INTERNATIONAL STANDARD

ISO 15076-1

First edition
2005-12-01

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

Part 1:
Based on ICC.1:2004-10

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

Partie 1: Sur la base de l'ICC.1:2004-10

Reference number
ISO 15076-1:2005(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Foreword

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

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

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

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

ISO 15076-1 was prepared by the *International Color Consortium*, in cooperation with Technical Committees ISO/TC 130 *Graphic technology* and ISO/TC42 *Photography*, under the provisions of the Cooperative Agreement between ISO/TC130 and the *International Color Consortium* dated 2003-07-11.

ISO 15076-1 is technically identical to ICC.1:2004-10, *Image technology colour management — Architecture, profile format, and data structure (Profile version 4.2.0.0).*

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

— *Part 1: Based on ICC.1:2004-10*

Contents

Page

Introduction

0.1 General

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

It is assumed that the reader has a nominal understanding of colour science, such as familiarity with the CIELAB colour space, general knowledge of device characterizations, and familiarity with at least one operating system level colour management system.

0.2 International Color Consortium

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

The initial version of the standard developed by the consortium has undergone various revisions and it was agreed by ICC that its revision 4.2 should be proposed as an International Standard. It is that revision which has formed the basis of this International Standard. The ICC will continue to administer its own version of the document and, if enhancements are made, they will be seriously considered for future revisions of this International Standard. ISO TC130 will work to ensure that there are no significant differences between the ICC and ISO versions of the document.

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

0.3 Colour Management Architecture and Profile Connection Space

The underlying architecture assumed in this International Standard is based around a reference colour space that is unambiguously defined. The colour specification method selected was that defined by CIE which is internationally accepted. The CIE system enables a set of tristimulus values (XYZ) to be specified for a coloured stimulus. These tristimulus values enable a user to determine whether colours match, and the degree of mis-match between any that do not. It follows that it is possible to define the colour of a sample by these tristimulus values (or some defined transformation of them) for matching by colour reproduction.

Calculation of the XYZ values for transmitting or reflecting media is achieved from the spectral sum-product of the reflectance or transmittance of the sample, the relative spectral power distribution of the illuminant used to view it and the 'sensitivity' of the standard observer. However, as CIE defines two standard observers, two measurement geometries (for reflecting media) and a large number of illuminants, it is necessary to restrict these options in order to have a system that is not ambiguous for a particular application. For this International Standard ICC have defined such a restriction, based on ISO 13655:1996, Graphic Technology - Spectral measurement and colorimetric calculation for graphic arts images, and the resultant colour space is known as the Profile Connection Space (PCS). Furthermore, the simple CIE system (whether XYZ or the CIELAB values derived from them) does not accommodate the effect of surrounding stimuli to the sample being measured (which can be different for various types of media) or the level of illumination. Both of these affect appearance so the PCS values do not by themselves specify appearance. To overcome this problem the PCS is used in two different ways. The first simply describes the colorimetry of actual originals and their reproductions through the colorimetric rendering intents. The second, which describes the colorimetry of an image colour rendered to a standard reference medium under a specified viewing condition, is employed for the perceptual rendering intent. Thus it may incorporate corrections for appearance, and other desired rendering effects, as well as accommodating differences between the device and the reference PCS dynamic range. When required the viewing conditions may be specified to allow appearance to be determined for the colorimetric rendering intents.

So, in summary, the PCS is based on XYZ (or CIELAB) determined for a specific observer (CIE Standard 1931 Colorimetric Observer - often known colloquially as the 2 degree observer), relative to a specific illuminant (D50 - a chromatic adaptation transform is used if necessary), and measured with a specified measurement geometry ($0^o/45^o$ or $45^o/0^o$), for reflecting media. Measurement procedures are also defined for transmitting media. (Since the conversion from XYZ to CIELAB is quite unambiguous profile builders can use either, and the application is able to determine which has been used from a tag in the header).

For colorimetric renderings, where the measured data was not made relative to D50 the profile builder is expected to correct the data to achieve this. However a mechanism for identifying the chromatic adaptation used in such situations is provided. For the perceptual rendering intent the same viewing conditions are assumed, but an additional constraint is added in that a reference medium and illumination level is specified in order to provide a more robust mechanism for describing colour rendering (including gamut mapping). In the following paragraphs the reference colour space referred to should be taken to include the viewing conditions and reference medium when the perceptual intent is being considered. For the perceptual rendering intent profile builders are expected to undertake any corrections for appearance effects if the viewing conditions used for monitors and transmitting media (such as dark surrounds) differ from those typical for reflecting media.

Figure 1 shows how a reference colour space can be used to provide the common interface for colour specification between devices. Without it a separate transformation would be required for each pair of devices. If there are n devices in a system, and it is necessary to provide a transformation between each device and every other device, n^2 transforms would need to be defined and n new transforms would need to be defined every time a new device is added. By use of a reference colour space only n transforms need be defined and only one new transform needs to be defined each time a new device is added.

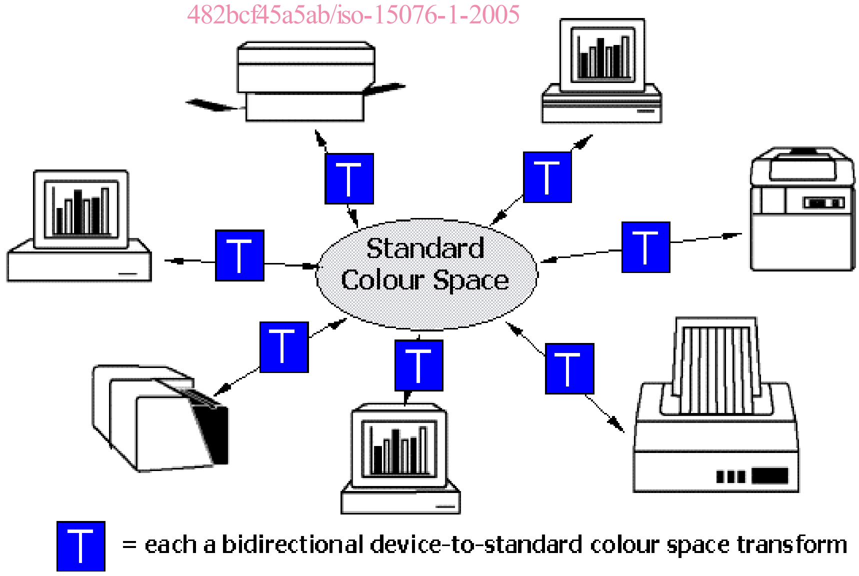

Figure 1 — Use of a reference colour space

While images could be encoded directly in the reference colour space defined by the PCS this will not generally be the case. For precision reasons it is usually desirable to define the transformation between the device colour space and the PCS at a higher precision than the bit-depth of the image. So, the transformation between a device colour space and the PCS is usually defined at high precision. If this transformation is provided with any image file appropriate to that device it can be utilised when images are reproduced. By combining the profiles for the pair of devices for which image reproduction is required, using the common PCS as the interface as shown in Figure 1, appropriate colour reproduction is assured with a minimal loss of precision. In order that the transformation between the device colour space and the PCS can be interpreted by all applications it is important that it be defined in an open specification. The profile format defined in this International Standard provides that specification.

0.4 Rendering intents

In general, actual device colour gamuts will fail to match each other, and that of the reference medium, to varying degrees. Because of this mismatch, and because of the needs of different applications, four rendering intents (colour rendering styles) are defined in this specification. Each one represents a different colour reproduction compromise. The colorimetric rendering intents operate directly on measured colorimetric values, though possibly with correction for chromatic adaptation when the measured values were not calculated for the D50 PCS illuminant. The other rendering intents (perceptual and saturation) operate on colorimetric values which are corrected in an as-needed fashion to account for any differences between devices, media, and viewing conditions.

Two colorimetric rendering intents are specified in this International Standard, though only one is directly defined in the profile. The defined colorimetric intent (media-relative colorimetric intent) is based on media-relative colorimetry in which data is normalised relative to the media white point for reflecting and transmitting media. (Thus the media white will have the PCS CIELAB values (100, 0, 0)). However, because the profile is also required to contain the PCS values of the media white, relative to the perfect reflecting diffuser or transmitter under D50, it is possible for all the media-relative values to be re-calculated relative to these. When this is done the resultant rendering intent is known as the absolute colorimetric intent. The use of media-relative colorimetry enables colour reproductions to be defined which maintain highlight detail, while keeping the medium ‘white’, even when the original and reproduction media differ in colour. However, this procedure inevitably introduces some change in all colours in the reproduction. When an exact colour match is required for all within gamut colours the absolute colorimetric rendering intent will define this.

The colour rendering of the perceptual and saturation rendering intents is vendor specific. The former, which is useful for general reproduction of pictorial images, typically includes tone scale adjustments to map the dynamic range of one medium to that of another, and gamut warping to deal with gamut mismatches. The latter, which is useful for images which contain objects such as charts or diagrams, usually involves compromises such as trading off preservation of hue in order to preserve the vividness of pure colours.

For perceptual transforms it is desirable, in order to optimise colour rendering, to place some bounds on the colour gamut of the PCS values. For this reason a reference medium and reference viewing condition have been defined which apply only to the perceptual rendering. The reference medium is defined as a hypothetical print on a substrate with a white having a neutral reflectance of 89%, and a density range of 2,4593. The reference viewing condition is the P2 condition specified in ISO 3664 - Viewing conditions - for Photography and Graphic Technology, i.e. D50 at 500 lux for viewing reflecting media. A neutral surround, of 20% reflectance is assumed.

The choice of a reference medium with a realistic black point for the perceptual intent provides a well-defined aim when tonal remapping is required. Inputs with a dynamic range greater than a reflection print (for example, a slide film image, or the colorimetry of high-range scenes) can have their highlights and shadows smoothly compressed to the range of the print in such a way that these regions can be expanded again without undue loss of detail on output to wide-range media. Likewise, images from original media with limited dynamic range can be colour rendered to the expanded dynamic range of the reference medium, in order to ensure interoperability.

Profiles generally offer more than one transformation, each of which is applicable to a specific rendering intent. When the intent is selected the appropriate transformation is selected by the colour management application. The choice of rendering intent is highly dependent upon the intended use. In general the peceptual rendering intent is most applicable for the rendering of natural images, though not always. In particular, in a proofing environment - where the colour reproduction obtained on one device is simulated on another - colorimetric rendering is most appropriate.

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

0.5 Device profiles

Device profiles provide colour management systems with the information necessary to convert colour data between native device colour spaces and device independent colour spaces. This International Standard divides colour devices into three broad classifications: input devices, display devices and output devices. For each device class, a series of base algorithmic models are described which perform the transformation between colour spaces. Figures 2 and 3 show examples of these models, which provide a range of colour

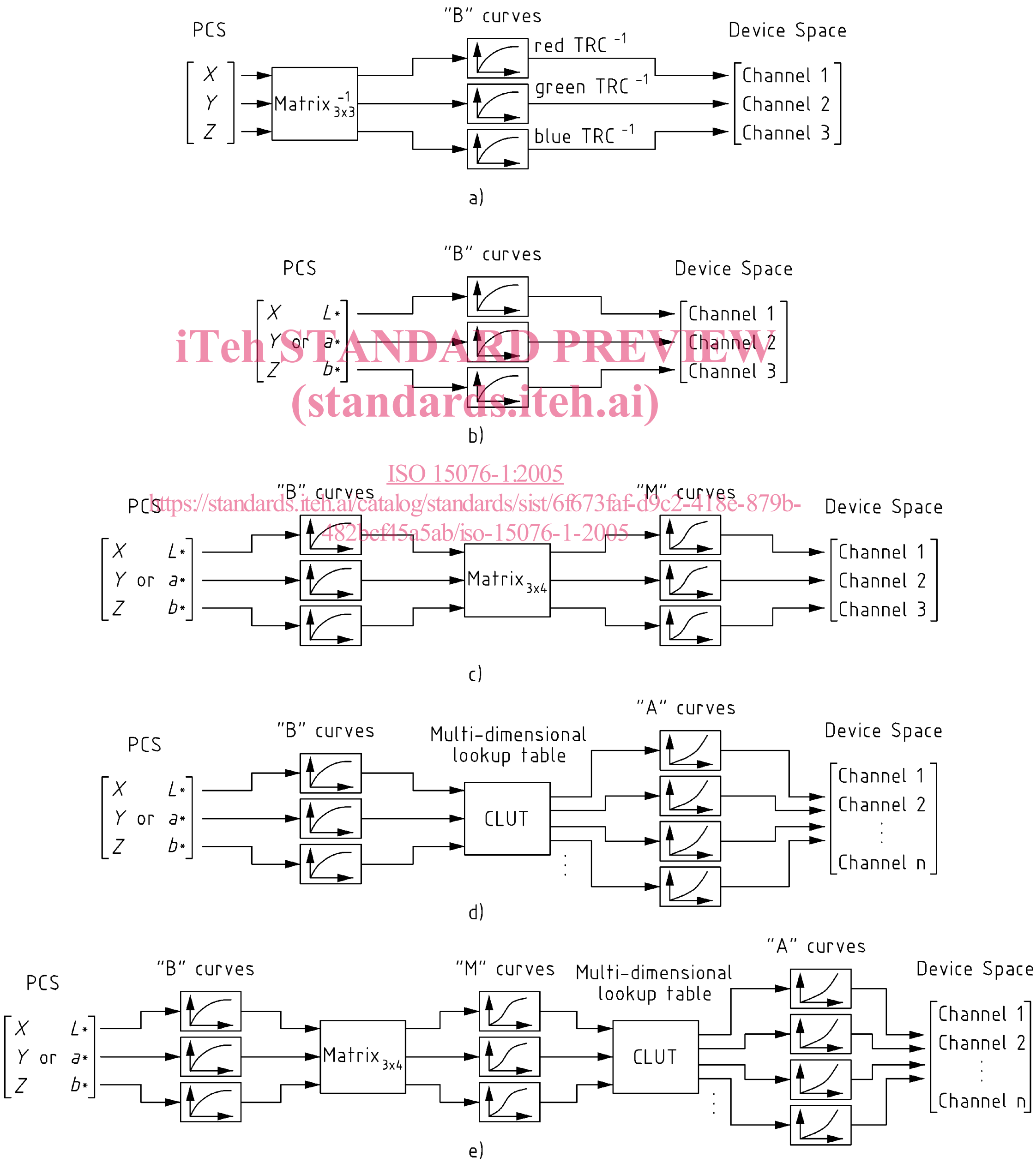

Figure 2 — The different ways of converting a colour from PCS to device space. (a) Matrix/TRC model (b)-(e) The four different ways of applying a lutBtoAType table. Only (d) and (e) can be used if the device space has more than 3 components/colour.

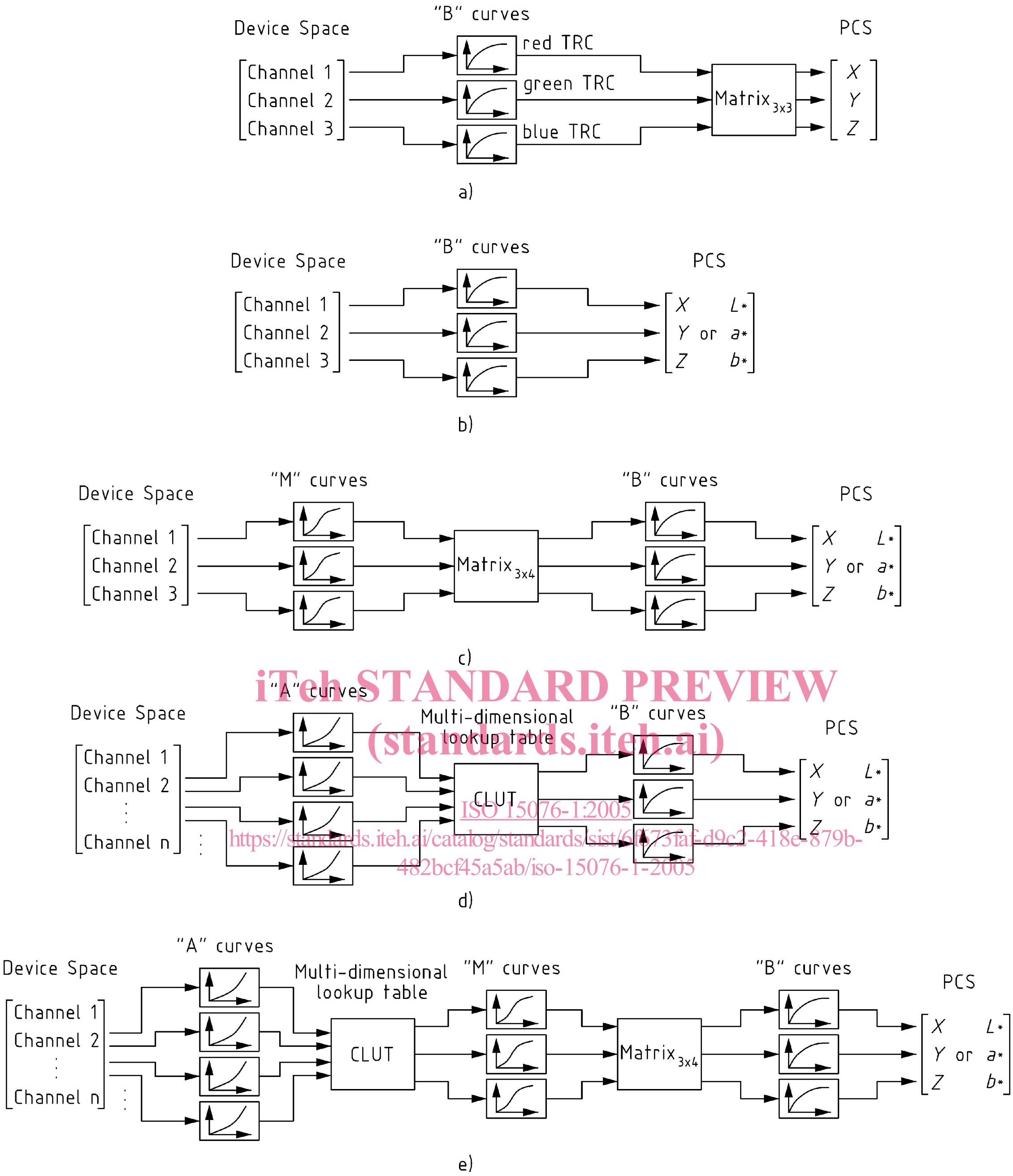

Figure 3 — Examples of converting a colour from device to PCS. (a) Matrix/TRC model (b)-(e) The four different ways of applying a lutAtoBType table. Only (d) and (e) can be used if the device space has more than 3 components/colour.

quality and performance results. Each of the base models provides different trade-offs in memory footprint, performance and image quality. The necessary parameter data to implement these models is described in the appropriate tag type descriptions in clause 10. This required data provides the information for the colour management framework default colour management module (CMM) to transform colour information between native device colour spaces. A representative architecture using these components is illustrated in Figure 4.

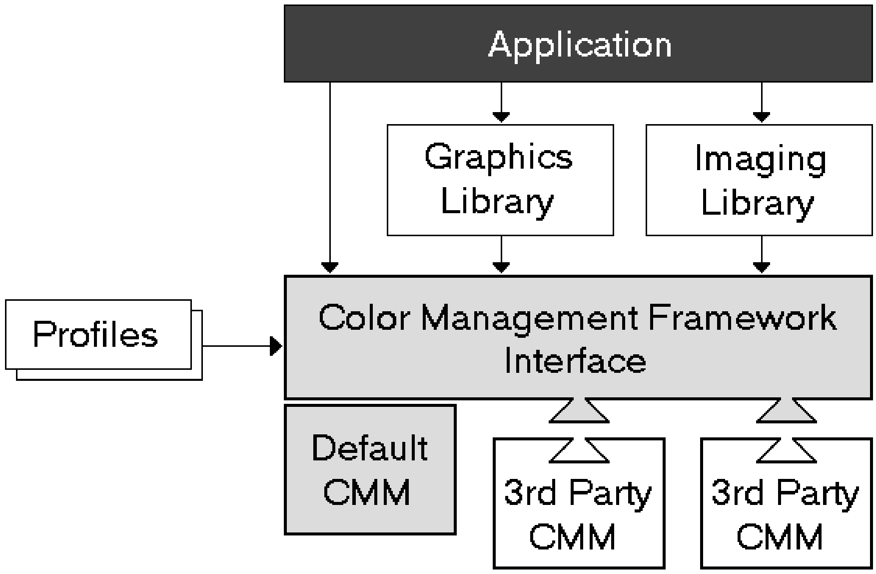

Figure 4 — Colour management architecture

0.6 Profile element structure

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

The required tags provide the complete set of information necessary for the default CMM to translate colour information between the Profile Connection Space and the native device space. Each profile class determines which combination of tags is required.

In addition to the required tags for each device profile, a number of optional tags are defined that can be used for enhanced colour transformations. Examples of these tags include PostScript Level 2 support, calibration support, and others. In the case of required and optional tags, all of the signatures, an algorithmic description (where appropriate), and intent are registered with the International Color Consortium. Private data tags allow CMM developers to add proprietary value to their profiles. By registering just the tag signature and tag type signature, developers are assured of maintaining their proprietary advantages while maintaining compatibility with this International Standard. However, since the overall philosophy of this format is to maintain an open, cross-platform standard, developers are encouraged to keep the use of private tags to an absolute minimum.

0.7 Embedded profiles

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

0.8 Other profiles

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

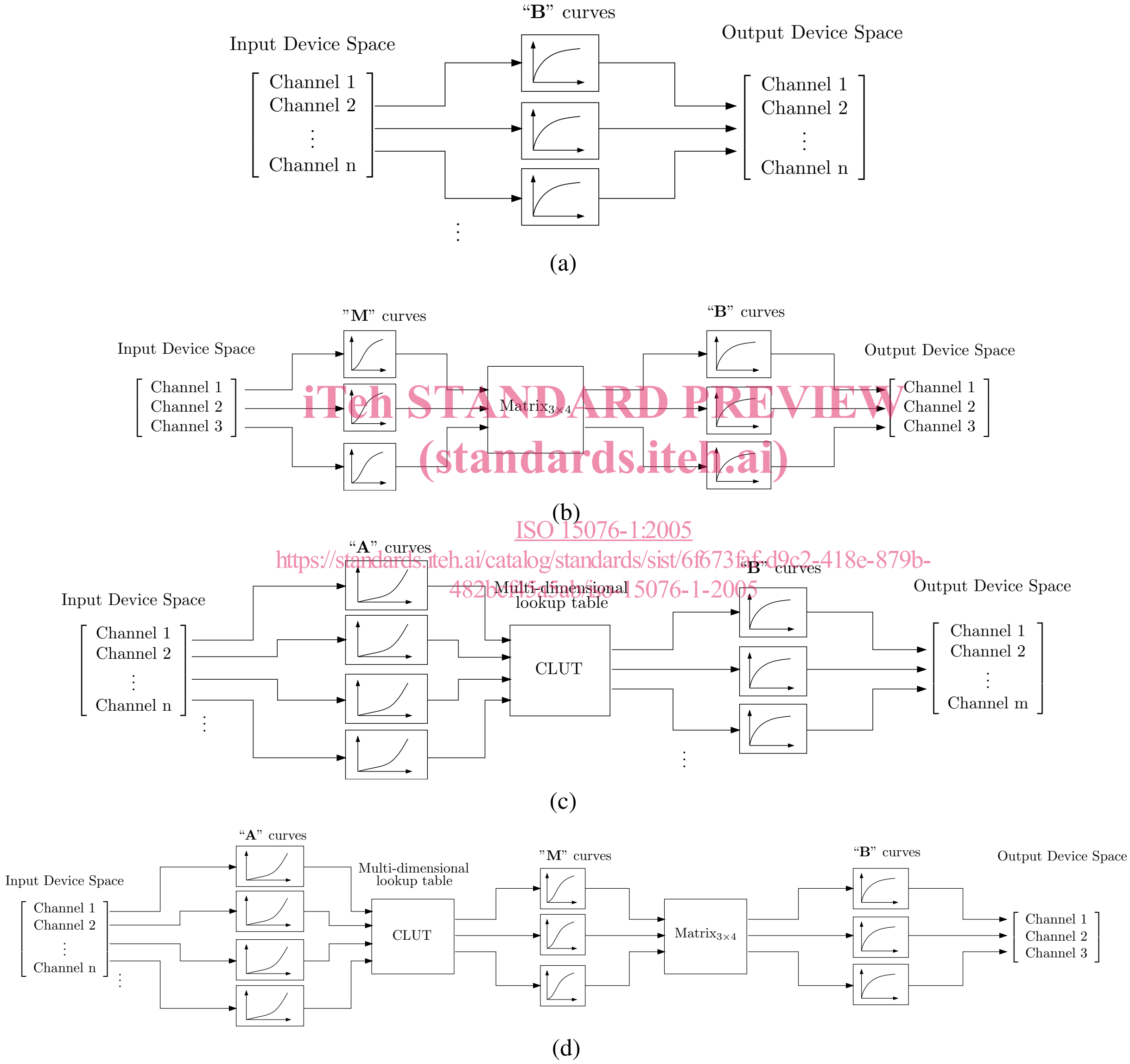

Figure 5 — Examples of converting a colour from device to device using a DeviceLink profile. (a) TRC model (b) Matrix/TRC model (c) CLUT, plus TRC model (d) CLUT, plus matrix, plus CRT model. Only (a), (c) and (d) can be used if the device space has more than 3 components/colour.

ColorSpace conversion profiles provide a transformation between a non-device colour space and the PCS, which can prove useful in workflows in which reference colour spaces different from those selected by ICC are utilised. Abstract profiles are defined from PCS to PCS and enable colour transformations to be defined that provide some specific colour effects. Named Colour profiles provide a mechanism for specifying the relationship between device values and the PCS for specific colours, rather than for general images

0.9 Organizational description of this International Standard

This International Standard addresses a very complex set of issues and the organization of this document strives to provide a clear, clean, and unambiguous explanation of the entire format. To accomplish this, the overall presentation is from a top-down perspective, beginning with the summary overview presented above, followed by the necessary background information and definitions needed for unambiguous interpretation of the text. A description of the Profile Connection Space and Rendering Intents is then provided before continuing down at increasing levels of detail into a byte stream description of the format. Clause 6 describes the Profile Connection Space and Rendering Intents; clause 7 describes the structure of the various fields required in a profile; and clause 8 describes the content of the required tags for each profile class. Clause 9 lists the various tag types (optional and required) and briefly summarises the function of the tag as well as listing the signature and allowed tag types for each. The tag types are defined in clause 10. Annex A provides additional information pertaining to the colour spaces and rendering intents used in this International Standard while Annex B provides the necessary details to embed profiles into PICT, EPS, TIFF, and JFIF files. Annex C provides a general description of the PostScript Level 2 tags used in this International Standard while Annex D provides some background material on the Profile Connection Space. Annex E provides additional information pertaining to Chromatic Adaptation and the chromaticAdaptationTag while Annex F describes some the computational models assumed in this International Standard. Annex G summarises in tabular form the required tags for each profile class as specified in clause 8.

0.10 Patent statement

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the outputResponseTag, (support of the outputResponseTag is optional), given in subclause 9.2.27. ISO takes no position concerning the evidence, validity and scope of this patent right. Eastman Kodak Company, the holder of this patent right has assured the ISO that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from Eastman Kodak Company, 343 State street, Rochester, NY 14650.

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

Part 1:
Based on ICC.1:2004-10

1 Scope

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

NOTE The technical content of this document is identical to that of ICC.1:2004-10.

2 Compliance and registration

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

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

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

3 Normative references

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

ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*

ISO 639-1:2002, *Codes for the representation of names of languages — Part 1: Alpha-2 code*

ISO/IEC 646:1991, *Information technology — ISO 7-bit coded character set for information interchange*

ISO 3166-1:1997, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

ISO 3664:2000, *Viewing conditions — Graphic Technology and Photography*

ISO 13655:1996, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

IEC 61966-2-1 (1999-10), *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space — sRGB*