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Image technology colour management — Extensions to architecture, profile format and data structure

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Gestion des couleurs dans les technologies de l'image — Extensions d'architecture, de format de profil et de structure de données

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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).

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This document was prepared by Technical Committee ISO/TC 130, *Graphic technology*, in cooperation with the International Color Consortium (ICC).

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 General

This document defines specifications that provide a platform for defining extended (iccMAX) colour management profiles and systems for various colour workflow domains. It can be thought of as an extension to ISO 15076-1, defined by the International Color Consortium® (ICC). ISO 15076-1 specifies a profile format that is intended to provide a cross-platform profile format for the creation and interpretation of colour data. Central to ISO 15076-1 is the encoding of colour transforms between device colour encodings and profile connection spaces (PCSs) based upon D50 colorimetry with the CIE 1931 Standard 2-degree observer. For many workflows ISO 15076-1 has proven adequate for defining successful colour management systems. For other workflows ISO 15076-1 has been found to be limited in the flexibility of encoding colour transforms as well as defining means of profile colour connection that incorporate physical attributes of colour in addition to mere colour appearance.

The intent of this document is to provide a platform on which domain-specific specifications can be defined that make use of these extensions to the existing cross-platform profile format of ISO 15076-1. Thus, there is greater flexibility for defining colour transforms and PCSs to meet needs that cannot easily be met with ISO 15076-1. As such, it is not envisioned that all colour management systems that use this document will implement all the features or capabilities specified by this document. Specific requirements related to what is necessary to be implemented and supported relative to this document can be found in workflow domain specifications. Additionally, for some domain-specific workflows it is envisioned that there will be the need for simultaneous support for and interaction between ISO 15076-1 and profiles defined by this document.

It is assumed that the reader of this document has a good understanding of ISO 15076-1 as well as 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.

The following subclauses introduce a few of the more significant differences from ISO 15076-1.

0.1 Extended profile connection spaces

0.1.1 ISO 15076-1 PCS encoding

In ISO 15076-1 PCS transform results are encoded relative to D50 with a 2-degree observer. If and when ISO 15076-1-based profiles are used in conjunction with this document, the PCS encoding specified in ISO 15076-1 are used with necessary conversions as needed.

0.1.2 Extended PCS encoding

PCS encoding is extended to allow PCS transform results to be relative to arbitrary illuminants and observers. Profile connection conditions (PCC) provided by either a profile or directly to the colour management module (CMM) can be applied to convert between different illuminants and observers. Additionally, a profile can define use of a spectrally-based PCS independent of the colorimetric-based PCS usage, with separate transform data between device encoding and the colorimetry and spectral PCS encodings.

0.2 Extended transform encoding

0.2.1 ISO 15076-1 transform encoding

ISO 15076-1 defines transforms using integer encoding in AToBx and BToAx tags. Floating point transform encoding can additionally be specified in optional DToBx and BToDx tags using multi-processing element tags.

Integer-based LUT tags have specific requirements for transform data and order.

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The multi-processing element tag type allows a sequence of transform elements to be applied in order to transform between device encoding and PCS encoding. The processing elements consist of matrices, one-dimensional curve sets and *n*-dimensional lookup tables.

0.2.2 iccMAX extended transform encoding

Spectrally-based PCS transforms are encoded using DToBx/BToDx tags when a spectral PCS is used. Colorimetric-based PCS transforms are encoded in matrix/TRC based profiles or AToBx/BToAx tags. Additionally, AToBx/BToAx tag transforms can be encoded using the multi-processing element tag type.

The multi-processing element tag type is extended to provide greater flexibility as well as encoding brevity in defining transforms. Extended elements include a stack-based programmable transform calculator, single-segment curves, N-D lookup tables with integer encoding, colour appearance model (CAM) conversions, sparse matrix processing and tint arrays.

Multi-processing element-based tags are used to define PCC within a profile. The CMM applies these tags as needed to perform PCS conversions.

0.2.3 Late-binding processing elements

The multi-processing element tag type has been extended to allow for processing elements that provide late-binding of the observer and/or illuminant from the PCC utilized by the profile. Either spectral information inside select processing elements is converted to colorimetric data shortly before processing of colour transforms is to be performed, or spectral to colorimetric transforms are established for processing of colour transformations. This late-binding of spectral to colorimetric processing is based on the PCC utilized by the multi-processing element. The media-white point and illuminant colorimetry used for absolute/relative PCS processing is also adjusted based upon the combined profile/PCC relationships when late-binding processing elements are used.

0.3 Colour encoding space profiles

0.3.1 General

In ISO 15076-1, profiles define transforms that go from device to PCS. However, in some workflows the essential requirement is a method of defining what the data are rather than providing a transform that converts the data into a representation of colour.

0.3.2 Colour space encoding

This document establishes a ColorEncodingSpace profile class to define profiles that can be used when the content owner wishes to identify the colour encoding of digital colour content and does not wish to provide a colour transformation to be used in converting or adapting the digital colour content from the identified current colour space encoding to any other colour space encoding.

0.4 Multiplex connection space profiles

0.4.1 General

Generally, the data encoding sides of profile transforms are not used to connect profiles using ISO 15076-1. Connection of data encoding channels is only meaningful when the number, order and encoding of the data encoding channels are identical. However, in some workflows, flexibility in the number and order of the channels is desirable with a meaningful way of identifying the encoding of the channels.

0.4.2 Multiplex connection space encoding

This document defines an additional profile connection mechanism that allows multiplex connection space (MCS) channels to be connected. MCS connection provides a means of defining flexible connection between “device like” channels of profiles that are identified by name. Order and existence of channels is flexible with the ability for a profile to specify subset requirements on the MCS channels in the connected profile and default values specified for missing channels. The input profile class

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has been extended to have an optional tag that connects to an MCS. Additionally, MultiplexLink and MultiplexVisualization profile classes have been defined for MCS processing.

0.5 Bidirectional reflection distribution function (BRDF) and directional emission profiles

0.5.1 General

ISO 15076-1 assumes 0:45 measurement geometry for reflection prints and diffuse radiance of displays. However, in many conditions colour appearance can change due to changes in lighting or viewing angle. Such goniochromatic effects cannot be encoded or communicated using ISO 15076-1.

0.5.2 Bidirectional reflection distribution function encoding

This document provides the ability to encode bidirectional reflection distribution function (BRDF) information, as well as example surface information, that 3D rendering systems can use to emulate goniochromatic effects. In this case the BRDF information is provided directly to the 3D rendering system without extensive colour management system involvement. Additionally, BRDF information can be used to define and communicate goniochromatic properties of named colours.

0.5.3 Directional emission function encoding

This document provides the ability to encode directional emission information which can be used to define and communicate goniochromatic properties of colours by viewing angle and relative position on a display.

0.6 Rendering intents

In ISO 15076-1 four rendering intents are defined: perceptual, media-relative colorimetry, ICC-absolute colorimetry and saturation. For the purposes of supporting spectrally-based PCSs, the media-relative colorimetry and ICC-absolute colorimetry intents are referred to in this document as media-relative and ICC-absolute intents which apply to both colorimetric as well as spectral conditions.

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Image technology colour management — Extensions to architecture, profile format and data structure

1 Scope

This document is based on ISO 15076-1, and describes an expanded profile specification and profile connections that permit greater flexibility and functionality than ISO 15076-1. All definitions and requirements in ISO 15076-1 are therefore in force unless otherwise specified by this document. This document defines minimum structural and operational requirements for writing and reading ICC profiles. Additional workflow requirements and restrictions are defined in domain-specific interoperability conformance specification (ICS) documents approved and registered by the ICC.

In this document, some ISO 15076-1 types have been removed, and others have been added. A colour management module (CMM) compatible with profiles conforming to this document will have backwards compatibility with profiles conforming to ISO 15076-1.

Where the name of a type in this document is the same as a type in ISO 15076-1, the type definition is based on the ISO 15076-1 definition. The exception is the definition of the MPE type, which has been expanded.

Where the extensions described in this document are not required in a particular workflow, ISO 15076-1 is used as the basis for colour management profiles and architectures.

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

ISO 17972-1, *Graphic technology — Colour data exchange format — Part 1: Relationship to CxF3 (CxF/X)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

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

3.1.1
profile connection conditions
PCC
information used to define illuminant, observer for PCS along with transforms to convert to and from custom colorimetry and standard D50 colorimetry for the standard 2° observer

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3.1.2
profile connection space
PCS
colour space used to connect the source and destination profiles

Note 1 to entry: See ISO 15076-1:2010, Annex D for a full description.

3.2 Abbreviated terms

ANSI	American National Standards Institute
BRDF	bidirectional reflectance distribution function
CAM	colour appearance model
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)
CRD	colour rendering dictionary
CRT	cathode-ray tube
EPS	encapsulated postscript
ICC	International Color Consortium
ICS	interoperability conformance specification
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LCD	liquid crystal display
LUT	lookup table
MCS	multiplex connection space
PCC	profile connection conditions
PCS	profile connection space
RGB	red, green, blue
TIFF	tagged image file format
TRC	tone reproduction curve

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4 Extended basic types

4.1 General

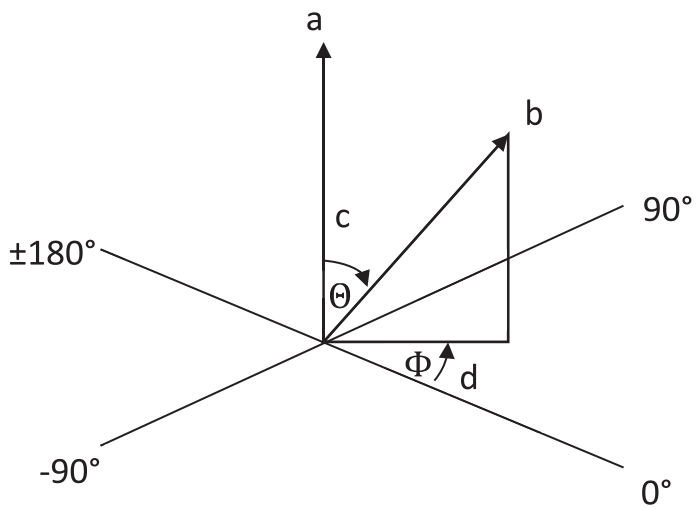
This document assumes the inclusion of all basic types listed in ISO 15076-1, with the exception of 7-bit ASCII. Only extended types in this document are listed below.

4.2 Extended basic type listing

4.2.1 azimuthNumber

An azimuthNumber corresponds to an azimuth angle for BRDF and directional transformations. It shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the BRDF function tags (brdfAToB0Tag, brdfAToB1Tag, brdfAToB2Tag, brdfAToB3Tag, brdfBToA0Tag, brdfBToA1Tag, brdfBToA2Tag, brdfBToA3Tag, brdfBToD0Tag, brdfBToD1Tag, brdfBToD2Tag, brdfBToD3Tag, brdfDToB0Tag, brdfDToB1Tag, brdfDToB2Tag, brdfDToB3Tag, directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The azimuthNumber encoding range shall be from 0,0 to 1,0, with 0,0 representing −180,0 degrees and 1,0 representing +180,0 degrees. Figure 1 shows the azimuth angle in relation to the normal and zenith angles.



Key

a surface normal

b lighting/viewer

c zenith angle

d azimuth angle

Figure 1 — Normal, zenith and azimuth angles

4.2.2 float16Number

A float16Number shall be a half-precision 16-bit floating-point number as specified in IEEE 754, excluding infinities and “not a number” (NaN) values.

NOTE 1 A 16-bit IEEE 754 floating-point number has a 5-bit exponent and a 10-bit mantissa.

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

4.2.3 float64Number

A float64Number shall be a double-precision 64-bit floating-point number as specified in IEEE 754, excluding infinities, and "not a number" (NaN) values.

NOTE 1 A 64-bit IEEE 754 floating-point number has an 11-bit exponent and a 52-bit mantissa.

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

4.2.4 horizontalNumber

A horizontalNumber corresponds to the horizontal relative position of a viewing field for directional transformations. It shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the directional function tags (directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The horizontalNumber encoding range shall be from −1,0 to 1,0 with −1,0 representing the leftmost position, 0,0 representing the center and 1,0 representing the rightmost position.

4.2.5 Sparse matrix encodings

4.2.5.1 General

Sparse matrices shall be encoded using compressed row order, which facilitates efficient multiplication of column vectors as well as the interpolation between sparse matrices. A sparse matrix shall be encoded as a variable structure with internal padding within a fixed size data block. The use of a fixed data block size allows for the efficient indexing of arrays of sparse matrices.

In addition to encoding the number of rows, number of columns and number of matrix data entries, the compressed row order encoding shall include three sub-arrays: a padded array of matrix entry data values, a padded array of matrix entry column identifiers, and an array of offsets to successive rows stored in the matrix data and column index arrays.

Successive offset values in the row start offset array shall be greater than or equal to preceding values. The number of matrix data entries associated with a row can therefore be found by subtracting the offset of the row by the offset of the succeeding row.

Successive matrix entry column index values associated with any single row shall be monotonically increasing.

Information about operations with sparse matrices can be found in Annex E.

Multiple sparse matrix encodings are permitted, but shall differ in the encoding of the matrix entry data values as follows:

— The sparseMatrixUInt8 encoding shall use uInt8Numbers to encode matrix data values (Table 1). The internal representation of the values 0 to 255 shall represent matrix values 0,0 to 1,0.

— The sparseMatrixUInt16 encoding shall use uInt16Numbers to encode matrix data values (Table 2). The internal representation of the values 0 to 65 535 shall represent matrix values 0,0 to 1,0.

— The sparseMatrixFloat16 encoding shall use float16Numbers to encode matrix values (Table 3).

— The sparseMatrixFloat32 encoding shall use float32Numbers to encode matrix values (Table 4).

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Table 1 — sparseMatrixUInt8 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number of matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column index array	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N-1	N	Matrix entry data array	uInt8Number[N]
O+N...end		Data padding, shall be 0	

Table 2 — sparseMatrixUInt16 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns(C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*2-1	N*2	Matrix entry data values	uInt16Number[N]
O+N*2...end		Data padding, shall be 0	

Table 3 — sparseMatrixFloat16 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*2-1	N*2	Matrix entry data values	float16Number[N]
O+N*2...end		Data padding, shall be 0	

Table 4 — sparseMatrixFloat32 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number

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Table 4 *(continued)*

Byte position	Field length (bytes)	Content	Encoded as...
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*4-1	N*4	Matrix entry data values	float32Number[N]
O+N*4...end		Data padding, shall be 0	

4.2.5.2 Compact padding

When sparse matrices are encoded in a profile they shall be compacted so that the index and data padding result in the matrix entry data values and the end of the sparse matrix being aligned on a 4 byte boundary.

NOTE Compact padding can result in variability in the size of individual sparse matrices in a sparse matrix array or sparse matrix LUT.

4.2.5.3 Fixed block size padding

When a colour space uses sparse matrix encoding it is useful for the internal encoding to use a fixed block size determined by the number of samples associated with the colour space.

NOTE One method of internally encoding Sparse Matrices within a CMM adjusts the index and data padding to allow the number of matrix entries to vary without the size of the encoded data block size changing. The block size therefore determines a fixed upper limit to the number of entries that can be encoded.

When fixed block size padding is used, the maximum number of matrix entries (M) that can be encoded for each of the sparse matrix encodings is determined by the fixed data block size (B) used to store the sparse matrix, the number of rows (R) and the byte size (S) of a matrix entry data value as shown in Formula (1):

$$M = \text{floor}\ ((B - 8 - 2*R - (S - 1)]/(S + 2)) \quad (1)$$

When fixed block size padding is used for each of the sparse matrix encodings in Table 1 to Table 4 the offset of the matrix entry data array (O) is determined by the number of rows (R) and the maximum number of matrix entries (M), as well as the byte size (S) of a matrix entry data value as shown in Formula (2):

$$O = \text{floor}\ ((8 + 2*R + 2*M + (\mathrm{S} - 1))/\mathrm{S})\ *\mathrm{S} \quad (2)$$

4.2.6 sparseMatrixEncodingType

When encoding sparse matrices the exact data encoding type used shall be specified using a sparseMatrixEncodingType parameter. Where used, values for a sparseMatrixEncodingType parameter shall be encoded as defined in Table 5.

Table 5 — sparseMatrixEncodingType selection of sparse matrix encoding in SparseMatrixLut

sparseMatrixEncodingType	Sparse matrix encoding
1	sparsematrixUInt8
2	sparseMatrixUInt16
3	sparseMatrixFloat16
4	sparseMatrixFloat32

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4.2.7 spectralRange

The spectralRange data type shall be used to specify spectral ranges. This data type shall be made up of two float16Number values and a uInt16Number value that define the starting wavelength, ending wavelength and total number of steps in the range. The encoding of a spectralRange data type is shown in Table 6.

Table 6 — spectralRange encoding

Byte position	Field length (bytes)	Field contents	Encoded as...
0 to 1	2	Start wavelength	float16Number
2 to 3	2	End wavelength	float16Number
4 to 5	2	Steps in wavelength range	uInt16Number

4.2.8 tintArray

A tintArray defines the relationship between a single input value (tint) and multiple output values. A tintArray is used by both the multi processing element tintArrayElement (11.2.14) as well as the namedColorStructure (12.2.5). Any of the numeric array types (e.g. uInt8ArrayType) are permitted in a tintArray. The relationship between N tints (each made up of M samples per tint) in a tintArray is depicted in Table 7.

Table 7 — tintArray sample index assignments

Tint index	Sample 1	Sample 2	...	Sample M-1	Sample M
0	0	1	...	M-2	M-1
1	M	M+1	...	2M-2	2M-1
...	...	...	...	...	...
N-2	(N-2)M	(N-2)M+1	...	(N-1)M-2	(N-1)M-1
N-1	(N-1)M	(N-1)M+1	...	NM-2	NM-1

A tint array shall have N × M entries in the array.

NOTE Assignment of tint values ranging from 0,0 to 1,0 to tint indices can vary and is specific to the use case in which a tint array is used.

4.2.9 valueEncodingType

When encoding values in sampled curves and colour lookup tables (CLUTs) the exact data encoding type used shall be specified using a valueEncodingType parameter. Values for a valueEncodingType parameter shall be as defined in Table 8. Encoded values for the float32Number and float16Number types shall represent the actual encoding number. Encoded values for the uInt16Number and uInt8Number types shall represent an encoding between the range of 0,0 to 1,0.

Table 8 — valueEncodingType values

valueType	value Encoding
0	float32Number
1	float16Number
2	uInt16Number
3	uInt8Number

Values for a valueEncodingType may be encoded as either a uInt16Number or a uInt32Number.

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4.2.10 verticalNumber

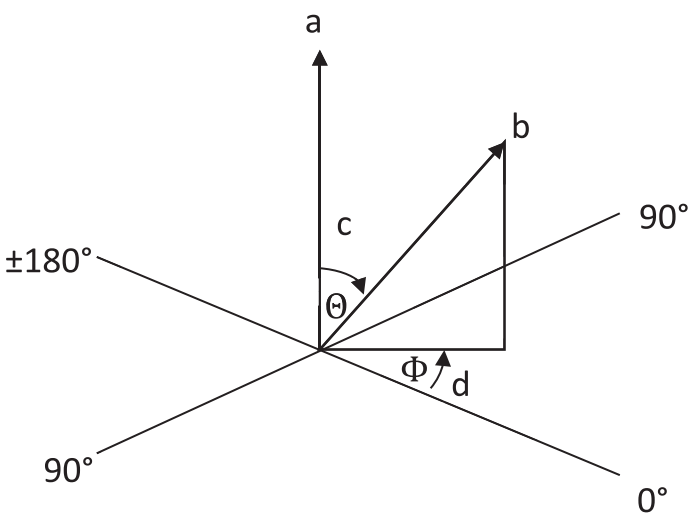
A verticalNumber corresponds to the vertical relative position of a viewing field for directional transformations. For example, the viewing field of a display represents the physical limits of the display. A verticalNumber shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the directional function tags (directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The verticalNumber encoding range shall be from −1,0 to 1,0 with −1,0 representing the topmost position, 0,0 representing the center and 1,0 representing the bottommost position.

4.2.11 zenithNumber

A zenithNumber can be used to specify to a zenith angle θ for BRDF and directional transformations or to define geometry of measurement. It shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the BRDF function tags (brdfAToB0Tag, brdfAToB1Tag, brdfAToB2Tag, brdfAToB3Tag, brdfBToA0Tag, brdfBToA1Tag, brdfBToA2Tag, brdfBToA3Tag, brdfBToD0Tag, brdfBToD1Tag, brdfBToD2Tag, brdfBToD3Tag, brdfDToB0Tag, brdfDToB1Tag, brdfDToB2Tag, brdfDToB3Tag, directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionaDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The zenithNumber encoding range shall be from 0,0 to 1,0, with 0,0 representing 0,0 degrees and 1,0 representing 90,0 degrees. Figure 2 shows the zenith angle in relation to the normal and azimuth angles.



Key

a surface normal

b lighting/viewer

c zenith angle

d azimuth angle

Figure 2 — Normal, zenith and azimuth angles

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5 Conformance

Any colour management system, application, utility or device driver that claims full conformance with this document shall have the ability to read the profiles as they are defined in this document, including all specified tags and types. Any profile-generating software and/or hardware that claims full conformance with this document shall have the ability to create profiles as they are defined in this document, including all specified tags and types.

In addition, software or hardware may claim partial conformance with this document by reading and/or creating profiles that contain a subset of the tags and types listed in a separate domain-specific ICS approved and registered by the ICC.

Software conforming to this document shall use the ICC profiles generated in accordance with this document, or with an approved ICS.

Unambiguous operation of profiles in workflow scenarios identified in an ICS is provided by the use of CMM processing control options. For more information about workflow scenarios and CMM processing options see Annex K.

A colour management system, profile-generating software and/or hardware application, utility or device driver that claims full or partial conformance with this document shall also conform with all definitions and requirements in ISO 15076-1 unless otherwise specified by this document, and shall register all signatures for CMM type, device manufacturer, device model, profile tags and profile tag types with the ICC to ensure that all profile data are uniquely defined. Domain-specific specification documents (ICSs) shall also be registered. The registration authority for all of these is the ICC Technical Secretary.

NOTE See the ICC website (http://www.color.org) for contact information.

6 Expanded PCSs, rendering intents and device encoding

6.1 General considerations

This document describes extensions to profiles and their connections that permit a greater flexibility and functionality than ISO 15076-1. Where such extensions are not needed in a particular workflow, users should continue to use ISO 15076-1 as the basis for colour management profiles and architectures.

6.2 Extensions to device colour encoding

The number of channels associated with a colour space is determined from the colour space signature. Extensions that allow for processing elements to utilize up to 65 535 channels require uniquely defined colour space signatures associated with up to 65 535 channels. This is accomplished by extending the signature definition to use the binary representation of the actual number of channels within the 32-bit signature. The 16 most significant bits (corresponding to textual digits) shall match an extended colour space type (signature identifier), and the 16 least significant bits shall define a binary representation of the number of channels (signature channels). This results in a colour space signature containing 32 bits that cannot be represented as four text characters.

A six-character text string shall be used for cases when a textual representation of these extended colour space signatures is desired with the first two characters corresponding to the signature identifier and the last four digits corresponding to a hexadecimal representation of the signature channels. (Thus: “nc0014” corresponds to the 32-bit hexadecimal extended colour space signature encoding (6e630014h) used in the profile which represents N-channel data with twenty device channels.) Having a six-character text representation of an extended colour space signature is for convenience purposes only for describing the signature value (as colour signatures are only encoded as binary 32-bit values within profiles). Extended N channel device data colour space signature encoding is provided in Table 9.

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Table 9 — Extended data colour space signatures

Spectral colour space type	Signature identifier	Signature channels	Combined hex encoding	Signature representation
N channel device data	'nc' (6e63h)	1 … 65 535 (0001h … FFFFh)	6e630001h … 6e63FFFFh	"nc0001" … "ncFFFF"
None (PCS defined by PCS header field)	0	0	00000000h	0

6.3 Extensions to PCSs

6.3.1 General

ISO 15076-1 defines PCSs in terms of D50 colorimetry with the CIE 1931 standard 2-degree observer. The resulting transform data are therefore encoded relative to this illuminant and observer. Use of the chromatic adaptation tag in ISO 15076-1 provides a means of converting encoded PCS transform results for the media white point to and from actual illuminant/observer colorimetry. A CMM that is in conformance with this document shall always provide transforms to and from D50/2-degree colorimetry that can be used when connecting profiles. Such transforms shall make use of the profile connection condition tags defined in this document rather than the chromatic adaptation tag defined in ISO 15076-1. This document extends profile connection to allow direct encoding of colour data in transforms with arbitrary illuminants and observers. This results in the CMM performing conversions between PCS observer and illuminant colorimetry as needed using profile connection conditions (PCC). The PCC defines information about the observer and illuminant as well as transforms between custom observer/illuminant conditions and the standard D50/2-degree observer colorimetry. Where PCC are used to connect profiles, the CMM shall either use the PCC from within a profile or a PCC provided by the CMM. Profiles based on colorimetry using an illuminant other than CIE D50 or a colorimetric observer other than the CIE 1931 standard observer (known as the 2-degree observer) shall encode profile connection condition tags (see 6.3.2).

Additional PCSs can be specified that are based upon spectral representation of colour rather than colorimetry. A spectral PCS use is defined and encoded separately from colorimetric PCS use within a profile. Therefore both colorimetric and spectral PCS transforms can simultaneously exist in a profile. Profile connection condition tags shall also be encoded within a profile whenever a spectral PCS is used within a profile.

Additional tags can be provided in a profile that can define surface characteristics such as gloss, with relationships between lighting and viewing angle defined. These tags provide an additional connection interface separate from the PCS. These BRDF transforms provide information for three-dimensional rendering systems that are capable of rendering light interactions based upon the surface characteristics. The measurement angle tag also allows the profile generator to identify the measurement geometry used to generate the PCS data in the profile.

Lastly, a multiplex-based connection method is introduced that allows profiles to be connected using named multiplex channels. This can be considered as an extension of device-channel-based connection with flexibility and channel matching rules.

6.3.2 Profile connection conditions

The standard PCS shall be defined to use the 2-degree observer under D50 illumination. Whenever either a non-standard PCS or a spectral PCS is used, three tags shall be encoded in a profile and shall be used to define default PCC for a profile. In cases of spectral PCS use or late-binding colorimetric processing elements, a CMM may optionally be provided or use external PCC, thus overriding the defaults provided by the profile.

The spectralViewingConditions tag shall define the spectral power distribution of the illuminant, colour matching functions (CMFs) of the observer and the lighting levels of the surround. If the

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spectralViewingConditions are different from the standard PCS viewing conditions then two tags are used to convert between custom and standard connection conditions (see 9.2.105).

The customToStandardPCC tag shall define a transform that converts from the custom viewing condition colorimetry to standard viewing condition colorimetry (see 9.2.56).

The standardToCustomPCC tag shall define a transform that converts from standard viewing condition colorimetry to the custom viewing condition (see 9.2.107).

Apart from the spectral tables, all other tables, both forward and inverse, shall convert colours between the colour space of the PCS and coding values of the colour reproduction device, taking into account the reference and actual viewing conditions.

6.3.3 Spectral PCSs

6.3.3.1 General

This document allows for a spectrally-based PCS to be defined for DToBx/BToDx tags using a spectralPCS signature field in the profile header. The use of DToBx/BToDx tags for colorimetric processing has been deprecated in this document. Additional header fields are also added to allow specification of spectral information used by the profile.

A distinction is made between self-emitting colours and non self-emitting colours, here referred to as luminous colours and object colours. Luminous colours are characterized by their emission spectra, whereas for object colours reflectance or transmission spectra are used. These three types of spectra are referred to as object characterization spectra.

Reflectance spectra are specified in relation to the perfect reflector whereas transmission spectra are related to a perfect transmitter. Therefore, both types of spectra can be seen as relative data. For emission spectra, Y tristimulus values correspond to luminance values, and hence these are regarded as absolute data.

Different types of spectral data can be defined. In normal circumstances, only reflectance, transmission or emission spectra are used but in other circumstances additional data shall be provided according to the processing to be carried out. To represent bi-spectral data, a Donaldson matrix is used and is specified by bi-spectral data fields in the header.

6.3.3.2 Encoding spectral data

To define the use of a spectrally-based PCS, one of the spectral colour space signatures in Table 10 shall be used to encode the colour space implied by the spectralPCS field of the profile header. These colour space signatures define both the colour space type and the number of channels associated with the colour space. Therefore, the number of signature channels associated with the spectralPCS colour space signature shall match the number of channels indicated by the steps field(s) of the corresponding spectralRange structures in the profile header.

Table 10 — Spectral colour space signatures

Spectral colour space type	Signature identifier	Signature channels	Combined hex encoding	Signature representation
None (PCS defined by PCS header field)	0	0	00000000h	0
Reflectance spectra with N channels	'rs' (7273h)	1 … 65 535 (0001h … FFFFh)	72730001h … 7273FFFFh	"rs0001" … "rs-FFFF"
Transmission spectra with N channels	'ts' (7473h)	1 … 65 535 (0001h … FFFFh)	74730001h … 7473FFFFh	"ts0001" … "tsFFFF"

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Table 10 *(continued)*

Spectral colour space type	Signature identifier	Signature channels	Combined hex encoding	Signature representation
Radiant (emission) spectra with N channels	'es' (6573h)	1 … 65 535 (0001h … FFFFh)	65730001h … 6573FFFFh	"es0001" … "esFFFF"
Bi-spectral reflectance spectra with N total channels	'bs' (6273h)	1 to 65 535 (0001h … FFFFh)	62730001h … 6273FFFFh	"bs0001" … "bsFFFF"
Bi-spectral reflectance using sparse matrix with N equivalent output channels	'sm' (736d)	1 to 65 535 (0001h … FFFFh)	736D0001h … 736DFFFFh	"sm0001" … "smFFFF"

NOTE Spectral colour space signatures use the same 32-bit binary encoding mechanism as N colour device data signatures (see 6.2.1), with each having a six-character signature representation.

Spectra are normally represented according to their canonical basis, i.e. the spectrum is sampled uniformly along the wavelength axis. The wavelength range is represented by a start wavelength (S), end wavelength (E) and number of steps (n). The wavelength interval between steps (I) is then given by Formula (3).

$$I = (E - S)/(n - 1) \tag{3}$$

6.3.3.3 Spectral consistency of tags in profiles

Apart from measurement files embedded in profiles, spectral data in all other tags are assumed to be sampled at uniform intervals, with a given start, end wavelength and number of steps. The dimensions and range of the spectra in the different tags have to be defined consistently. For normal spectra, it means that the spectral dimension of object characterization spectra have to be the same. If the object characterization spectra are defined by the Donaldson matrix, the Donaldson matrix has to be an nXm matrix with m defined internally in the corresponding colour table. For multiple spectra, suppose k, the object characterization spectra are a column vector with length kXn in the colour tables, but after processing also n dimensional spectra are obtained.

The spectral type of the object characterization spectra is defined in the profile header.

Tags containing measurement files are seen as separate entities and hence the previous conditions do not have to be fulfilled.

6.3.3.4 Spectral fluorescence connection spaces

The characterization of the interaction of light with a diffuse surface can be accomplished using a Donaldson matrix. The multiplication of such a matrix by a vector representing the illumination results in a vector representing the light reflected off the surface. Columns of a Donaldson matrix correspond to incident wavelengths of light and rows of a Donaldson matrix correspond to reflected wavelengths of light. Diagonal entries (where incident and reflected wavelengths are the same) correspond to spectral reflectance. Off diagonal entries (below the diagonal) represent the contribution of a change in the reflected light's wavelength (typically due to fluorescence). Fluorescence occurs when light is absorbed and then re-emitted at a longer wavelength. Using Donaldson matrices to represent colours in an ICC profile allows for a more complete description of colour to be encoded than using only spectral reflectance or simple colorimetry. Examples of various spectral calculations can be found in Annex A.

However, directly encoding a Donaldson matrix in a profile can be inefficient. For example, if 41 wavelengths are used to represent an illuminant (300 nm to 700 nm with a 10 nm interval) and 31 wavelengths are used to represent the reflected light (400 nm to 700 nm with a 10 nm interval) then a corresponding Donaldson matrix encodes 31 × 41 = 1 271 entries. However, most of the off diagonal

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entries are zero with the only entries with non-zero data for fluorescent terms. By using a sparse matrix encoding (which only encodes non-zero entries of a matrix), large profile files can be avoided while simultaneously reducing processing overhead because fewer computations need to be performed. This results in a compression of information and requires that interpolation and application of the matrices be carried out correctly.

When using Donaldson matrices to represent colour values in a colour LUT, intermediate matrices shall be determined (using interpolation) to establish the intermediate "colour". However, since a Donaldson matrix is associated with a single combination of device code values, interpolation between matrices associated with different device code values needs to be performed to estimate a Donaldson matrix for intermediate device code values.

The use of a single sparse matrix LUT encoding can be used in two contexts. The first is in a tag containing a single dimensional array of sparse matrices representing different tint values of a single colour (used by NamedColors). The second is a multi-dimensional table of sparse matrices in the context of a multi-process element which is useful for characterizing a device using Donaldson matrices for each possible input combination.

Normally colour lookup tables (CLUTs) define multiple output samples for each input coordinate in lookup table. A sparse matrix expands the meaning of the output colour samples being passed around in a CMM. When sparse matrices are implied by a colour space the array of colour samples should instead be interpreted as using a sparse matrix encoding. The number of samples defined in a sparse matrix colour space establishes the upper limit to the number of matrix entries that can be encoded. A compressed row order encoding of sparse matrices is utilized. This encoding format allows for efficient interpolation of matrices as well as efficient multiplication of vectors by sparse matrices.

6.3.4 BRDF connection

None of the transforms defined by ISO 15076-1 support BRDF as an input to a transform. It is possible for a CMM to transform BRDF values to connection space values that are needed.

Extended information about using BRDF with tags encoded in profiles defined by this document can be found in Annex G.

6.3.5 Directional viewing connection

None of the transforms defined by ISO 15076-1 support directional or positional information as input to a transform. It is possible for a CMM to transform both directional angles and relative positional information to determine connection space values that are needed in order to compute device values. Reverse transforms are also possible to determine device values that achieve connection space values.

Extended information about using directional tags encoded in profiles defined by this document can be found in Annex H.

6.4 Multiplex connection spaces

6.4.1 General

This document allows for a connection space defined by multiplex channel identification for AToM0/MToA0/MToB0/MToS0 tags using a multiplex connection space (MCS) signature field in the profile header. If this field is zero, then multiplex connection is not defined.

MCS connection is performed by passing values for multiplex channels between profiles that have identical multiplex channel type values (defined in the multiplexTypeArrayTag of both profiles). The MCS subset requirements shall be met before profiles can be linked (see 7.2.13). Once these requirements are met the channels with a multiplex channel type in the source profile that are not in the destination profile are ignored, and channels with multiplex channel types in the destination profile that are not in the source profile are processed with the multiplex channel value defined for

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the channel in the multiplexDefaultValuesTag or zero if this tag is not present. Figures 3 and 4 show examples of MCS profile connection.

Figure 3 — Workflow connecting a MultiplexIdentification (MID)/input profile, a MultiplexVisualization (MVIS) profile and an output profile

Figure 4 — Workflow connecting a MultiplexIdentification (MID)/input profile with a MultiplexLink (MLNK) profile

Examples of MCS workflows and connection scenarios can be found in Annex I.

6.4.2 MCS signature encoding

To define the use of MCS connection with multiplex channel identification the signatures in Table 11 shall be used to encode the MCS field of the profile header. These colour space signatures define both the colour space type and the number of channels associated with the colour space.

Table 11 — Multiplex colour space signatures

Multiplex colour space type	Signature identifier	Signature channels	Combined hex encoding	Signature representation
None (no MCS is used)	0	0	0	0
Multiplex channel values with N channels	'mc' (6d63h)	1 … 65 535 (0001h … FFFFh)	6d630001h … 6d63FFFFh	"mc0001" … "mcFFFF"

NOTE Multiplex colour space signatures use the same 32-bit binary encoding mechanism as N colour device data signatures (see 6.2.1), with each having a six-character signature representation.

6.5 Colour encoding space profiles

This document provides a means of defining a colour encoding relative to a named reference encoding. Therefore it defines what the data are (not how they are transformed). The reference shall be a registered colour encoding in the ICC three-component colour encoding registry.

Because the transform is not defined by the profile, the CMM is responsible for determining what transform to use.

The intent of ColorEncodingSpace profiles is to allow for profile files that have a minimum data structure that can be embedded in images with clear, concise and non-redundant (canonical) information relative to a "named" reference provided to the CMM for determining the actual transforms to apply.

Minimally, a ColorEncodingSpace profile shall have a header, a tag directory and a referenceNameTag (see 9.2.103) which defines the named reference encoding associated with the colour encoding space.

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Various modes of operation are defined for ColorEncodingSpace profiles in 8.7. Brief guidelines for transform determination by the CMM can be found in Annex J.

NOTE It is envisioned that the set of required and optional named colour encoding spaces will be defined by ICSs external to this document.

7 Profile requirements

7.1 General

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) profile tagged element data as defined in 7.4.

This is illustrated in Figure 5.

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. Extended ICC profiles may support tags defined as using either the multiProcessElementsType or the tagStructType. Multiple processing elements are defined in Clause 11. Tag structure types are defined in Clause 12. Tag array types are defined in Clause 13.

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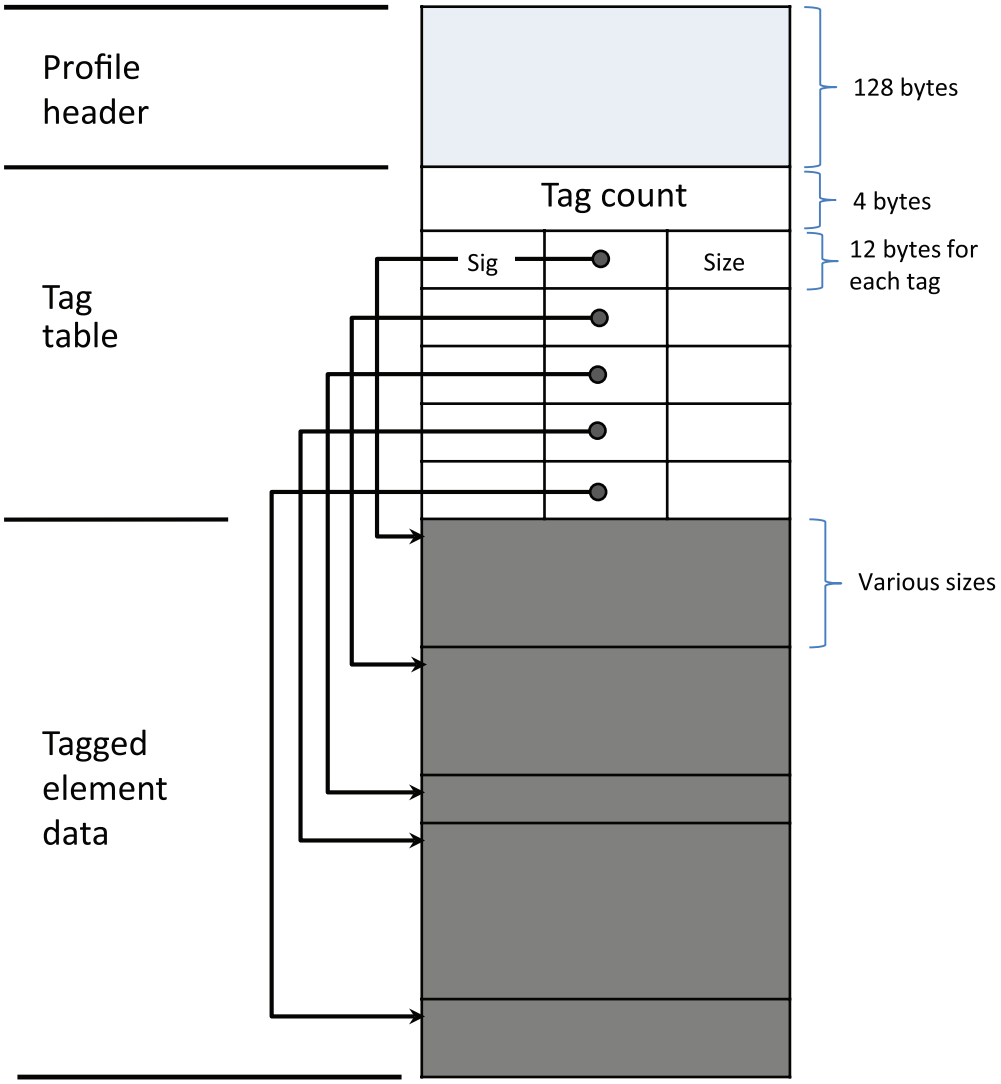

Figure 5 — Profile structure

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 (ISO 646, character 0/0).

NOTE 1 This implies that the length of the file is 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.

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7.2 Profile header

7.2.1 General

ISO 15076-1 defines a single header specification for defining ICC profiles. ISO 20677 extends the use of the ICC header in two ways. For spectral PCS support additional entries have been defined. For ColorEncodingSpace profile device class profiles a minimal subset of header field entries is defined.

7.2.2 Extended profile header field definitions

The encoding of the profile header with spectral PCS support shall be as shown in Table 12.

Table 12 — Profile header fields

Byte position	Field length (bytes)	Field contents	Encoded as...
0 to 3	4	Profile size	uInt32Number; See 7.2.4
4 to 7	4	Preferred CMM type	4-byte signature; see 7.2.5
8 to 11	4	Profile version and sub-version number	uInt32Number; see 7.2.6
12 to 15	4	Profile/device class	4-byte signature; see 7.2.7
16 to 19	4	Colour space of data (possibly a derived space)	4-byte signature; see 7.2.8
20 to 23	4	PCS	4-byte signature; see 7.2.9
24 to 35	12	Date and time this profile was first created	dateTimeNumber; see 7.2.10
36 to 39	4	'acsp' (61637370h) profile file signature	4-byte signature; see 7.2.11
40 to 43	4	Primary platform signature	4-byte signature; see 7.2.12
44 to 47	4	Profile flags to indicate various options for the CMM such as distributed processing and caching options	uInt32Number; see 7.2.13
48 to 51	4	Device manufacturer of the device for which this profile is created	4-byte signature; see 7.2.14
52 to 55	4	Device model of the device for which this profile is created	4-byte signature; see 7.2.15
56 to 63	8	Device attributes unique to the particular device setup such as media type	uInt64Number see 7.2.16
64 to 67	4	Rendering Intent	uInt32Number; see 7.2.17
68 to 79	12	The nCIEXYZ values of the PCS illuminant, computed with the PCS observer	XYZNumber; see 7.2.18
80 to 83	4	Profile creator signature	4-byte signature; see 7.2.19
84 to 99	16	Profile ID	uInt64Number[2]; see 7.2.20
100 to 103	4	Spectral PCS	4-byte signature; see 7.2.21
104 to 109	6	Spectral PCS wavelength range	spectralRange; See 7.2.22

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Table 12 *(continued)*

Byte position	Field length (bytes)	Field contents	Encoded as...
110 to 115	6	Bi-spectral PCS wavelength range	spectralRange; see 7.2.23
116 to 119	4	MCS signature	uInt32Number; see 7.2.24
120 to 123	4	Profile/device sub-class	4-byte signature; see 7.2.25
124 to 127	4	Reserved bytes shall be zero (00h)	uInt32Number; see 7.2.26

A spectral-only profile shall be defined by setting the PCS header field to zero, setting the spectral PCS field to the desired spectral colour space, and only providing spectral DToBx and BToDx tables in the profile.

7.2.3 ColourEncodingSpace class profile header field definitions

A ColourEncodingSpace class profile shall use only the ICC header fields defined in Table 13 with the other fields either set according to ISO 15076-1 or optionally zero filled.

Table 13 — ColourEncodingSpace profile header fields

Byte position	Field length bytes	Field contents	Encoded as...
0 to 3	4	Profile size	uInt32Number
4 to 7	4	Reserved bytes shall be zero (00h)	
8 to 11	4	Profile version number	5,0 or higher
12 to 15	4	'cenc' (63656E63h) profile device class	
16 to 19	4	Colour space of data (possibly a derived space)	‘RGB ’ (52474220h) or ‘YCC ‘(59434320h)
20 to 35	16	Reserved bytes shall be zero (00h)	
36 to 39	4	‘acsp’ (61637370h) profile file signature	See 7.2.11
40 to 127	88	Reserved bytes shall be zero (00h)	

7.2.4 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 any pad bytes. It shall be encoded as a uInt32Number.

7.2.5 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 CMM registry. If no preferred CMM is identified, this field shall be zero (00000000h).

7.2.6 Profile version and sub-version field (bytes 8 to 11)

The profile version with which the profile conforms 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 shall be used to identify the profile sub-class version where byte 10 shall be used to identify the sub-class major version and byte 11 shall be used to identify the sub-class minor version. When a sub-class is not associated with a profile (when the Pprofile/device sub-class field is zero) then bytes 10 and 11 shall be zero. The major and minor versions are set by the International Color Consortium (ICC). Profile sub-class versions

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shall be established by profile sub-class specification documents. The profile version and sub-version number consistent with this specification is "5.0.0.0" (encoded as 05000000h).

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

7.2.7 Profile/device class field (bytes 12 to15)

This field shall contain one of the profile class signatures shown in Table 14.

There are three basic classes of device profiles: Input, Display and Output profiles. In addition to the three basic device profile classes, eight 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 eight additional profile classes are DeviceLink, ColorSpace, ColorEncodingSpace, Abstract, NamedColor, MultiplexIdentification, MultiplexLink and MultiplexVisualization.

Table 14 — Profile classes

Profile class	Signature	Hexidecimal 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
ColorEncodingSpace profile	‘cenc‘	63656E63h
MultiplexIdentification profile	‘mid ’	6D696420h
MultiplexLink profile	‘mlnk’	6d6c6e6bh
MultiplexVisualization profile	‘mvis’	6d766973h

7.2.8 Data colour space field (Bytes 16 to 20)

This field shall contain the signature of the data colour space expected on the A side of the profile transforms.

The names and signatures of the permitted data colour spaces shall be as shown in Table 15.

Table 15 — Data colour space signatures

Colour space type	Signature	Hexidecimal encoding
nCIEXYZ or PCSXYZ[a]	‘XYZ ’	58595A20h
CIELAB or PCSLAB[b]	‘Lab ’	4C616220h
CIELUV	‘Luv ’	4C757620h
YCbCr	‘YCbr’	59436272h
CIEYxy	‘Yxy ’	59787920h

[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.

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Table 15 *(continued)*

Colour space type	Signature	Hexidecimal encoding
LMS	‘LMS ‘	4C4D5320h
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
N channel device data	*Represented as* “nc0001” – “ncFFFF”	6e630001h – 6e63FFFFh
None	0	00000000h

[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.

NOTE Extended “N channel device data” signatures use a 32-bit binary encoding (see 6.2.1) with a six-character signature representation.

Channel encoding order shall be associated with the order that channel names are identified in the signature (for example given signature ‘RGB’ the channel order shall be channel 1 – R, channel 2 – G, channel 3 – B) with the following exceptions: for the signature ‘GRAY’ there is only 1 channel; for the signature ‘YCbr’ the channel order shall be channel 1 – Y, channel 2 – Cb, channel 3 – Cr; for xCLR and N channel data the order shall be the same as the incoming device channel order.

For abstract profiles the data colour space signature shall one of the signatures in Table 15. If set to zero the spectral PCS signature and spectral range fields shall be used to define the A side of the transform.

For MultiplexLink and MultiplexVisualization profiles the data colour space signature shall be zero.

7.2.9 PCS field (Bytes 20 to 23)

For all profile classes (see Table 14), other than a DeviceLink or MultiplexLink profile, the PCS encoding shall be one of the signatures as defined in Table 16. When the profile/device class is a DeviceLink profile or MultiplexLink, the value of the PCS shall be the appropriate data colour space from Table 15. The field represents the colour space on the B-side of the transform.

The PCS for AToBx/BToAx tags shall always be defined by the PCS field.

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To define the use of a colorimetric-based PCS one of the non-spectral colour space signatures in Table 16 shall be used to encode the colour space implied by the PCS field of the profile header. These colour space signatures define both the colour space type and the number of channels associated with the colour space.

Table 16 — Non-spectral PCS colour space signatures

Colour space type	Signature	Hexidecimal encoding
nCIEXYZ or PCSXYZ[a]	'XYZ '	58595A20h
CIELAB or PCSLAB[b]	'Lab '	4C616220h
None (spectral PCS defined by spectral PCS header field)	0	00000000h

[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.

Channel encoding order shall be associated with the order that channel names are identified in the signature.

7.2.10 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.

7.2.11 Profile file signature field (bytes 36 to 39)

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

7.2.12 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 17. If no primary platform is identified, this field shall be zero (00000000h).

Table 17 — Primary platforms

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

7.2.13 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, 1 and 2 shall be used as indicated in Table 18.

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Table 18 — 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)
2	1	MCS channels in this profile shall be a subset of the MCS channels in the profile it is connected to (set to 1 if true, 0 if false)

Bit 2 shall define MCS subset requirements for connecting profiles. When bit 2 is set the CMM shall be instructed to fail the linking of the profile containing this bit (containing profile) to another profile (second profile) using an MCS based connection if the second profile does not contain all the channels in its MCS (defined in second profile's multiplexTypeArrayTag, see 9.2.85) that the containing profile has in its MCS (defined in the containing profile's multiplexTypeArrayTag, see 9.2.85).

7.2.14 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 at http://www.color.org (see Clause 5). If not used, this field shall be zero (00000000h).

7.2.15 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 at http://www.color.org (see Clause 5). If not used, this field shall be zero (00000000h).

7.2.16 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 19.

Table 19 — 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 and white media (1)
4	1	Paper/paperboard (0), non-paper-based (1)
5	1	Non-textured (0), textured (1)
6	1	Isotropic (0), non-isotropic (1)
7	1	Non self-luminous (0) or self-luminous (1)
8 to 31	24	Reserved (set to binary zero)
32 to 63	32	Use not defined by ICC (vendor specific)

NOTE Notice that bit 0 to bit 6 describe the media, not the device. For example, a profile for a colour scanner that has been loaded with black and white film has bit 3 set on, regardless of the value in the data colour space field (see 7.2.8). If the media is not inherently "colour" or "black and 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.

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7.2.17 Rendering intent field (bytes 64 to 67)

The rendering intent field shall specify the rendering intent that 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 selects 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, for example 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 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 20.

Table 20 — Rendering intents

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

7.2.18 PCS illuminant field (bytes 68 to 79)

The PCS illuminant field shall contain the nCIEXYZ values of the PCS illuminant. If the PCS illuminant is D50, the values shall be X = 0,964 2, Y = 1,0 and Z = 0,824 9 encoded as an XYZNumber. If the PCS illuminant is not D50, the values shall correspond to the colorimetry of the illuminant as computed using the illuminant and observer values specified in the spectralViewingConditions tag, as described in 9.2.105.

See Annex A for further details.

NOTE These values are the nCIEXYZ values of CIE illuminant D50.

The precise value of the PCS illuminant depends on the precision and method of computation. CIE Publication 15[11] gives a different value for Z, which corresponds to an nCIEXYZ value of 0,825 1. Such close approximations should be considered as D50.

7.2.19 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 at http://www.color.org. If not used, this field shall be zero (00000000h).

7.2.20 Profile ID field (bytes 84 to 99)

This field, if not zero (00h), shall hold the profile ID. The profile ID shall be calculated using the MD5 fingerprinting method as defined in Internet RFC 1321[12]. The entire profile, whose length is given by the size field in the header, with the profile flags field (bytes 44 to 47, see 7.2.13), rendering intent field (bytes 64 to 67, see 7.2.14), and profile ID field (bytes 84 to 99) in the profile header temporarily set to zeros (00h), shall be used to calculate the ID. A profile ID field value of zero (00h) shall indicate that a profile ID has not been calculated.

It is recommended that profile creators compute and record a profile ID.

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7.2.21 Spectral PCS field (bytes 100 to 103)

This field, when non-zero, defines the meaning of spectrally-based PCS data in a profile.

If DToBx/BToDx or brdfDToBx/brdfBToDx or directionalDToBx/directionalBToDx tags are present and this field is non-zero, then the use of a spectrally-based PCS shall be defined for DToBx/BToDx or brdfDToBx/brdfBToDx or directionalDToBx/directionalBToDx tags. If this field is zero then the use of DToBx/BToDx or brdfDToBx/brdfBToDx or directionalDToBx/directionalBToDx is not defined.

Spectral data shall be assumed to be sampled at equal intervals, with a given start, end wavelength and number of steps. Unless otherwise specified, the type, dimensions and range of the spectra in the different tags shall be defined by the spectral PCS field in addition to the spectral PCS range and bi-spectral PCS range fields.

For normal spectra (i.e. spectra containing no fluorescent emission component), this implies that the spectral dimension of object characterization spectra shall be the same. If the object characterization spectra are defined by the Donaldson matrix, the Donaldson matrix shall be an nXm matrix with m defined internally in the corresponding colour table.

A distinction is made between self-emitting colours and reflective colours, here referred to as luminous colours and object colours. Luminous colours are characterized by their emission spectra, whereas for object colours reflectance or transmission spectra are used. These three types of spectra are referred to as object characterization spectra.

Reflectance spectra are specified in relation to the perfect reflector whereas transmission spectra are related to a perfect transmitter. Therefore, both types of spectra can be seen as relative data. For emission spectra, luminance values are used, hence these are regarded as absolute data.

To define the use of a spectrally-based PCS, one of the spectral colour space signatures in Table 21 shall be used to encode the colour space implied by the spectralPCS field of the profile header. These colour space signatures define both the colour space type and the number of channels associated with the colour space. Therefore, the number of channels implied by the spectralPCS colour space signature shall match the number of channels indicated by the steps field(s) of the corresponding spectralRange structures (7.2.22 and 7.2.23) in the profile header.

Table 21 — BToDx/DToBx or brdfBToDx/brdfDToBx or directionalBToDx/directionalDToBx spectral colour space signatures

Spectral colour space type	Signature identifier	Signature channels	Combined hexidecimal encoding	Signature representation
None (PCS defined by PCS header field)	0	0	00000000h	0
Reflectance spectra with N channels	'rs' (7273h)	1 … 65 535 (0001h … FFFFh)	72730001h … 7273FFFFh	"rs0001" … "rs-FFFF"
Transmission spectra with N channels	'ts' (7473h)	1 … 65 535 (0001h to FFFFh)	74730001h … 7473FFFFh	"ts0001" … "tsFFFF"

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Table 21 *(continued)*

Spectral colour space type	Signature identifier	Signature channels	Combined hexidecimal encoding	Signature representation
Radiant (emission) spectra with N channels	'es' (6573h)	1 … 65 535 (0001h … FFFFh)	65730001h … 6573FFFFh	"es0001" … "es-FFFF"
Bi-spectral reflectance spectra with N total channels	'bs' (6273h)	1 to 65 535 (0001h … FFFFh)	62730001h … 6273FFFFh	"bs0001" … "bsFFFF"
Bi-spectral reflectance using sparse matrix with N equivalent output channels	'sm' (736d)	1 to 65 535 (0001h … FFFFh)	736D0001h … 736DFFFFh	"sm0001" … "sm-FFFF"

NOTE Spectral colour space signatures use the same 32-bit binary encoding mechanism as N colour device data signatures (see 6.2.1), with each having a six-character signature representation.

Different types of spectral data can be defined. In most circumstances, only reflectance, transmission or emission spectra are used, but in other circumstances additional data shall be provided according to the processing to be carried out. The range of normal spectra shall be indicated by the spectral PCS range field in the header (7.2.22). To represent bi-spectral data, a form of Donaldson matrix is used and the incident wavelengths corresponding to the columns of the matrix shall be specified by the bi-spectral PCS range field in the header (7.2.23).

7.2.22 Spectral PCS range field (bytes 104 to 109)

This field shall specify the spectral range used for a spectrally-based PCS when the spectralPCS signature field in the profile header is non-zero. If the spectralPCS field is zero then this field shall be zero.

Spectra are normally represented according to their canonical basis, i.e. the spectrum is sampled at equal intervals along the wavelength axis. The wavelength range is represented by a start wavelength (S), end wavelength (E) and number of steps (n). The wavelength interval between steps is given by Formula (4).

$$I = (E - S)/(n - 1) \tag{4}$$

Unless otherwise specified, spectral data in all tags shall be uniformly sampled, with a given start, end wavelength and number of steps as defined by this field. The dimensions and range of the spectra in the different tags shall be defined consistently. For normal spectra, this means that the spectral dimension of object characterization spectra shall be the same.

7.2.23 Bi-Spectral PCS range field (bytes 110 to 115)

This field shall specify the spectral range of the incident light used for a spectrally-based PCS when the spectralPCS signature field in the profile header indicates the use of Bi-spectral reflectance. Otherwise this field shall be zero.

Bi-spectral reflectance characterizes of the interaction of light with a diffuse surface using a Donaldson matrix. The multiplication of such a matrix by a vector representing the illumination results in a vector representing the light reflected off the surface. Columns of a Donaldson matrix correspond to incident wavelengths of light and rows of a Donaldson matrix correspond to reflected wavelengths of light.

Diagonal entries (where incident and reflected wavelengths are the same) correspond to spectral reflectance. Off diagonal entries (below the diagonal) represent the contribution of a change in the reflected light's wavelength (typically due to fluorescence). Fluorescence occurs when light is absorbed and then re-emitted at a longer wavelength. Using Donaldson matrices to represent colours in an

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ICC profile allows for a more complete description of colour to be encoded than using only spectral reflectance or simple colorimetry.

7.2.24 MCS field (bytes 116 to 119)

The MCS for AToM0/MToA0/MToB0/MToS0 tags shall always be defined by the MCS field. The field represents the colour space on the M-side of the transform. When this field is non-zero the multiplex channel identification shall be encoded by a multiplexTypeArrayTag (see 9.2.85).

For the MultiplexIdentification and MultiplexVisualization profile classes (see Table 14), the MCS encoding shall be one of the signatures as defined in Table 22.

NOTE Multiplex colour space signatures use the same 32-bit binary encoding mechanism as N colour device data signatures (see 6.2.1), with each having a six-character signature representation.

Table 22 — AToM0/MToA0/MToB0/MToS0 MCS signatures

Multiplex colour space type	Signature identifier	Signature channels	Combined hexidecimal encoding	Signature representation
Multiplex channel values with N channels	'mc' (6d63h)	1 … 65 535 (0001h … FFFFh)	6d630001h … 6d63FFFFh	"mc0001" … "mcFFFF"

For the input profile class (Table 14) the MCS encoding shall be one of the signatures as defined in Table 23.

Table 23 — AToM0/MToA0/MToB0/MToS0 MCS signatures

Multiplex colour space type	Signature identifier	Signature channels	Combined hexidecimal encoding	Signature representation
None (no MCS is used)	0	0	0	0
Multiplex channel values with N channels	'mc' (6d63h)	1 … 65 535 (0001h … FFFFh)	6d630001h … 6d63FFFFh	"mc0001" … "mcFFFF"

For all other profile classes (Table 14) the MCS encoding shall be zero.

7.2.25 Profile/device sub-class (bytes 124 to 127)

This field allows for a profile/device subclass signature associated with the profile class. This field's purpose is to provide a connection with ICS documents that provide specifications for specific colour management workflows. If this field is zero then no profile/device subclass shall be associated with the profile type. When this field is set then the profile sub-version field shall also identify the version associated with the profile/device sub-class that can be referenced with an ICS document.

7.2.26 Reserved field (bytes 124 to 127)

This field of the profile header is reserved for future ICC definition and shall be zero.

7.3 Tag table

7.3.1 Overview

The tag table acts as a table of contents for the tags and an index into the tag data element in the profiles. It shall consist of a 4-byte entry that contains a count of the number of tags in the table followed by a

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series of 12-byte entries with one entry for each tag. The tag table therefore contains 4 + 12*n* bytes where *n* is the number of tags contained in the profile. The entries for the tags within the table are not required to be in any particular order nor are they required to match the sequence of tag data element within the profile.

Each 12-byte tag entry following the tag count shall consist of a 4-byte tag signature, a 4-byte offset to define the beginning of the tag data element and a 4-byte entry identifying the length of the tag data element in bytes. Table 24 illustrates the structure for this tag table. 7.3.2 to 7.3.5 specify the position and content of the entries composing the tag table.

Table 24 — Tag table structure

Byte offset	Field length (bytes)	Content	Encoded as...
0 to 3	4	Tag count (*n*)	
4 to 7	4	Tag signature	
8 to 11	4	Offset to beginning of tag data element	uInt32Number
12 to 15	4	Size of tag data element	uInt32Number
16 to (12*n*+3)	12(*n*−1)	Signature, offset and size respectively of subsequent *n*−1 tags	
Key *n:* Number of tags contained in the profile			

NOTE The byte offset shown in Table 24 is with respect to the 128-byte header. Thus the tag table starts at byte position 128.

7.3.2 Tag count (byte position 0 to 3)

Byte positions 0 to 3 shall specify the number of tags contained in the tag table, encoded as a uInt32Number.

7.3.3 Tag signature (byte position 4 to 7 and repeating)

Byte positions 4 to 7 (and repeating at 12-byte intervals) shall specify the signature of a tag listed in Clause 9, or of a private tag. Signatures of private tags shall be registered with the ICC as defined in Clause 5.

7.3.4 Offset to beginning of tag data element (byte position 8 to 11 and repeating)

Byte positions 8 to 11 (and repeating at 12-byte intervals) shall specify the address of the beginning of the tag data element, with respect to the beginning of the profile data stream (which has an address of zero), encoded as a uInt32Number.

NOTE For profiles that are not embedded, the number specified is the same as the file offset.

All tag data elements shall start on a 4-byte boundary (relative to the start of the profile data stream) and the two least-significant bits of each tag data offset shall be zero. This means that a tag starting with a 32-bit value is properly aligned without the tag handler needing to know the contents of the tag.

7.3.5 Tag data element size (byte position 12 to 15 and repeating)

The tag data element size shall be the number of bytes in the tag data element encoded as a uInt32Number. The value of the tag data element size shall be the number of actual data bytes and shall not include any padding at the end of the tag data element.

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7.4 Tag data

The first set of tag data elements shall immediately follow the tag table and all tag data elements, including the last tag data element, shall be padded by no more than three following pad bytes to reach a 4-byte boundary.

The size of individual tag data elements and the accumulated size of all tag data elements shall only be restricted by the limits imposed by the 32-bit tag data offset value and the 32-bit tag data element size value.

8 Required tags

8.1 General

8.2 to 8.10 identify the tags that are required, in addition to the header defined in 7.2, for each profile type.

NOTE Profiles can include additional tags beyond those listed as required.

The intent of requiring certain tags with each type of profile is to provide a common base level of functionality. If a custom CMM is not present, then the required tags have enough information to allow the default CMM to perform the requested colour transformations. The particular models are identified for each profile type and described in detail in Annex A. While the data provided by the required tags might not provide the level of quality obtainable with optional tags and private data, the data provided is adequate for sophisticated device modelling.

8.2 Common requirements

With the exception of ColorEncodingSpace, DeviceLink, MultiplexIdentification and MultiplexLink profiles, all profiles shall contain the following tags:

— profileDescriptionTag (see 9.2.101);

— copyrightTag (see 9.2.55);

— mediaWhitePointTag (see 9.2.88) if the PCS field in header is non-zero;

— spectralWhitePointTag (see 9.2.106) if the spectralPCS field in profile header is non-zero.

NOTE 1 A ColorEncodingSpace profile is not required to have either a profileDescriptionTag, copyrightTag, mediaWhitePointTag or spectralWhitePointTag.

NOTE 2 A DeviceLink, MultiplexIdentification or MultiplexLink profile is not required to have a mediaWhitePointTag or spectralWhitePointTag.

8.3 Input profiles

Input profiles are generally used with devices such as scanners and digital cameras.

In addition to the tags listed in 8.2 an input profile shall contain one or more of the following: AToB0Tag (see 9.2.1), AToB1Tag (see 9.2.2), AToB2Tag (see 9.2.3), AToB3Tag (see 9.2.4), DToB0Tag (see 9.2.76), DToB1Tag (see 9.2.77), DToB2Tag (see 9.2.78), DToB3Tag (see 9.2.79).

The colorantInfoTag (9.2.53) should be used for colour spaces with either an ‘xCLR’ signature or a signature represented by “ncXXXX”. It enables the names and optionally colorimetric and/or spectral values of the colorants to be specified for these colour spaces (Table 15), as these names are not otherwise implicit in the choice of the colour space.

The BToA0Tag (see 9.2.30), BToA1Tag (see 9.2.39), BToA2Tag (see 9.2.40), BToA3Tag (see 9.2.41), BToD0Tag (see 9.2.42), BToD1Tag (see 9.2.43), BToD2Tag (see 9.2.44) and BToD3Tag (see 9.2.45) may

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also be included in an N-component LUT-based input profile. If these are present, their usage shall be as defined in Table 25 (see 9.2.1).

The gamutBoundaryDescriptor0Tag (see 9.2.80), gamutBoundaryDescriptor1Tag (see 9.2.81), gamutBoundaryDescriptor2Tag (see 9.2.82) and/or gamutBoundaryDescriptor3Tag (see 9.2.83) may be included.

MCS connection may be included in addition to PCS based tags. When the MCS header field is non-zero the input class shall also include an AToM0Tag (see 9.2.5) and a multiplexTypeArrayTag (see 9.2.85).

8.4 Display profiles

This class of profiles represents display devices such as monitors and projectors.

In addition to the tags listed in 8.2 a display profile shall contain the following tags:

— one or more of the following: AToB0Tag (see 9.2.1), AToB1Tag (see 9.2.2), AToB2Tag (see 9.2.3), AToB3Tag (see 9.2.4), DToB0Tag (see 9.2.76), DToB1Tag (see 9.2.77), DToB2Tag (see 9.2.78), DToB3Tag (see 9.2.79);

— one or more of the following: BToA0Tag (see 9.2.38), BToA1Tag (see 9.2.39), BToA2Tag (see 9.2.40), BToA3Tag (see 9.2.41), BToD0Tag (see 9.2.42), BToD1Tag (see 9.2.43), BToD2Tag (see 9.2.44), BToD3Tag (see 9.2.45).

The colorantInfoTag (9.2.52) is a recommended tag for colour spaces with either an ‘xCLR’ signature or a signature represented by “ncXXXX”. It enables the names and optionally colorimetric and/or spectral values of the colorants to be specified for these colour spaces (Table 15), as these names are not otherwise implicit in the choice of the colour space.

The gamutBoundaryDescriptor0Tag (see 9.2.80), gamutBoundaryDescriptor1Tag (see 9.2.81), gamutBoundaryDescriptor2Tag (see 9.2.82), and/or gamutBoundaryDescriptor3Tag (see 9.2.83) may be included.

8.5 Output profiles

Output profiles are used to support devices such as printers and film recorders. The types of profiles available for use as output profiles are N-component LUT-based and Monochrome.

In addition to the tags listed in 8.2 an output profile shall contain the following tags:

— one or more of the following: AToB0Tag (see 9.2.1), AToB1Tag (see 9.2.2), AToB2Tag (see 9.2.3), AToB3Tag (see 9.2.4), DToB0Tag (see 9.2.76), DToB1Tag (see 9.2.76), DToB2Tag (see 9.2.76), DToB3Tag (see 9.2.76);

— one or more of the following: BToA0Tag (see 9.2.38), BToA1Tag (see 9.2.39), BToA2Tag (see 9.2.40), BToA3Tag (see 9.2.41), BToD0Tag (see 9.2.42), BToD1Tag (see 9.2.43), BToD2Tag (see 9.2.44), BToD3Tag (see 9.2.45).

The colorantInfoTag (9.2.52) is a recommended tag for colour spaces with either an ‘xCLR’ signature or a signature represented by “ncXXXX”. It enables the names and optionally colorimetric and/or spectral values of the colorants to be specified for these colour spaces (Table 15), as these names are not otherwise implicit in the choice of the colour space.

The gamutBoundaryDescriptor0Tag (see 9.2.80), gamutBoundaryDescriptor1Tag (see 9.2.81), gamutBoundaryDescriptor2Tag (see 9.2.82) and/or gamutBoundaryDescriptor3Tag (see 9.2.83) may be included.

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8.6 DeviceLink profile

A device link profile shall contain the following tags:

— profileDescriptionTag (see 9.2.101);

— copyrightTag (see 9.2.55);

— one or more of the following: AToB0Tag (see 9.2.1), DToB0Tag (see 9.2.76).

A profileSequenceInformationTag (see 9.2.102) may be included.

This profile contains a pre-evaluated transform that cannot be undone, which represents a one-way link or connection between devices. It does not represent any device model nor can it be embedded into images.

The single AToB0Tag may contain data for any one of the four possible rendering intents. The rendering intent used is indicated in the header of the profile.

The data colour space field (see 7.2.8) in the DeviceLink profile shall be the same as the data colour space field of the first profile in the sequence used to construct the device link. The PCS field (see 7.2.9) shall be the same as the data colour space field of the last profile in the sequence.

If the data colour space field is set to xCLR, where x is hexadecimal 1 to F or has a signature representation of "ncXXXX" where XXXX is hexadecimal 0001 to FFFF, the colorantInfoTag (9.2.52) is a recommended tag to specify the names and optionally colorimetric and/or spectral values of the input colorants (Table 15), as these names are not otherwise implicit in the choice of the colour space. These colorants represent the input values of the profile.

Correspondingly, if the PCS field is set to xCLR where x is hexadecimal 1 to F or has a signature representation of "ncXXXX" where XXXX is hexadecimal 0001 to FFFF, the colorantInfoOutTag (9.2.53) is a recommended tag to specify the names and optionally colorimetric and/or spectral values of the output colorants (Table 15), as these names are not otherwise implicit in the choice of the colour space. These colorants represent the output values of the profile.

NOTE The colorantOrderTag 'clro' specifies the laydown order of the input colorants, and the colorantoOrderOutTag specifies the laydown order of the output colorants.

8.7 ColorEncodingSpace profile

A ColorSpaceEncoding profile [signature 'cenc' (63656e63h)] shall contain the following tag: referenceNameTag (see 9.2.103).

A ColorSpaceEncoding profile may also contain a colorEncodingParamsTag and a colorSpaceNameTag defined by the following criteria.

In the first mode of operation the referenceNameTag solely contains the text "ISO 22028-1" (quotes excluded) and the elements in the colorEncodingParamsTag shall uniquely determine the colour space encoding parameters and the colorSpaceNameTag shall define the name associated with the colour space encoding.

In the second mode of operation the referenceNameTag contains any text besides "ISO 22028-1" (quotes excluded). In this case the colorSpaceNameTag defines the colour space name and a colorEncodingParamsTag may optionally be present. If the colorEncodingParamsTag exists then any elements in the colorEncodingParamsTag shall provide overrides to the assumed default values for the encoding space. Any elements not in the colorEncodingParamsTag shall have assumed default values associated with the colour space encoding.

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8.8 ColorSpace profile

In addition to the tags listed in 8.2 a ColorSpace profile shall contain the following tags:

— one or more of the following: AToB0Tag (see 9.2.1), AToB1Tag (see 9.2.2), AToB2Tag (see 9.2.3), AToB3Tag (see 9.2.4), DToB0Tag (see 9.2.76), DToB1Tag (see 9.2.77), DToB2Tag (see 9.2.78) or DToB3Tag (see 9.2.79);

— one or more of the following: BToA0Tag (see 9.2.38), BToA1Tag (see 9.2.39), BToA2Tag (see 9.2.40), BToA3Tag (see 9.2.41), BToD0Tag (see 9.2.42), BToD1Tag (see 9.2.43), BToD2Tag (see 9.2.44) or BToD3Tag (see 9.2.45).

This profile provides the relevant information to perform a transformation between colour encodings and the PCS. This type of profile is based on modelling rather than device measurement or characterization data. ColorSpace profiles may be embedded in images.

For ColorSpace profiles, the device profile dependent fields are set to zero if irrelevant.

The gamutBoundaryDescriptor0Tag (see 9.2.80), gamutBoundaryDescriptor1Tag (see 9.2.81), gamutBoundaryDescriptor2Tag (see 9.2.82) and/or gamutBoundaryDescriptor3Tag (see 9.2.83) may be included.

8.9 Abstract profile

In addition to the tags listed in 8.2 an abstract profile shall contain one or more of the following tags: AToB0Tag (see 9.2.1), DToB0Tag (see 9.2.76).

This profile represents an abstract transform and does not represent any device model. Colour transformations using abstract profiles are performed from PCS to PCS. Abstract profiles cannot be embedded in images.

8.10 NamedColor profile

In addition to the tags listed in 8.2 a NamedColor profile shall contain the following tag: namedColorTag (see 9.2.99).

NamedColor profiles can be thought of as sibling profiles to device profiles. For a given device there would be one or more device profiles to handle process colour conversions and one or more named colour profiles to handle named colours.

The namedColorTag provides a combination of PCS, spectral PCS and optional device representation for each named colour in a list of named colours. NamedColor profiles can be device specific in that their data are shaped for a particular device. There might be multiple NamedColor profiles to account for different consumables or multiple named colour vendors. The PCS and spectral PCS representations are provided to support general colour management functionality, and are useful for display and emulation of the named colours.

When using a NamedColor profile with the device for which it is intended, the device representation of the colour specifies the exact device coordinates for each named colour, if available. The PCS and spectral PCS representations in conjunction with the device's output profile can provide an approximation of these exact coordinates. The exactness of this approximation is a function of the accuracy of the output profile and the colour management system performing the transformations.

The combination of the PCS, spectral PCS and device representations provides for flexibility with respect to accuracy and portability.

Additional information about NamedColor profiles can be found in Annex D.

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8.11 MultiplexIdentification profile

In addition to the tags listed in 8.2, a MultiplexIdentification profile shall contain the following tags:

— AToM0Tag (see 9.2.6);

— multiplexTypeArrayTag (see 9.2.85).

This profile converts device values into independent multiplex channel values.

8.12 MultiplexLink profile

In addition to the tags listed in 8.2, a MultiplexIdentification profile shall contain the following tags:

— MToA0Tag (see 9.2.90);

— multiplexTypeArrayTag (see 9.2.85).

Profiles of this class can optionally provide the following tag: multiplexDefaultValuesTag (see 9.2.84).

This profile converts multiplex channel values to device values. MultiplexLink profiles shall not be embedded in images.

8.13 MultiplexVisualization profile

In addition to the tags listed in 8.2 a MultiplexVisualization profile shall contain the following tags:

— one or more of the following: MToB0Tag (see 9.2.91), MToB1Tag (see 9.2.92), MToB2Tag (see 9.2.93), MToB3Tag (see 9.2.94), MToS0Tag (see 9.2.95), MToS1Tag (see 9.2.96), MToS2Tag (see 9.2.97), or MToS3Tag (see 9.2.98);

— multiplexTypeArrayTag (see 9.2.85).

Profiles of this class can optionally provide the following tag: multiplexDefaultValuesTag (see 9.2.84).

This profile represents a visualization of multiplex channel values and does not represent any device model. Colour transformations using abstract profiles are performed from either MCS to device or MCS to PCS. MultiplexVisualization profiles shall not be embedded in images.

8.14 Precedence order of tag usage

8.14.1 General

There are several methods of colour transformation that can function within a single CMM. If data for more than one method are included in the same profile, the following selection algorithm shall be used by the software implementation.

8.14.2 Input, display, output or colour space profile types

For input, display, output or colour space profile types, the precedence order of the tag usage for PCSXYZ or PCSLab connection for a designated rendering intent shall be:

a) use the BToA0Tag, BToA1Tag, BToA2Tag, BToA3, AToB0Tag, AToB1Tag, AToB2Tag, or AToB3Tag designated for the rendering intent if present;

b) use the BToA0Tag or AToB0Tag if present, when the tags in 1 are not used;

c) use the BToA1Tag or AToB1Tag if present, when the tags in 1 and 2 are not used;

d) use the BToA3Tag or AToB3Tag if present, when the tags in 1 to 3 are not used.

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See Table 25.

When spectrally-based PCS connection is used and the spectralPCS header field is non-zero, for input, display, output or colour space profile types, the precedence order of the tag usage for a designated rendering intent shall be:

1) use the BToD0Tag, BToD1Tag, BToD2Tag, BToD3Tag, DToB0Tag, DToB1Tag, DToB2Tag or DToB3Tag designated for the rendering intent if the tag is present;

2) use the BToD0Tag or DToB0Tag if present, when the tags in 1 are not used;

3) use the BToD1Tag or DToB1Tag if present, when the tags in 1 and 2 are not used;

4) use the BToD3Tag or DToB3Tag if present, when the tags in 1 to 3 are not used.

See Table 25.

When MCS connection is used for input profile types, the precedence order of the tag usage for a designated rendering intent shall be: use the AToM0Tag.

8.14.3 Abstract profile types

For abstract profile types when PCSXYZ or PCSLab connection is used, the precedence order of the tag usage shall be: use the AToB0Tag.

For abstract profile types when a spectrally-based PCS is used, the precedence order of the tag usage shall be: use the DToB0Tag.

8.14.4 DeviceLink profile types

For the DeviceLink profile type, the precedence order of the tag usage shall be: use the AToB0Tag.

8.14.5 MultiplexIdentification profile types

For the MultiplexIdentification profile type, the precedence order of the tag usage shall be: use the AToM0Tag.

8.14.6 MultiplexLink profile types

For either the MultiplexIdentification profile type or the input type when a device to multiplex channel transform is desired, the precedence order of the tag usage shall be: use the MToA0Tag.

8.14.7 MultiplexVisualization profile types

For the MultiplexVisualization profile type, when a multiplex channel to colorimetric PCS transform is desired with PCSXYZ or PCSLab connection for a designated rendering intent, the precedence order of the tag usage shall be:

a) use the MToB0Tag, MToB1Tag, MToB2Tag, MToB3Tag designated for the rendering intent if present;

b) use the MToB0Tag if present, when the tags in 1 are not used;

c) use the MToB1Tag if present, when the tags in 1 and 2 are not used;

d) use the MToB3Tag if present, when the tags in 1 to 3 are not used.

For the MultiplexVisualization profile type, when a multiplex channel to spectral PCS transform is desired using a spectrally-based PCS connection for a designated rendering intent and the spectralPCS header field is non-zero, the precedence order of the tag usage shall be:

1) use the MToS0Tag, MToS1Tag, MToS2Tag, MToS3Tag designated for the rendering intent if present;

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2) use the MToS0Tag if present, when the tags in 1 are not used;

3) use the MToS1Tag if present, when the tags in 1 and 2 are not used;

4) use the MToS3Tag if present, when the tags in 1 to 3 are not used.

8.14.8 MCS to parameter-based BRDF profile table usage

For the MultiplexVisualization profile type, when a MCS to parameter-based BRDF colorimetric transform is desired with PCSXYZ or PCSLab connection for a designated rendering intent, the precedence order of the tag usage shall be:

a) use the brdfMToB0Tag, brdfMToB1Tag, brdfMToB2Tag or brdfMToB3Tag designated for the rendering intent if present;

b) use the brdfMToB0Tag if present, when the tags in 1 are not used;

c) use the brdfMToB1Tag if present, when the tags in 1 and 2 are not used;

d) use the brdfMToB3Tag if present, when the tags in 1 to 3 are not used.

For the MultiplexVisualization profile type, when a MCS to parameter-based BRDF spectral transform is desired with a spectrally-based PCS connection for a designated rendering intent and the spectralPCS header field is non-zero, the precedence order of the tag shall be:

1) use the brdfMToS0Tag, brdfMToS1Tag, brdfMToS2Tag or brdfMToS3Tag designated for the rendering intent if the tag is present;

2) use the brdfMToS0Tag when the tags in 1 are not used;

3) use the brdfMToS1Tag when the tags in 1 and 2 are not used;

4) use the brdfMToS3Tag if present, when the tags in 1 to 3 are not used.

8.14.9 BRDF profile table usage

For input, display, output or colour space profile types that provide BRDF function tags which are desired to be used, the precedence order of the tag usage for PCSXYZ or PCSLab connection for a designated rendering intent shall be:

a) use the brdfBToA0Tag, brdfBToA1Tag, brdfBToA2Tag, brdfBToA3, brdfAToB0Tag, brdfAToB1Tag, brdfAToB2Tag or brdfAToB3Tag designated for the rendering intent if present;

b) use the brdfBToA0Tag or brdfAToB0Tag if present, when the tags in 1 are not used;

c) use the brdfBToA1Tag or brdfAToB1Tag if present, when the tags in 1 and 2 are not used;

d) use the brdfBToA3Tag or brdfAToB3Tag if present, when the tags in 1 to 3 are not used.

When spectrally-based PCS connection is used and the spectralPCS header field is non-zero, for input, display, output or colour space profile types that provide BRDF tags which are desired to be used, the precedence order of the tag usage for a designated rendering intent shall be:

1) use the brdfBToD0Tag, brdfBToD1Tag, brdfBToD2Tag, brdfBToD3Tag, brdfDToB0Tag, brdfDToB1Tag, brdfDToB2Tag or brdfDToB3Tag designated for the rendering intent if the tag is present;

2) use the brdfBToD0Tag or brdfDToB0Tag when the tags in 1 are not used;

3) use thebrdf BToD1Tag or brdfDToB1Tag when the tags in 1 and 2 are not used;

4) use the brdfBToA3Tag or brdfDToB3Tag if present, when the tags in 1 to 3 are not used.

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8.14.10 Parameter-based BRDF profile table usage

For input, display, output or colour space profile types that provide colorimetric parameter-based BRDF tags which are desired to be used, the precedence order of the tag usage for a designated rendering intent shall be:

a) use the brdfColorimetricParameter0Tag, brdfColorimetricParameter1Tag, brdfColorimetricParameter2Tag, brdfColorimetricParameter3Tag, designated for the rendering intent if present;

b) use the brdfColorimetricParameter0Tag if present, when the tags in 1 are not used;

c) use the brdfColorimetricParameter1Tag if present, when the tags in 1 and 2 are not used;

d) use the brdfColorimetricParameter3Tag if present, when the tags in 1 to 3 are not used.

For input, display, output or colour space profile types that provide spectral parameter-based BRDF tags which are desired to be used and the spectralPCS header field is non-zero, the precedence order of the tag usage for a designated rendering intent shall be:

1) use the brdfSpectralParameter0Tag, brdfSpectralParameter1Tag, brdfSpectralParameter2Tag, brdfSpectralParameter3Tag designated for the rendering intent if the tag is present;

2) use the brdfSpectralParameter0Tag when the tags in 1 are not used;

3) use the brdfSpectralParameter1Tag when the tags in 1 and 2 are not used;

4) use the brdfSpectralParameter3Tag if present, when the tags in 1 to 3 are not used.

8.14.11 Directional profile table usage

For input, display, output or colour space profile types that provide directional tags which are desired to be used, the precedence order of the tag usage for PCSXYZ or PCSLab connection for a designated rendering intent shall be:

a) use the directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3, directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag or directionalAToB3Tag designated for the rendering intent if present;

b) use the directionalBToA0Tag or directionalAToB0Tag if present, when the tags in 1 are not used;

c) use the directionalBToA1Tag or directionalAToB1Tag if present, when the tags in 1 and 2 are not used;

d) use the directionalBToA3Tag or directionalAToB3Tag if present, when the tags in 1 to 3 are not used.

When spectrally-based PCS connection is used and the spectralPCS header field is non-zero, for input, display, output or colour space profile types that provide BRDF tags which are desired to be used, the precedence order of the tag usage for a designated rendering intent shall be:

1) use the directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag or directionalDToB3Tag designated for the rendering intent if the tag is present;

2) use the directionalBToD0Tag or directionalDToB0Tag when the tags in 1 are not used;

3) use thedirectional BToD1Tag or directionalDToB1Tag when the tags in 1 and 2 are not used;

4) use the directionalBToD3Tag or directionalDToB3Tag if present, when the tags in 1 to 3 are not used.

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9 Tag definitions

9.1 General

The public tags defined by extended ICC profiles conforming to this document are listed in 9.2 in alphabetical order. All tags, including private tags, have as their first four bytes a tag signature to identify to profile readers what kind of data are contained within a tag. Each entry in 9.2 contains the tag signatures that shall be used for that tag, the permitted tag types for each tag (see Clause 10) and a brief description of the purpose of each tag.

These individual tags are used to create all possible profiles. The tag signature indicates only the type of data and does not imply anything about the use or purpose for which the data are intended. Clause 8 specifies the tags that shall be included for each type of profile. Any other tag in 9.2 may be used as an optional tag as long as they are not specifically excluded in the definition of a profile class.

The interpretation of some tags is context dependent. This dependency is described in Table 25 which provides a summary of the rendering intent associated with each of the main profile classes and models. The term "undefined" means that the use of the tag in that situation is not specified by the ICC. The ICC recommends that such tags not be included in profiles. If the tag is present, its use is implementation dependent. In general, the BToAxTags represent the inverse operation of the AToBxTags, and DToAxTags represent the inverse of AToDxTags.

9.2 Specific tag listing

9.2.1 AToB0Tag

Tag signature: ‘A2B0’ (41324230h).

Permitted tag types: lutAToBType or multiProcessElementsType.

This tag defines a colour transform from Device, Colour Encoding or colorimetric PCS, to colorimetric PCS, or a colour transform from Device 1 to Device 2, using lookup table tag element structures or a multiProcessElementsType transform. For most profile classes it defines the transform to achieve colorimetric-based perceptual rendering (see Table 25). The processing mechanisms are described in lutAToBType or multiProcessElementsType (see 10.2.12 and 10.2.16).

Table 25 — Profile classes and defined AToBx rendering intents

Profile class	AToB0Tag	AToB1Tag	AToB2Tag	AToB3Tag
Input	Device to colorimetric PCS: perceptual	Device to colorimetric PCS: media relative	Device to colorimetric PCS: saturation	Device to colorimetric PCS: absolute
Display	Device to colorimetric PCS: perceptual	Device to colorimetric PCS: media relative	Device to colorimetric PCS: saturation	Device to colorimetric PCS: absolute
Output	Device to colorimetric PCS: perceptual	Device to colorimetric PCS: media relative	Device to colorimetric PCS: saturation	Device to colorimetric PCS: absolute
ColorSpace	Colour encoding to colorimetric PCS: perceptual	Colour encoding to colorimetric PCS: media relative	Colour encoding to colorimetric PCS: saturation	Colour encoding to colorimetric PCS: absolute
Abstract	Colorimetric PCS to colorimetric PCS	Undefined	Undefined	Undefined
DeviceLink	Device 1 to Device2	Undefined	Undefined	Undefined

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