TECHNICAL SPECIFICATION

ISO/TS 21830

First edition
2018-09

Image technology colour management — Black point compensation for n-colour ICC profiles

Technologie de l'image — BPC pour profil à n couleurs

Reference number
ISO/TS 21830:2018(E)

Contents

Page

Foreword

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

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Introduction

The xCLR ICC profiles that are used in digital printing applications are often CMYK ICC profiles extended with red, orange, green, blue and/or violet colourants. Hence there is a need to specify black point compensation (BPC) for a well-defined class of xCLR ICC profiles, where xCLR refers to a device-dependent colour space defined in ISO 15076-1 and ICC.1:2001-04, specified for 3 to 15 device colourants wherein the value of x is a hexadecimal digit within the range 3 to F inclusive. Such xCLR ICC profiles are also commonly referred to as n-colour profiles.

To guarantee continuity of the black point compensation procedure between CMYK devices and printing devices with extended colourant sets, xCLR ICC profiles follow the constraints and calculation of output-capable CMYK ICC profiles wherever possible, as specified in ISO 18619:2015.

Limiting xCLR ICC profiles to CMYK plus combinations from the set of red, orange, green, blue and violet colourants is a logical extension of the CMYK colourant set to enhance the printing gamut as applied in digital print. Some of the key additional assumptions which will likely result in predictive and expected behaviour for black point compensation calculations include:

— in a similar fashion to most CMYK colourants, the colourants chosen for use with the xCLR ICC profiles should result in a colour gamut featuring a large range of neutral colours;

— the physical colourants should be sufficiently transparent with well-saturated CMY primaries in order to keep the gamut shell well-formed and permit the black point compensation algorithm to work correctly;

— a well-behaving forward model can be constructed near the darkest neutral, with a well-defined darkest colour, thus guaranteeing a good approximation using curve-fitting as defined by ISO 18619:2015, 4.2.5.5.

In the case of 4CLR ICC profiles, which are constrained by ISO 15076-1 as well as ICC.1:2001-04 to not refer to CMYK device-dependent colour spaces, the 4CLR colour space should behave similarly to CMYK device-dependent colour spaces, and conforms to the requirements defined by the key assumptions given above for other xCLR ICC profiles.

An additional class of xCLR ICC profiles for consideration by this document are 3CLR and CMY ICC profiles. For 3CLR ICC profiles, the colourants should be CMY-like in the sense of being chromatic colourants with widely-spaced hue angles (as distinct from achromatic colourants such as grey or black). As a result, BPC for 3CLR ICC profiles is defined by this document, and follows the same approach as for CMY ICC profiles.

The BPC method described in this document does not give meaningful results for most 2CLR ICC profiles, hence these types of ICC profiles are excluded from this document.

In addition, this document extends the BPC method for the ICC v4 profile types with the device-dependent colour spaces described above for corresponding ICC v2 profiles as defined by ICC.1:2001-04.

The black point compensation procedure defined in ISO 18619:2015 is specified for ICC profiles with data colour spaces Gray, RGB, CMYK and CIELAB, as identified in 15076-1. As an increasing number of output ICC profiles for digital printing applications are available with more than four colourants, there is a need to extend black point compensation to n-colour ICC profiles, also referred to as xCLR or extended process ICC profiles.

Image technology colour management — Black point compensation for n-colour ICC profiles

1 Scope

This document specifies a procedure, including computation, for extending the method described in ISO 18619:2015 to n-colour ICC profiles specifically for the xCLR cases where the colourants are either CMYK plus combinations from the set of red, orange, green, blue and violet or where, for the 3CLR case, the colourants are CMY-like chromatic colourants with widely-spaced hue angles. Other types of colour spaces which are otherwise permitted by 15076-1, such as 2CLR (two-device colourants), are not addressed by this document.

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 18619:2015, *Image technology colour management — Black point compensation*

3 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
output-capable xCLR ICC profile
ICC profile containing a transform from the ICC PCS encoding to the xCLR data colour space encoding, where xCLR refers to one of the ICC profile colour spaces where *x* is hexadecimal 3 to F

4 Extension of black point compensation to n-colour ICC profiles

4.1 Constraints

In this document the black point compensation procedure is extended to ICC v4 profiles conforming to ISO 15076-1 and ICC v2 profiles conforming to ICC.1:2001-04 with the following characteristics:

— the ICC profile class is one of Input, Display, Output or ColorSpace;

— the ICC profile data colour space is one of Gray, RGB, CMYK, or xCLR;

— the ICC profile includes a lut-based transform from the ICC PCS encoding to the colour space encoding;

— the data colour space xCLR has a minimum of three channels.

Black point compensation per this document may be applied to a colour conversion where

— the *SourceProfile* and the *DestinationProfile* are conforming xCLR ICC profiles per this document or ICC profiles that meet the requirements of ISO 18619:2015;

— the rendering intent shall be one of relative colorimetric, perceptual or saturation.

The limitations mentioned on xCLR ICC profiles to be used with black point compensation imply that the subset of vertices (V) does not need to be defined. This set is required if the ICC profile is used as SourceProfile and does not contain a transform from the ICC PCS encoding to the colour space encoding.

In general, the black point compensation procedure results in a desired contrast reproduction for colour gradations if the combination of three or more colourants form a relatively dark neutral colour. For printing devices this condition is typically obtained by making use of a CMY colourant set, often extended with a black colourant. Hence, in this extension the minimal dimension of the xCLR data colour space considered is 3 whereas the maximal dimension is 4 + *m*, allowing a CMYK process to be extended with *m* additional colourants.

These *m* additional colourants should be drawn from a subset of red, orange, green, blue and violet. In order for the black point compensation algorithm to work correctly, the colour vectors of the colourants should be orthogonal. In practice, this means that the set of colourants should not include combinations such as both heavy and light cyan, heavy and light magenta or heavy and light black. Only one colourant of such heavy/light sets should be included in the set of colourants which form the process colour space.

As a consequence, it is assumed that a 3CLR ICC profile is a CMY-like colour device, so as a best practice of assigning colour spaces to the ICC profile, its data colour space should be replaced by the colour space CMY. A 4CLR ICC profile on the other hand is assumed to behave as a CMYK ICC profile, so as a best practice of assigning colour spaces to the ICC profile, in this case preferably CMYK is used as the data colour space. xCLR ICC profiles with more than four channels should contain a CMYK-like subspace. The remaining channels are typically limited to a subset of the set red, orange, green, blue and violet. Preferably the red, orange, green, blue and violet colourants are outside the gamut of the CMYK colourant subset of the xCLR ICC profile. Red and orange are defined here as colours between magenta and yellow, green as a colour between yellow and cyan, and blue and violet as colours between cyan and magenta.

In the same way as for CMY and CMYK processes, the colourants of a xCLR ICC profile should be sufficiently transparent, which helps to ensure that the forward model of the ICC profile will be well-behaved to allow the black point compensation algorithm to work correctly. In a similar fashion, the colourant set should not contain a white colourant, which is typically opaque.

4.2 Computation

4.2.1 General

Black point compensation is applied according to the outline specified in ISO 18619:2015, 4.2.1. The algorithm for computing black point compensation and terms not explicitly defined in this document are defined in ISO 18619:2015.

In brief, these steps are:

1) calculation of the *SourceBlackPoint* of the *SourceProfile*;

2) calculation of the *DestinationBlackPoint* of *DestinationProfile*;

3) a mapping from *SourceBlackPoin*t to *DestinationBlackPoint* as specified in ISO 18619:2015, 4.2.6.

4) applying the mapping in a colour conversion as specified in ISO 18619:2015, 4.2.7.

As only the first two steps depend on the data colour space, only the calculation of *SourceBlackPoint* and *DestinationBlackPoint* needs to be specified for xCLR ICC profiles.

NOTE As in ISO 18619:2015, *SourceBlackPoint*, *DestinationBlackPoint* and other colour space coordinates are all coordinate triplets defined in the L*a*b* coordinate space.

As ISO 18619:2015 explicitly defines algorithm steps for only Gray, RGB, and CMYK ICC profiles, it is necessary to expand the language in the algorithm description to also allow for xCLR ICC profiles. In general, this should be implemented by interpreting all instances where the algorithm in ISO 18619:2015 refers to calculations made for "CMYK" ICC profiles to be "CMYK or xCLR" ICC profiles. There are only two subclauses where this replacement is relevant and necessary: ISO 18619:2015, 4.2.3 and ISO 18619:2015, 4.2.5.2.1. The relevant subclauses are reproduced below indicating the explicit changes required to allow black point compensation for the type of xCLR ICC profiles defined in this document to be calculated.

4.2.2 Computing the SourceBlackPoint

The *SourceBlackPoint* is computed by first defining *LocalBlack* of *SourceProfile* and then using this to compute the *SourceBlackPoint*.

A *LocalBlack* value for the source colour space is defined as follows:

— If *SourceProfile* is an output-capable CMYK or xCLR ICC profile,

  — *LocalBlack* shall be set to **T** ((0, 0, 0), *LabIdentityProfile*, *SourceProfile*, *Perceptual*).

— If *SourceProfile* is not an output-capable CMYK or xCLR ICC profile,

  — If the data colour space of *SourceProfile* is CIELAB,

    — *LocalBlack* shall be set to (0, 0, 0).

  — If the data colour space of *SourceProfile* is Gray, RGB, CMYK, or xCLR,

    — LocalBlack shall be set to **D** (*SourceProfile*, *RenderingIntent*).

The *SourceBlackPoint* is then calculated as follows:

— *Li* shall be set to the L* component of **T** (*LocalBlack*, *SourceProfile*, *LabIdentityProfile*, *RenderingIntent*).

If *Li* is greater than 50,

— *SourceBlackPoint* shall be set to (50, 0, 0),

else

— *SourceBlackPoint* shall be set to (*Li*, 0, 0).

4.2.3 InitialLAB Calculation

If *RenderingIntent* is not RelativeColorimetric, then *InitialLab* shall be set to (0,0,0), else *InitialLab* should be calculated as follows:

LocalBlack = **T** ((0,0,0), *LabIdentityProfile*, *DestinationProfile*, *Perceptual*)

InitialLab = **T** (*LocalBlack*, *DestinationProfile*, *LabIdentityProfile*, *RenderingIntent*)

a* and b* components of *InitialLab* shall be set to 0.

If the L* of *InitialLab* exceeds 50, then the L* component of *InitialLab* shall be set to 50.

