) and a luminance factor of F_K = 0,003 125 relative to the display white. Accordingly, the reference display black point tristimulus values are $X_K = F_K X_0$ = 0,301 3, $Y_K = F_K Y_0$ = 0,312 5, and $Z_K = F_K Z_0$ = 0,257 8.

NOTE The luminance factor of 0,003 125 corresponds to a luminance value of 0,5 cd/m^2.

4.4 eciRGB (2008) colour image encoding

4.4.1 General

The eciRGB (2008) colour space is an extended additive RGB colour space defined by a set of additive primaries, a white point, a black point, and a colour component transfer function.

4.4.2 Colour space chromaticities and luminance

The *x-y* chromaticity values for the eciRGB primaries shall be as given in Table 1. All chromaticity values specified in this document shall be based on the CIE 1931 two-degree standard observer defined in ISO 11664-1.

The colour space white point, corresponding to equal amounts of the three RGB primaries, shall have the *x-y* chromaticity values of CIE Illuminant D_{50} given as given in Table 1.

Table 1 — CIE chromaticities for reference medium primaries and white point

	x	*y*	*u′*	*v′*
Red	0,670 0	0,330 0	0,476 9	0,528 5
Green	0,210 0	0,710 0	0,075 7	0,575 7
Blue	0,140 0	0,080 0	0,152 2	0,195 7
White	0,345 7	0,358 5	0,209 2	0,488 1

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

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

4.4.3 Colour space encodings

The value range for eciRGB (2008) colour space component values shall be [0, 1].

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

Integer encodings shall be unsigned with 8 bits or 16 bits per component, with the same number of bits for all three components. R, G, and B are the linear tristimulus values for the conversion from and to XYZ. These values are transferred into the non-linear values R′, G′, B′ with a component value range [0, 1] using the transfer function mentioned in 4.4.6.3 . They shall be encoded over the code value range [0, max. integer value]. R′, G′, B′ code values of 0, 0, 0 shall represent the colour space black point, and max. integer code values shall represent the colour space white point.

For integer encodings, all code values shall be within the colour 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 colour space black point, and code values 1.0, 1.0, 1.0 shall represent the colour space white point. Component values outside the range [0, 1] are not allowed for floating-point encodings.

4.4.4 Image state

The image state of the eciRGB (2008) colour image encoding shall be output-referred as defined in ISO 22028-1.

4.4.5 Normalized and absolute XYZ tristimulus values

4.4.5.1 Obtaining XYZ 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 4.2.6.

4.4.5.2 Normalizing 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.

$$X = \frac{(X_a - X_K) \times X_W}{(X_W - X_K) \times Y_W}$$
$$Y = \frac{(Y_a - Y_K)}{(Y_W - Y_K)} \quad (1)$$
$$Z = \frac{(Z_a - Z_K) \times Z_W}{(Z_W - Z_K) \times Y_W}$$

4.4.5.3 Converting from normalized XYZ to absolute XYZ tristimulus values

4.4.5.3.1 General

The normalized XYZ tristimulus values 0,000 0, 0,000 0, 0,000 0 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0,964 2, 1,000 0, 0,824 9 shall correspond to the reference display white point.

4.4.5.3.2 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.

$$X_a = X \times (X_W - X_K) \times \frac{Y_W}{X_W} + X_K$$
$$Y_a = Y \times (Y_W - Y_K) + X_K \quad (2)$$
$$Z_a = Z \times (Z_W - Z_K) \times \frac{Y_W}{Z_W} + Z_K$$

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.

4.4.6 Encoding an image in 24-bit eciRGB (2008) colour image encoding

4.4.6.1 General

An image's normalized XYZ tristimulus values shall be encoded in 24-bit eciRGB (2008) colour image encoding as follows.

The normalized XYZ tristimulus values 0,000 0, 0,000 0, 0,000 0 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0,964 2, 1,000 0, 0,824 9 shall correspond to the reference display white point.

4.4.6.2 Converting normalized XYZ to RGB tristimulus values

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

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1{,}782\,760 & -0{,}496\,985 & -0{,}269\,010 \\ -0{,}959\,362 & 1{,}947\,800 & -0{,}027\,581 \\ 0{,}085\,932 & -0{,}174\,467 & 1{,}322\,830 \end{bmatrix} \times \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{3}$$

R, G, B tristimulus values with all component values within the range [0, 1] shall be within the colour gamut of the eciRGB (2008) colour image encoding.

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

4.4.6.3 Applying the normative eciRGB(2008) colour component transfer function

The linear R, G, B tristimulus values shall be converted to eciRGB (2008) component values R′, G′, B′ as follows:

$$\begin{aligned} R' &= 1{,}16 \times \sqrt[3]{R} - 0{,}16 && \text{for } R \geq 0{,}008\,856 \\ R' &= 9{,}033 \times R && \text{for } R < 0{,}008\,856 \\ G' &= 1{,}16 \times \sqrt[3]{G} - 0{,}16 && \text{for } G \geq 0{,}008\,856 \\ G' &= 9{,}033 \times G && \text{for } G < 0{,}008\,856 \\ B' &= 1{,}16 \times \sqrt[3]{B} - 0{,}16 && \text{for } B \geq 0{,}008\,856 \\ B' &= 9{,}033 \times B && \text{for } B < 0{,}008\,856 \end{aligned} \tag{4}$$

The resulting eciRGB (2008) component values R′, G′, B′ shall be represented in floating point encodings or integer encodings.

4.4.6.4 Encoding eciRGB (2008) component values as integers

The eciRGB (2008) component values may be encoded in integer encodings, using 8 bits or 16 bits per component. When such encodings are used, the eciRGB (2008) component values R′, G′, B′ shall be encoded as R′8, G′8, B′8 8-bit channels in 24-bit eciRGB (2008) colour image encoding as follows:

$$\begin{aligned} R'_8 &= Round(255 \times R') \\ G'_8 &= Round(255 \times G') \\ B'_8 &= Round(255 \times B') \end{aligned} \tag{5}$$

For eciRGB (2008) colour image encodings using integer encodings with number of bits per component (N) other than eight, 255 in the above formulae shall be replaced with ($2N$–1).

4.4.7 Decoding 24-bit eciRGB (2008) to XYZ (D50) values

4.4.7.1 General

An image encoded in 24-bit eciRGB (2008) colour image encoding shall be decoded into normalized XYZ tristimulus values as follows.

The conversion from eciRGB (2008) colour image encoding to normalized XYZ shall be the inverse of the conversion from normalized XYZ to eciRGB (2008) colour image encoding that was given in 4.4.5.

4.4.7.2 Decoding integers to eciRGB (2008) component values

The three R′8, G′8, B′8 8-bit channel values in 24-bit eciRGB (2008) colour image encoding shall be assumed to be unsigned integers and shall be converted to eciRGB (2008) component values R′, G′, B′ as follows:

$$R' = \frac{R'_8}{255}$$
$$G' = \frac{G'_8}{255} \quad (6)$$
$$B' = \frac{B'_8}{255}$$

For eciRGB (2008) colour image encodings using integer encodings with number of bits per component (n) other than eight, 255 in above formulae shall be replaced with (2^n–1).

4.4.7.3 Inverting the colour component transfer function

The eciRGB (2008) component values R′, G′, B′ in the range [0, 1] shall be converted to R, G, B tristimulus values in the range [0, 1] as follows:

$$\begin{aligned} R &= 0{,}110\,7 \times R' && \text{for } R' < 0{,}08 \\ R &= (0{,}862\,1 \times R' + 0{,}137\,9)^3 && \text{for } R' \geq 0{,}08 \\ G &= 0{,}110\,7 \times G' && \text{for } G' < 0{,}08 \\ G &= (0{,}862\,1 \times G' + 0{,}137\,9)^3 && \text{for } G' \geq 0{,}08 \\ B &= 0{,}110\,7 \times B' && \text{for } B' < 0{,}08 \\ B &= (0{,}862\,1 \times B' + 0{,}137\,9)^3 && \text{for } B' \geq 0{,}08 \end{aligned} \quad (7)$$

4.4.7.4 Converting RGB to normalized XYZ values

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

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0{,}650\,204 & 0{,}178\,077 & 0{,}135\,938 \\ 0{,}320\,250 & 0{,}602\,071 & 0{,}077\,679 \\ 0{,}000\,000 & 0{,}067\,839 & 0{,}757\,173 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (8)$$

NOTE The matrix is derived from the colour space chromaticity coordinates. The normalized XYZ tristimulus values 0,000 0, 0,000 0, 0,000 0 shall correspond to the reference display black point. The normalized XYZ tristimulus values 0,964 2, 1,000 0, 0,824 9 shall correspond to the reference display white point.

Annex A
(informative)

The eciRGB (2008) ICC profile considerations

Profiles for eciRGB can be constructed based on ICC.1:2001 (Version 2.4.0) to ensure compatibility with older software or based on ISO 15076-1 (Version 4.2.0) for compatibility with newer applications.

For both profile versions, specific header fields and tags shall be set as follows:

— Profile class = mntr

— Colour space = RGB

— PCS space = XYZ

— PCS illuminant = 0,964 2, 1,000 0, 0,824 9

— The rXYZ tag shall be set to 0,650 3, 0,320 3, 0,000 0.

— The gXYZ tag shall be set to 0,178 0, 0,602 1, 0,067 8.

— The bXYZ tag shall be set to 0,135 9, 0,077 7, 0,757 1.

— The wtpt tag shall be set to 0,964 2, 1,000 0, 0,824 9.

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

For profiles based on ICC.1:2001(Version 2.4.0), specific header fields and tags shall be set as follows:

— Version = 2.4.0

— The ASCII part of the desc tag shall be set to eciRGB (2008)

— The rTRC, gTRC, bTRC tags shall specify a transfer curve as a table with a sufficient number of points in compliance with the colour component transfer function as specified in 4.4.6.3.

NOTE 1 eciRGB (2008) component values can be stored in a 16-bit encoding. A small table size will cause appreciable interpolation errors. A large table size will increase storage overhead for images with embedded profiles. A number of 700 points has been found a good compromise between table size and interpolation error in typical CMMs. Since all three tags use the same data, tag data sharing is recommended, which reduces the profile size by a factor of 3.

For profiles based on ISO 15076-1 (Version 4.2.0), specific header fields shall be set as follows:

— Version = 4.2.0

— The desc tag shall have a single entry for language code en (English), region code US, set to eciRGB (2008).

— The rTRC, gTRC, bTRC tags shall specify a parametric curve type 3 with parameters γ = 3,000 0, a = 0,862 1, b = 0,137 9, c = 0,110 7, d = 0,080 0, which result in the colour component transfer function as specified in 4.4.6.3.

NOTE 2 The main advantage of using this profile version is that the colour component transfer function can be specified as a function, which avoids a large table and interpolation errors.

Annex B
(informative)

Practical tolerances for viewing eciRGB (2008) encoded images

B.1 General

No tolerances are specified for eciRGB (2008) colour image encoding in Clause 4 of this Technical Specification, as Clause 4 defines the reference conditions for eciRGB (2008). This informative section provides tolerances for practical construction and calibration of display systems.

It is important to make a distinction between the eciRGB (2008) colour image encoding as a reference encoding and any physical device approximating this encoding. As a reference encoding, the eciRGB (2008) colour image encoding is exact, with no tolerances or variations in colour appearance. However, physical devices will usually exhibit variations from an ideal design specification for any number of reasons. Thus, an eciRGB (2008)-compatible device is one that sufficiently approximates the reference eciRGB (2008) colour image encoding within acceptable tolerances so that users may approximate an accurate view of eciRGB (2008)-encoded images.

Given this, an eciRGB (2008)-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 colour reproduction occurs when devices exactly match the reference. The information given below is intended as guidance for 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 annex are applicable to real display systems to be used for evaluation of the colour quality of eciRGB (2008)-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 colour appearance of eciRGB (2008)-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 colour calibrated for the actual viewing environment.

B.2 Parameter tolerances for viewing eciRGB (2008)-encoded data on a calibrated display system

B.2.1 Display white point

The white point luminance should be within the range 125 cd/m^2 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.

B.2.2 Contrast ratio

The contrast ratio should be within the range 230:1 to 400:1.

B.2.3 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.

B.2.4 Colour space chromaticities

The chromaticity coordinates for the display primaries should be within an area around the primaries specified by the corners mentioned in Tables B.1 and B.2.

Table B.1 — Definition of u'-v' chromaticity coordinates for the display primaries

	u'_1	v'_1	u'_2	v'_2	u'_3	v'_3	u'_4	v'_4
Red	0,487	0,531	0,487	0,525	0,457	0,522	0,457	0,534
Green	0,088	0,579	0,083	0,565	0,070	0,577	0,075	0,581
Blue	0,163	0,197	0,157	0,186	0,143	0,197	0,150	0,213

Table B.2 — Definition of x-y chromaticity coordinates for the display primaries

	x_1	y_1	x_2	y_2	x_3	y_4	x_4	y_4
Red	0,684	0,332	0,670	0,319	0,638	0,322	0,667	0,349
Green	0,240	0,715	0,206	0,652	0,200	0,720	0,218	0,737
Blue	0,148	0,080	0,140	0,073	0,133	0,081	0,144	0,092

B.2.5 Tonal response

If possible, the monitor's tonal response curve shall be calibrated to match the colour component transfer function specified in 4.4.6.3. If the monitor or the calibration software does not allow to match the colour component transfer function, the monitor should be calibrated to achieve a transfer function having an exponent "gamma" in a value range of 2.0 to 2.4 for the individual colour components and for the neutral axis. In this case the software used to view the images shall have the ability to compensate for the difference between the inverse colour component transfer function and the gamma value.

B.2.6 Ambient illumination level

The ambient illuminance level should be limited by the 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.

B.2.7 Ambient illumination chromaticity

The ambient illuminance chromaticity should be limited by the tolerances for the black point chromaticity. The ambient illumination chromaticity may be D50 to D65 if the black point chromaticity is kept within the tolerances given above. The chromaticity of the ambient illumination affects the chromaticity of the black point through veiling glare.