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Graphic technology — Prepress digital data exchange —

Part 3: CIELAB standard colour image data (CIELAB/SCID)

Technologie graphique — Échange de données numériques de préimpression —

Partie 3: Données d'images en couleur normalisées CIELAB (CIELAB/SCID)

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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.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

This second edition cancels and replaces the first edition (ISO 12640-3:2007), of which it constitutes a minor revision. The changes are as follows:

— CIE Publication 15:2004 has been changed to CIE Publication 15 Colorimetry;

— in 3.4, the definition of colour space has been updated based on revision to CIE Publication 17 in 2020;

— in the Bibliography, CIE S 17:2020 ILV has been updated to International lighting vocabulary, 2nd edition.

A list of all parts in the ISO 12640 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

0.1 Need for standard digital test images

Standard test images provide a set of data that can be used for any of the following tasks:

— evaluating the colour reproduction of imaging systems;

— evaluating colour image output devices;

— evaluating the effect of image processing algorithms applied to the images;

— evaluating the coding technologies necessary for the storage and transmission of high-definition image data.

Because they exist as standard, well-defined, high-quality image data sets, typical of the range of image content commonly encountered, they enable users to be confident that the images will produce good quality reproductions, if properly rendered, and that they provide a reasonable test of the evaluation task being undertaken. No limited set of images can fully test any system, but the sets provided give as reasonable a test as can be expected from a limited image set. Furthermore, the existence of a standard image data set enables users in different locations to produce comparisons without the need to exchange images prior to reproduction.

However, different applications require that the standard image data be provided in different image states using different image encodings (see ISO 22028-1). The user needs to select those appropriate to the evaluation task being undertaken. Whilst transformation of the image data to another image state is always possible, there is, in general, no agreement amongst experts as to how this is best done. Thus, it has been considered preferable to provide data in three different image states in the various parts of ISO 12640.

ISO 12640-1 provides a set of 8-bits-per-channel data that is defined in terms of CMYK dot percentages. The colours resulting from reproduction of CMYK data are strictly defined only at the time of printing and, as such, the data are only applicable to evaluation of CMYK printing applications. Transformations to other image states and colour encodings are not necessarily well defined. In fact, the data might not even be useful for CMYK printing processes different from those typically found in traditional graphic arts applications as the image data are defined to produce “pleasing” images when reproduced on systems using “typical” inks and producing “typical” tone value rendering. Printing systems that use inks of a distinctly different colour, or produce a very different tone value rendering, will not reproduce them as pleasing images without a well-defined colour transformation. Moreover, with a bit depth of only 8 bits per channel, any colour transformation employed will probably introduce artefacts.

ISO 12640-2 provides a set of test image data encoded both as XYZ tristimulus values with a depth of 16 bits per channel and as sRGB (defined in IEC 61966-2-1) with a bit depth of 8 bits per channel. (The higher bit depth for the XYZ encoding is necessary because of the perceptual non-uniformity of the XYZ colour space.) Both sets of data are optimized for viewing on a reference sRGB CRT display in the reference sRGB viewing environment, and relative to CIE standard illuminant D65 for which the XYZ values were computed. The images are mainly designed to be used on systems utilizing sRGB as the reference encoding, and as such are mainly applicable to the consumer market and those systems for which the colour monitor is the “hub” device. Although such systems are used for some applications in the graphic arts industry, sRGB is by no means the most common image encoding. Furthermore, a particular drawback is the fact that the sRGB colour gamut is quite different in shape than the colour gamut of typical offset printing. This difference can necessitate fairly aggressive colour re-rendering to produce optimal prints from sRGB image data.

In order to be useful for applications where large, print-referred output gamuts are encountered, common in graphic technology and photography, it was felt that it would be desirable to produce an image set in which some colours are permitted to be encoded close to the boundary of the full colour gamut attainable with surface colours. Furthermore, from the perspective of colour management it is advantageous if the images are referenced to illuminant D50, which is the predominant reference

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illuminant used in graphic arts and photography, both for viewing and measurement. For this reason it has also become the predominant reference illuminant for most colour management applications.

The purpose of this document is, therefore, to provide a test image data set with a large colour gamut related to illuminant D50. The bit depth of the natural images is 16 bits per channel, while the colour charts and vignettes are 8 bits per channel.

0.2 Definition of the reference colour gamut

The reference colour gamut defined for this document originated from three quite separate sources. However, it was noted that there was considerable similarity between the three. One definition came from work within ISO/TC 130 itself, and this arose by consideration of various sets of published data, which together were taken to define the colour gamut of surface colours. The other definitions arose from work within Hewlett-Packard, which was focused on the colour gamut obtainable by printing, and that of a group of German photographic printing experts. The similarity of these led to the conclusion that it is desirable to reconcile them into a single gamut that would be taken as the reference colour gamut for this document. Full details of the reference colour gamut and its derivation are given in Annex B.

0.3 Characteristics of the test images

The performance of any colour reproduction system is normally evaluated both subjectively (by viewing the final output image) and objectively (by measurement of control elements). This requirement dictated that the test images include both natural scenes (pictures) and synthetic images (colour charts and colour vignettes). Because the results of subjective image evaluation are strongly affected by the image content, it was important to ensure that the natural images were of high quality and contained diverse subject matter. However, by requiring images to look natural, it is difficult within a single, relatively small sample set to produce elements in the scene that contain the subtle colour differences required in such test images and that cover the full reference colour gamut defined. It is also important to have some images that contain subtle differences in near-neutral colours. Thus, while most images contain colours that extend to the gamut boundary, this is often only for a limited range of hues in each image. The full reference colour gamut can only be explored by utilizing the synthetic colour chart.

A survey was conducted of all ISO/TC 130 member countries to identify desirable image content and to solicit submission of suitable images for consideration. The image set that resulted consists of eight natural images, eight colour charts and two colour vignettes. The natural images include flesh tones, images with detail in the extreme highlights or shadows, neutral colours, brown and wood-tone colours that are often difficult to reproduce, memory colours, complicated geometric shapes, fine detail, and highlight and shadow vignettes. The colour charts and colour vignettes show the reference colour gamut (in CIE Lab colour space) in cross-sections for 16 and 8 hue angles, respectively.

0.4 File format of the digital test images

All of the images consist of pixel interleaved data (L^* then a^* then b^*) with the data origin at the upper left of the image, as viewed naturally, and organized by rows. These data are available as individual files, which are a normative part of this part of this document. The image file format is as specified in ISO 12639:2004, Annex H, with BitsPerSample set to 16, 16, 16. The images can be imported and manipulated as necessary by a wide variety of imaging software tools and platforms commonly in general use in the industry. See Annex D for details of the TIFF header.

All colour charts and vignettes consist of files in Adobe®[1)] PDF format.

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Graphic technology — Prepress digital data exchange —

Part 3:
CIELAB standard colour image data (CIELAB/SCID)

1 Scope

This document specifies a set of standard large gamut colour images (encoded as 16-bit CIELAB digital data) that can be used for the evaluation of changes in image quality during coding, image processing (including transformation, compression and decompression), displaying on a colour monitor and printing. These images can be used for research, testing and assessing of output systems such as printers, colour management systems and colour profiles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 12639:2004, *Graphic technology — Prepress digital data exchange — Tag image file format for image technology (TIFF/IT)*

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

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

PDF Reference: *Adobe Portable Document Format, Version 1.4* 3rd edition., Adobe Systems Incorporated, (ISBN 0-201-75839-3)

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
checksum
sum of the digits in a file that can be used to check if a file has been transferred properly

Note 1 to entry: Often, only the least significant bits are summed.

3.2
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 are capable of being created using a particular output device and/or medium

[SOURCE: ISO 12640-4:2011]

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3.3
colour sequence
order in which the colours are stored in a data file

3.4
colour space
geometric representation of colour in space

Note 1 to entry: A colour space is usually of three dimensions

Note 2 to entry: This entry was numbered 845-03-25 in IEC 60050-45:1987

[SOURCE: CIE S 17:2020 ILV: International Lighting Vocabulary, 2nd edition, modified]

3.5
colour value
numeric values associated with each of the pixels

3.6
data range
range of integers for a given variable in between a minimal and maximal value

3.7
global colour change
change to the colours in an image (often selectively by colour region) applied consistently to all parts of the image

Note 1 to entry: This is in contrast to a local colour change where selected spatial areas of an image are changed separately from the rest of the image area.

3.8
orientation
specifies the origin and direction of the first line of data with respect to the image content as viewed by the end user

Note 1 to entry: The codes used to specify orientation are contained in ISO 12639.

3.9
pixel
smallest discrete picture element in a digital image file

3.10
pixel interleaving
colour data organized such that the L^*, a^* and b^* colour space values for one pixel are followed by the same sequence of colour values for the next pixel; the specific order of colour components is determined by the ColorSequence tag as defined in ISO 12639

Note 1 to entry: Other forms of colour data interleaving are line and plane.

4 Requirements

This document consists of the images contained in the 18 image data files which are part of this document. Their file names are listed in Table 4. The image characteristics of these data are described in Clause 5 and the electronic data structure in Clause 6.

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5 Data description and definition

5.1 Data set definition

The set of standard colour image data consists of eight natural (photographed) images and ten synthetic images created digitally on a computer. The synthetic images consist of eight colour charts consisting of various patches, each 10 mm square, and two colour vignettes. The natural images are identified as N1 to N8, and each of them also has a descriptive name derived from the picture content (e.g. bride and groom). The synthetic images are identified as CC1 to CC8, CV1 and CV2.

The images are identified by the designation CIELAB/SCID. The co-ordinates of the text insertion are provided in Annex E.

NOTE The image set defined in this document is based on the large gamut defined in Annex B. Image sets contained in other document are based on different gamuts and can be more suitable for use in evaluation of other applications.

5.2 Colour encoding used in this document

5.2.1 Image data encoding

The image data encoding shall be in accordance with the requirements of ISO 22028-1.

The image data are the desired CIELAB colorimetry defined by CIE Publication 15[10], and measured in accordance with ISO 13655, of reproductions of the images on the reference medium, with the reference medium white point selected as the colour space white point. The image data are output-referred, having been rendered to the reference medium of the ICC.1:2004-04[11] perceptual rendering intent, which is defined as a hypothetical print on a substrate specified to have a neutral reflectance of 89 % (the reference medium white point) and the darkest printable colour on this medium is assumed to have a neutral reflectance of 0,347 31 % of the substrate reflectance (the reference medium black point). The rendering target colour gamut for the reference medium is specified in Annex B. The reference viewing environment is based on standard viewing condition P2, as specified for graphic arts and photography in ISO 3664, but extended in the following way: the surfaces immediately surrounding the image are assumed to be a uniform matt grey with a reflectance of 20 %. The reference viewing environment is also assumed to have a viewing flare of 0,75 % of the luminance of the reference white. The CIELAB image data are encoded as specified in 5.2.3 and 5.2.4.

5.2.2 Image data arrangement

The image data are pixel-interleaved in the colour sequence of L^* then a^* then b^* (16 bits) for the natural images and L^* then a^* then b^* (8 bits) for the colour charts and the vignettes. The arrangement of data follows the scanning of each image from the upper left corner to the upper right, then moving to the next lower horizontal line. The resolution is 12 pixels/mm for every natural image.

5.2.3 CIELAB image data (16 bits per channel)

The CIELAB data for the natural images are encoded as 16-bit integers per channel, derived by multiplying the L^*, a^* and b^* values for each pixel with the corresponding value for the data range.

$$
\begin{aligned}
L^*_{16\text{bit}} &= \text{round}\left(65\,535 \times \frac{L^*}{100}\right) \\
a^*_{16\text{bit}} &= \text{round}\,(256 \times a^*) \\
b^*_{16\text{bit}} &= \text{round}\,(256 \times b^*)
\end{aligned}
\tag{1}
$$

where $L^*_{16\text{bit}}$, $a^*_{16\text{bit}}$ and $b^*_{16\text{bit}}$ represent normalised 16-bit values of L^*, a^* and b^*.

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The data range of the values is:

$L^* \in \{0..100\}$, $a^* \in \{-128..+127\}$ and $b^* \in \{-128..+127\}$,

$L^*_{16bit} \in \{0..65\ 535\}$, $a^*_{16bit} \in \{-32\ 768..+32\ 512\}$ and $b^*_{16bit} \in \{-32\ 768..+32\ 512\}$, a^*_{16bit} and b^*_{16bit} are signed integers.

NOTE −32 678 = −128 × 256, and 32 512 = 127 × 256.

5.2.4 CIELAB image data (8 bits per channel)

The CIELAB data for the colour charts are encoded as 8-bit integers per channel, derived by multiplying the L^*, a^* and b^* values for each pixel with the corresponding value for the data range.

$$L^*_{8bit} = \text{round}\left(255 \times \frac{L^*}{100}\right)$$
$$a^*_{8bit} = \text{round}(a^*) \qquad (2)$$
$$b^*_{8bit} = \text{round}(b^*)$$

where L^*_{8bit}, a^*_{8bit} and b^*_{8bit} represent normalised 8 bit values of L^*, a^* and b^*.

The data range of the values is:

$L^* \in \{0..100\}$, $a^* \in \{-128..+127\}$ and $b^* \in \{-128..+127\}$,

$L^*_{8bit} \in \{0..255\}$, $a^*_{8bit} \in \{-128..+127\}$ and $b^*_{8bit} \in \{-128..+127\}$, the a^*_{8bit} and b^*_{8bit} are signed integers.

5.3 Natural images

The characteristics of the eight natural images, shown in Figure 1, are given in Table 1.

Table 1 — Characteristics for natural images

Parameter	Characteristics
Resolution	12 pixels/mm
Colour values	16 bits/channel L^*, a^* and b^*, with respect to illuminant D50 (defined as media-relative, i.e. such that a white in the image has the L^*, a^* and b^* values of 100, 0, 0)
File format	ISO 12639:2004, Annex H, with BitsPerSample set to 16, 16, 16 This format also readable with TIFF 6.0 with extension, photometric interpretation tag 8, CIELAB, signed encoding.
Label on image	CIELAB/SCID
Image data orientation	Horizontal scanning starting from top left and ending at bottom right

NOTE The natural images have been colour-rendered to produce the desired image colorimetry on the reference print medium as described in Annex B. For the most part, the image colours will be within the reference colour gamut. However, it is possible for some image colours to be slightly outside (this is somewhat dependent on how the convex hull of the gamut is constructed). It is sometimes necessary to gamut map the results of colour rendering and re-rendering processing to exactly fit the destination device colour gamut.

The description and typical usage of the natural images are given in Table 2. The descriptive names of these images are given following the identification code. Figure 1 shows reduced size sRGB reproductions of the natural images. Statistical and gamut data for each of the natural images are shown in Annex F, as histograms of the L^* values and a^* versus b^* plots for each image, respectively.

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Table 2 — Natural images

Name	Aspect, image size	Description and typical usage
N1 Bride and groom	Horizontal, 2 560 × 2 048 pixels	Image of a bride wearing white clothes and groom wearing black clothes. Used to evaluate the rendering of human skin tones and neutral colours, especially highlights and shadows.
N2 People	Horizontal, 2 560 × 2 048 pixels	Image consisting of five people wearing colourful clothes, sitting on a dark leather couch. Used to evaluate the colour rendering of extremely colourful objects in the presence of skin tones and neutrals.
N3 Cashew nuts	Vertical, 2 048 × 2 560 pixels	Image of dried fruits and filled containers used to evaluate tonal and colour rendering, in particular adjustments for grey component replacement.
N4 Meal	Horizontal, 2 560 × 2 048 pixels	Image with widely recognizable cooked food and pastel colours. Used to evaluate high-key tonal rendering and food memory colours.
N5 Mandolin	Vertical, 2 048 × 2 560 pixels	Image of goods, including metallic objects, used to evaluate the reproduction of colours, as well as the reproduction of the lustrous appearances of metallic objects.
N6 Tailor scene	Horizontal, 2 560 × 2 048 pixels	Still-life image of textile used to evaluate the tone reproduction in a range of neutrals and textile structures (object moiré).
N7 Wool	Horizontal, 2 560 × 2 048 pixels	Image of different coloured balls of wool used to evaluate the reproduction of details in highly chromatic areas.
N8 Fruits	Square, 2 024 × 2 024 pixels	Image of a range of fruits and vegetables. The memory colours of strawberries, oranges, lemons, green grapes, apples, pears, tomatoes and bell peppers are particularly suitable for the evaluation of the naturalness of colour re-rendering processes.

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a) N1 Bride and groom

b) N2 People

c) N3 Cashew nuts

d) N4 Meal

e) N5 Mandolin

f) N6 Tailor scene

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g) N7 Wool

h) N8 Fruits

Figure 1 — Reduced size sRGB reproductions of the natural images

5.4 Synthetic images

5.4.1 Colour charts

There are eight colour charts, each of which consists of a number of colour patches that sample the reference colour gamut. Each chart contains a number of patches at two hue angles, with each pair separated by 180°. The design intent was to provide samples at hue angle intervals of 22,5° (from 0° to 337,5°). However, the limitations imposed by 8-bit data means that the intended hue angles can only be approximated to within ±1°.

The colour charts show all the samples within the reference colour gamut at L^* intervals of 10 (from L^* = 0 to L^* = 100) and C^*_{ab} intervals of 10 (from C^*_{ab} = 0 to the C^*_{ab} value above the maximum C^*_{ab} value for that L^* value from the reference colour gamut). These maximum C^*_{ab} values are given in Table 3, and are derived from the reference colour gamut described in Annex B of this document, rounded to the nearest value. Again, the limitations of the 8-bit data mean that the intended values shown in Table 3 can only be approximated. The L^* values achieved are to within ±0,2, and the C^*_{ab} values to within ±1 C^*_{ab}.

Because of this design, the maximum and minimum L^* values, and maximum C^*_{ab} values, in the charts lie outside the reference colour gamut. This ensures that the whole of the reference colour gamut can be evaluated (within the patch sampling limitations of the charts). The CIELAB values for each patch in the charts are given in Annex G.

NOTE Applications that show the CIELAB values when these files are opened are likely to show the L^* values as the integer value given in Table 3, despite the limited accuracy caused by the 8-bit resolution. Thus, these are the values quoted in Annex G.

The size of each chart is 275 mm × 137 mm. The size of each colour patch is 10 mm × 10 mm and the distance between adjacent patches is 1 mm. Each chart has a grey background of L^* = 80.

Figure 2 shows reduced size reproductions of the eight colour charts.

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