INTERNATIONAL STANDARD

ISO 16760

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Graphic technology — Prepress data exchange — Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows

Technologie graphique — Échange de données pré-impression — Préparation et visualisation d'images RGB à utiliser dans les flux de travail des arts graphiques basés sur le RGB

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 130, *Graphic technology*.

Introduction

This International Standard provides guidelines for image preparation and print simulation in a graphic arts print workflow using RGB images (RGB workflow).

Digital still camera (DSC) images have now largely replaced film in the prepress stage of graphic arts printing and most images printed originate from digital cameras. Standard document exchange using PDF/X-4 and PDF/X-5 formats supports the use of RGB content and provides a 'late binding' printing solution where colour conversion is performed only when the document is printed. In this way, all of the original image data can be retained and the conversion for print can be optimised based on the original image content, key image attributes, and the available press colour gamut. These standard document formats provide an ideal framework for RGB workflow.

The current best practice for image preparation is to view and adjust images on display. When RGB images are adjusted, proofing mode is selected for a reference printing condition and a calibrated monitor is used. In this way, users can see an accurate preview of the printed result. This workflow is shown in Figure 1.

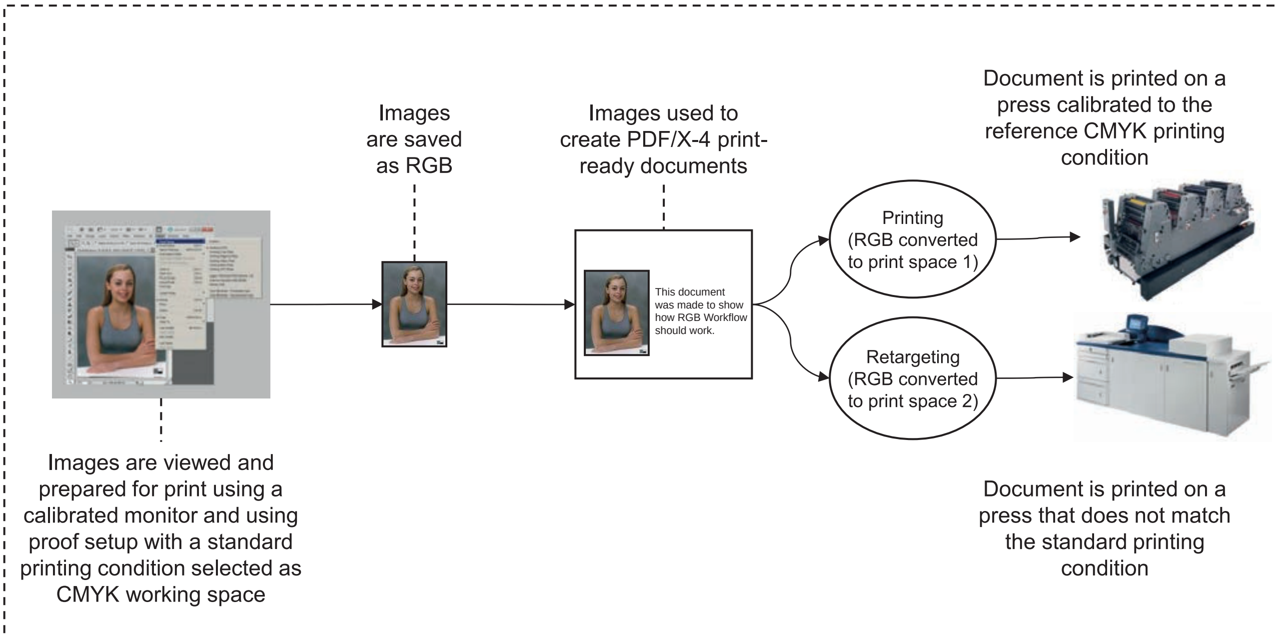


Figure 1 — Current best practice RGB workflow

There are a number of limitations in this workflow:

— Although it is possible to set up a calibrated monitor and viewing environment defined by Adobe RGB (1998) Colour Image Encoding or ISO/IEC 61966-2-1, it is not usually the case that all stakeholders have a calibrated monitor and the same viewing conditions. In the proposed RGB workflow, an RGB Reference Print can be shared easily among stakeholders.

— For inexperienced users, critical colour judgement on screen is harder than on print and so the resulting colour might not be what the user desires. The proposed RGB workflow is described for both experts and inexperienced users.

— The intended printing condition needs to be communicated to every stakeholder by independent means and all users need to know how to set up a viewing environment appropriate to the printing condition. In the proposed RGB workflow, the intended printing condition is included as metadata with the image.

— The approval status of an image is not clearly shown. In the proposed RGB workflow, the approval status is included as metadata with the image.

The proposed RGB workflow addresses these limitations as shown in Figure 2. In this RGB workflow, candidate images are printed on an RGB Reference Printer that has been calibrated to produce an accurate simulation of the intended printing condition. These printed images are checked in a controlled print viewing environment and, if necessary, further adjustments are made until the intended print result is achieved. When RGB image files are created and checked in this way, metadata that describes the intended printing condition and the image approval status is added.

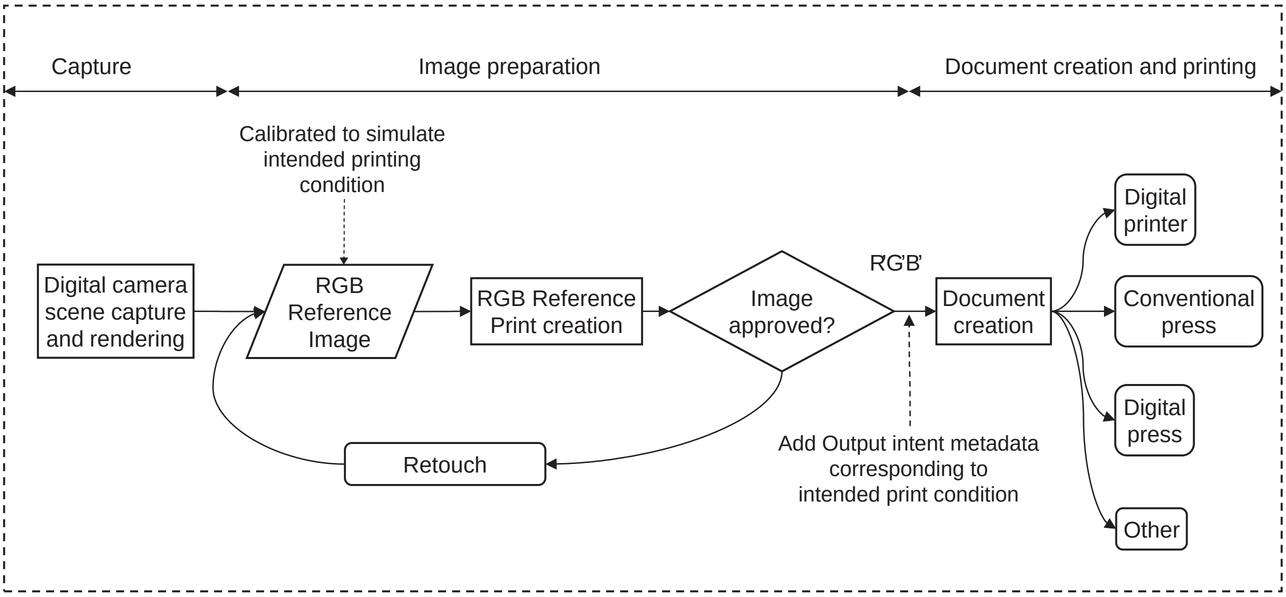


Figure 2 — RGB workflow from scene to printing via RGB image data

Careful preparation of RGB images holds the key to a successful RGB workflow. There are a number of aspects to consider when preparing images for print, including the identification of image highlight and shadow points and the careful mapping of important image colours into the colour gamut of the printing press. Since most printing processes have a significantly different colour gamut size and shape from the set of colours represented in an image, care needs to be taken when editing images so that important colours are retained. This is done most effectively by associating the RGB image with a CMYK press profile. This International Standard describes how to prepare these RGB images. Figure 2 shows the RGB workflow described by this International Standard and R'G'B' is the prepared RGB image.

NOTE For the proposed workflow, although a calibrated soft proof viewing environment is not required, the calibration of a reference printer is required and this print needs to be viewed in a standard calibrated viewing environment. If possible, printers with automatic calibration need to be used in cases where users are not familiar with the calibration process.

When this workflow is adopted, images can be prepared and incorporated in documents which can be printed on multiple printing systems producing prints with a similar appearance.

When the RGB image data are approved based on a hardcopy print, consistent judgement can be made.

This workflow is supported by the PDF/X-4 and PDF/X-5 standard document formats. Documents are expected to be approved using ISO 12647-8 (validation print) or ISO 12647-7 (contract proof).

It is envisaged that printing systems will be developed to produce prints that conform to this International Standard. It can be the case that systems that already conform to the requirements of ISO 12647-8 or ISO 12647-7 will be extended to produce RGB Reference Prints. Such systems will provide an easy means for users to ensure that images and the documents that include these images are printed reliably.

This workflow relates to images that are destined for four-colour commercial printing. Photographers need to be aware that alternative file versions of an image can still be required for specialized printing conditions.

Annex D provides further details of key RGB workflow concepts.

Graphic technology — Prepress data exchange — Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows

1 Scope

This International Standard specifies requirements for an RGB workflow for graphic arts printing based on the use of reflection prints (RGB Reference Prints) as the evaluation vehicle for coloured images. It provides guidelines on the creation of print-targeted RGB images (RGB Reference Images) and simulation prints.

This International Standard requires the identification of a pair of ICC profiles for each image: an image profile and a profile describing the reference printing system. These profiles provide individual colour transformations for gamut mapping and colour separation. This International Standard does not provide any guidance as to how these gamut mapping or colour separation transforms can be specified.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 11664-4 (CIE S 014-4/E:2007), *Colorimetry — Part 4: CIE 1976 L*a*b* Colour space*

ISO 12234-1, *Electronic still-picture imaging — Removable memory — Part 1: Basic removable-memory model*

ISO 13655, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

ISO 15076-1:2010, *Image technology colour management — Architecture, profile format and data structure — Part 1: Based on ICC.1:2010*

ISO 15790, *Graphic technology and photography — Certified reference materials for reflection and transmission metrology — Documentation and procedures for use, including determination of combined standard uncertainty*

ISO 18619[1)], *Image technology colour management — Black point compensation*

ISO 19445[2)], *Graphic technology — Metadata for graphic arts workflow — XMP metadata for image and document proofing*

ISO/IEC 10918-1, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines — Part 1*

ISO/CIE 11664-6 (CIE S 014-6/E:2013), *Colorimetry — Part 6: CIEDE2000 Colour-difference formula*

TIFF, Revision 6.0 Final, Adobe Systems Incorporated, June 3, 1992

3 Terms and definitions

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

1) Under preparation.

2) Under preparation.

3.1
RGB colour space
three-component colour encoding defined by a linear transform from CIE XYZ

Note 1 to entry: Such a transform can be specified as a 3 × 3 matrix, and the transform between XYZ and additive RGB is then performed by multiplying by this matrix or its inverse.

Note 2 to entry: Adobe RGB (1998) is an example of an RGB colour space.

3.2
characterized printing condition
printing condition for which process control aims are defined and for which the relationship between input data (printing-tone values, usually CMYK) and the colorimetry of the printed image is documented

Note 1 to entry: The relationship between input data (printing tone values) and the colorimetry of the printed image is commonly referred to as characterization.

Note 2 to entry: It is generally preferred that the process control aims of the printing condition and the associated characterization data be made publicly available via the accredited standards process or industry trade associations.

3.3
colour gamut
solid in a colour space, consisting of all those colours that are: present in a specific scene, artwork, photograph, photomechanical, or other reproduction; or capable of being created using a particular output device and/or medium

[SOURCE: ISO 22028-1:2004, 3.8]

3.4
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 1 to entry: Colour rendering generally consists of one or more of the following: compensating for differences in the input and output viewing conditions, tone scale and colour gamut mapping to map the scene colours onto the dynamic range and colour gamut of the reproduction, and applying preference adjustments.

Note 2 to entry: In the terminology defined in ISO 22028-1, some of the transforms described in this International Standard would be better described as colour re-rendering, however, this International Standard does not differentiate between colour rendering and colour re-rendering transforms and uses the term ‘colour rendering’ for both.

[SOURCE: ISO 22028-1:2004, 3.11]

3.5
highlight point
luminance level or image area corresponding to a reference white in the principal subject area of a scene

Note 1 to entry: Lightness of the objects in the scene are viewed in relation to this reference white. This can be a white “object” such as a piece of paper, a shirt, etc. or some such object which does not even appear in the scene but with which a comparison is made by reference to one’s memory of such objects.

Note 2 to entry: Image areas brighter than this point are called highlights. These include specular highlights, diffuse highlights that are more highly illuminated than the principal area and fluorescent colours.

Note 3 to entry: This wording is based on Bartleson and Breneman[22] and Giorgianni and Madden[23].

3.6
output intent
metadata used to communicate the intended printing condition, usually by means of an ICC Profile

3.7
prepress
first stage of the graphic technology workflow, prior to printing, that includes all the operations necessary for the preparation of images and image carriers

3.8
RGB Reference Image
RGB image prepared according to this specification which can provide a reliable reference to printed appearance for evaluation by stakeholders

3.9
RGB Reference Print
print of an RGB Reference Image that has been prepared in conformance with this International Standard

3.10
RGB Reference Printer
printing system that is capable of producing RGB Reference Prints

Note 1 to entry: RGB Reference Printers do not use RGB inks but typically use CMYK inks, converting from RGB to CMYK before printing.

3.11
shadow point
luminance level or image area corresponding to a maximum dark point and/or area of a scene that should be reproduced as a dark end of grey gradient on a print or a display

4 RGB workflow overview

4.1 General

RGB images are represented in an RGB colour space such as sRGB or Adobe RGB (1998) and as part of the prepress processing need to be converted to CMYK or similar colour space for printing. It is now standard industry practice to convert to a characterized printing condition, for example, CGA/TS 21-CRPC6, Fogra39, or JapanColor using ICC colour conversion.

NOTE The reference printing conditions that are provided as examples here are for offset lithography; however, the principles of this International Standard apply to all standardised printing conditions.

This Clause describes how to make RGB Reference Images (4.2) and how to make simulation prints (RGB Reference Prints) based on the characterized printing condition (4.3).

4.2 RGB Reference Images

4.2.1 Configuration of RGB workflow

Figure 3 shows image-processing workflow using RGB Reference Images. A process to convert RGB images to RGB Reference Images shall be supported and a process to convert RGB Reference Images to simulation print should be supported.

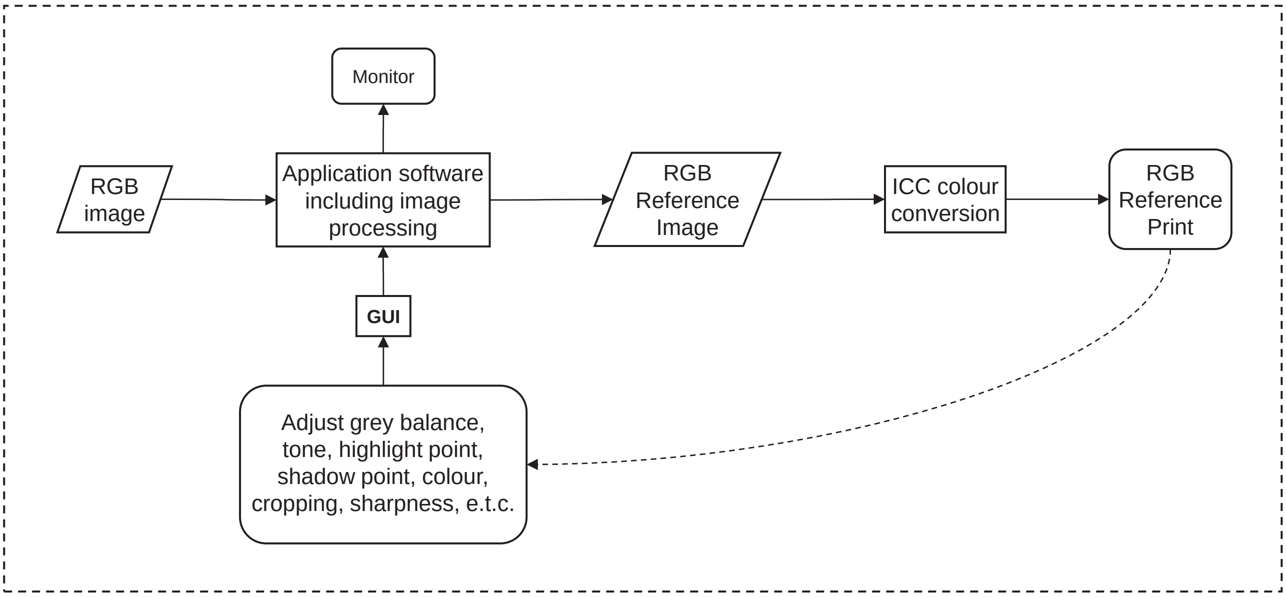


Figure 3 — Image processing workflow for creating RGB reference print

Components of this workflow comprise processing hardware, processing software, and image data files.

Processing hardware comprises a computer, a monitor, and a printer.

Processing software usually comprises operating system software of the computer and application software. These software components shall support ICC profile-based colour management.

Image data files are of two types: "RGB image" which is an unprocessed input image data file (RGB image in Figure 3) and the second 'RGB Reference Image' which is an output image data file prepared for printing (RGB Reference Image in Figure 3). Both images shall be display-referred.

NOTE Examples of display-referred images include images encoded as sRGB and Adobe RGB (1998) (commonly referred to as "Adobe RGB images" and "sRGB images").

4.2.2 Setup and calibration

Setup and calibration of system hardware and software shall be performed prior to its use.

Monitors shall be calibrated and profiled using appropriate hardware and software. Each monitor should have a gamut that can adequately represent the intended print condition(s).

NOTE 1 ISO 12646 and ISO 14861 provide a good reference to ensure that monitors are set up appropriately for soft proofing.

NOTE 2 In some cases, software-based calibration can reduce the number of levels and so it is usually more effective to use hardware calibration where the monitor's physical controls and/or its internal lookup tables are modified, perhaps in conjunction with the graphic card's lookup tables.

Printers shall be calibrated and profiled using appropriate hardware and software to ensure that prints produced meet the aims specified in Clause 6.

4.2.3 Operation procedure

Creation of RGB Reference Images shall be performed as follows.

a) Open input RGB image to be displayed using colour management of system software and application software.

b) Adjust grey balance, highlight point, and shadow point using application software (tone-setup).

c) Adjust colour to make preferred reproduction.

d) Check print-simulation image on the monitor (optional when an RGB Reference Print is made).

e) Create an RGB Reference Print and view in standard conditions to check image result (optional but highly recommended for inexperienced users).

f) Store RGB Reference Image (R'G'B') and add output-intent tag as specified in 5.2 using application software.

NOTE 1 At step a), the RGB image is likely to be display-referred.

NOTE 2 In some instances, legacy profiles might produce a sub-standard perceptual rendering and fail to achieve an acceptable appearance match. Additional image editing might be required. Alternatively, a print that achieves an appearance match to the original RGB image can be made using an ICC Profile that provides an appearance match transform (for example, using CIECAM) in its Perceptual Rendering Intent.

4.2.4 Highlight and shadow point adjustment

The way in which the highlight point and shadow point is selected is beyond the scope of this document. Users shall select desired highlight and shadow points for each image.

For an average-key image encoded in 8 bits, the desired highlight and shadow points of an RGB Reference Image are approximately code values of 246 and 15 respectively. The relationship between these values and tone reproduction of typical press printing profiles is shown in Annex A.

4.2.5 Additional data requirements

In order to provide colour rendering information, in particular the intended output rendering of the RGB Reference Print and to enable automatic printing of the RGB Reference Print (Figure 6 — Case C), the following rendering information and parameters shall be added to the image files:

a) colour characterization of source data;

b) rendering intent;

c) black point compensation;

d) output intent profile.

Colour characterization of source data shall be included in the form of an ICC Profile or colour space name as specified for the appropriate file format.

Colour rendering parameters b) to d) are specified for each file format in the following clauses. The parameters shall be included as specified in this clause as extensions to the file format as specified in 5.2 or as XMP metadata as specified in 5.3.

At the time of image preparation, these parameters shall be attached to the image file either before an RGB Reference Print is made or following the approval of the RGB Reference Print.

When RGB Reference Prints are created and when RGB Reference Soft Proofs are displayed from an RGB reference image, these parameters shall be recognized and the appropriate colour transforms applied to the image to meet the output colour rendering condition to ensure that the printed output meets the reproduction tolerances specified in Clause 6.

4.3 Print-simulation workflow

4.3.1 Basic functions of print-simulation workflow

Figure 4 shows the basic image-processing functions of the print-simulation workflow and Figure 5 shows a more concrete example using actual ICC profiles.

NOTE The Reference RGB image will usually be different from the original RGB image as its colour is constrained by the gamut of the intended printing condition.

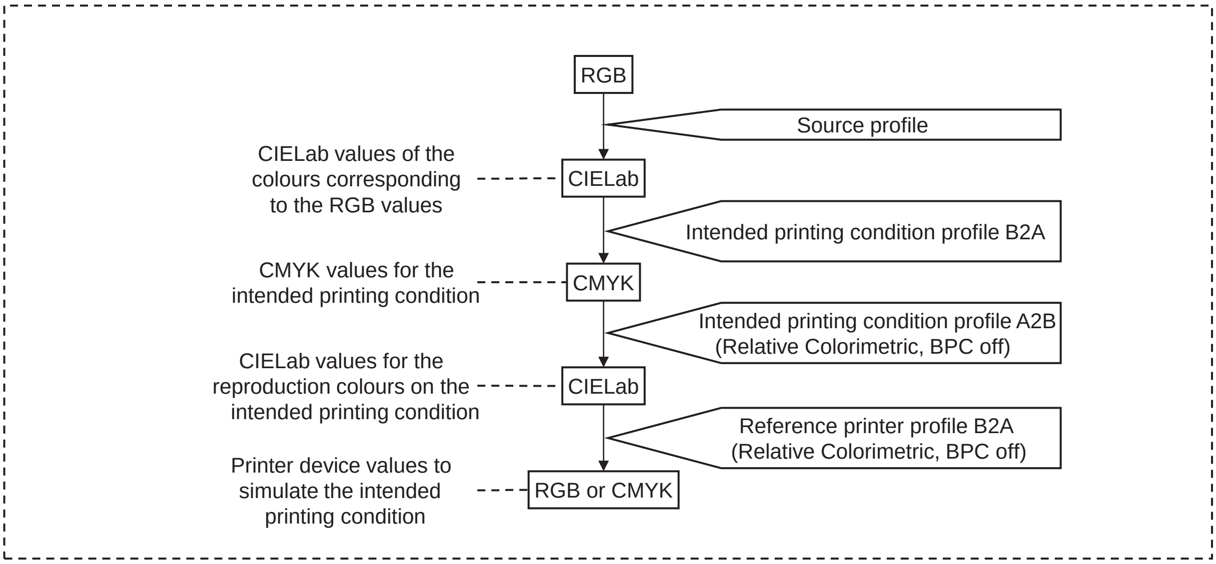


Figure 4 — Basic image-processing components of print-simulation workflow

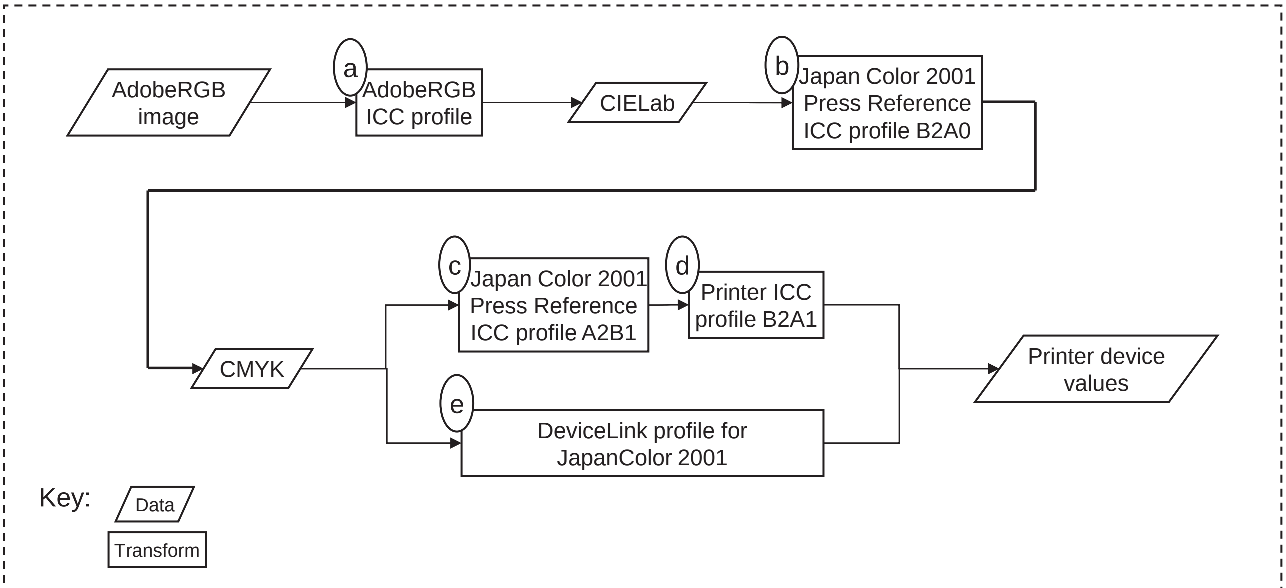


Figure 5 — Print-simulation workflow using commonly available ICC profiles and rendering intents

Figure 5 shows various states of image data and transformation of image data. The image processing workflow shall be as follows:

a) conversion from display-referred RGB values to CIELAB values using ICC profile of display-referred RGB;

b) conversion from CIELAB values to CMYK tone values using ICC profile of intended printing system;

NOTE Perceptual intent (B2A0) for the conversion steps a) and b) for colour communication among stakeholders is recommended.

c) conversion from CMYK values to CIELAB values of print using ICC profile of intended printing system;

d) conversion from CIELAB values of print to reference printer device values (typically RGB or CMYK) using ICC profile of the reference printer.

RelativeColorimetric Intent (A2B1 and B2A1 table of the ICC profile) should be used for conversion steps c) and d). A DeviceLink profile may be used for this conversion (step e in Figure 5).

4.3.2 Ways to achieve basic functions

There are three ways to achieve the basic functions as shown in Figure 6 and each case is further explained below in more detail.

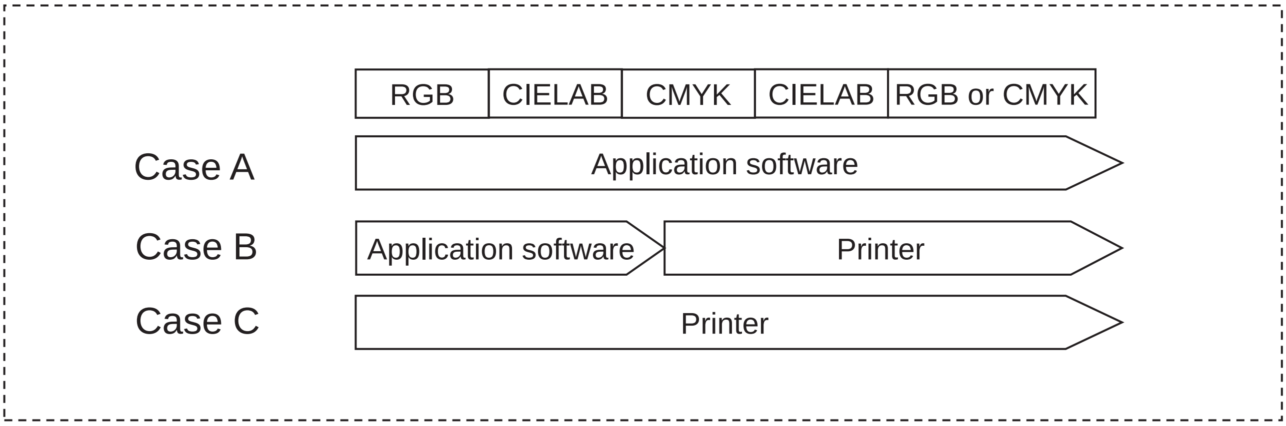


Figure 6 — Three methods to achieve basic functions

a) The application software executes all colour conversions using the source profile, the intended printing condition profile, and the reference printer profile and sends the device value image to the printer. The printer or the printer driver receives the device value image and prints it.

b) The application software applies the colour conversion from RGB to CMYK using the source profile and the intended printing condition profile and sends CMYK image including the intended printing condition profile to the printer. The printer or the printer driver receives the CMYK image and applies the colour conversion from CMYK to the device values of the reference printer using the intended printing condition profile and the reference printer profile and makes the RGB Reference Print for the intended printing condition.

NOTE 1 In some cases, the application software might send only CMYK image and an operator sets the printer or printer driver to simulation mode for the intended printing condition.

c) The application software sends RGB image including the source profile and the intended printing condition profile to the printer. The printer or the printer driver receives the RGB image and performs all colour conversions using the source profile, the intended printing condition profile, and the reference printer profile and makes the RGB Reference Print for the reference printing condition.

NOTE 2 In some case, the application software might send only RGB image and an operator specifies the source profile and the intended printing condition profile at the printer or printer driver.

In all cases, the output intent tag shall be added to the RGB image file to communicate the intended printing condition to stakeholders.

5 File format requirements

5.1 Data delivery

RGB Reference Images shall be delivered as EXIF (JPEG) as defined in ISO 12234-1, or as JFIF (JPEG) as defined in ISO/IEC 10918-5, or as TIFF (RGB) as defined in TIFF Revision 6 (Baseline).

Except by prior agreement between all of the stakeholders in the RGB workflow, all three image formats shall be supported.

Subsequently, these parameters indicate the reference print condition for which the image was checked.

NOTE By prior agreement between the stakeholders, images might also be delivered as PDF as long as the metadata required by this International Standard is included.

5.2 File format extensions

5.2.1 General

Some image writing software may find it more convenient to add the additional parameters as extensions to the file format and this clause describes how this shall be done. Care needs to be taken to ensure consistency between the XMP metadata and the file extension data. The guidelines defined by the metadata working group should be followed to ensure consistency between these two sets of data.

5.2.2 Tiff file

5.2.2.1 RenderingIntent

This field is used to specify the colour rendering intent to be used for colour conversion as defined by ISO 15076-1.

Tag = 51126 (C7B6 H)

Type = SHORT

Count = 1

Default = value of RenderingIntent from header of embedded ICC profile or media relative colorimetric, if no profile is embedded.

Allowed values:

0 = Perceptual

1 = Media relative colorimetric

2 = Saturation

3 = ICC absolute colorimetric

5.2.2.2 UseBlackPtComp

This field is used to indicate whether or not black point compensation should be used for colour conversion as defined by ISO 18619.

Tag = 51127 (C7B7 H)

Type = SHORT

Count = 1

Default = off

Allowed values:

0 = black point compensation shall not be used

1 = black point compensation shall be used

5.2.2.3 OutputIntentProfileURL

This field is used to encode the URL of an ICC profile that should be used as the destination profile when converting to CMYK. When this tag is used, only profiles from the ICC profile registry should be referenced. This tag shall not be used when the OutputIntentProfile tag is used.

Tag = 51128 (C7B8 H)

Type = ASCII

Count = length

5.2.2.4 OutputIntentProfile

If this tag is used, the output intent profile for the reference printing condition is embedded in the file. This tag shall not be used when the OutputIntentProfileURL tag is used.

Tag = 51129 (C7B9 H)

Type = UNDEFINED (treated as 8-bit bytes)

Count = size of embedded ICC profile in bytes

Offset = the file offset, in bytes, to the beginning of the ICC profile

If this tag is used, the output intent profile specified in OutputIntentProfileDescription is embedded in the file. Like all IFD entry values, the embedded profile data shall begin on a 2-byte boundary, so the value offset will always be an even number.

5.2.3 JPEG (JFIF and EXIF)

5.2.3.1 General

Parameters and metadata for RGB images that are required when making RGB Reference Prints are added using the generic box structure and the box embedding mechanism defined in Annex G to JPEG-based image interchange formats including EXIF or JFIF as specified in ISO/IEC 10918-1/ITU-T T.81.

5.2.3.2 RenderingIntent

This box is used to specify the colour rendering intent to be used for colour conversion as defined by ISO 15076-1.

Box Type (TBox) = “Rint” (52696E74 H)

Payload Type = 2-byte integer

Box Length (LBox) = 10 (0A H)

Payload allowed values:

0 = Perceptual

1 = Media relative colorimetric

2 = Saturation

3 = ICC absolute colorimetric

5.2.3.3 UseBlackPtComp

This box is used to indicate whether or not black point compensation should be used for colour conversion as defined by ISO 18619.

Box Type (TBox) = "UBPC" (55425043 H)

Payload Type = 2-byte integer

Box Length (LBox) = 10 (0A H)

Payload allowed values:

0 = black point compensation shall not be used

1 = black point compensation shall be used

5.2.3.4 OutputIntentProfileURL

This box is used to encode the URL of an ICC profile that should be used as the destination profile when converting to CMYK. When this tag is used, only profiles from the ICC profile registry should be referenced. This box shall not be used when the OutputIntentProfile box is used.

Box Type (TBox) = "OUrl" (4F55726C H)

Payload Type = ASCII

Box Length (LBox) = 8 + length

5.2.3.5 OutputIntentProfile

If this box is used, the output intent profile for the reference printing condition is embedded in the file. This box shall not be used when the OutputIntentProfileURL box is used.

Box Type (TBox) = "Oipr" (4F697072 H)

Payload Type = sequence of 8-bit bytes

Box Length (LBox) = 8 + size of embedded ICC profile in bytes

NOTE If this box is used, the output intent profile specified in OutputIntentProfileURL is embedded in the file.

5.3 XMP data for approval status

Rendering information and parameters may be provided as XMP metadata. Where XMP metadata is used, it shall conform to the requirements for image proofing defined in ISO 19445.

6 RGB Reference Prints

6.1 Colour measurement and viewing

Colour measurements shall be made using a spectrocolourimeter that is in accordance with ISO 13655 and standardized correctly to its factory settings and that takes accurate and repeatable measurements within the specified tolerances. The CIELAB colour coordinates *L**, *a**, *b** shall be calculated as detailed in ISO 13655.

The ISO 13655 measurement condition and backing should be selected based on correspondence with the measurement condition used in the characterization of the reference printing condition. Where the measurement condition requirements are not known or measurements are being made of substrate alone, measurement conditions shall be as specified in ISO 13655 for M0 and white backing and should be as specified in ISO 13655 for M1 and white backing. Typical aim values for common reference printing conditions are provided in Annex E.

In some cases, colour aim values are defined relative to the substrate. In these cases, the aim values shall be converted to absolute colour values using the method specified in Annex F using the measurement of the actual print substrate. In this way, the measured values can easily be compared to these absolute colours.

CIEDE2000 (ΔE_{00}) colour differences shall be calculated as detailed in ISO/CIE 11664-6. In this specification approximate CIELAB 1976 (ΔE_{ab}) colour differences, calculated as detailed in ISO 13655 are shown in brackets and because there is no direct correlation with ΔE_{00}, these should be regarded as informative references.

All colour measurements and computed colour differences shall be reported, accompanied by an associated total uncertainty (using the coverage factor k = 1). The evaluation method should be performed as outlined in ISO 15790. It should include an estimate of the inter-instrument agreement between the two different measurement instruments both believed to be conforming to ISO 13655. The value may also be extracted from the manufacture’s specification or from a certificate of calibration from the manufacturer. The inter-instrument agreement, uncertainly, should be added in quadrature to the uncertainty determined by experimental readings, as outlined in ISO 15790. If not defined otherwise, this criterion can be considered as having been fulfilled when the tolerance limit(s) occupy no more than 50 % of the covered uncertainty.

All colour measurements shall be rounded with the same precision as the defined tolerance value.

NOTE 1 A colour difference of ΔE_{00} = 5,4 will be rounded to 5 and will be in conformance if the tolerance is defined as $\Delta E_{00} \leq 5$. The same colour difference will be not in conformance when the tolerance is stipulated as $\Delta E_{00} \leq 5{,}0$.

NOTE 2 Although the industry is struggling to develop metrologically based techniques for the evaluation of the quality of proof-to-print matches, unfortunately, most industry trade groups still rely on visual comparisons. It is recognized that these evaluations are highly dependent on both the subject matter chosen and on the observers participating.

Viewing of prints shall be in accordance with Annex B.

6.2 RGB Reference Print requirements

6.2.1 Print substrate colour

Where possible, the substrate shall have a similar level of optical brightening agent as the actual print substrate.

The colour of the substrate shall not vary more than by a CIEDE2000 colour difference of 2,5 when successively subjected to the following storage conditions in the dark:

— for 24 h at 25 °C and at a relative humidity of 25 %;

— 24 h at 40 °C and a relative humidity of 80 %;

— one week at 40 °C and at a relative humidity of 10 %.

In cases where the actual print substrate differs from the reference print substrate (as indicated by the characterization data set or ICC Profile for the reference printing condition) by more than 3 CIEDE2000, a media relative colour adjustment shall be made using the principles outlined in Annex F.

6.2.2 Margin information

Every RGB Reference Print should bear a human-readable comment that includes at least the following information:

— conformance level ("RGB Reference Print according to ISO 16760");

— RGB image file name;

— printing system designation;

— substrate material type;

— printing condition being simulated;

— time and date of production;

— time and date of last calibration.

RGB Reference Prints should include colorant types, colour management profile(s) used, RIP name and version, scaling (if applied), type of coating, dedicated data preparation, type of paper/structure simulation, such as noise or patterning (if applied), and image ID.

6.2.3 Print stability

For some printing technologies, the colour of prints changes in the period immediately following printing.

Manufacturers of RGB printers used for RGB Reference Prints shall specify the time necessary for printed colour to become stable or provide colour shift data from which the print stability period can be determined and the period for which the print remains stable.

The user shall take the steps necessary to ensure that printed test charts and RGB Reference Prints are stable before making measurements or assessing the printed result.

6.2.4 RGB digital control strip

An RGB digital control strip shall be printed using the reference printing condition.

This control strip shall comprise a minimum of three grey patches with equal RGB values of (76/255), (128/255), and (192/255) which shall be checked visually and should be used for user's routine measurement for daily control. These three patches shall be no smaller than 5 mm and should be placed on each RGB reference print.

6.3 Regular checks of RGB Reference Printer

6.3.1 Colour requirements

A set of RGB test patches should be printed and measured before the RGB Reference Printer is used for the first time and following any significant change such as a change of ink cartridge or batch of substrate to check the reproduction accuracy of neutrals and memory colours. These patches are defined in Annex C for Adobe RGB (1998).

There are 64 grey steps and four memory colours representing typical values for light skin, dark skin, grass, and sky each with 27 colour steps. In addition, there is a set of 6 × 6 × 6 RGB patches representing all combinations of the values 0/255, 52/255, 94/255, 143/255, 197/255, 255/255.

NOTE 1 The set of 6 × 6 × 6 patches are taken from ISO 12640-4, S1 where the step differences are determined such that the grey patches (R = G = B) represent L* = 0, 20, 40, 60, 80, 100 with a* = b* = 0 in the AdobeRGB space.

For each printing condition to be simulated, image patch values for Adobe RGB (1998) described in Annex C should be printed using either Perceptual or RelativeColorimetric rendering intent.

NOTE 2 In the U.S. and Europe, the default rendering intent for non-expert users is RelativeColorimetric. In Japan, the default is Perceptual.

These patches should then be measured as described in 6.1 and the measurements compared with the aim values for each patch. The CIELAB colour coordinates of the RGB test patches should agree with the pertinent aim values for the image rendering condition within the tolerances specified in Table 1.

Table 1 — Tolerances for control patches

Control patch description	Tolerance
64 grey patches	Average $\Delta E_{00} \leq 2{,}75$ ($\Delta E_{ab} \leq 3$)
27 colours for dark skin	Average $\Delta E_{00} \leq 3$ ($\Delta E_{ab} \leq 3{,}5$)
27 colours for light skin	Average $\Delta E_{00} \leq 3{,}3$ ($\Delta E_{ab} \leq 4$)
27 colours for blue sky	Average $\Delta E_{00} \leq 3{,}3$ ($\Delta E_{ab} \leq 4$)
27 colours for foliage	Average $\Delta E_{00} \leq 3{,}3$ ($\Delta E_{ab} \leq 4$)
6 × 6 × 6 patches	Average $\Delta E_{00} \leq 4$ ($\Delta E_{ab} \leq 6$) 95 % percentile $\Delta E_{00} \leq 5$ ($\Delta E_{ab} \leq 6{,}5$)

6.3.2 Determining aim values

The CIELAB aim values for each patch should be determined using the Adobe RGB (1998) profile as the source profile and a destination profile for all supported printing condition. All RGB test patches should be printed and measured and the measured values compared with the aims. This process should be repeated for all of the supported printing conditions.

Aim values should be calculated using the following rendering intent(s) supported by the RGB Reference Printer (RelativeColorimetric or Perceptual).

a) Patch RGB values should be converted to CMYK values for the reference printing condition using the supported output intent(s) using an Adobe RGB (1998) ICC profile as the source and an ICC profile for the reference printing condition as the destination.

b) Each set of CMYK values should be converted to the RGB reference printer values using RelativeColorimetric output intent. This conversion is achieved using the ICC profile for the reference printing condition as the source profile and the RGB reference printer profile as the destination profile.

6.3.3 Reproduction of vignettes

Reproductions of the RGB data in accordance with ISO 12640-4, S2 should show no visible steps within the tone value reproduction limits if viewed under ISO viewing condition P2, in accordance with ISO 3664.

6.3.4 Uniformity test

Regular checks of the printer's uniformity should be conducted.

The variability of the coloration across the validation print format should be verified by printing each of the three test forms: R = G = B = (76/255), R = G = B = (128/255), and R = G = B = (192/255). These forms should each cover the entire printing area. Each test form should be measured at nine locations on each sheet as follows. Divide the printed area into thirds both horizontally and vertically and measure at the centre of each area. All selected locations across the printed test area for each test tint, after the stabilization period, should have the following:

a) standard deviation less than or equal to 1,5 for CIE L*, a*, and b*;

b) maximum CIEDE2000 colour difference of two units between the average of the nine readings and any one reading.

NOTE The requirements specified in a) and b) are not statistically consistent but have been observed to be achievable in a well-controlled digital printing system.

Annex A
(informative)

Relationship between highlight and neutral tone value

Images encoded as Adobe RGB (1998) have display-referred image state. Those images are converted to print-referred images using ICC profiles according to the steps described in 4.3. These profiles convert the appearance on the standard monitors to the appearance of printed matter under P2 condition of ISO 3664. Figure A.1 shows the relationship between RGB neutral tone (L*) of Adobe RGB (1998) and printed tone (L*) of corresponding printed matter using ICC profiles from Adobe RGB (1998) to CMYK. Three plots of typical press printing profiles: Japan Color2001coated, ISOcoated_v2_eci, and GRACoL2006_Coated1v2 are shown. The conversion process of left side of Figure A.1 is as follows:

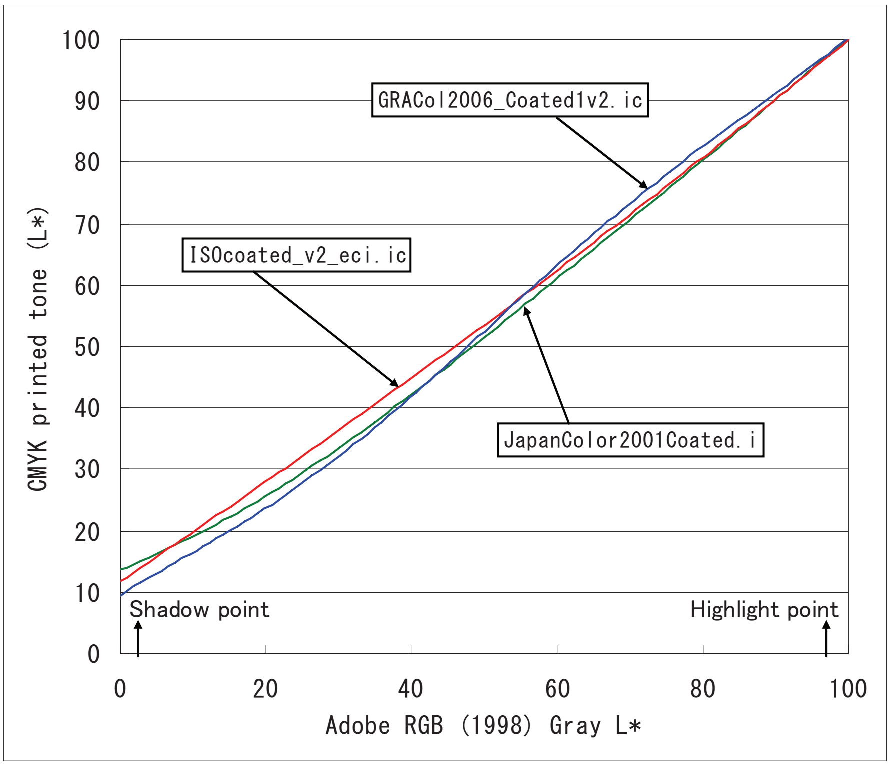
Adobe RGB (1998) → Perceptual → CMYK tone value → Relative-colorimetric → L*a*b*

NOTE 1 As perceptual conversion is highly dependent on profiling software, well-established profiles as shown in this Annex should be used.

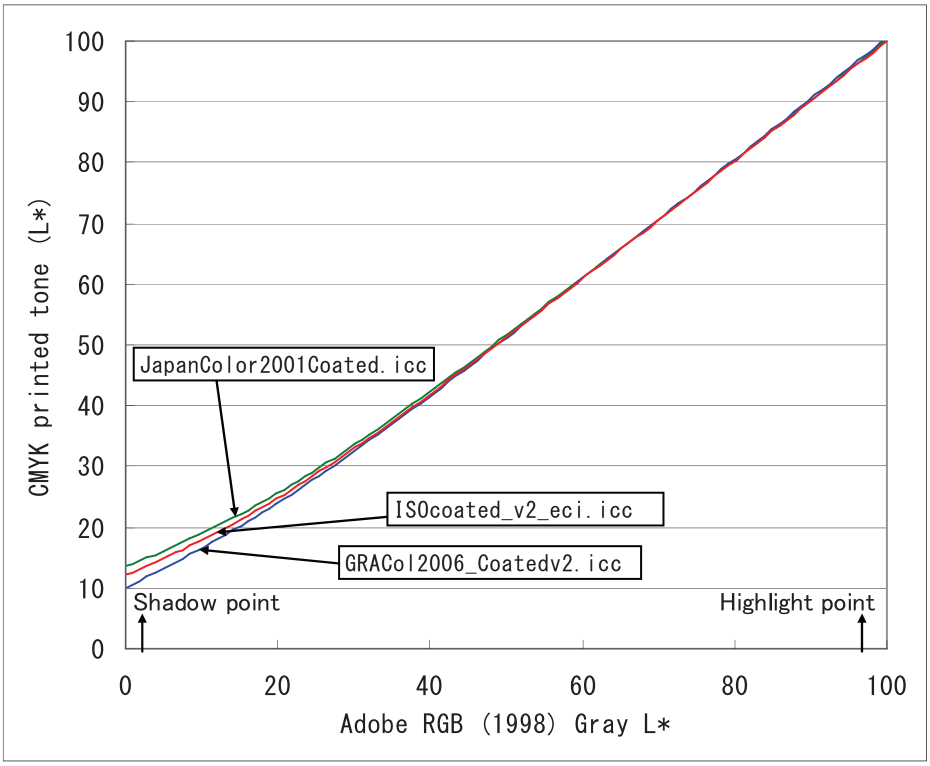
The conversion process of the right side of Figure A.1 is as follows:

Adobe RGB (1998) → Relative-colorimetric(BPC_on) → CMYK tone value → Relative-colorimetric → L*a*b*

Three plots are very similar with each other except shadow region in case of the right side of Figure A.1.



a) Perceptual



b) Relative Colorimetric + BPC

Figure A.1 — Relationship between RGB neutral tone (L*) and printed tone (L*)

The highlight and shadow points for a correctly prepared RGB reference image should correspond to RGB values of nearly 246 and 15 for average-key images. These points are shown in Figure A.1. Although corresponding CMYK values depend on press printing profiles, these should be inside of the tone value reproduction limit such as 2 % to 98 % for coated paper specified in ISO 12647-2.

NOTE 2 These RGB values are provided by Reference.[24] Nearly same values such as 240 to 250 (highlight point) and 10 to 20 (shadow point) are provided in some documents. In the document, CMYK and equivalent grayscale values are also provided, such as CMYK = 5 %, 3 %, 3 %, 0 % and equivalent gray scale = 4 % for highlight point (RGB = 244) and CMYK = 65 %, 53 %, 51 %, 95 % and equivalent gray scale = 96 % for shadow point (RGB = 10) based on U.S. Sheetfed Uncoated profile. These data correspond to typical traditional scanner setup values for the highlight point (3 % to 5 %) and shadow point (95 % to 97 %). Some prepress companies recommend using an RGB value of 220 as the highlight point. This recommended value enables an RGB image to be retouched easily.

Annex B
(normative)

Viewing condition

It is a good plan to complement the measurements and visual checks of reference print colour test chart in Annex C by visual judgements of a panel of colour experts. The problems are how to exclude the influences of subjective judgement, observer fatigue, and varying viewing conditions.

All hardcopy proofs are to be compared to a high-quality press print which represents the intended printing condition that is to be simulated by the proof print. Viewing shall be in accordance with ISO 3664. A viewing booth conforming to ISO 3664, ISO viewing conditions P2, and with a viewing area of at least 100 cm width and 75 cm in depth should be used. The light source of the viewing booth should be allowed to stabilize in colour temperature for at least 30 min or until measurement demonstrates stabilization. All extraneous materials are to be removed from the sides and back of the viewing booth so as to not affect the evaluations. All room lights are to be reduced in order to ensure that no extraneous light different from D50 is disturbing the visual appraisal.

Annex C
(normative)

RGB Reference Print colour test chart

For checks on the uniformity of grey scales and on the consistency of memory colours, the series of RGB test patches shown in Table C.1 and Table C.2 shall be used.

The series of patches in Table C.1 comprises 64 grey steps (1 to 64) and 27 steps of each of four memory colours (65 to 172). The memory colour patches representing typical values for dark skin, light skin, blue sky, and foliage are interleaved at each lightness level.

The series of patches in Table C.2 comprises a set of RGB patches with all combinations of values 0/255, 52/255, 94/255, 143/255, 197/255, and 255/255.

All patches are encoded as Adobe RGB (1998). The Adobe RGB (1998) values for each patch are shown in Table C.1 and Table C.2.

Table C.1 — RGB values for image patches

No.	R	G	B		No.	R	G	B		No.	R	G	B
1	255	255	255		26	152	152	152		51	52	52	52
2	252	252	252		27	148	148	148		52	48	48	48
3	248	248	248		28	144	144	144		53	44	44	44
4	240	240	240		29	140	140	140		54	40	40	40
5	236	236	236		30	136	136	136		55	36	36	36
6	232	232	232		31	132	132	132		56	32	32	32
7	228	228	228		32	128	128	128		57	28	28	28
8	224	224	224		33	124	124	124		58	24	24	24
9	220	220	220		34	120	120	120		59	20	20	20
10	216	216	216		35	116	116	116		60	16	16	16
11	212	212	212		36	112	112	112		61	12	12	12
12	208	208	208		37	108	108	108		62	8	8	8
13	204	204	204		38	104	104	104		63	4	4	4
14	200	200	200		39	100	100	100		64	0	0	0
15	196	196	196		40	96	96	96		65	90	74	66
16	192	192	192		41	92	92	92		66	92	74	59
17	188	188	188		42	88	88	88		67	92	74	52
18	184	184	184		43	84	84	84		68	95	71	66
19	180	180	180		44	80	80	80		69	96	71	59
20	176	176	176		45	76	76	76		70	97	71	52
21	172	172	172		46	72	72	72		71	99	68	66
22	168	168	168		47	68	68	68		72	100	68	59
23	164	164	164		48	64	64	64		73	101	68	52
24	160	160	160		49	60	60	60		74	102	85	77
25	156	156	156		50	56	56	56		75	103	85	69

Table C.1 *(continued)*

No.	R	G	B		No.	R	G	B		No.	R	G	B
76	104	85	62		109	190	147	123		142	120	135	161
77	107	82	77		110	191	167	153		143	120	133	178
78	108	82	70		111	192	167	144		144	123	132	170
79	109	82	62		112	194	167	135		145	126	132	161
80	111	79	77		113	196	164	153		146	77	99	67
81	112	79	70		114	198	163	144		147	78	99	60
82	113	79	63		115	199	163	136		148	79	99	52
83	114	97	88		116	202	160	153		149	82	97	67
84	115	97	80		117	203	160	144		150	83	97	60
85	116	97	73		118	205	160	136		151	84	97	52
86	119	94	88		119	83	113	151		152	87	95	67
87	120	94	80		120	87	113	143		153	88	95	60
88	121	94	73		121	90	113	135		154	89	95	53
89	124	91	88		122	89	111	151		155	88	111	78
90	125	90	81		123	93	110	143		156	89	111	70
91	126	90	73		124	96	110	135		157	91	111	63
92	163	141	127		125	95	108	151		158	93	109	78
93	165	141	119		126	99	108	143		159	94	109	70
94	166	140	111		127	102	108	135		160	96	109	63
95	169	137	127		128	95	125	164		161	98	107	78
96	170	137	119		129	98	125	156		162	99	107	70
97	171	137	111		130	102	125	130		163	101	106	63
98	174	134	127		131	101	123	131		164	99	123	89
99	175	134	119		132	105	123	132		165	101	123	81
100	177	134	111		133	108	122	133		166	102	123	73
101	177	154	140		134	108	120	134		167	105	121	89
102	178	154	131		135	111	120	135		168	106	121	81
103	180	153	123		136	114	120	136		169	107	121	74
104	182	150	140		137	107	138	137		170	110	119	89
105	184	150	131		138	111	138	138		171	111	119	81
106	185	150	123		139	114	137	139		172	113	119	74
107	188	147	140		140	114	135	140					
108	189	147	131		141	117	135	141					

Figure C.1 shows one possible layout of image patches.

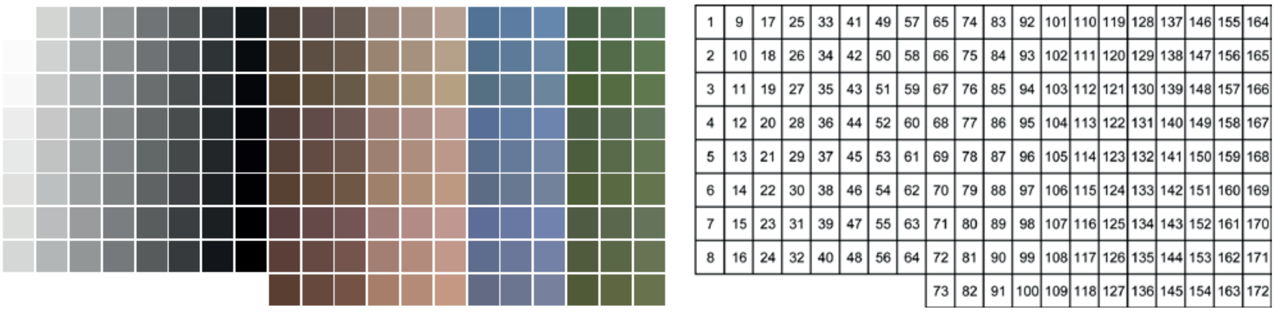


Figure C.1 — One possible layout of image patches

Table C.2 — RGB values for 6 × 6 × 6 patches

No.	R	G	B		No.	R	G	B		No.	R	G	B
1	0	0	0		31	255	0	0		61	197	52	0
2	0	0	52		32	255	0	52		62	197	52	52
3	0	0	94		33	255	0	94		63	197	52	94
4	0	0	143		34	255	0	143		64	197	52	143
5	0	0	197		35	255	0	197		65	197	52	197
6	0	0	255		36	255	0	255		66	197	52	255
7	52	0	0		37	0	52	0		67	255	52	0
8	52	0	52		38	0	52	52		68	255	52	52
9	52	0	94		39	0	52	94		69	255	52	94
10	52	0	143		40	0	52	143		70	255	52	143
11	52	0	197		41	0	52	197		71	255	52	197
12	52	0	255		42	0	52	255		72	255	52	255
13	94	0	0		43	52	52	0		73	0	94	0
14	94	0	52		44	52	52	52		74	0	94	52
15	94	0	94		45	52	52	94		75	0	94	94
16	94	0	143		46	52	52	143		76	0	94	143
17	94	0	197		47	52	52	197		77	0	94	197
18	94	0	255		48	52	52	255		78	0	94	255
19	143	0	0		49	94	52	0		79	52	94	0
20	143	0	52		50	94	52	52		80	52	94	52
21	143	0	94		51	94	52	94		81	52	94	94
22	143	0	143		52	94	52	143		82	52	94	143
23	143	0	197		53	94	52	197		83	52	94	197
24	143	0	255		54	94	52	255		84	52	94	255
25	197	0	0		55	143	52	0		85	94	94	0
26	197	0	52		56	143	52	52		86	94	94	52
27	197	0	94		57	143	52	94		87	94	94	94
28	197	0	143		58	143	52	143		88	94	94	143
29	197	0	197		59	143	52	197		89	94	94	197
30	197	0	255		60	143	52	255		90	94	94	255

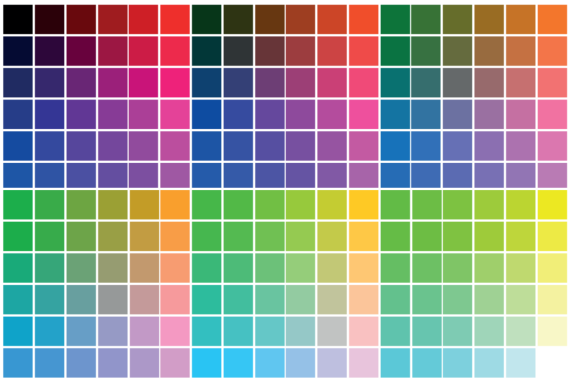
Table C.2 *(continued)*

No.	R	G	B		No.	R	G	B		No.	R	G	B
91	143	94	0		131	143	143	197		171	197	197	94
92	143	94	52		132	143	143	255		172	197	197	143
93	143	94	94		133	197	143	0		173	197	197	197
94	143	94	143		134	197	143	52		174	197	197	255
95	143	94	197		135	197	143	94		175	255	197	0
96	143	94	255		136	197	143	143		176	255	197	52
97	197	94	0		137	197	143	197		177	255	197	94
98	197	94	52		138	197	143	255		178	255	197	143
99	197	94	94		139	255	143	0		179	255	197	197
100	197	94	143		140	255	143	52		180	255	197	255
101	197	94	197		141	255	143	94		181	0	255	0
102	197	94	255		142	255	143	143		182	0	255	52
103	255	94	0		143	255	143	197		183	0	255	94
104	255	94	52		144	255	143	255		184	0	255	143
105	255	94	94		145	0	197	0		185	0	255	197
106	255	94	143		146	0	197	52		186	0	255	255
107	255	94	197		147	0	197	94		187	52	255	0
108	255	94	255		148	0	197	143		188	52	255	52
109	0	143	0		149	0	197	197		189	52	255	94
110	0	143	52		150	0	197	255		190	52	255	143
111	0	143	94		151	52	197	0		191	52	255	197
112	0	143	143		152	52	197	52		192	52	255	255
113	0	143	197		153	52	197	94		193	94	255	0
114	0	143	255		154	52	197	143		194	94	255	52
115	52	143	0		155	52	197	197		195	94	255	94
116	52	143	52		156	52	197	255		196	94	255	143
117	52	143	94		157	94	197	0		197	94	255	197
118	52	143	143		158	94	197	52		198	94	255	255
119	52	143	197		159	94	197	94		199	143	255	0
120	52	143	255		160	94	197	143		200	143	255	52
121	94	143	0		161	94	197	197		201	143	255	94
122	94	143	52		162	94	197	255		202	143	255	143
123	94	143	94		163	143	197	0		203	143	255	197
124	94	143	143		164	143	197	52		204	143	255	255
125	94	143	197		165	143	197	94		205	197	255	0
126	94	143	255		166	143	197	143		206	197	255	52
127	143	143	0		167	143	197	197		207	197	255	94
128	143	143	52		168	143	197	255		208	197	255	143
129	143	143	94		169	197	197	0		209	197	255	197
130	143	143	143		170	197	197	52		210	197	255	255
211	255	255	0		213	255	255	94		215	255	255	197

Table C.2 *(continued)*

No.	R	G	B		No.	R	G	B		No.	R	G	B
212	255	255	52		214	255	255	143		216	255	255	255

Figure C.2 shows one possible layout of these patches.



1	7	13	19	25	31	37	43	49	55	61	67	73	79	85	91	97	103
2	8	14	20	26	32	38	44	50	56	62	68	74	80	86	92	98	104
3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93	99	105
4	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94	100	106
5	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95	101	107
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108
109	115	121	127	133	139	145	151	157	163	169	175	181	187	193	199	205	211
110	116	122	128	134	140	146	152	158	164	170	176	182	188	194	200	206	212
111	117	123	129	135	141	147	153	159	165	171	177	183	189	195	201	207	213
112	118	124	130	136	142	148	154	160	166	172	178	184	190	196	202	208	214
113	119	125	131	137	143	149	155	161	167	173	179	185	191	197	203	209	215
114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216

Figure C.2 — One possible layout of 6 × 6 × 6 patches

Annex D
(informative)

Key RGB workflow concepts

D.1 Conventional film workflow and digital still camera workflow comparison

In a conventional graphic arts workflow, skilled scanner operators were responsible for creating CMYK reference documents from an original (film transparencies, film prints, and other printed material) using a colour scanner. Photographers usually provided a number of candidate originals and one of these was selected to be scanned. When scanning, the operators set up highlight and shadow points, tone curve, and colour adjustment to create a CMYK image optimised for print. In this conventional workflow, the original allowed stakeholders (photographer, scanner operator, printer, and print buyer) to communicate intended appearance such as tone reproduction and colour. Figure D.1 shows a conventional film workflow.

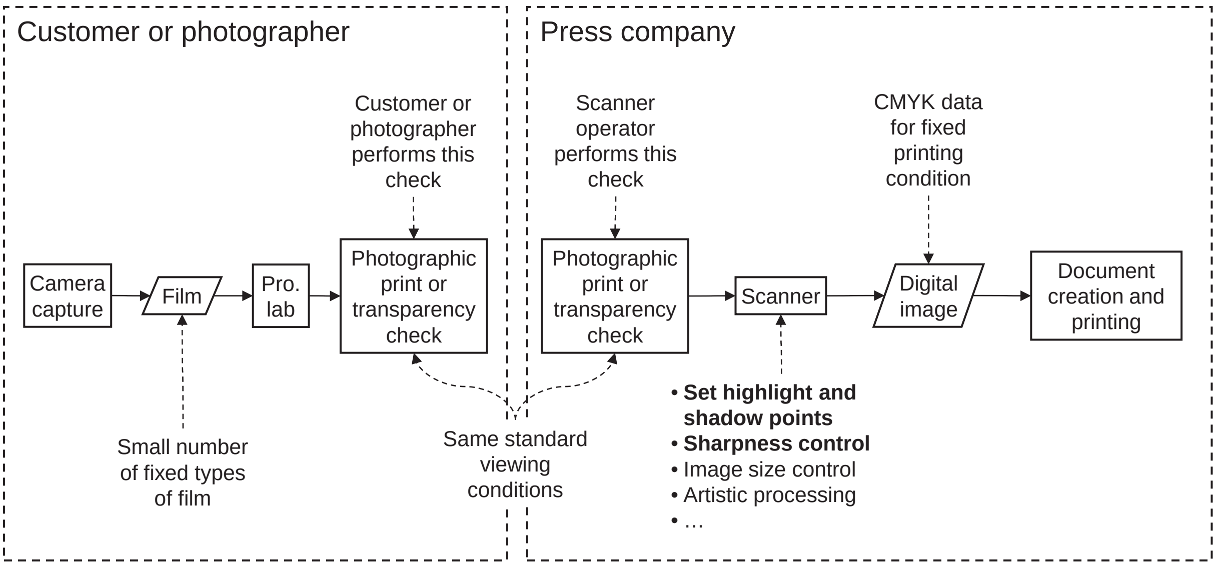


Figure D.1 — Conventional (hardcopy) workflow

One major difference between conventional film workflow and DSC workflow is that a DSC image is just data and has no associated physical reference. When preparing DSC images for print, it remains an important requirement to be able to set up highlight and shadow points, tone reproduction, and colour adjustments. It is also important to be able to communicate intended appearance between stakeholders. The document preparation process for an RGB workflow needs carefully prepared RGB images. Figure D.2 shows typical DSC input workflow.

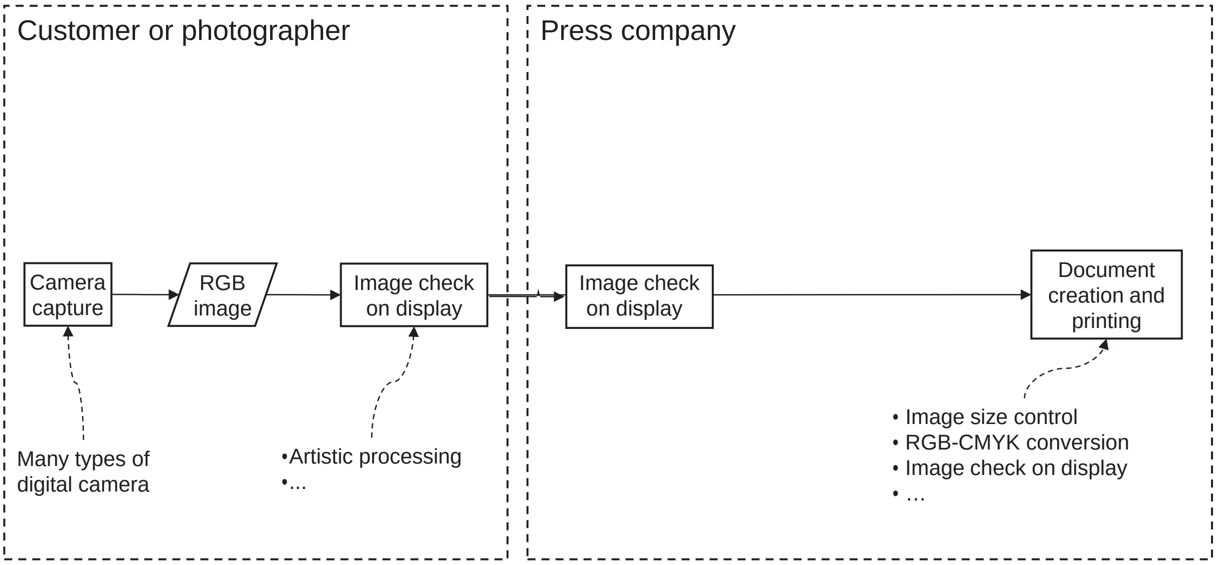


Figure D.2 — Digital camera workflow

D.2 Use of colour monitors in an RGB workflow

D.2.1 General

Colour monitors may be used in order to check, re-touch, and confirm that RGB images have been correctly prepared for printing; however, in this case, users should be aware that the appearance of images on a display is different from that of a print and so the checking of colour difference using a display is difficult for inexperienced users.

D.2.2 Image appearance

An RGB digital image is just data and does not usually have a fixed appearance in the way that a film transparency or hardcopy print does but relies on a colour monitor to provide its appearance. RGB images have display-referred image state as specified in ISO 22028-1 and so, for example, the appearance of an image encoded as Adobe RGB (1998) is specified by the Adobe RGB (1998) standard which includes a monitor description and viewing condition.

NOTE 1 Adobe RGB (1998) is a typical colour space used in the printing industry.

When using a monitor for soft proofing, software that supports a proofing mode shall be used and the intended printing condition selected. In some cases, it may be difficult to ensure that all stakeholders (photographers, prepress operators, printers, and print buyers) set up their colour monitor to such a standard condition.

NOTE 2 One solution to this problem is that the same monitor and viewing condition is used by all stakeholders; however, this is not usually possible in practice.

Using an RGB Reference Print of the image avoids this problem to some extent as the same reference print can be shared among stakeholders.

D.2.3 Colour difference

In most cases, it is easier for inexperienced users to judge colour difference on print than it is on a monitor.

It is very difficult for inexperienced users to check and retouch RGB images on a monitor. For example, the highlight point and shadow point selection can be checked by high-skilled prepress operator and RGB images prepared using equivalent CMYK tone value but most inexperienced users cannot do this.

This International Standard describes how to use an RGB Reference Print instead of a monitor in order to share and communicate the appearance of RGB images between stakeholders.

D.3 Setting highlight and shadow points

D.3.1 General

When performing RGB to CMYK conversion of images for print, it is important to control carefully a number of aspects that include the following:

a) adjustment of tone curve and grey balance;

b) adjustment of colour (including enhancement);

c) setting of highlight and shadow points.

In a conventional scanner process, these parameters are set and processing is performed to ensure that printable CMYK data are produced from a transparency or photographic print. These same parameters need to be set and similar processing is needed when converting digital camera RGB data to CMYK data. This processing is poorly defined today and it is often not clear to participants in the workflow whether the responsibility for such adjustment should be performed at the time of image capture or at the time of document creation.

D.3.2 Adjustment of grey balance

Grey area in the scene is reproduced as grey in the reproduction system in certain tolerance using RGB balance.

D.3.3 Colour adjustment (including enhancement)

In a conventional scanning system, this process is not usually considered to be an adjustment for light source colour balance and then adjustment of image colour and is usually thought of as a grey balance adjustment followed by a colour adjustment.

In conventional scanning process, further image enhancement is used to compensate for reproduction degradation in the output system (for example, as caused by screening). In a conventional scanning system, this process was not considered to be in two parts distinguishing input processes from output processes.

D.3.4 Importance of highlight and shadow points

Most original scenes contain information that covers a broad range of luminance. In many cases, a considerable amount of that information occurs at very high luminance, including luminance above a reference white in the principal subject area of a scene. Sources of such information include specular highlights, diffuse highlights, scene areas that are more highly illuminated than the principal subject area, and fluorescent colours. The reference white in the principal subject area corresponds to the highlight point.

Because of the visual importance of the above-white information, most photographic materials are designed to record an extensive dynamic range of luminance information, often two or three times above a reference white. When printing, the highest luminance level is limited by paper white. If we want to record the ‘above-white’ information on paper using a linear mapping, a luminance value of two or three times above the reference white (that is 0,3 to 0,5 log luminance above) needs to be mapped to the paper white which would mean that the optical density of the highlight point (reference white in the principal area) would be mapped to 0,3 to 0,5 of the paper white density. This 0,3 to 0,5 density is much too dark to be acceptable by hardcopy observers. For this reason, the highlight point is set to be slightly darker than paper white (about 0,03 to 0,05) and the above-white information is compressed between this point and paper white. For this reason, it is very important to be able to define the highlight point in the DSC image and to map this colour to the correct optical density point of the hardcopy reproduction system.

When these DSC images are reproduced on a display, human observers can adapt and see these images in the same way as they would see a projected transparency in a dark room and, in such a viewing environment, it is quite acceptable to have an optical density of the reference white set to 0,3 to 0,5 from the maximum luminance level of the display. In other words, these images appear to be correctly adjusted if there is no other white cue on the display or in the observer's viewing field. As discussed previously, this 0,3 to 0,5 density level to the reference white would be unacceptable for hardcopy print. For this reason, it is difficult to optimize these images for hardcopy output by only observing them on the display in the usual viewing condition. In a traditional workflow, the scanner operator usually sets the printed pixel values of the expected highlight point area in the image.

The shadow point corresponds to the darkest point that needs to be reproduced (the dark end of the gradient). This point, along with the highlight point, is used to map the dynamic range of important content in the scene to the available reproduction colour gamut of the intended printing system. It is well known that determining tone curves for such a mapping depends on the accurate identification of highlight and shadow points. To some extent, the selection of these points depends on the intent of the photographer or print buyer. Some image colour densities such as skin tones are nearly constant and, in many cases, can be used to determine highlight and shadow points.

D.3.5 Sharpness

It is often necessary to sharpen an image to increase its apparent resolution. This needs to be applied based on the image sampling, scaling when placed in a document, and effective printing resolution. Since this International Standard deals with image preparation and does include document preparation, the way in which sharpness should be handled is not within the scope of this International Standard.

D.4 Key aspects of RGB workflow

If the RGB image has been prepared according to the guidelines in this International Standard, it is easy to predict colour chromaticities using ICC profiles and to make the RGB Reference Print. Figure D.3 shows a simulation print workflow. RGB Reference Images should be adjusted in terms of tone, colour, sharpness, and other variables; however, this International Standard confines its scope to tone and colour.

There are several advantages in using RGB Reference Prints:

— The same image appearance can easily be shared between stakeholders using standard print viewing conditions. It is easier to set up a calibrated RGB Reference Printer and standard print viewing conditions than to set up standard monitor viewing conditions.

— It is easy to communicate intended colour result between stakeholders.

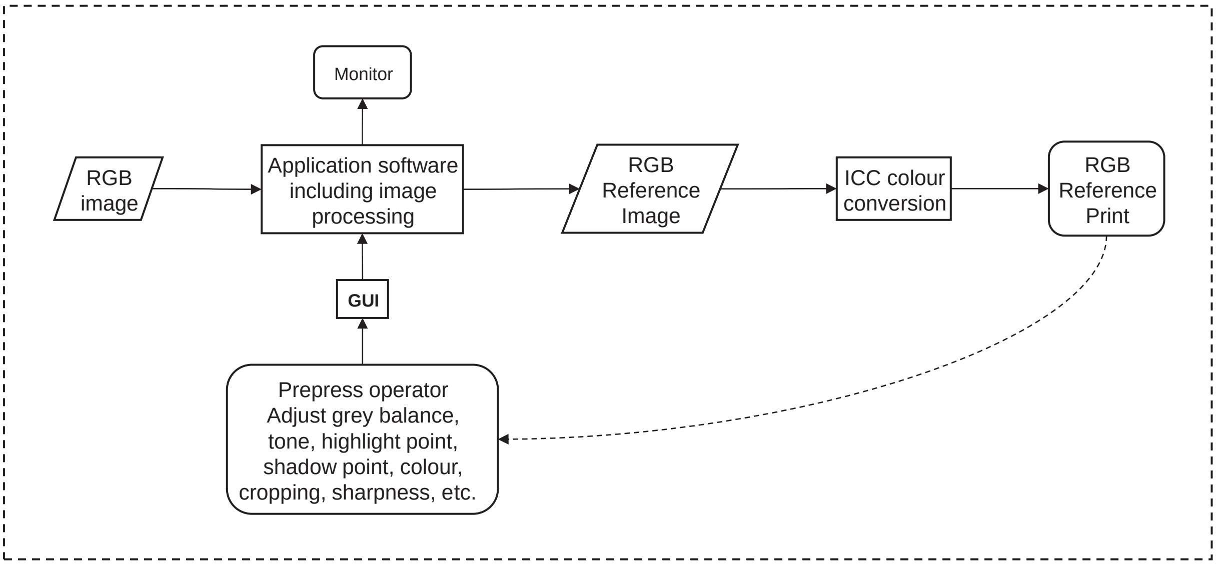


Figure D.3 — Image processing workflow using RGB Reference Image

NOTE The print-simulation printer should be a relatively inexpensive consumer-use printer and half-tone screen requirements are not needed because the main purpose of this print is to transfer "appearance of RGB image" among stakeholders.

D.5 Various prints used in graphic arts workflow

There are three kinds of standardised digital prints in graphic arts workflow. The first is a contract proof (ISO 12647-7) and the second is a validation print (ISO/DIS 12647-8); these are both page-based. The third is the RGB Reference Print described in this International Standard which is component (image) based. Those characteristics are shown in Table D.1.

Table D.1 — Comparison of three kinds of digital print in graphic arts workflow

	RGB Reference Print (ISO 16760)	**Validation Print** (ISO 12647-8)	**Contract Proof** (ISO 12647-7)
Objective	Image colour communication among stakeholders To check/retouch RGB component data to make CMYK-ready data using reference print prior to composing stage	Checking at design and document composition stage To check image quality and layout of page after composing almost the same as printed matter Image quality includes tone, colour, and sharpness	Contract proof To check image quality and layout of page after composing almost the same as printed matter Image quality includes tone, colour, and sharpness
Intended audience	Photographers, Graphic Designers, Print buyers	Designers, Prepress operators	Prepress operators, Printers, and print buyers
Workflow stage	Image preparation	Concept design, prototyping	Printing and/or prepress
Data source	RGB Images	CMYK or virtual CMYK document pages	CMYK or virtual CMYK document pages

Table D.1 *(continued)*

	RGB Reference Print (ISO 16760)	**Validation Print (ISO 12647-8)**	**Contract Proof (ISO 12647-7)**
Printer (Colour gamut)	Office use/Personal use Full CMYK colour gamut is not needed	Semi-industrial use/Office use Almost CMYK full colour gamut	Industrial use CMYK full colour gamut
Printed image quality	Moderate	Relatively high	High
Colour accuracy	Sufficient enough for colour communication	Relatively high	High
Sharpness	Not needed	Necessary	Necessary

Annex E
(informative)

Example aim values for common rendering options

Typical aim values for various rendering options (combinations of ICC profiles and rendering intent) are provided to show the effect of these options on image aim values.

Files E1 to E4 provide Adobe RGB (1998) encoding values and typical CIELAB aim values for a combination of two different image rendering options and three reference printing conditions for each test patch of the GreyAndMemory image colours (Table C.1) and the 6 × 6 × 6 colour image array (Table C.2).

The rendering options are perceptual and relative colorimetric with black point compensation (BPC).

The reference printing conditions are the following:

— JapanColor — JapanColor2001Coated.icc [Japan Color 2001 Coated] ICC Profile is used to define the reference printing conditions;

— SWOP — USWebCoatedSWOP2006Grade3Paper.icc [U.S. Web Coated (SWOP) v2] ICC Profile is used to define the reference printing conditions;

— Fogra 39 — CoatedFOGRA39.icc [Coated FOGRA39 (ISO 12647-2:2004)] ICC Profile is used to define the reference printing conditions.

Media Relative L*a*b* values are calculated from L*a*b* measurement data as described in Annex F.

The files included in the electronic insert are the following:

— File E1 — Typical aim values for perceptual rendering for grey and memory image patches;

— File E2 — Typical aim values for relative colorimetric (with BPC) for grey and memory image patches;

— File E3 — Typical aim values for perceptual rendering for ‘6 × 6 × 6 patches;

— File E4 — Typical aim values for relative colorimetric (with BPC) for ‘6 × 6 × 6 patches.

Annex F
(normative)

Media relative measurements

F.1 General

In some cases, it is more convenient to use media-relative CIELAB instead of the more usual illuminant-relative (D50) CIELAB measurements. This is especially useful in cases where differences in the substrate colour are not important. This Annex provides guidance on the calculation and communication of media-relative CIELAB.

F.2 Notation

When communicating CIELAB colour measurement data, it is important to know the ‘white stimulus’ used for X_n, Y_n, and Z_n when calculating the CIELAB values. This is not usually communicated explicitly but is implied by the viewing condition, for example, in graphic arts; this is usually defined as the light reflected from a perfect reflecting diffuser by the D50 illumination in the standard viewing environment.

When media-relative measurements are used, it is important to avoid confusion and where these are communicated, they shall be clearly indicated using the subscript ‘mr’ (for example, $\text{CIELAB}_{\text{mr}}$, L^*_{mr}, a^*_{mr}, b^*_{mr}).

F.3 Definition

Media-relative CIELAB values are defined by the CIELAB formulae as defined in ISO 11664-4 as follows:

$$L^* = 116f(Y/Y_n) - 16 \quad \text{(F.1)}$$

$$a^* = 500[f(X/X_n) - f(Y/Y_n)] \quad \text{(F.2)}$$

$$b^* = 200[f(Y/Y_n) - f(Z/Z_n)] \quad \text{(F.3)}$$

where

$$f(X/X_n) = (X/X_n)^{1/3} \qquad \text{if } (X/X_n) > (24/116)^3 \quad \text{(F.4)}$$

$$f(X/X_n) = (841/108)(X/X_n) + 16/116 \qquad \text{if } (X/X_n) \le (24/116)^3 \quad \text{(F.5)}$$

and

$$f(Y/Y_n) = (Y/Y_n)^{1/3} \qquad \text{if } (Y/Y_n) > (24/116)^3 \quad \text{(F.6)}$$

$$f(Y/Y_n) = (841/108)(Y/Y_n) + 16/116 \qquad \text{if } (Y/Y_n) \le (24/116)^3 \quad \text{(F.7)}$$

and

$$f(Z/Z_n) = (Z/Z_n)^{1/3} \qquad \text{if } (Z/Z_n) > (24/116)^3 \quad \text{(F.8)}$$

$$f(Z/Z_n) = (841/108)(Z/Z_n) + 16/116 \quad \text{if } (Z/Z_n) \le (24/116)^3 \tag{F.9}$$

where X, Y, and Z are CIE tristimulus values for the patch being measured and X_n, Y_n, and Z_n are the tristimulus values of the print substrate or white point of a display.

The following formulae represent the reverse transformation:

$$f(Y/Y_n) = (L^* + 16)/116 \tag{F.10}$$

$$f(X/X_n) = a^*/500 + f(Y/Y_n) \tag{F.11}$$

$$f(Z/Z_n) = f(Y/Y_n) - b^*/200 \tag{F.12}$$

$$X = X_n[f(X/X_n)]^3 \quad \text{if } f(X/X_n) > 24/116 \tag{F.13}$$

$$X = (108/841)X_n[f(X/X_n) - 16/116] \quad \text{if } f(X/X_n) \le 24/116 \tag{F.14}$$

$$Y = Y_n[f(Y/Y_n)]^3 \quad \text{if } f(Y/Y_n) > 24/116 \tag{F.15}$$

$$Y = (108/841)Y_n[f(Y/Y_n) - 16/116] \quad \text{if } f(Y/Y_n) \le 24/116 \tag{F.16}$$

$$Z = Z_n[f(Z/Z_n)]^3 \quad \text{if } f(Z/Z_n) > 24/116 \tag{F.17}$$

$$Z = (108/841)Z_n[f(Z/Z_n) - 16/116] \quad \text{if } f(Z/Z_n) \le 24/116 \tag{F.18}$$

NOTE The value of 24/116 in Formulae (F.15) and (F.16) corresponds to a value of $L^* = 8$.

F.4 Conversion

Illuminant-relative CIELAB measurements can be converted to media-relative CIELAB in two steps as follows:

a) Convert illuminant-relative CIELAB values to X, Y, Z using Formulae (F.10) to (F.18) with the values X_n, Y_n, and Z_n set to the tristimulus values of the illuminant (D50).

b) Convert these X, Y, Z values to media-relative CIELAB values ($CIELAB_{mr}$) with the values X_n, Y_n, and Z_n set to the tristimulus values of the print substrate or display white.

Similarly, media-relative ($CIELAB_{mr}$) measurements can be converted to illuminant-relative CIELAB in two steps as follows:

c) Convert media-relative $CIELAB_{mr}$ values to X, Y, Z using Formulae (F.10) to (F.18) with the values X_n, Y_n, and Z_n set to the tristimulus values of the print substrate or display white.

d) Convert these X, Y, Z values to illuminant-relative CIELAB values with the values X_n, Y_n, and Z_n set to the tristimulus values of the illuminant (D50).

Annex G
(normative)

JPEG extension (JPEG-XT) marker segment

G.1 Background

ISO/IEC JTC 1/SC 29 is developing an International Standard (ISO 18477) for the Scalable Compression and Coding of Continuous-Tone Still Images (JPEG XT). The particular box structure described in this Annex is important for the encoding of data in ISO 16760 and will be included in ISO/IEC 18477-3. Although ISO/IEC 18477-3 will not be finalized for some time, the box structure specified here is based on a preliminary draft of ISO/IEC 18477-3 and the syntax described is considered by SC 29 to be stable. It is included here to allow ISO 16760 to proceed to publication prior to the completion of ISO/IEC 18477-3.

G.2 Introduction

The syntax element and the building block defined in this Annex is called a box. This International Standard defined several types of boxes; the definition of each specific box type defines the kind of information that may be found within a box of that type.

Boxes are not top-level syntax elements, but are themselves wrapped in JPEG XT marker segments introduced in G.3. Since boxes may logically carry more than 64K (65 536) bytes of payload data in contrast to marker segments which can at most carry 64K of data, a single **logical box** may need to be broken up into several marker segments. Syntax elements within the marker segment then instruct the decoder how to put the contents in the marker segment back into a single box.

G.3 Marker assignments

The additional marker shown in Table G.1 is defined in G.4.

Table G.1 — Additional marker and marker segments

Code assignment	Symbol	Description	Defined in
0xFFEB	APP_{11}	JPEG XT Marker	G.4

Each box is encapsulated in at least one JPEG XT marker segment and may extend over several marker segments if the size of its payload data exceeds the capacity of the JPEG XT marker. See G.4 for details on the mapping between JPEG XT marker segments and logical boxes.

G.4 JPEG XT boxes

JPEG XT structures any additional data that remains invisible to legacy decoders in JPEG XT boxes. A **box** is a generic data container that has both a type and a body that carries its actual payload. The type is a four-byte identifier that allows decoders to identify its purpose and the structure of its content. As a JPEG XT file may carry several boxes of identical type, these boxes are logically distinct and differ in the value of the **Enumerator field En** of the JPEG XT marker segment (see Figure G.1).

Boxes are embedded into the codestream format by encapsulating them into one or several JPEG XT marker segments. Since boxes can grow large in size, a single box may extend over multiple JPEG XT marker segments, and decoders may have to merge multiple marker segments before they can attempt to decode the box content. JPEG marker segments that belong to the same logical box and require merging prior to interpretation have **identical Enumerator fields En,** but differ in the **Sequence Number Z.**

The JPEG XT marker segment consists of the APP_{11} marker the size of the marker segment in bytes (not including the marker), a common identifier identical for all boxes and box types, the box enumerator field, the sequence number field, the box length, the box type, and the actual box payload data. The box length field can be extended by a Box Length Extension field that allows box sizes beyond 2^{32}-1 bytes. Figure G.1 depicts the high-level syntax of a JPEG XT marker segment.

0xFFEB	Le	CI Common Identifier	En Enum-erator	Z Sequence Number	LBox Box Length	TBox Box Type	XLBox Box Length Extension (optional)	Payload Data

Figure G.1 — Organization of the JPEG XT marker segment

The meaning of the fields of the JPEG XT marker segment is as follows:

The Le field is the size of the marker segment, not including the marker. It measures the size from the Le field up to the end of the marker segment.

NOTE 1 Since boxes can extend over several marker segments, the Le field is typically **not** related to the Box Length field and care needs to be taken not to confuse the two. The Le field defines the amount of data carried by a single marker segment; the Box Length is the logical size of the box. If a box extends over multiple JPEG XT marker segments, the Le field measures the total size of each individual marker segment and can differ from segment to segment, whereas the Box Length field remains identical in all segments that contribute to the same logical box.

The Common Identifier is a 16-bit field that allows decoders to identify an APP_{11} marker segment as a JPEG XT marker segment. Its value shall be 0x4A50. It is identical for all boxes and all box types.

The Enumerator is a 16-bit field that disambiguates between JPEG XT marker segments of box identical type, but differing content. That is, data that belongs to logically distinct boxes with the same box type differ in their Enumerator value. Encoders shall concatenate the payload data of those JPEG XT marker segments whose Enumerator **and** Type Identifier fields are identical in the order of increasing sequence numbers.

NOTE 2 A codestream containing multiple boxes of the same box type uses the enumerator field to instruct the decoder which JPEG XT marker segments to merge into one box.

The Sequence Number is a 32-bit field that specifies the order in which payload data shall be merged. Concatenation proceeds in the order of increasing Sequence Number.

The **Box Length LBox** is a four byte field that specifies the box length. It measures the size of the payload data of all JPEG XT markers of the same box type and enumerator combined, plus the size of **a single copy** of the Box Type, plus the size of **a single copy** of the Box Length, plus the length of a **single copy** of the Box Length Extender, if present. The box length does not include the size of the sequence number, the enumerator, the common identifier, the marker length, or the marker.

NOTE 3 A box having a payload data of 32 bytes will, by this, have a box length of 32 + 4 + 4 = 40. If this box is split evenly over two JPEG XT marker segments, each marker segment will have a Le value of 2 + 2 + 2 + 4 + (4 + 4 + 16) = 50.

If the size of the box payload is less than 2^{32}-8 bytes, then all fields **except the XLBox field**, that is, Le, CI, En, Z, LBox, and TBox, shall be present in **all JPEG XT marker** segments representing this box, regardless of whether the marker segment starts this box or continues a box started by a former JPEG XT marker segment.

The **Box Type TBox** is a 32-bit field that specifies the type of the payload data, and thus its syntax. Since ISO/IEC 18477-3 and its family specify their own box types for JPEG XT and ITU|ISO/IEC may add additional box types that define additional meta-information on the image, decoders shall disregard box types that they do not understand.

If the box length is larger than 2^{32} bytes, the LBox field is no longer sufficient to encode the box length and the XLBox field is required additionally. In this case, the LBox field shall be one and the XLBox field carries the box size instead. If the box length is larger than 2^{32}, the XLBox field shall be present in all JPEG XT marker segments of the same box type and same enumerator, and its value shall be identical in all JPEG XT marker segments of the same Box Type and same Enumerator.

The payload data carries the contents of the box. This International Standard specifies the use of a box to encode output intent parameters including an ICC Profile whose syntax is specified in ISO 15076-1.

See Table G.2.

Table G.2 — JPEG extensions marker parameters and sizes

Parameter	Size (bits)	Value	Meaning
APP_{11}	16	0xFFEB	Identifies all JPEG XT marker segments.
Le	16	8..65 535	Length of the marker segment, including the size itself, all parameters, and the size of the payload data contained in this marker segment alone. Does not include the marker itself.
CI	16	0x4A50 (ASCII encoding of "JP")	The special value 0x4A50 (ASCII: 'J' 'P') allows readers to distinguish the JPEG Extensions marker segment from other uses of the APP_{11} marker. Readers shall ignore APP_{11} markers for the purpose of decoding JPEG extensions if this value does not match.
En	16	1..65 535	Disambiguates payload data of the same box type and defines which payload data are to be concatenated. Only payload data whose box type and enumerator are identical shall be concatenated. The value zero is reserved for ITU|ISO purposes.
Z	32	$1..2^{32}$-1	Sequence number defining the order in which the payload data shall be concatenated. Concatenation shall proceed in order of increasing Z values. The value zero is reserved for ITU|ISO purposes.
LBox	32	1 or $8..2^{32}$-1	Box length. This is the total length of the concatenated payload data, including a single copy of the LBox and Tbox field, and a single copy of the XLBox field, if present. The values zero and 2 to 7 are reserved for ITU|ISO purposes and shall not be used.
TBox	32	$0..2^{32}$-1	Box type. The box type defines the syntax of the concatenated payload data. Also, the box type and the enumerator specify which payload data to merge.
XLBox	0 or 64	$16..2^{64}$-1	If the LBox field is one, this field contains the size of the concatenated payload data plus the box overhead instead. Otherwise, this field is missing. The values 0 to 15 are reserved for ITU|ISO purposes.
Payload Data	Varies	Varies	The syntax of the concatenated payload data is box specific.

Bibliography

[1] ISO 12642-1:2011, *Graphic technology — Input data for characterization of four-colour process printing — Part 1: Initial data set*

[2] ISO 12646, *Graphic technology — Displays for colour proofing — Characteristics and viewing conditions*

[3] ISO 14861, *Graphic technology — Requirements for colour soft proofing systems*

[4] ISO 15930 (all parts), *Graphic technology — Prepress digital data exchange using PDF*

[5] ISO 12647-2, *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 2: Offset lithographic processes*

[6] RGB workflow guide 2007 (Japan Advertising Photographers' Association) [viewed 2014-02-12] Available from http://www.apa-japan.com/download/pdf/RGB2007.pdf .

[7] Digital Camera Guide, Dai Nippon Printing, [viewed 2014-02-12] Available from http://www.dnp.co.jp/news/070717.pdf and http://www.dnp.co.jp/news/100621_guide.pdf.

[8] Universal Photographic Digital Imaging Guidelines (UPDIG): Universal Quick Guide [viewed 2014-02-12] Available from http://www.updig.org/pdfs/updig_universal_quickguide_v40.pdf

[9] Universal Photographic Digital Imaging Guidelines (UPDIG). Photographer Guidelines [viewed 2014-02-12] Available from http://www.updig.org/pdfs/updig_photographers_guidelines_v40.pdf

[10] Universal Photographic Digital Imaging Guidelines (UPDIG): Image Receiver Guidelines [viewed 2014-02-12] Available from http://www.updig.org/pdfs/updig_image_receivers_guidelines_v40.pdf

[11] DIGIPIX3 Compendium for Digital Photography [viewed 2014-02-12] Available from http://www.eci.org/_media/downloads/digital_photography/digipix3_v300_en.pdf

[12] ISO/TR 17321-2:2012, *Graphic technology and photography — Colour characterization of digital still cameras (DSCs) — Part 2: Considerations for determining scene analysis transforms*

[13] New flatbed color scanner with automatic operation, Makoto Hirosawa; Shinji Asada; Naokatsu Nishiguchi; Yoshihiro Kishida;Takashi Sakamoto; Noriyuki Shimano, SPIE Proceedings Vol. 1184 Neugebauer Memorial Seminar on Color Reproduction, Kazuo Sayanagi, Editors, pp.137-144 (1 June 1990)

[14] CIPA DC-008-2010/JEITA CP-3451B, Exchangeable image file format for digital still cameras; Exif Version 2.3

[15] CIPA DC-008-2010/JEITA CP-3461B, Design rule for Camera File system; DCF Version 2.0. Edition, 2010

[16] The following ICC profiles are available from Adobe at: http://www.adobe.com/support/downloads/iccprofiles/iccprofiles_mac.html *or*http://www.adobe.com/support/downloads/iccprofiles/iccprofiles_win.html Japan Color 2001 Coated, U.S. Web Coated (SWOP) v2 and Coated FOGRA39 (ISO 12647-2: 2004)

[17] ISO 12647-7:2013, *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 7: Proofing processes working directly from digital data*

[18] ISO 12647-8, *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 8: Validation print processes working directly from digital data*

[19] ISO 22028-1:2004, *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange — Part 1: Architecture and requirements*

[20] ISO/IEC 61966-2-1:1999, *Multimedia systems and equipment — Colour measurement and management —Colour management —Part 2-1: Default RGB colour space — sRGB*

[21] ISO 12640-4, *Graphic technology — Prepress digital data exchange — Part 4: Wide gamut display-referred standard colour image data [Adobe RGB (1998)/SCID]*

[22] Bartleson C.J., & Breneman E.J. Brightness Reproduction in the Photographic Process. Photographic Science and Engineering. 1967, **11** () pp. 254–261

[23] Giorgianni E.J., & Madden T.E. Digital Color Management - Encoding Solutions. Chapter 12. Addison-Wesley, Massachusetts, 1998, pp. 266.

[24] Help Adobe com: [viewed 2014-02-12] Available from http://help.adobe.com/en_US/photoshop/cs/using/WSfd1234e1c4b69f30ea53e41001031ab64-7669a.html

[25] Miller R. The Tone System", [viewed 2014-02-12] Available from http://www.thetonesystem.com/index.html

[26] Adobe R.G.B. 1998*) Color Image Encoding:* Version 2005-05, May 2005 Available from Internet http://www.adobe.com/digitalimag/pdfs/AdobeRGB1998.pdf

ICS 37.100.99; 35.240.30

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