BS ISO 15076-1:2010

BSI Standards Publication

Image technology colour management — Architecture, profile format and data structure

Part 1: Based on ICC.1:2010

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This British Standard is the UK implementation of ISO 15076-1:2010. It supersedes BS ISO 15076-1:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PAI/43, Graphic technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Part 1:
Based on ICC.1:2010

Gestion de couleur en technologie d'image — Architecture, format de profil et structure de données —

Partie 1: Fondé sur l'ICC.1:2010

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Foreword

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

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

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

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

ISO 15076-1 was prepared by the *International Color Consortium*, in cooperation with Technical Committees ISO/TC 130 *Graphic technology* and ISO/TC 42 *Photography*, under the provisions of the Cooperative Agreement between ISO/TC130 and the *International Color Consortium* dated 2003-07-11.

This second edition cancels and replaces the first edition (ISO 15076-1:2005), which has been technically revised to incorporate changes made in the profile specification. These include the addition of the perceptual intent reference medium colour gamut, new technology signatures, a floating-point device encoding range, a colorimetric intent image state tag, and a profile sequence identifier tag. In addition, the mediaBlackPointTag has been deleted and PCSXYZ is no longer limited to the PCS illuminant.

ISO 15076-1 is technically identical to ICC.1:2010, *Image technology colour management — Architecture, profile format, and data structure (Profile version 4.3.0.0)*.

ISO 15076 consists of the following parts, under the general title *Image technology colour management — Architecture, profile format and data structure*:

— *Part 1: Based on ICC.1:2010*

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Introduction

0.1 General

This part of ISO 15076 specifies the profile format defined by the International Color Consortium® (ICC). The intent of this format is to provide a cross-platform profile format for the creation and interpretation of colour data. Such profiles can be used to translate between different colour encodings, and to transform colour data created using one device into another device's native colour encoding. The acceptance of this format by application and operating system vendors allows end users to transparently move profiles, and images with embedded profiles, between different systems. For example, this allows a printer manufacturer to create a single profile for multiple applications and operating systems.

It is assumed that the reader of this part of ISO 15076 has a good understanding of colour science and imaging, such as familiarity with CIE, ISO and IEC colour standards, general knowledge of device measurement and characterization, and familiarity with at least one operating system level colour management system.

0.2 International Color Consortium

The International Color Consortium was formed with the primary intent of developing and administering a colour profile format standard, and for the registration of the associated tag signatures and descriptions. The founding members of this consortium were Adobe Systems Inc., Agfa-Gevaert N.V., Apple Computer, Inc., Eastman Kodak Company, FOGRA (Honorary), Microsoft Corporation, Silicon Graphics, Inc., Sun Microsystems, Inc., and Taligent, Inc. These companies committed to fully support the standard in their operating systems, platforms and applications. The consortium has since been expanded and now has over 60 members.

The initial version of the standard developed by the ICC has undergone various revisions, and it was agreed by the ICC that its revision 4.2 first be proposed as an International Standard. It is that revision which formed the basis of first edition of this part of ISO 15076 (ISO 15076-1:2005). This second edition is based on ICC revision 4.3, which is a minor ICC revision and is therefore fully backward compatible with 4.2. All the technical specifications contained in the first edition (ISO 15076-1:2005) are also given in this second edition, and new specifications exclusive to this second edition are clearly identified. Informative material has also been updated and clarified. The ICC will continue to administer its own version of ICC.1:2010 and, if enhancements are made, will be seriously considered for future revisions of this part of ISO 15076. ISO/TC 130 will work to ensure that there are no significant differences between the ICC and ISO versions of this part of ISO 15076.

The ICC web site (www.color.org) provides supplementary information relevant to this part of ISO 15076 and additional resources for developers and users. It also provides information on how to become a member of ICC.

0.3 Colour management architecture and profile connection space

The underlying architecture assumed in this part of ISO 15076 is based around a reference colour space that is unambiguously defined. The colour specification method selected was that defined by CIE which is internationally accepted. The CIE system enables a set of tristimulus values (CIEXYZ) to be specified for a coloured stimulus. These tristimulus values enable a user to determine whether colours match in appearance when viewed by a typical observer in a specific viewing environment. It follows that it is possible to define the colour appearance of a sample by these tristimulus values (or some defined transformation of them) for a specified state of viewer adaptation. The colour appearance is simply the appearance of the colour to a typical human observer, as opposed to the physical characteristics of the colour stimulus, which is not fully specified using tristimulus values.

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Calculation of the CIEXYZ values for transmitting or reflecting media is achieved from the spectral sum-product of the reflectance or transmittance of the sample, the relative spectral power distribution of the illumination source used to view it and the spectral 'sensitivity' of the standard observer. However, as CIE defines two standard observers, two measurement geometries (for reflecting media) and a large number of standard illuminants, it is necessary to restrict these options in order to have a colour specification system that is not ambiguous for a particular application. For this part of ISO 15076, the ICC has defined such a restriction, based on ISO 13655, and the resultant colour spaces are known as PCSXYZ and PCSLAB. Furthermore, the simple CIE system (whether CIEXYZ or the CIELAB values derived from them) does not accommodate the effect of surrounding stimuli to the sample being measured (which can be different for various types of media) or the illumination. Both of these affect appearance so the PCS values do not by themselves specify appearance. To overcome this problem, the PCS is used in two different ways. The first accounts only for the assumed state of chromatic adaptation of the viewer, and describes the colorimetry of actual originals and their reproductions, chromatically adapted to the PCS adopted white chromaticity, through the colorimetric rendering intents. The second, which describes the colorimetry of an image colour rendered to a standard reference medium under a specified viewing condition, is employed for the perceptual rendering intent and optionally for the saturation rendering intent. Thus, it can incorporate corrections for different states of viewer adaptation and other desired rendering effects, as well as accommodating differences between actual colour encoding and device dynamic ranges and colour gamuts, and those of the perceptual intent reference medium. When required, the viewing conditions can be specified to allow colour appearance to be determined for the colorimetric rendering intents.

So, in summary, the PCS is based on CIEXYZ (or CIELAB) determined for a specific observer (CIE Standard 1931 Colorimetric Observer, often known colloquially as the 2 degree observer), relative to a specific illuminant chromaticity (that of CIE D50), and measured with a specified measurement geometry (0°:45° or 45°:0°), for reflecting media. Measurement procedures are also defined for transmitting and self-luminous media. Since the conversion from CIEXYZ to CIELAB is quite unambiguous, profile builders can use either colour space for the PCS; the colour management system is able to determine which has been used from a tag in the header.

For colorimetric renderings where the measured data were not obtained relative to a D50 adopted white chromaticity, the profile builder is expected to adapt the data to achieve this. Therefore, a mechanism for identifying the chromatic adaptation used in such situations is provided. For the perceptual rendering intent the viewing conditions and reference medium are specified in order to provide a clear target for colour rendering and re-rendering (including gamut mapping). In the following paragraphs, the reference colour space, to which reference is made, needs to include the viewing conditions and reference medium when the perceptual intent is being considered. For the perceptual rendering intent, profile builders are expected to undertake any corrections for appearance effects if the viewing conditions used for monitors and transmitting media (such as dark surrounds) differ from those typical for reflecting media, and to account for differences between actual media and the reference medium.

Figure 1 shows how a reference colour space can be used to provide the common interface for transformations between different colour encodings, as used by different devices, or even different operational modes of the same device. Without it, a separate transformation would be required for each pair of device modes. If there are n device modes to be supported in a system, and it is necessary to provide a transformation between each pair of device modes, n^2 transforms would need to be defined and n new transforms would need to be defined every time a new device mode was added. As a new printer device mode can consist simply of a new paper type, this is not a practical solution. By using a reference colour space, only n transforms need be defined and only one new transform needs to be defined each time a new device mode is added; whatever device-to-device transforms are needed can be constructed by linking the source and destination profiles using the reference colour space as the interface.

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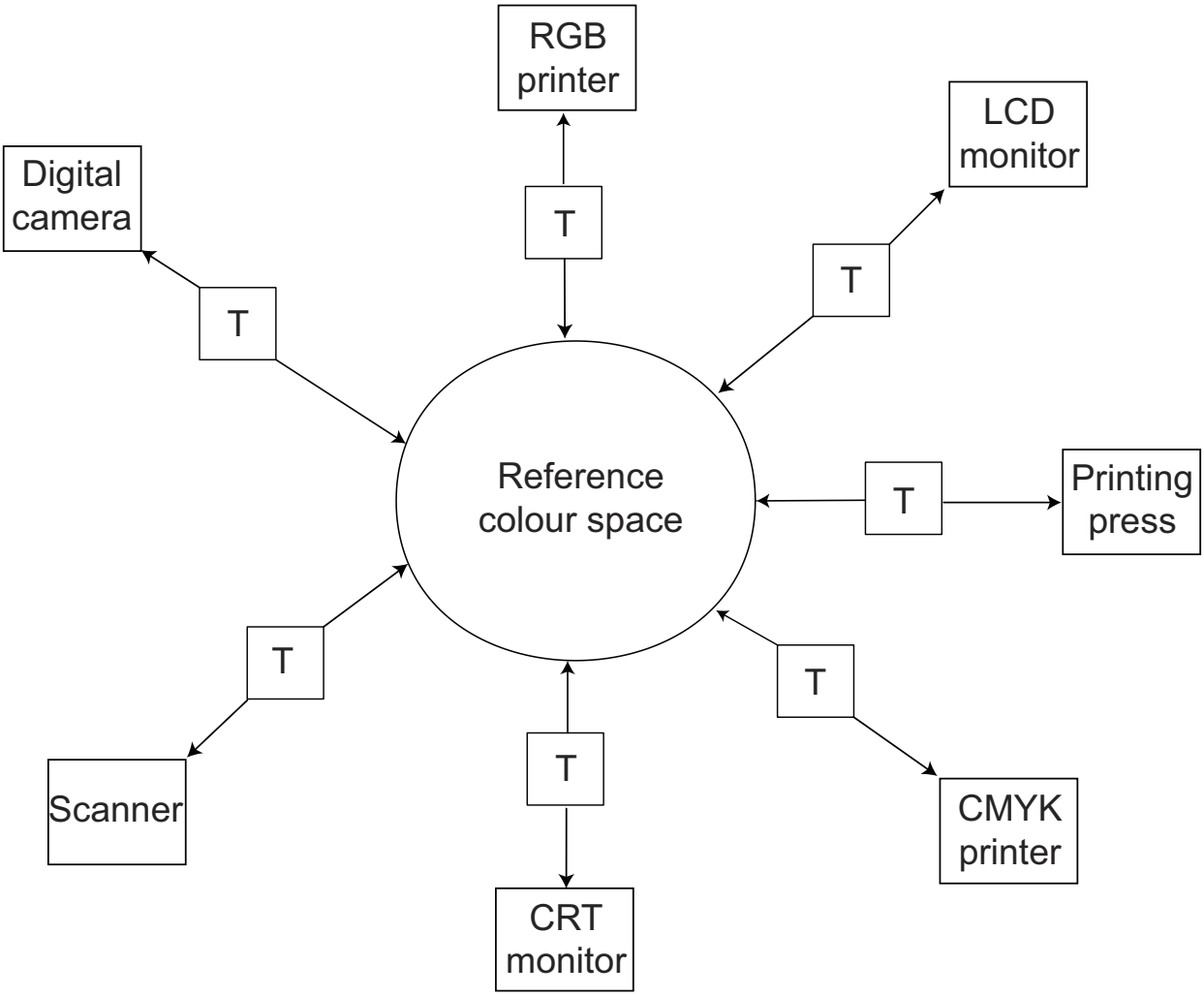

Key

T colour management transform

Figure 1 — Use of a reference colour space

While images can be encoded directly in PCSXYZ or PCSLAB, this will not generally be the case. A number of colour encodings for open exchange have been standardized to meet a variety of needs. Depending on the use case, different bit depths, image states, reference media and colour gamuts are needed. Devices also have different characteristics resulting in different native encodings. Except for a few cases where default encodings for key system devices are used for exchange (like the sRGB encoding), it is not practical or productive to attempt to restrict system colour encoding support.

For reasons of precision, it is usually desirable to define the transformation between the colour data encoding and the profile connection space (PCS) at a high precision. If the transformation between a colour data encoding and the PCS is provided with an image file, it can be utilized when images are reproduced. In order that the transformation between the colour data encoding and the PCS can be interpreted by all applications it is important that it be defined in an open specification. The profile format defined in this part of ISO 15076 provides that specification.

0.4 Rendering intents

In general, actual device colour gamuts will fail to match each other, and that of the perceptual intent reference medium, to varying degrees. Because of this mismatch, and because of the needs of different applications, four rendering intents (colour rendering styles) are defined in this part of ISO 15076. Each one represents a different colour reproduction objective. The colorimetric rendering intents operate directly on

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measured colorimetric values, with correction for chromatic adaptation when the measured values were not obtained relative to the PCS adopted white chromaticity. The other rendering intents (perceptual and saturation) operate on colorimetric values which are adjusted in an as-needed fashion to account for any differences between devices, media, and viewing conditions.

Two colorimetric rendering intents are specified in this part of ISO 15076, though only one is included fully constructed in the profile. The included media relative colorimetric intent is based on media-relative colorimetry, which is normalized relative to the unprinted media white for reflecting, transmitting, and self luminous media, or, in the case of colour encodings and capture, to the colour encoding values that correspond to the highest perceived brightness. Thus the media white will have the values of 100, 0, 0 in PCSLAB. This ensures that highlight clipping will not occur when the media-relative colorimetric intent is used. The use of media-relative colorimetry enables colour reproductions to be defined which maintain highlight detail, while keeping the medium 'white', even when the original and reproduction media differ in colour. However, this rendering intent introduces some change in all colours in the reproduction when the media whites of the source and destination do not match.

The PCS adopted white is defined to be the radiance of a perfect reflecting diffuser illuminated by a source with a spectral power distribution matching that of CIE Illuminant D50. ICC profiles contain the values of the media white, adapted to be relative to the chromaticity of the PCS adopted white. For the ICC-absolute colorimetric rendering intent, all of the colorimetric values are re-calculated to be relative to the tristimulus values of the PCS adopted white. When source and destination viewing conditions are identical and an exact colour match is required for all within-gamut colours (including the source medium colour), the ICC-absolute colorimetric rendering intent should be used. This rendering intent can also be useful in other situations.

The colour rendering of the perceptual and saturation rendering intents is vendor specific. The former, which is useful for general reproduction of pictorial images, typically includes tone scale adjustments to map the dynamic range of one medium to that of another, and gamut reshaping and mapping to deal with gamut mismatches. The latter has historically been useful for images which contain objects such as charts or diagrams, and usually involves compromises such as trading off preservation of hue in order to preserve the vividness of pure colours. As the saturation rendering intent is neither required to contain colorimetric characterization information or to use the perceptual intent reference medium, it is the only option, in proprietary systems, for providing colour rendering and re-rendering transforms to and from custom reference media represented in the PCS. For broader interoperability when using the saturation rendering intent, the perceptual reference medium can be used, and its use indicated.

For perceptual transforms it is necessary, in order to optimize colour rendering, to provide a realistic target for the colour rendering. For this reason, a reference medium and reference viewing condition have been defined which apply only to the perceptual rendering. The reference medium is defined as a hypothetical reflection print on a substrate with a white having a neutral reflectance of 89 %, and a density range of 2,459 3. The reference viewing condition is the P2 condition specified in ISO 3664, i.e. D50 at 500 lx for viewing reflecting media. A neutral surround of 20 % reflectance is assumed. The colour gamut of the reference medium is qualitatively specified as that of a reflection print, and whatever colour gamut is used in the PCS is required to be consistent with the specified dynamic range of the perceptual reference medium. It is recommended that the reference gamut specified in ISO 12640-3 be used as a more explicit target gamut for improved interoperability. Profile creators should consider this gamut to be the target for perceptual intent colour rendering and re-rendering to the PCS. Likewise, the perceptual intent colour re-rendering from the PCS needs to assume this gamut as the starting gamut for colour re-rendering to the destination medium. However, even when the use of this gamut is indicated, perceptual intent transforms need to be designed to produce the best visual results, and need not conform exactly to this gamut in the PCS.

The choice of a reference medium with a realistic black point for the perceptual intent provides a well-defined aim when colour rendering or re-rendering are required. Inputs with a dynamic range greater than a reflection print (e.g. a slide film image, or the colorimetry of high-range scenes) can have their highlights and shadows smoothly compressed to the range of the reference medium in such a way that these regions can be expanded again without undue loss of detail on output to wide-range media. Likewise, images from original media with limited dynamic range can be colour re-rendered to the expanded dynamic range of the reference medium, in order to produce better quality in subsequent reproductions. Bi-directional transform pairs (e.g. data-to-PCS and PCS-to-data for each rendering intent) in the profiles can be used to undo prior PCS-to-data colour re-rendering so that a differently optimized reproduction can be produced for a different reproduction medium.

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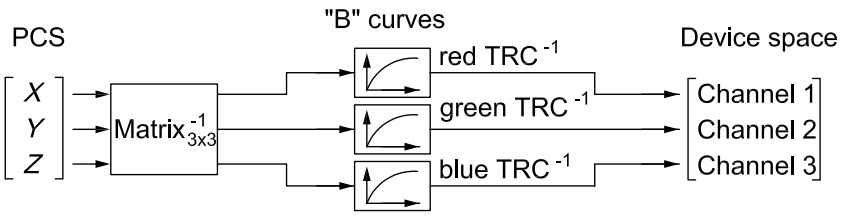
Profiles generally offer different transformations for different rendering intents. When the rendering intent is selected the corresponding transformation is selected by the colour management system. The choice of rendering intent is highly dependent upon the intended use. In general, the perceptual rendering intent is most applicable for the colour re-rendering of natural images, to make pleasing and aesthetically similar, but not exactly matching, reproductions on different media. The ICC-absolute colorimetric rendering intent is most appropriate for a proofing environment, where the colour reproduction obtained on one device is simulated on another. The media-relative colorimetric rendering intent is appropriate when mapping of the source medium white to the destination medium white is desired, but a full colour re-rendering is not.

For those requiring further information, an extended discussion of many of the issues described above is provided in Annex D.

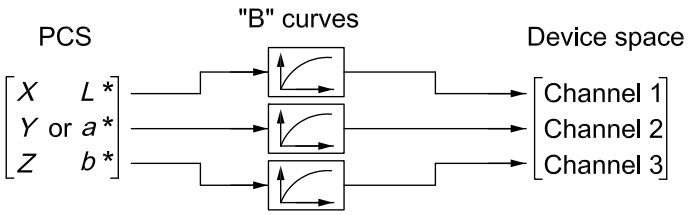
0.5 Colour profiles

Colour profiles provide colour management systems with the information necessary to convert colour data between different colour encodings, including device encodings. This part of ISO 15076 divides colour devices into three broad classifications, i.e. input devices, display devices and output devices. For each device class, a series of base algorithmic models are described which perform the transformation between colour encodings. Figures 2 and 3 show examples of these models, which provide different trade-offs in memory footprint, colour quality and performance results. The matrix tone reproduction curve (TRC) model is explained in detail in 8.3.3 and 8.4.3, the lutAToBType and lutBToAType in 10.10 and 10.11, and the multiProccessElementsType in 10.14. The necessary parameter data to implement these models is described in the appropriate tag type descriptions in Clause 10. This required data provides the information for the colour management framework default colour management module (CMM) to transform colour information between colour encodings. A representative architecture using these components is illustrated in Figure 4.

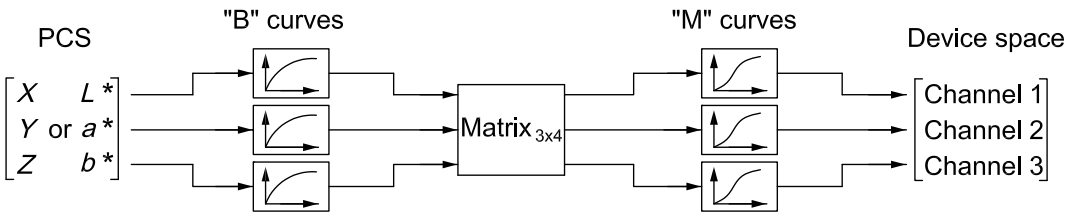
NOTE Only the models shown in Figures 2d), 2e), 2f), 3d), 3e) and 3f) can be used if the device space has more than three components/colours.



a) Using a matrix/TRC model



b) Using a lutBToAType model



c) Using a lutBToAType model

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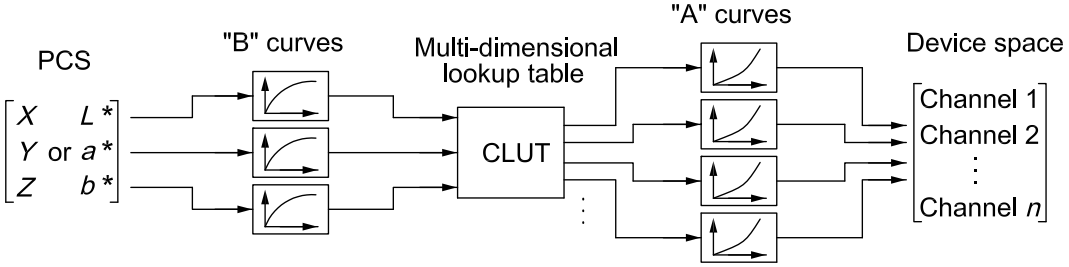
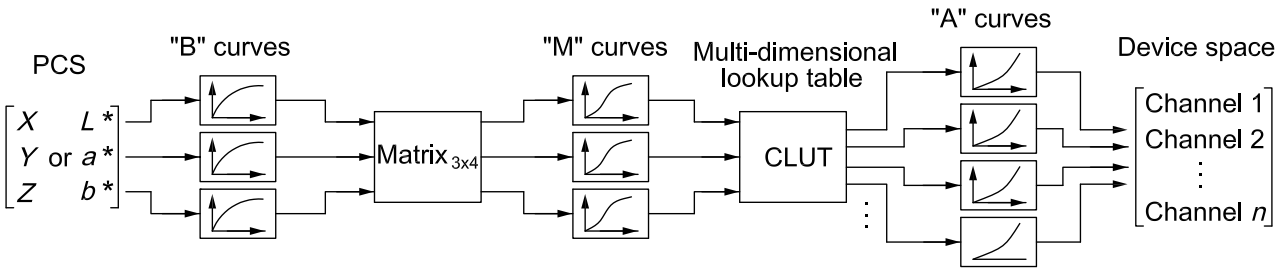
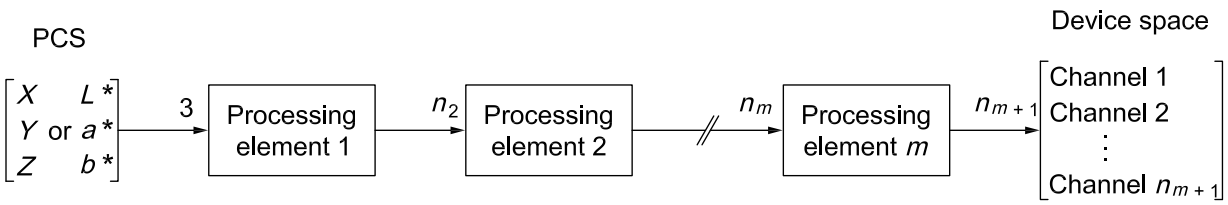


d) Using a lutBToAType model

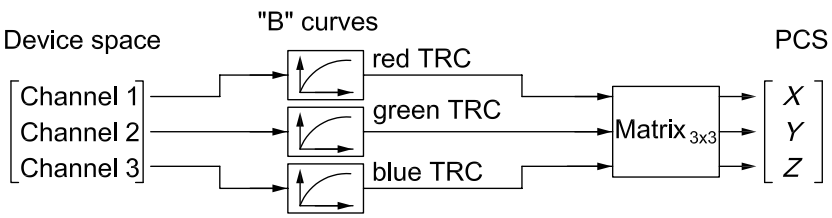


e) Using a lutBToAType model

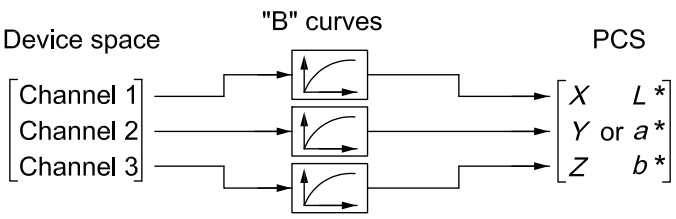


f) Using a multiProcessElementsType tag

Figure 2 — Examples of different ways of converting a colour from PCS to device space



a) Using a matrix/TRC model



b) Using a lutAToBType model

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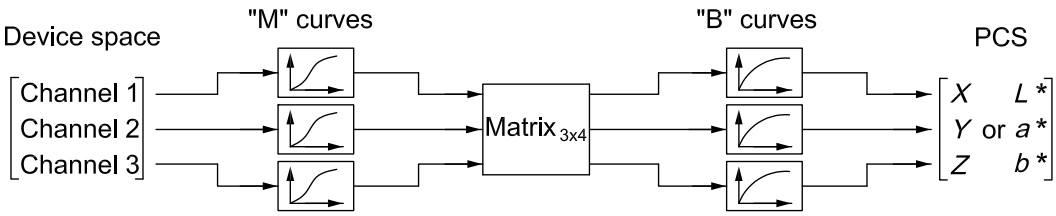
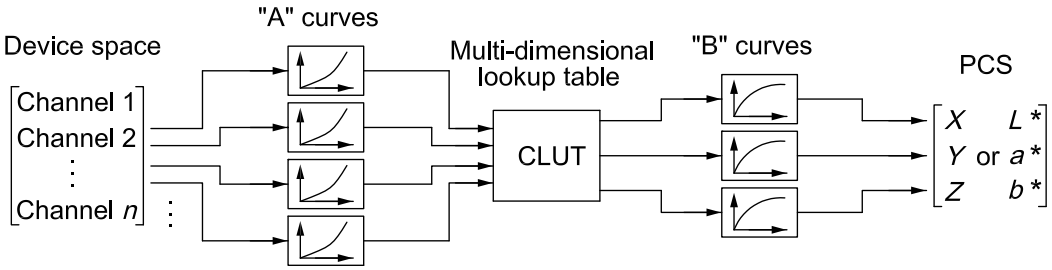
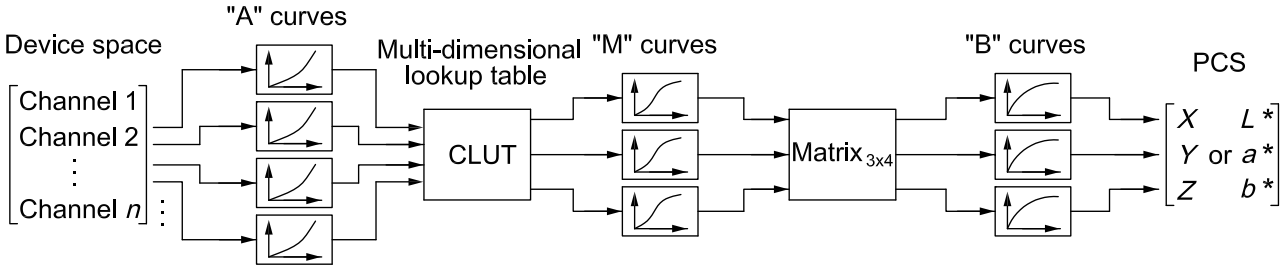


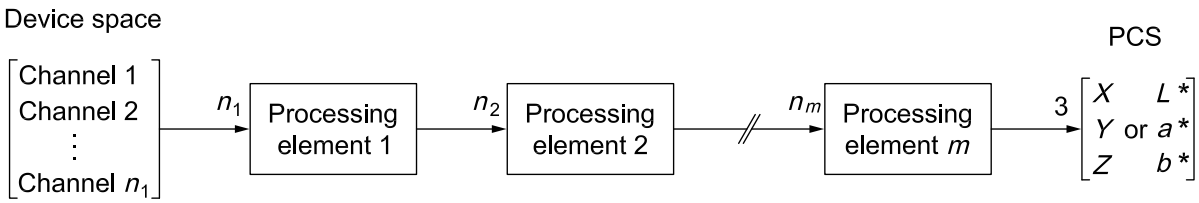
c) Using a lutBToAType model



d) Using a lutBToAType model



e) Using a lutBToAType model



f) Using a multiProccessElementsType tag

Figure 3 — Examples of different ways of converting a colour from device to PCS

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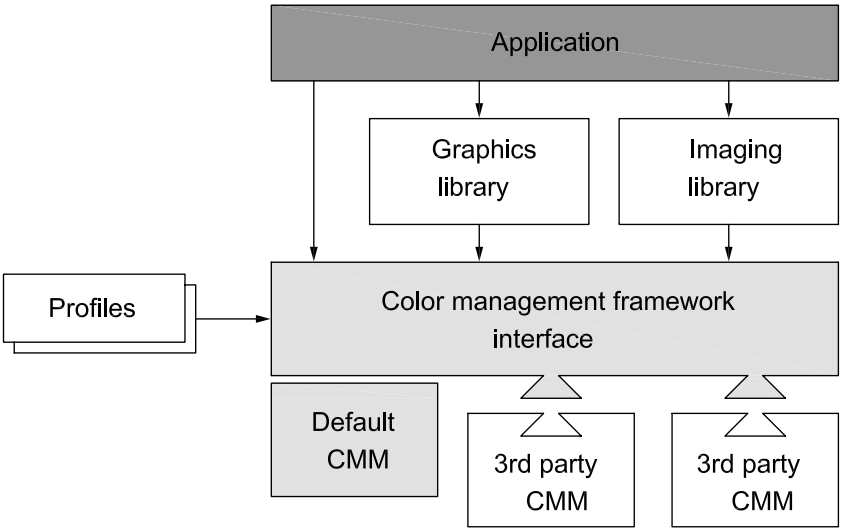

Figure 4 — Colour management architecture

0.6 Profile element structure

The profile structure is defined as a header followed by a tag table followed by a series of tagged elements that can be accessed randomly and individually. This collection of tagged elements provides three levels of information for developers: required data, optional data and private data. An element tag table provides a table of contents for the tagging information in each individual profile. This table includes a tag signature, the beginning address offset and size of the data for each individual tagged element. Signatures in this part of ISO 15076 are defined as a 4-byte hexadecimal number. This tagging scheme allows developers to read in the element tag table and then randomly access and load into memory only the information necessary to their particular software application. Since some instances of profiles can be quite large, this provides significant savings in performance and memory. The detailed descriptions of the tags, along with their intent, are included later in this part of ISO 15076.

The required tags provide the complete set of information necessary for the CMM to translate colour information between the PCS and the data colour encoding. Each profile class determines which combination of tags is required.

In addition to the required tags for each colour profile, a number of optional tags are defined that can be used for enhanced capabilities. In the case of required and optional tags, all of the signatures, an algorithmic description (where appropriate), and intent are registered with the International Color Consortium. Private data tags allow CMM developers to add proprietary value to their profiles. By registering just the tag signature and tag type signature, developers are assured of maintaining their proprietary advantages while maintaining compatibility with this part of ISO 15076. However, since the overall philosophy of this format is to maintain an open, cross-platform standard, developers are encouraged to keep the use of private tags to an absolute minimum.

0.7 Embedded profiles

In addition to providing a cross-platform standard for the colour profile format, this part of ISO 15076 also describes the convention for embedding these profiles within graphics documents and images. Embedded profiles allow users to transparently move colour data between different computers, networks and even operating systems without having to worry if the necessary profiles are present on the destination systems. The intention of embedded profiles is to allow the interpretation of the associated colour data. Embedding profiles are described in Annex B of this part of ISO 15076.

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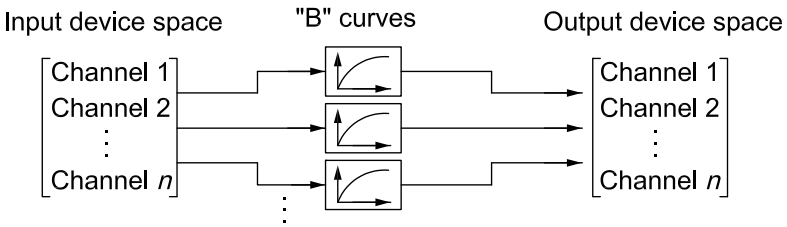
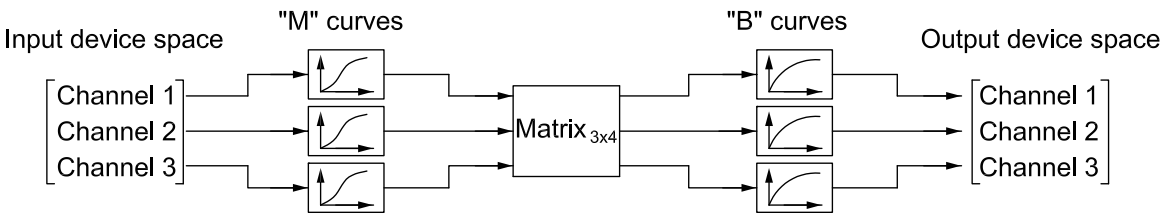
0.8 Other profiles

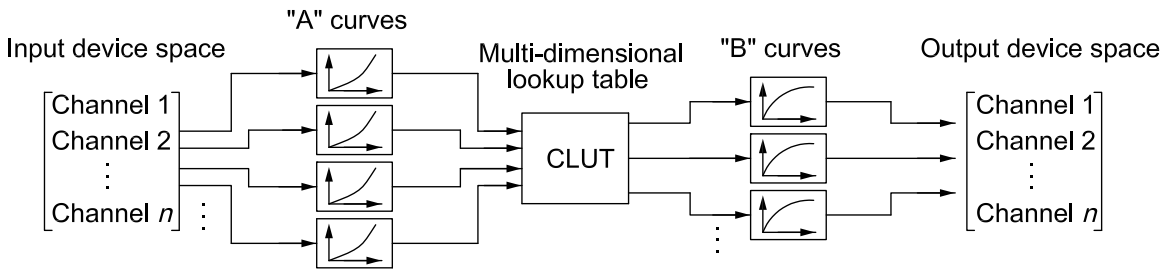
Four profile types, in addition to the device profile types described above, are defined in this part of ISO 15076. DeviceLink profiles provide a dedicated transformation from one device encoding to another, which can be useful in situations where such a transformation is used frequently or has required optimisation to achieve specific objectives. (Figure 5 shows the various algorithmic models which can be used to construct a DeviceLink profile.)



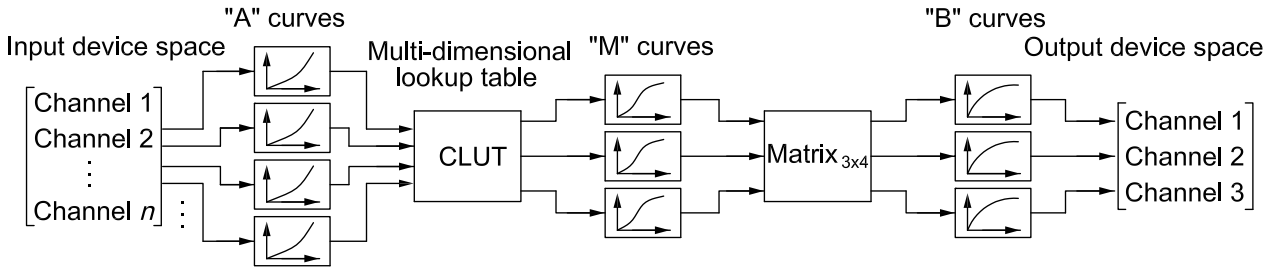
a) Using a TRC model



b) Using a matrix and TRC model



c) Using a colour lookup table (CLUT), and a TRC model



d) Using a CLUT, a matrix, and a TRC model

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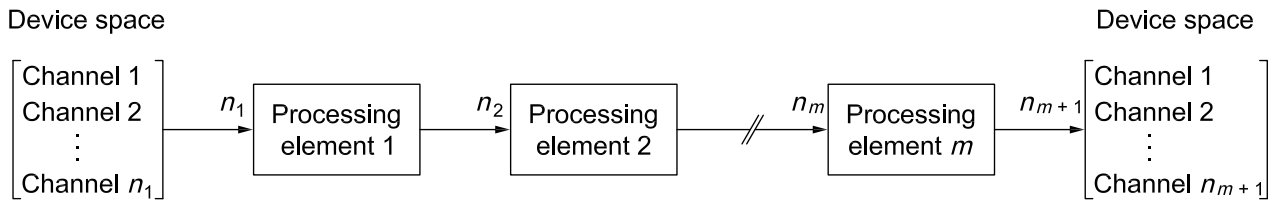

e) Using a multiProccessElementsType tag

Figure 5 — Examples of converting a colour from device to device using a DeviceLink profile

ColorSpace profiles provide transformations between standard colour encodings and the PCS, providing a means for supporting existing and future colour encodings with backward compatibility. Abstract profiles are defined from PCS to PCS and enable colour transformations to be defined that provide some specific colour effects. NamedColor profiles provide a mechanism for specifying the relationship between device values and the PCS for specific colours, rather than for general images.

0.9 Organizational description of this part of ISO 15076

This part of ISO 15076 addresses a very complex set of issues and it has been organized to provide a clear, clean, and unambiguous explanation of the entire format. To accomplish this, the overall presentation is from a top-down perspective, beginning with the summary overview presented above, followed by the necessary background information and definitions needed for unambiguous interpretation of the text. A description of the PCS and rendering intents is then provided before continuing down at increasing levels of detail into a byte stream description of the format. Clause 6 describes the PCS and rendering intents; Clause 7 describes the structure of the various fields required in a profile; and Clause 8 describes the content of the required tags for each profile class. Clause 9 lists the various tags (optional and required) and briefly summarizes the function of the tags as well as listing the signature and permitted tag types for each. The tag types are defined in Clause 10. Annex A provides additional information pertaining to the data colour encodings and rendering intents used in this part of ISO 15076 while Annex B provides details for embedding profiles into EPS, TIFF, and JPEG files. Annex C provides a general description of the PostScript Level 2 tags used in this part of ISO 15076 while Annex D provides some background material on the PCS. Annex E provides additional information pertaining to chromatic adaptation and the chromaticAdaptationTag while Annex F describes some computational models assumed in this part of ISO 15076. Annex G summarizes in tabular form the required tags for each profile class as specified in Clause 8.

0.10 Patent statement

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this part of ISO 15076 can involve the use of a patent concerning the outputResponseTag, (support of the outputResponseTag is optional), given in 9.2.36.

ISO takes no position concerning the evidence, validity and scope of this patent right. The holder of this patent right has assured the ISO that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from:

Intellectual Property Standards and Transactions
Eastman Kodak Company
343 State Street,
Rochester, NY 14650
USA

Attention is drawn to the possibility that some of the elements of this part of ISO 15076 may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

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INTERNATIONAL STANDARD ISO 15076-1:2010(E)

Image technology colour management — Architecture, profile format and data structure —

Part 1:
Based on ICC.1:2010

1 Scope

This part of ISO 15076 specifies a colour profile format and describes the architecture within which it can operate. This architecture supports the exchange of information which specifies the intended colour image processing of digital data. The required reference colour spaces and the data structures (tags) are also specified.

NOTE The technical content of this part of ISO 15076 is identical to that of ICC.1:2010.

2 Normative references

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

ISO 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

ISO 639-1, *Codes for the representation of names of languages — Part 1: Alpha-2 code*

ISO/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

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

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

DIN 16536-2, *Testing of prints and printing inks in graphic technology — Colour density measurements on on-press or off-press prints — Part 2: Instrument specifications for reflection densitometers and their calibration*

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

ITU-R BT.709-2, *Parameter values for the HDTV standards for production and international programme exchange*

SMPTE RP 145, *SMPTE C Color Monitor Colorimetry. Available from:* <http://store.smpte.org/category-s/22.htm>

Internet RFC 1321, *The MD5 Message-Digest Algorithm*, R. Rivest, April 1992, Available from Internet <ftp://www.ietf.org/rfc/rfc1321.txt>

IEEE 754, *Standard for Binary Floating-Point Arithmetic. Available from:* <http://ieeexplore.ieee.org>

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3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1
adopted white
spectral radiance distribution as seen by an image capture or measurement device and converted to colour signals that are considered to be perfectly achromatic and to have an observer adaptive luminance factor of unity; i.e. colour signals that are considered to correspond to a perfect white diffuser

NOTE 1 The adopted white can vary within a scene.

NOTE 2 No assumptions should be made concerning the relationship between the adapted or adopted white and measurements of near perfectly reflecting diffusers in a scene, because measurements of such diffusers will depend on the illumination and viewing geometry, and other elements in the scene that can affect perception. It is easy to arrange conditions for which a near perfectly reflecting diffuser will appear to be grey or coloured.

[ISO 22028-1]

3.1.2
ASCII text string
sequence of bytes, each containing a graphic character specified in ISO/IEC 646, the last character in the string being a NULL (character 0/0)

3.1.3
big-endian
addressing the bytes within a 16-bit, 32-bit or 64-bit value from the most significant to the least significant, as the byte address increases

3.1.4
bit position
bits are numbered such that bit 0 is the least significant bit

3.1.5
byte
8-bit unsigned binary integer

3.1.6
byte offset
number of bytes from the beginning of a field

3.1.7
CIELAB
CIE 1976 L^*, a^* and b^* values calculated from nCIEXYZ according to CIE 15

3.1.8
CIEXYZ
XYZ tristimulus values based on the CIE 1931 Standard Colorimetric Observer as defined in CIE 15

NOTE Y is expressed in candelas per square meter.

3.1.9
nCIEXYZ
CIEXYZ values that have been uniformly scaled so that $Y = 1{,}0$ for the adopted white

NOTE In this part of ISO 15076, this is referred to as ICC-absolute colorimetry.

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3.1.10
colour encoding
generic term for a quantized digital encoding of a colour space, encompassing both colour space encodings and colour image encodings

[ISO 22028-1]

NOTE Values specified by an encoding are the closest representation to the colour space or image values permitted by the encoding precision.

3.1.11
colour management
communication of the associated data required for unambiguous interpretation of colour content data, and application of colour data conversions, as required, to produce the intended reproductions

NOTE 1 Colour content can consist of text, line art, graphics, and pictorial images, in raster or vector form, all of which can be colour managed.

NOTE 2 Colour management considers the characteristics of input and output devices in determining colour data conversions for these devices.

3.1.12
colour rendering
mapping of image data representing the colour-space coordinates of the elements of a scene to output-referred image data representing the colour-space coordinates of the elements of a reproduction

NOTE Colour rendering generally consists of one or more of the following:

— compensating for differences in the input and output viewing conditions,

— tone scale and gamut mapping to map the scene colours onto the dynamic range and colour gamut of the reproduction, and

— applying preference adjustments.

[ISO 22028-1]

3.1.13
encoding maximum white
highest luminance achromatic colour that can be represented using a specified colour encoding

NOTE For the purpose of this definition, a colour is achromatic if it has the same chromaticity as the adopted white. The choice of the adopted white is an user decision.

3.1.14
fixed point
method of encoding a real number into binary by putting an implied binary point at a fixed bit position

NOTE Many of the tag types defined in this part of ISO 15076 contain fixed point numbers. Several references can be found (MetaFonts, etc.) illustrating the benefit of fixed point representation when compared to pure floating point representation in very structured circumstances.

3.1.15
hexadecimal
numeral system with a radix, or base, of 16, written using the symbols 0–9 and A–F, or a–f

NOTE The notation used to indicate hexadecimal numbers in this part of ISO 15076 is xxh.

3.1.16
image state
attribute of a colour image encoding indicating the rendering state of the image data

[ISO 22028-1]

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3.1.17
media white point
reference colour that is used as the basis for scaling of media relative transforms

NOTE In a reproduction process, this is usually the colour with the highest luminance that can be produced by an imaging medium, measured using the specified measurement geometry. In a capture process this is usually the colour associated with the device side encoding maximum white.

3.1.18
NULL
character coded in position 0/0 as specified in ISO/IEC 646

3.1.19
PCS
profile connection space
colour space used to connect the source and destination profiles

NOTE See Annex D for a full description.

3.1.20
PCS adopted white
adopted white where the spectral radiance distribution is that of the PCS illuminant

3.1.21
PCS illuminant
illuminant with the spectral radiance distribution of CIE illuminant D50 and nCIEXYZ $X = 0{,}964\ 2$, nCIEXYZ $Y = 1{,}0$, nCIEXYZ $Z = 0{,}824\ 9$

3.1.22
PCSLAB
CIELAB values calculated from PCSXYZ

3.1.23
PCSLAB encoding
PCSLAB values that have been encoded as 8-bit or 16-bit numbers, or as floating point numbers

3.1.24
PCSXYZ
nCIEXYZ values that have been linearly scaled so that PCSXYZ $X = 0{,}964\ 2$, PCSXYZ $Y = 1{,}0$, PCSXYZ $Z = 0{,}824\ 9$ for media white

3.1.25
PCSXYZ encoding
PCSXYZ values that have been encoded as 16-bit numbers, or as floating point numbers

3.1.26
picture-referred image state
image state associated with image data that represents the colour-space coordinates of the elements of a hardcopy or softcopy image, encompassing both original-referred image data and output-referred image data

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

NOTE 2 Picture-referred image data will generally be colour-rendered for a specific real or virtual imaging medium and viewing condition.

NOTE 3 Picture-referred image data can include image data that do not originate from an original scene, such as text, line art, vector graphics and other forms of original artwork.

[ISO 22028-1]

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3.1.27
rendering intent
style of mapping colour values from one image description to another

NOTE See Clause 6 and Annexes A and D for a description of the four rendering intents (ICC-absolute colorimetric, relative colorimetric, perceptual and saturation) used in ICC profiles

3.1.28
scene
spectral radiances of a view of the natural world as measured from a specified vantage point in space and at a specified time

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

[ISO 22028-1]

3.1.29
spot colour
single colorant, identified by name, whose printing tone-values are specified independently from the colour values specified in a colour coordinate system

3.1.30
signature
alphanumerical 4-byte value, registered with the ICC

NOTE Shorter values are padded at the end with 20h bytes.

3.1.31
viewing flare
veiling glare that is observed in a viewing environment but not accounted for in radiometric measurements made using a prescribed measurement geometry

[ISO 22028-1]

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

3.1.32
veiling glare
light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

[ISO 22028-1]

3.2 Abbreviated terms

ANSI American National Standards Institute

CIE *Commission Internationale de l'eclairage*
(International Commission on Illumination)

CLUT Colour lookup table (multi-dimensional)

CMM Colour management module

CMY Cyan, magenta, yellow

CMYK Cyan, magenta, yellow, key (black)

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CRD Colour rendering dictionary

CRT Cathode-ray tube

EPS Encapsulated PostScript

ICC International Color Consortium

IEC International Electrotechnical Commission

ISO International Organization for Standardization

LCD Liquid crystal display

LUT Lookup table

PCS Profile connection space

RGB Red, green, blue

TIFF Tagged Image File Format

TRC Tone reproduction curve

4 Basic number types

4.1 General

The basic numeric types used in this part of ISO 15076 are defined in 4.2 to 4.15.

NOTE As defined in 7.1, all profile data is encoded as big-endian.

4.2 dateTimeNumber

A dateTimeNumber is a 12-byte value representation of the time and date, where the byte usage is assigned as specified in Table 1. The actual values are encoded as 16-bit unsigned integers (uInt16Number, see 4.10).

Table 1 — dateTimeNumber

Byte position	Field length bytes	Content	Encoded as
0 to 1	2	Number of the year (actual year, e.g. 1994)	uInt16Number
2 to 3	2	Number of the month (1 to 12)	uInt16Number
4 to 5	2	Number of the day of the month (1 to 31)	uInt16Number
6 to 7	2	Number of hours (0 to 23)	uInt16Number
8 to 9	2	Number of minutes (0 to 59)	uInt16Number
10 to 11	2	Number of seconds (0 to 59)	uInt16Number

All the dateTimeNumber values in a profile shall be in Coordinated Universal Time (UTC, also known as GMT or ZULU Time). Profile writers are required to convert local time to UTC when setting these values. Programs that display these values may show the dateTimeNumber as UTC, show the equivalent local time (at current locale), or display both UTC and local versions of the dateTimeNumber.

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4.3 float32Number

A float32Number shall be single-precision 32-bit floating-point number as specified in IEEE 754, excluding un-normalized numbers, infinities, and “not a number” (NaN) values.

NOTE 1 A 32-bit IEEE 754 floating-point number has an 8-bit exponent and a 23-bit mantissa.

NOTE 2 Although un-normalized numbers, infinities and NaN values are not stored in the ICC Profile, such values can occur as a result of CMM computations.

4.4 positionNumber

Positions of some data elements are indicated using a position offset with the data element’s size. This data type allows this information to be stored as a single entity. Table 2 shows the positionNumber encoding.

Table 2 — positionNumber encoding

Byte position	Field length bytes	Content	Encoded as
0 to 3	4	Offset to data element in bytes	uInt32Number
4 to 7	4	Size of data element in bytes	uInt32Number

4.5 response16Number

A response16Number is an 8-byte value, used to associate a normalized device code with a measurement value, where byte usage shall be assigned as specified in Table 3.

Table 3 — response16Number

Byte position	Field length bytes	Content	Encoded as
0 to 1	2	16-bit number in the interval [DeviceMin to DeviceMax][a]	uInt16Number
2 to 3	2	Reserved, shall be zero	
4 to 7	4	Measurement value	s15Fixed16Number

[a] DeviceMin is encoded as 0000h and DeviceMax is encoded as FFFFh.

4.6 s15Fixed16Number

An s15Fixed16Number is a fixed signed 4-byte (32-bit) quantity which has 16 fractional bits as shown in Table 4.

Table 4 — s15Fixed16Number

Number	Encoded as
–32 768,0	80000000h
0	00000000h
1,0	00010000h
32 767 + (65 535/65 536)	7FFFFFFFh

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4.7 u16Fixed16Number

A u16Fixed16Number is a fixed unsigned 4-byte (32-bit) quantity having 16 fractional bits as shown in Table 5.

Table 5 — u16Fixed16Number

Number	Encoded as
0	00000000h
1,0	00010000h
65 535 + (65 535/65 536)	FFFFFFFFh

4.8 u1Fixed15Number

A u1Fixed15Number is a fixed unsigned 2-byte (16-bit) quantity having15 fractional bits as shown in Table 6.

Table 6 — u1Fixed15Number

Number	Encoded as
0	0000h
1,0	8000h
1 + (32 767/32 768)	FFFFh

4.9 u8Fixed8Number

A u8Fixed8Numberfixed is an unsigned 2-byte (16-bit) quantity having 8 fractional bits as shown in Table 7.

Table 7 — u8Fixed8Number

Number	Encoded as
0	0000h
1,0	0100h
255 + (255/256)	FFFFh

4.10 uInt16Number

A uInt16Number is an unsigned 2-byte (16-bit) integer.

4.11 uInt32Number

A uInt32Number is an unsigned 4-byte (32-bit) integer.

4.12 uInt64Number

A uInt64Number is an unsigned 8-byte (64-bit) integer.

4.13 uInt8Number

A uInt8Number is an unsigned 1-byte (8-bit) integer.

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4.14 XYZNumber

An XYZNumber is a set of three fixed signed 4-byte (32-bit) quantities used to encode CIEXYZ, nCIEXYZ, and PCSXYZ tristimulus values where byte usage is assigned as specified in Table 8. Although the CIE specifies that for reflecting and transmitting media Y should be normalized such that it has the value 100,0 for the perfect diffusing reflector or transmitter, in this part of ISO 15076, for reasons of coding efficiency, Y is specified such that it has the value 1,0 for the perfect diffusing reflector or transmitter for nCIEXYZ.

NOTE 1 Signed numbers are employed for this type to accommodate negative values arising during calculations.

Table 8 — XYZNumber

Byte position	Field length bytes	Content	Encoded as
0 to 3	4	CIEXYZ X, nCIEXYZ X, or PCSXYZ X	s15Fixed16Number
4 to 7	4	CIEXYZ Y, nCIEXYZ Y, or PCSXYZ Y	s15Fixed16Number
8 to 11	4	CIEXYZ Z, nCIEXYZ Z, or PCSXYZ Z	s15Fixed16Number

4.15 Seven-bit ASCII

Alpha-numeric values, and other input and output codes, shall conform to the American Standard Code for Information Interchange (ASCII) specified in ISO/IEC 646.

5 Conformance

Any colour management system, application, utility or device driver that claims conformance with this part of ISO 15076 shall have the ability to read the profiles as they are defined in this part of ISO 15076. Any profile-generating software and/or hardware that claims conformance with this part of ISO 15076 shall have the ability to create profiles as they are defined in this part of ISO 15076. ICC conforming software shall use the ICC profiles in an appropriate manner.

This part of ISO 15076 requires that signatures for CMM type, device manufacturer, device model, profile tags and profile tag types shall be registered to ensure that all profile data is uniquely defined. The registration authority for these data is the ICC Technical Secretary.

NOTE See the ICC Web Site (www.color.org) for contact information.

6 Profile connection space, rendering intents, and device encoding

6.1 General considerations

The PCS is the reference colour space in which colours are encoded in order to provide an interface for connecting source and destination transforms. The PCS values constitute an encoding of a CIE colorimetric specification.

Four rendering intents are specified in this part of ISO 15076:

a) ICC-absolute colorimetric;

b) media-relative colorimetric;

c) perceptual;

d) saturation.

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Each represents a type of colour rendering (mapping of colour values) that is useful for various imaging workflows. The colorimetric intents preserve the colorimetry of in-gamut colours at the expense of out-of-gamut colours. The mapping of out-of-gamut colours is not specified but should be consistent with the intended use of the transform. The perceptual and saturation rendering intents modify colorimetric values to account for any differences between devices, media, and viewing conditions.

The requirements for these rendering intents are given in 6.2 and discussed further in Annex D.

Profiles are required to contain transformations for one, or more, of these rendering intents. Clause 6 specifies which rendering intents are required, and which are optional, for the various classes of profiles.

NOTE When present, the colorimetricIntentImageStateTag indicates the image state of the colorimetry produced by the colorimetric intent transforms.

6.2 Rendering intents

6.2.1 General

The colorimetric rendering intents operate on measurement-based colorimetric values as adapted to the PCS adopted white chromaticity. This adaptation, when required, shall be indicated in the chromaticAdaptationTag. For the purposes of this part of ISO 15076, chromatic adaptation should be calculated using the linear Bradford model. Details of this model are provided in Annex E.

NOTE 1 The original measurement values can be determined from PCS values by applying the inverse chromatic adaptation transformation. This inversion is not usually performed. Since the PCS values are already adapted to the PCS adopted white chromaticity when constructing the profiles, neither the forward nor the inverse chromatic adaptation transforms need to be applied by the CMM in normal use of the profiles.

For the other intents transformations shall be assumed to be specified relative to the PCS illuminant. However, for these transformations profiles are not required to specify any chromatic adaptation that may have been employed in the calculation of the transformation data.

In transforms for the media-relative and ICC-absolute colorimetric intents, for Input profiles the PCS values may represent a colour rendering of the actual original captured. Likewise for Output profiles, the PCS values may be colour rendered by the output device to the actual medium. However, wherever ICC profiles are used, unless the colorimetric intent image state tag is present, the PCS values resulting from such transforms shall be interpreted as the colorimetry of the original and reproduction, regardless of whether such colorimetry is the actual colorimetry. If the colorimetric intent image state tag is present, then the interpretation of the colorimetry of the resulting PCS values shall be according to the value recorded in that tag.

NOTE 2 All PCS colorimetry is picture-referred unless otherwise indicated in the colorimetric intent image state tag.

6.2.2 Media-relative colorimetric intents

Transformations for this intent shall re-scale the in-gamut, chromatically adapted tristimulus values such that the white point of the actual medium is mapped to the PCS white point (for either input or output) as defined in 6.3.2.

NOTE Transforms for the media-relative colorimetric intent represent media-relative measurements of the captured original (for Input profiles), or media-relative colour reproductions produced by the output device (for Output profiles) unless otherwise indicated in the colorimetricIntentImageStateTag.

6.2.3 ICC-absolute colorimetric intent

Transformations for this intent shall leave the chromatically adapted nCIEXYZ tristimulus values of the in-gamut colours unchanged.

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The DToB3 and BToD3 tags contain separate transforms for the ICC-absolute colorimetric intent. This allows for an absolute expression of colorimetric data, limited only by the range of float32Number values. The mediaWhitePointTag is *not* used in processing DToB3 and BToD3 tags.

When DToB3 and BToD3 tags are not present (or not used), profiles do not contain a separate transform for the ICC-absolute colorimetric intent. When this intent is needed, it shall be generated, as described in 6.3.2, using the mediaWhitePointTag, which specifies the CIE 1931 XYZ tristimulus values of the white point of the actual medium, as represented in the PCS. In this way, ICC-absolute colorimetric rendering may be obtained by using the media-relative colorimetric intent transformations (AToB1, BToA1) for the source and destination profiles and scaling the PCS values by the ratio of the destination profile mediaWhitePointTag to the source profile mediaWhitePointTag (see Annex D for more information). As specified in 9.2.34, for monitor profiles the mediaWhitePointTag shall be set to the PCS white point (defined in 6.3.4.3). Likewise, if the viewer is assumed to completely adapt to the white point of the medium for any other media (i.e. the media white looks like a perfect reflecting diffuser) the mediaWhitePointTag should be set to the PCS white point.

NOTE 1 Transforms for the ICC-absolute colorimetric intent represent measurements of the captured original relative to a hypothetical perfectly reflecting or transmitting diffuser (for Input profiles), or colour reproductions produced by the output device relative to a hypothetical perfectly reflecting or transmitting diffuser (for Output profiles), unless otherwise indicated in the in the colorimetricIntentImageStateTag.

NOTE 2 This definition of ICC-absolute colorimetry is sometimes called “relative colorimetry” in CIE terminology, since the data has been normalized relative to the perfect diffuser viewed under the same illumination source as the sample.

6.2.4 Perceptual intent

In perceptual transforms the PCS values represent hypothetical measurements of a colour reproduction on the reference reflective medium. By extension, for the perceptual intent, the PCS represents the appearance of that reproduction as viewed in the reference viewing environment by a human observer adapted to that environment. The exact colour rendering of the perceptual intent is vendor specific.

NOTE 1 The reference medium and viewing environment are defined in 6.3.3.

NOTE 2 The perceptual intent is useful when it is not required to exactly maintain image colorimetry (such as with natural images), with input and output media that are substantially different.

NOTE 3 When using the perceptual intent, the colour rendering to the reference medium serves to ensure that Input and Output profiles from different manufacturers will work reasonably well together, although the results from different combinations of profiles will likely be different due to the proprietary nature of the colour rendering contained in this intent.

6.2.5 Saturation intent

The exact colour rendering of the saturation intent is vendor specific and involves compromises such as trading off preservation of hue in order to preserve the vividness of pure colours.

6.3 Profile connection space

6.3.1 Chromatic adaptation

The PCS adopted white chromaticity shall be the chromaticity of the D50 illuminant defined in ISO 3664.

6.3.2 Colorimetric specification

6.3.2.1 General

The measurement parameters for the PCS, and all other colour spaces defined in this part of ISO 15076, shall be based on ISO 13655. The colorimetry shall be assumed not to contain any flare or other defect caused by inadequacies in the optical system of the instrument and illumination used to make the measurements, but shall be assumed to include the surface reflection component normally associated with the prescribed measurement geometry.

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The PCS colour space encodings shall be based on media-relative colorimetry in which tristimulus values are relative to the values in the mediaWhitePointTag. For the perceptual rendering intent the medium for calculation of the media-relative colorimetry shall be the reference medium defined in 6.3.3.

6.3.2.2 Translation between media-relative colorimetric data and ICC-absolute colorimetric data

The translation from ICC-absolute colorimetric data to media-relative colorimetry data is given by Equations (1) to (3).

$$X_r = \left[\frac{X_i}{X_{mw}}\right] X_a \tag{1}$$

$$Y_r = \left[\frac{Y_i}{Y_{mw}}\right] Y_a \tag{2}$$

$$Z_r = \left[\frac{Z_i}{Z_{mw}}\right] Z_a \tag{3}$$

where

X_r, Y_r, Z_r	are the media-relative colorimetric data (i.e. PCSXYZ);
X_a, Y_a, Z_a	are the ICC-absolute colorimetric data (i.e. nCIEXYZ);
X_{mw}, Y_{mw}, Z_{mw}	are the nCIEXYZ values of the media white point as specified in the mediaWhitePointTag;
X_i, Y_i, Z_i	are the PCSXYZ values of the PCS white point defined in 6.3.4.3.

The translation from media-relative colorimetry data to ICC-absolute colorimetric data is given by Equations (4) to (6):

$$X_a = \left[\frac{X_{mw}}{X_i}\right] X_r \tag{4}$$

$$Y_a = \left[\frac{Y_{mw}}{Y_i}\right] Y_r \tag{5}$$

$$Z_a = \left[\frac{Z_{mw}}{Z_i}\right] Z_r \tag{6}$$

where

X, Y, Z	are the CIE tristimulus values;
X_n, Y_n, Z_n	are the CIE values of the illuminant white point.

6.3.2.3 Computation of PCSLAB

When values are encoded as PCSLAB, these shall be computed from the PCSXYZ tristimulus values as specified in Annex A, noting that:

$$\frac{X}{X_n} \quad \text{is replaced by} \quad \frac{X_r}{X_i} \quad \left(\text{or } \frac{X_a}{X_{mw}}\right) \tag{7}$$

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$$\frac{Y}{Y_n} \quad \text{is replaced by} \quad \frac{Y_r}{Y_i} \quad \left(\text{or } \frac{Y_a}{Y_{mw}}\right) \tag{8}$$

$$\frac{Z}{Z_n} \quad \text{is replaced by} \quad \frac{Z_r}{Z_i} \quad \left(\text{or } \frac{Z_a}{Z_{mw}}\right) \tag{9}$$

6.3.3 Reference viewing environment and medium for the perceptual rendering intent

6.3.3.1 General

Because perceptual rendering generally involves mapping the colours of a source to be well-suited for a destination medium (i.e. colour rendering and/or colour re-rendering), it is desirable that the perceptual intent PCS reference medium (PRM) and associated viewing conditions be well-defined. Then, the source profile can perceptually render from the source to the PRM, and the destination profile can perceptually render from the PRM to the destination medium. The PRM, in the PCS, serves as the common intermediate representation. Well-defined viewing conditions are required because they will affect the appearance of colour content represented on the PRM.

Perceptual rendering remains a proprietary art, due both to the current state of perceptual rendering algorithms, and also to the fact that viewer and application specific preferences can affect the nature of a desired reproduction (when exact colour matching is not the objective). It is not practical or desirable to specify standard perceptual rendering algorithms. Consequently, it is also not practical or desirable to require that perceptual rendering intents match an exact perceptual intent reference medium gamut (PRMG). Gamut mapping could be applied to clip the results of a perceptual rendering algorithm to a specific target gamut, but that would result in a loss of information and invertiblility. Therefore, the reference medium white point, black point, and viewing conditions attributes of the PRM are defined precisely, and the PRM gamut is defined to be a fuzzy target that can be used as the aim of perceptual rendering transforms, but does not have to be exactly matched.

6.3.3.2 Perceptual intent reference medium (PRM) characteristics

The reference medium is defined as a hypothetical print on a substrate specified to have a neutral reflectance of 89 %. The darkest printable colour on this medium is assumed to have a neutral reflectance of 0,309 11 %, which is 0,347 31 % of the substrate reflectance. These shall be assumed to be the white point and black point of the reference medium respectively.

NOTE The reference medium therefore has a linear dynamic range of 287,9 : 1 and a density range of 2,459 3.

6.3.3.3 Perceptual intent reference medium gamut (PRMG)

Perceptual rendering intent and saturation rendering intent transforms may optionally use the reflection colour gamut specified in ISO 12640-3, and provided in Table 9, as the PRMG. This colour gamut boundary description is intended only as an optional target for perceptual and saturation rendering intents, and these transforms should not clip to it. It is provided to enable improved interoperability of perceptual and saturation transforms.

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Table 9 — Maximum chroma values C^*_{ab}

h_{ab} [°]	Maximum C^*_{ab} for $L^*=$																				
	3,1373	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
0	0	11	26	39	52	64	74	83	91	92	91	87	82	75	67	57	47	37	25	13	0
10	0	10	24	38	50	62	73	82	90	92	91	87	82	75	67	58	48	37	26	13	0
20	0	10	23	37	50	62	73	84	93	94	94	90	85	78	70	60	50	39	27	14	0
30	0	9	22	35	48	61	74	86	98	100	101	96	90	83	75	65	54	42	30	15	0
40	0	8	21	34	47	60	73	83	93	97	101	99	97	90	83	73	61	47	34	17	0
50	0	8	20	32	43	55	66	77	88	95	99	101	100	98	92	85	72	56	40	20	0
60	0	7	17	27	37	47	57	67	76	84	91	96	100	102	103	98	90	72	51	26	0
70	0	6	16	25	34	43	52	60	68	76	83	90	96	100	104	107	109	100	74	37	0
80	0	6	15	23	32	40	48	57	64	71	78	85	91	97	103	107	110	113	110	70	0
90	0	6	14	22	30	39	47	55	62	68	75	82	88	95	101	106	112	117	120	123	0
100	0	6	14	22	30	38	46	54	61	68	74	81	88	94	100	106	109	112	112	92	0
110	0	6	14	22	31	39	47	55	63	69	76	83	89	96	100	103	106	107	102	75	0
120	0	6	15	24	32	41	49	58	66	73	80	87	93	98	101	102	99	91	73	50	0
130	0	6	16	25	35	44	54	63	72	80	87	93	97	101	99	94	86	73	56	34	0
140	0	7	18	28	38	48	57	67	77	86	95	98	101	97	93	85	75	61	44	26	0
150	0	7	19	30	40	51	62	72	83	92	97	99	96	91	85	76	66	52	37	22	0
160	0	7	20	32	44	56	68	80	92	96	99	97	92	87	79	70	59	46	33	19	0
170	0	8	20	32	43	53	64	75	85	91	96	93	89	82	75	65	55	42	30	17	0
180	0	8	20	31	41	52	62	72	81	87	92	90	86	79	71	61	52	40	28	15	0
190	0	8	20	30	40	50	60	68	76	82	87	85	82	76	69	60	50	39	27	14	0
200	0	8	20	30	38	47	56	63	70	76	82	81	77	72	66	58	49	38	27	14	0
210	0	8	20	29	37	46	53	60	66	73	79	80	75	70	64	57	49	38	27	14	0
220	0	8	20	29	37	45	52	59	65	71	76	75	72	68	63	56	48	38	27	14	0
230	0	9	20	29	38	46	53	59	65	70	75	73	71	66	61	54	46	36	26	13	0
240	0	10	22	31	40	48	55	61	67	71	74	70	66	61	56	49	41	32	23	12	0
250	0	11	24	34	43	51	59	65	70	73	71	68	63	58	52	45	38	30	21	11	0
260	0	14	27	38	48	57	64	69	73	73	70	66	61	56	50	43	35	28	20	10	0
270	0	17	32	45	55	65	70	75	75	73	70	66	61	55	49	42	34	27	19	10	0
280	0	21	42	55	68	75	81	80	79	76	72	67	61	55	49	41	34	26	18	9	0
290	0	26	52	68	83	86	89	87	84	80	75	69	63	57	50	42	35	27	18	10	0
300	0	25	69	82	95	94	93	91	88	85	79	73	66	59	52	44	36	28	19	10	0
310	0	21	51	74	91	97	100	98	95	90	84	77	70	63	55	47	39	30	20	10	0
320	0	18	41	62	79	91	102	101	98	95	89	83	76	68	60	51	42	32	22	11	0
330	0	16	35	53	71	82	91	100	104	102	98	91	84	76	67	57	47	36	24	12	0
340	0	14	31	46	61	73	83	92	101	103	99	95	89	80	71	61	50	38	26	13	0
350	0	12	28	42	55	68	77	86	94	96	93	90	85	77	68	58	48	37	25	13	0

The L^*, C^* and h values specified in this table are relative to the reference medium white with a reflectance factor of 0,89. To calculate values relative to a perfect reflecting diffuser, it is necessary to convert the table values to X, Y *and* Z values, scale the resulting X, Y *and* Z values by a factor of 0,89, and convert back to L^*, C^* and h relative to the perfect reflecting diffuser.

The values in this table are calculated for illuminant D50 and the CIE 1931, 2°, standard observer.

NOTE If the resolution of the data needs to be finer it would normally be adequate to obtain it by linear interpolation of the quoted data.

When the PRMG is used as the target colour gamut for perceptual and saturation transforms, this should be indicated with the corresponding profile tags as described in 9.2.37 and in 9.2.46.

Furthermore, as several popular source-to-destination colour re-rendering algorithms are defined via transformations of primaries and secondaries, approximate locations for red, green, blue, cyan, magenta and yellow in the PRMG have also been specified. These coordinates are provided in Table 10.

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Table 10 — PRMG "primary and secondary" colours

Colour coordinate	Red	Yellow	Green	Cyan	Blue	Magenta
L^*_{ab}	41	95	60	50	21	42
C^*_{ab}	98	123	100	76	95	102
h_{ab}	29	90	140	220	300	340

6.3.3.4 Perceptual intent reference medium viewing conditions

The reference viewing environment shall be based on standard viewing condition P2, as specified for graphic arts and photography in ISO 3664, but extended to include an "average" surround, i.e. the illumination of the image shall be assumed to be similar to the illumination of the rest of the environment. The surfaces immediately surrounding the image shall be assumed to be a uniform matt grey with a reflectance of 20 %. The reference viewing environment shall also be assumed to have a level of viewing flare of 0,007 5 (3/4 %) of the luminance of the reference medium in the reference viewing environment (1,06 cd/m^2). If the actual viewing environment differs from the reference viewing environment perceptual transforms shall be used to compensate for the difference in viewing environments.

NOTE ISO 3664 describes the appropriate illumination level for practical appraisal of prints as 500 lx (P2), which is specified to be typical of the level found in actual home and office viewing environments. This was deemed to be most appropriate for the reference viewing environment.

6.3.4 Colour space encodings for the PCS

6.3.4.1 General

The colorimetric data defined in 6.3.2 and 6.3.3 may be specified either as PCSXYZ or PCSLAB data. When specified as PCSXYZ data they shall be encoded using 16 bits per component while when specified as PCSLAB data they shall be encoded as either 8 bits per component or 16 bits per component. Additionally, within the context of DToBx and BToDx tags PCSXYZ or PCSLAB data shall be encoded using float32Number values that directly express PCSXYZ or PCSLAB colorimetry.

When converting from float32Number-based to integer-based encoding, component-wise clipping shall be applied if the floating-point value is outside the range that can be encoded as integers.

NOTE 1 These alternative methods are provided in order to satisfy conflicting requirements for accuracy and storage space. The profile header specifies which encoding method has been used. While supporting multiple encodings increases the complexity of colour management, it provides flexibility in addressing different user requirements such as colour accuracy and memory footprint.

NOTE 2 It is important to understand that the PCS encodings do not represent a quantization of the connection space. The purpose of the encodings is to allow points within the space to be specified. Since the processing models benefit from interpolation between table entries, the interpolated AToB results need to be used as the inputs to the BToA transforms. The AToB results are not rounded to the nearest encoding value. (AToB and BToA transforms are defined in 10.10 and 10.11)

6.3.4.2 General PCS encoding

For the 16-bit integer based PCSXYZ encoding, each component (PCSXYZ X, PCSXYZ Y, and PCSXYZ Z) is encoded as a u1Fixed15Number. This encoding was chosen to allow for PCSXYZ values that have an X or Z greater than 1,0.

For the XYZNumber based PCSXYZ encoding, each component (PCSXYZ X, PCSXYZ Y, and PCSXYZ Z) is encoded as a s15Fixed16Number. For the float32Number-based PCS encodings the actual PCSXYZ or PCSLAB values are directly encoded. The relationship between PCSXYZ encodings is shown in Table 11.

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Table 11 — PCSXYZ X, Y or Z encoding

Value (X, Y or Z)	u1Fixed15Number	s15Fixed16Number	float32Number
0,0	0000h	00000000h	**0,0**
1,0	8000h	00010000h	**1,0**
1,0 + (32 767,0 / 32 768,0)	FFFFh	0001FFFEh	1,999 969 482 421 875
NOTE 1,999 969 482 421 875 is 1,0 + 32 767,0 / 32 768,0 expressed as a float32Number.			

For the PCSLAB encodings, the PCSLAB L^* values have a different encoding than the PCSLAB a^* and PCSLAB b^* values. The PCSLAB L^* encoding is shown in Table 12.

Table 12 — PCSLAB L^* encoding

Value (PCSLAB L^*)	uInt8Number	uInt16Number	float32Number
0	00h	0000h	0,0
100,0	FFh	FFFFh	100,0

The PCSLAB a^* and PCSLAB b^* encoding is shown in Table 13.

Table 13 — PCSLAB a^* or PCSLAB b^* encoding

Value (PCSLAB a^* or PCSLAB b^*)	uInt8Number	uInt16Number	float32Number
–128,0	00h	0000h	–128,0
0	80h	8080h	0,0
127,0	FFh	FFFFh	127,0

NOTE 1 The integer encoding is not "two's complement" encoding, but a linear scaling after an offset of 128. This encoding was chosen to prevent discontinuities in CLUTs when going from negative to positive values.

NOTE 2 It is possible to convert between the 8-bit and 16-bit encodings by multiplying or dividing by 257. (See A.4.)

NOTE 3 Both the lut16Type and the namedColor2Type tag types (and *only* those tag types) use a legacy 16-bit encoding of PCSLAB L^*, PCSLAB a^* and PCSLAB b^* which is retained for backwards compatibility with an earlier profile version (version 2). To avoid confusion this encoding is specified in 10.8 "lut16Type".

6.3.4.3 PCS encodings for white and black

In transforms for the media-relative colorimetric, perceptual, and saturation rendering intents (all intents other than ICC-absolute colorimetric), the white point of the medium is represented in PCSXYZ and PCSLAB formats as shown in Table 14.

NOTE For the perceptual intent, the medium is the perceptual reference medium.

Table 14 — Encodings of PCS white point

Component	Value	8-bit encoding	16-bit encoding
PCSLAB L^*	100	FFh	FFFFh
PCSLAB a^*	0	80h	8080h
PCSLAB b^*	0	80h	8080h
PCSXYZ X	0,964 2	—	7B6Bh
PCSXYZ Y	1,000 0	—	8000h
PCSXYZ Z	0,824 9	—	6996h

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In transforms for all intents the perfect absorber (a theoretical medium that reflects absolutely no light) is represented in PCSXYZ and PCSLAB formats as shown in Table 15. Other reflectance values are mapped linearly to PCSXYZ.

Table 15 — Perfect absorber encodings

Component	Value	8-bit encoding	16-bit encoding
PCSLAB L^*	0,0	00h	0000h
PCSLAB a^*	0,0	80h	8080h
PCSLAB b^*	0,0	80h	8080h
PCSXYZ X	0,0	—	0000h
PCSXYZ Y	0,0	—	0000h
PCSXYZ Z	0,0	—	0000h

In transforms for the perceptual intent, the black point of the perceptual reference medium is defined in Table 16 in PCSLAB and PCSXYZ.

Table 16 — Encodings of the perceptual reference medium black point

Component	Value	8-bit encoding	16-bit encoding
PCSLAB L^*	3,137 3	08h	0808h
PCSLAB a^*	0,0	80h	8080h
PCSLAB b^*	0,0	80h	8080h
PCSXYZ X	0,003 357	—	006Eh
PCSXYZ Y	0,003 479	—	0072h
PCSXYZ Z	0,002 869	—	005Eh
NOTE Due to limited numerical precision, PCSXYZ Y might not exactly match PCSLAB L^*.			

6.4 Converting between PCSXYZ and PCSLAB encodings

Conversions between the PCSXYZ and PCSLAB encodings shall use the equations of the form specified in ISO 13655 with appropriate adjustments for the range.

When converting to integer-based encodings, any colours in the PCSXYZ encoding range that are outside of the PCSLAB encoding range shall be clipped on a per-component basis to the outside limits of the range of PCSLAB when transforming from PCSXYZ into PCSLAB. Conversely, any colours that occur in the PCSLAB encoding range that are outside of the encoding range of PCSXYZ shall be clipped on a per-component basis to the PCSXYZ range when transforming from PCSLAB into PCSXYZ.

When converting to float32Number-based encodings, conversion between PCSXYZ and PCSLAB is performed and encoded using the float32Number encoding of PCS values as defined in 6.3.4.2. No clipping is performed. In order to calculate PCSLAB values from negative PCSXYZ values, the straight line portion of the PCSLAB colour component transfer function below 0,008 856 shall be extended linearly below zero.

6.5 Device encoding

The specification of device value encoding is determined by the device. Normally, device values in the range of 0,0 to 1,0 are encoded using a 0 to 255 (FFh) range when using 8 bits and are encoded using a 0 to 65 535 (FFFFh) range when using 16 bits. When encoding using float32Number values in DToBx and BToDx tags, device values may be outside the 0,0 to 1,0 range.

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7 Profile requirements

7.1 General

7.1.1 An ICC profile shall include the following elements, in the order shown, as a single file:

a) a 128-byte profile header as defined in 7.2;

b) a profile tag table as defined in 7.3;

c) a profile tagged element data as defined in 7.4.

This is illustrated in Figure 6.

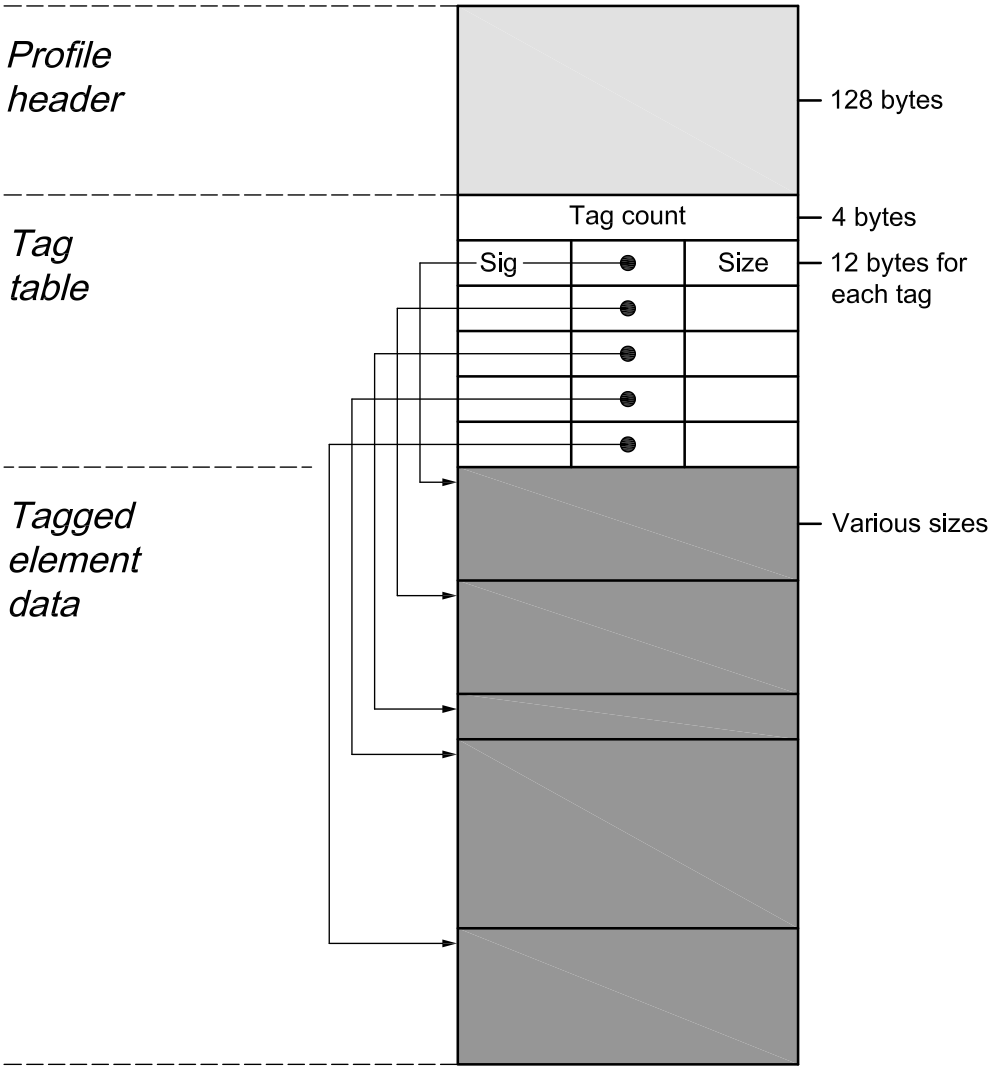

Figure 6 — Profile structure

7.1.2 The required tags for each profile type are tabulated in Clause 8. The definition of all publicly available tags and their signatures is contained in Clause 9 along with the permitted tag types for each tag. Tag types are defined in Clause 10.

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Within the profile structure:

a) all profile data shall be encoded as big-endian;

b) the first set of tagged element data shall immediately follow the tag table;

c) all tagged element data, including the last, shall be padded by no more than three following pad bytes to reach a 4-byte boundary;

d) all pad bytes shall be NULL (as defined in ISO/IEC 646, character 0/0).

NOTE 1 This implies that the length is required to be a multiple of four.

NOTE 2 The above restrictions result in two key benefits. First, the likelihood of two profiles which contain the same tag data, yet have different checksum values, is reduced. Second, all profiles are reduced to a minimum size.

7.2 Profile header

7.2.1 General requirements

The profile header provides the necessary information to allow a receiving system to properly search and sort ICC profiles. The profile header is 128 bytes in length and contains 18 fields. Table 17 gives the byte position, field length, and content of each element in the profile header. The encoding of the field contents shall be as defined in 7.2.2 to 7.2.19.

NOTE 1 Having a fixed length header allows for performance enhancements in profile searching and sorting applications.

NOTE 2 For ColorSpace and Abstract profiles (see 8.7 and 8.8) some of these fields are not relevant and can be set to zero.

Table 17 — Profile header fields

Byte position	Field length bytes	Field contents	Encoded as
0 to 3	4	Profile size	UInt32Number
4 to 7	4	Preferred CMM type	See 7.2.3
8 to 11	4	Profile version number	See 7.2.4
12 to 15	4	Profile/Device class	See 7.2.5
16 to 19	4	Colour space of data (possibly a derived space)	See 7.2.6
20 to 23	4	PCS	See 7.2.7
24 to 35	12	Date and time this profile was first created	dateTimeNumber
36 to 39	4	‘acsp’ (61637370h) profile file signature	See 7.2.9
40 to 43	4	Primary platform signature	See 7.2.10
44 to 47	4	Profile flags to indicate various options for the CMM such as distributed processing and caching options	See 7.2.11
48 to 51	4	Device manufacturer of the device for which this profile is created	See 7.2.12
52 to 55	4	Device model of the device for which this profile is created	See 7.2.13
56 to 63	8	Device attributes unique to the particular device setup such as media type	See 7.2.14
64 to 67	4	Rendering Intent	See 7.2.15
68 to 79	12	The nCIEXYZ values of the illuminant of the PCS	XYZNumber
80 to 83	4	Profile creator signature	See 7.2.17
84 to 99	16	Profile ID	See 7.2.18
100 to 127	28	Bytes reserved for future expansion and shall be set to zero (00h)	

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7.2.2 Profile size field (bytes 0 to 3)

The value in the profile size field shall be the exact size obtained by combining the profile header, the tag table, and the tagged element data, including the pad bytes for the last tag. It shall be encoded as a uInt32Number.

7.2.3 Preferred CMM type field (bytes 4 to 7)

This field may be used to identify the preferred CMM to be used. If used, it shall match a CMM type signature registered in the ICC registry (see Clause 5). If no preferred CMM is identified, this field shall be set to zero (00000000h).

7.2.4 Profile version field (bytes 8 to 11)

The profile version with which the profile is compliant shall be encoded as binary-coded decimal in the profile version field. The first byte (byte 8) shall identify the major version and byte 9 shall identify the minor version and bug fix version in each 4-bit half of the byte. Bytes 10 and 11 are reserved and shall be set to zero. The major and minor versions are set by the International Color Consortium. The profile version number consistent with this part of ISO 15076 is “4.3.0.0” (encoded as 04300000h).

NOTE A major version number change occurs only when changes made to the specification require that both CMMs and profile generating software be upgraded in order to correctly use or produce profiles conforming to the revised specification. A minor version number change will occur when profiles conforming to the revised specification can be processed by existing CMMs. For example, adding a required tag would require a major revision to the specification, whereas adding an optional tag would only require a minor revision.

7.2.5 Profile/device class field (bytes 12 to15)

This field shall contain one of the profile class signatures shown in Table 18.

There are three basic classes of device profiles, which are Input, Display and Output. In addition to the three basic device profile classes, four additional colour processing profiles are defined. These profiles provide a standard implementation for use by the CMM in general colour processing, or for the convenience of CMMs which may use these types to store calculated transforms. These four additional profile classes are DeviceLink, ColorSpace, Abstract and NamedColor.

Table 18 — Profile classes

Profile class	Signature	Hex encoding
Input device profile	‘scnr’	73636E72h
Display device profile	‘mntr’	6D6E7472h
Output device profile	‘prtr’	70727472h
DeviceLink profile	‘link’	6C696E6Bh
ColorSpace profile	‘spac’	73706163h
Abstract profile	‘abst’	61627374h
NamedColor profile	‘nmcl’	6E6D636Ch

7.2.6 Data colour space field (bytes 16 to 20)

This field shall contain the signature of the data colour space expected on the A side (device side) of the profile transforms. The names and signatures of the permitted data colour spaces are shown in Table 19. Signatures are left justified.

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Table 19 — Data colour space signatures

Colour space type	Signature	Hex encoding
nCIEXYZ or PCSXYZ[a]	'XYZ '	58595A20h
CIELAB or PCSLAB[b]	'Lab '	4C616220h
CIELUV	'Luv '	4C757620h
YCbCr	'YCbr'	59436272h
CIEYxy	'Yxy '	59787920h
RGB	'RGB '	52474220h
Gray	'GRAY'	47524159h
HSV	'HSV '	48535620h
HLS	'HLS '	484C5320h
CMYK	'CMYK'	434D594Bh
CMY	'CMY '	434D5920h
2 colour	'2CLR'	32434C52h
3 colour (other than those listed above)	'3CLR'	33434C52h
4 colour (other than CMYK)	'4CLR'	34434C52h
5 colour	'5CLR'	35434C52h
6 colour	'6CLR'	36434C52h
7 colour	'7CLR'	37434C52h
8 colour	'8CLR'	38434C52h
9 colour	'9CLR'	39434C52h
10 colour	'ACLR'	41434C52h
11 colour	'BCLR'	42434C52h
12 colour	'CCLR'	43434C52h
13 colour	'DCLR'	44434C52h
14 colour	'ECLR'	45434C52h
15 colour	'FCLR'	46434C52h

[a] The signature 'XYZ' refers to nCIEXYZ or PCSXYZ depending upon the context.

[b] The signature 'Lab' refers to CIELAB or PCSLAB depending upon the context.

7.2.7 PCS field (bytes 20 to 23)

For all profile classes (see Table 18), other than a DeviceLink profile, the PCS encoding shall be either PCSXYZ or PCSLAB and the signature shall be as defined in Table 19. When the profile/device class is a DeviceLink profile, the value of the PCS shall be the appropriate data colour space from Table 19. The field represents the colour space on the B side (PCS side) of the transform.

7.2.8 Date and time field (bytes 24 to 35)

This header field shall contain the date and time that the profile was first created, encoded as a dateTimeNumber.

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7.2.9 Profile file signature field (bytes 36 to 39)

The profile file signature field shall contain the value “acsp” (61637379h) as a profile file signature.

7.2.10 Primary platform field (bytes 40 to 43)

This field may be used to identify the primary platform/operating system framework for which the profile was created. The primary platforms that have been identified, and the signatures that shall be used are shown in Table 20. If there is no primary platform identified, this field shall be set to zero (00000000h).

Table 20 — Primary platforms

Primary platform	Signature	Hex encoding
Apple Computer, Inc.	‘APPL’	4150504Ch
Microsoft Corporation	‘MSFT’	4D534654h
Silicon Graphics, Inc.	‘SGI ’	53474920h
Sun Microsystems, Inc.	‘SUNW’	53554E57h

7.2.11 Profile flags field (bytes 44 to 47)

The profile flags field shall contain flags to indicate various hints for the CMM such as distributed processing and caching options. The least-significant 16 bits are reserved for the ICC. Flags in bit positions 0 and 1 shall be used as indicated in Table 21. Annex B describes embedding device profiles within EPS, TIFF, JFIF and GIF image files.

Table 21 — Profile flags

Bit position	Field length bits	Field contents
0	1	Embedded profile (0 if not embedded, 1 if embedded in file)
1	1	Profile cannot be used independently of the embedded colour data (set to 1 if true, 0 if false)

7.2.12 Device manufacturer field (bytes 48 to 51)

This field may be used to identify a device manufacturer. If used the signature shall match the signature contained in the appropriate section of the ICC signature registry found at www.color.org (see Clause 5). If not used this field shall be set to zero (00000000h).

7.2.13 Device model field (bytes 52 to 55)

This field may be used to identify a device model. If used the signature shall match the signature contained in the appropriate section of the ICC signature registry found at www.color.org (see Clause 5). If not used this field shall be set to zero (00000000h).

7.2.14 Device attributes field (bytes 56 to 63)

The device attributes field shall contain flags used to identify attributes unique to the particular device setup for which the profile is applicable. The least-significant 32 bits of this 64-bit value are defined by the ICC. Bit usage shall be used as shown in Table 22.

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Table 22 — Device attributes

Bit position	Field length bits	Attribute
0	1	Reflective (0) or transparency (1)
1	1	Glossy (0) or matte (1)
2	1	Media polarity, positive (0) or negative (1)
3	1	Colour media (0), black & white media (1)
4 to 31	28	Reserved (set to binary zero)
32 to 63	32	Use not defined by ICC (vendor specific)

NOTE Notice that bits 0, 1, 2, and 3 describe the media, not the device. For example, a profile for a colour scanner that has been loaded with black & white film will have bit 3 set on, regardless of the value in the data colour space field (see 7.2.6). If the media is not inherently "colour" or "black & white" (such as the paper in an inkjet printer), the reproduction takes on the property of the device. Thus, an inkjet printer loaded with a colour ink cartridge can be thought to have "colour" media.

7.2.15 Rendering intent field (bytes 64 to 67)

The rendering intent field shall specify the rendering intent which should be used (or, in the case of a DeviceLink profile, was used) when this profile is (was) combined with another profile. In a sequence of more than two profiles, it applies to the combination of this profile and the next profile in the sequence and not to the entire sequence. Typically, the user or application will set the rendering intent dynamically at runtime or embedding time. Therefore, this flag may not have any meaning until the profile is used in some context, e.g. in a DeviceLink or an embedded source profile.

The field is a uInt32Number in which the least-significant 16 bits shall be used to encode the rendering intent. The most significant 16 bits shall be set to zero (0000h).

The defined rendering intents are perceptual, media-relative colorimetric, saturation and ICC-absolute colorimetric. These shall be identified using the values shown in Table 23.

Table 23 — Rendering intents

Rendering intent	Value
Perceptual	0
Media-relative colorimetric	1
Saturation	2
ICC-absolute colorimetric	3

7.2.16 PCS illuminant field (Bytes 68 to 79)

The PCS illuminant field shall contain the nCIEXYZ values $X = 0{,}964\,2$, $Y = 1{,}0$ and $Z = 0{,}824\,9$ encoded as an XYZNumber. See Annex A for further details.

NOTE These values are the nCIEXYZ values of CIE illuminant D50

7.2.17 Profile creator field (bytes 80 to 83)

This field may be used to identify the creator of the profile. If used the signature should match the signature contained in the device manufacturer section of the ICC signature registry found at www.color.org. If not used this field shall be set to zero (00000000h).

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