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

Part 3:

**Reference input medium metric RGB  
colour image encoding (RIMM RGB)**

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*Photographie et technologie graphique — Codages par couleurs  
étendues pour stockage, manipulation et échange d'image  
numérique —*  
*ISO/TS 22028-3:2006*  
*Partie 3: Codage d'image en couleurs RVB par référence d'entrée par  
voie métrique*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 normative document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
- an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

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order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn.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.

ISO/TS 22028-3 was prepared by Technical Committee ISO/TC 42, *Photography*, in collaboration with Technical Committee ISO/TC 130, *Graphic technology*.

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

## Introduction

This part of ISO 22028 has been developed in order to meet the industry need for a complete, fully-documented, publicly-available definition of a wide-primary scene-referred extended colour gamut red-green-blue (RGB) colour image encoding. This encoding provides a way to represent scene-referred images that does not limit the colour gamut to those colours capable of being displayed on a CRT monitor, or require the use of negative RGB colorimetry co-ordinates.

A scene-referred extended colour gamut colour encoding is particularly desirable for professional photography applications. For example, colours captured by digital cameras, as well as conventional capture devices such as photographic film, can be outside those that can be represented within the colour gamut of a typical monitor or other types of output devices. Similarly, scene-referred images can have a larger luminance dynamic range than output-referred images since they have not been modified by a colour rendering process to fit the images to a specific output medium applying appropriate tone and colour reproduction aims. Retaining the unrendered scene-referred image data has the advantage that it preserves the option to make decisions about how a particular image is to be rendered. For example, a scene-referred image of a backlit scene can retain information about both the dark foreground region and the bright background region of the scene. This information can be used to make a properly exposed print of either the foreground region or the background region, or alternatively can be used to create an improved image by rendering the two regions differently.

By using a standard scene-referred extended colour gamut colour image encoding, images can be stored, interchanged and manipulated without restricting the image to a particular rendering intent or output device. The Reference input medium metric RGB (RIMM RGB) colour encoding specified in this part of ISO 22028 meets the needs of these types of applications. An extended dynamic range version of this colour image encoding known as Extended reference input medium metric RGB (ERIMM RGB) is also specified for use with high-dynamic range input sources. (E)RIMM RGB is intended to be a companion to the output-referred ROMM RGB colour image encoding specified in ISO/TS 22028-2. Both colour encodings are based on the same "wide RGB" additive colour space to facilitate the development of image processing algorithms and simple colour rendering transformations to convert scene-referred RIMM RGB images to rendered output-referred ROMM RGB images.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning extended range colour encodings given in 4.4 and 4.5. ISO takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the ISO that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from

Director, Corporate Commercial Affairs  
Eastman Kodak Company  
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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

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

## Part 3: Reference input medium metric RGB colour image encoding (RIMM RGB)

### 1 Scope

This part of ISO 22028 specifies a family of scene-referred extended colour gamut RGB colour image encodings designated as Reference input medium metric RGB (RIMM RGB). Digital images encoded using RIMM RGB can be manipulated, stored, transmitted, displayed, or printed by digital still picture imaging systems. Three precision levels are defined using 8-, 12- and 16-bits/channel. An extended luminance dynamic range version of RIMM RGB is also defined designated as Extended reference input medium metric RGB (ERIMM RGB). Two precision levels of ERIMM RGB are defined using 12- 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 22028-1:2004, *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange — Part 1: Architecture and requirements*

ISO/CIE 10527:1991, *CIE standard colorimetric observers*

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**

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  $3 \times 3$  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**

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**

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

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### 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;
- applying preference adjustments.

**3.9****colour space**

geometric representation of colours in space, usually of three dimensions

[CIE Publication 17.4:1987, 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****continuous colour space values**

real-valued, unbounded colour space values that have not been encoded using a digital encoding method

**3.13****digital imaging system**

system that records and/or produces images using digital data

**3.14****extended gamut**

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

**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 17.4:1987, 845-04-69]

### 3.17

#### **observer adaptive luminance factor**

ratio of the luminance of a stimulus to the luminance of a stimulus that an observer adapted to the viewing environment would interpret to be a perfect white diffuser

### 3.18

#### **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 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 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 is frequently considered to be the starting point for the colour re-rendering performed by a printer designed to receive sRGB image data.

### 3.19

#### **scene**

spectral radiances of a view of the natural world as measured from a specified vantage point in space and at a specified time

NOTE A scene can correspond to an actual view of the natural world or to a computer-generated virtual scene simulating such a view.

### 3.20

#### **scene-referred image state**

image state associated with image data that represents estimates of the colour space coordinates of the elements of a scene

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

NOTE 2 Scene-referred image data can be determined from raw DSC image data before colour rendering is performed. Generally, DSCs do not write scene-referred image data in image files, but some do so in a special mode intended for this purpose. Typically, DSCs write standard output-referred image data where colour rendering has already been performed.

NOTE 3 Scene-referred image data typically represents relative scene colorimetry estimates. Absolute scene colorimetry estimates can be calculated using a scaling factor. The scaling factor can be derived from additional information such as the image OECF, FNumber or ApertureValue, and ExposureTime or ShutterSpeedValue tags.

NOTE 4 Scene-referred image data can contain inaccuracies due to the dynamic range limitations of the capture device, noise from various sources, quantization, optical blurring and flare that are not corrected for, and colour analysis errors due to capture device metamerism. In some cases, these sources of inaccuracy can be significant.

NOTE 5 The transformation from raw DSC image data to scene-referred image data depends on the relative adopted whites selected for the scene and the colour space used to encode the image data. If the chosen scene adopted white is inappropriate, additional errors will be introduced into the scene-referred image data. These errors can be correctable if the transformation used to produce the scene-referred image data is known, and the colour encoding used for the incorrect scene-referred image data has adequate precision and dynamic range.

NOTE 6 The scene can correspond to an actual view of the natural world, or be a computer-generated virtual scene simulating such a view. It can also correspond to a modified scene determined by applying modifications to an original scene to produce some different desired scene. Any such scene modifications need to leave the image in a scene-referred image state, and need to be done in the context of an expected colour rendering transform.

**3.21****tristimulus value**

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

[CIE Publication 17.4:1987, 845-03-22]

**3.22****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 Publication 122, the veiling glare of a CRT display is referred to as ambient flare.

**3.23****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**

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**4.1 General**

Reference input medium metric RGB (RIMM RGB) is an extended colour gamut RGB colour image encoding of the colorimetry of a scene-referred image. The scene-referred image has the intended colour appearance when viewed in a specified 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 maximum luminance value corresponding to 200 % of a perfect diffuse reflector (i.e. an observer adaptive luminance factor of 2,0).

NOTE 1 Scene-referred image data can correspond to an actual view of the natural world, or a simulation of such a view. It can also correspond to a modified scene determined by applying modifications to an original scene. For example, such modifications could include removing haze from the captured image, or allowing a user to manually adjust the exposure/white balance. It could also include more complex operations such as using a “dodge-and-burn” algorithm to correct over-exposed regions of a backlit scene. (This can be viewed as being analogous to “re-lighting” the scene.) Scene modifications could also include applying desired changes to the scene such as simulating a “night” scene, making grass greener to make it look healthier, or making the sky bluer to make it look clearer. Any such scene modifications need to leave the image in a scene-referred image state, and need to be done in the context of the expected colour rendering transform. For example, typical colour rendering transforms will include a boost in the chroma of the image. Any boost in colourfulness of the scene (e.g. making the grass greener) must be done with the knowledge that there will be an additional chroma boost during colour rendering. Consequently, the colour rendering transform must be included in any image preview path that is used to provide subjective feedback to a user during the scene-editing process.

NOTE 2 The image colorimetry of the scene-referred image can contain inaccuracies due to the dynamic range limitations of the capture device, noise from various sources, quantization, optical blurring and flare that are not corrected for, and colour analysis errors due to capture device metamerism. In some cases, these sources of inaccuracy can be significant.

Three different precision levels are defined, and shall be identified as RIMM8 RGB, RIMM12 RGB and RIMM16 RGB, for 8-, 12- and 16-bits/channel (24-, 36- and 48-bits/pixel) representations, respectively.

Extended reference input medium metric RGB (ERIMM RGB) is an extended luminance dynamic range version of RIMM RGB having a maximum observer adaptive luminance factor of about 316. Two different precision levels are defined, and shall be identified as ERIMM12 RGB and ERIMM16 RGB, for 12- and 16-bits/channel (36- and 48-bits/pixel) representations, respectively.