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# Graphic technology — Printing from digital data across multiple technologies —

## Part 1: Principles

*Technologie graphique — Impression à partir de données numériques via des technologies multiples —*

*Partie 1: Principes*



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# Foreword

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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*.

This first edition of ISO 15339-1 cancels and replaces ISO/PAS 15339-1:2015, which has been technically revised.

The main changes are as follows:

— the normative references have been updated;

— former subclause 5.4.2 on tolerances has been deleted;

— former Annex B, Tolerancing schema, has been deleted and subsequent annex has been relabelled;

— published as an International Standard.

A list of all parts in the ISO 15339 series can be found on the ISO website.

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

# Introduction

This document is based on the premise that in the printing and publishing industries, electronic data are the intermediary for content storage and exchange throughout production including file preparation, job assembly, proofing, and process colour printing. It further assumes that data preparation can be largely process independent and that choice of the printing process or processes to be used for final production will be based primarily on run length requirements and substrates to be used. There are various tools in place to both define the relationship of digital data to printed colour for specific instances of printing and to manipulate data such that similar results can be obtained between and among different printing processes (see ISO/TS 10128). These specific instances of printing are typically described by colour characterization data.

When producing printed colour reproductions, it is important that the organizations responsible for material preparation, colour separation, proofing, and printing all working to a common set of parameters that uniquely define the intended visual characteristics of the final printed product. Such an agreement enables the correct production of suitable input data and subsequent production of proofs from these data. The purpose of a proof is to simulate the visual characteristics of the finished print product as closely as possible prior to production printing.

There is a unique relationship between ink, substrate, and printing process that limits the maximum chroma of the solids of the printing colorants and therefore limits the range of colours (colour gamut) that can be achieved for particular combinations. While special inks can be used, the commonly available ink pigments are used across all traditional ink processes. While toner and ink-jet systems have different colorant constraints than traditional ink processes, they tend to mimic traditional ink process aims and they will be treated as a variation of traditional ink processes. The achievable chroma range (gamuts) of ink-on-paper characterized reference printing conditions can generally be bracketed between cold-set printing on newsprint on the small end and by printing on gloss coated stocks (by a variety of processes) on the large end. Between these limits there is significant overlap of process/substrate combinations. The number of intermediate characterized reference printing conditions that are logical to define between smallest and largest is in part a function of the tolerances to which printing is expected to conform to the intended characterized reference printing condition. However, the intermediate characterized reference printing conditions also need to represent common widely used printing.

A colour characterization data set is required for each characterized reference printing condition specified. Because the intent of this document is that the data sets provided can be used as the reference for any printing process, they might not be aligned with the typical TVI and trapping associated with any specific printing process. The values selected need to represent in effect virtual printing on a virtual printing system.

It is important to realize that digital data can be encoded as already separated CMYK or can consist of un-separated data (typically in an RGB colour space) with supplementary information (ICC colour profiles, etc.) defining the colour intended on the printed sheet. Such unseparated data plus the associated supplementary data are sometimes referred to as “virtual CMYK” data. All data are encoded according to one of the PDF/X specifications (see the ISO 15930 series) to allow the necessary metadata which identifies the intended characterized reference printing condition to be included.

The colour of the printing substrate is a critical component of the colour appearance of a printed image (it behaves like a 5th colour). For halftone images, the colour of the substrate contributes mostly in the area not covered by ink. ISO 15339 is based on the assumption that the colour characterization data can be adjusted (fine-tuned) for the range of normal substrate colours expected and that different characterized reference printing conditions are not required for moderate differences in substrate colour.

Modern characterization data and profile evaluation tools allow identification of the colour of the solids, the colour and tone values of the single colour scales, and the CMY values associated with the neutral (achromatic) tone scale. Using the values derived from the colour characterization data for one printing process when printing on a printing process with substantially different characteristics, is the recommended input for process control aims used to conform to a particular characterized reference printing condition.

Annex B provides a description of the process independent workflow that is the basis for the concepts embodied in ISO 15339.

# Graphic technology — Printing from digital data across multiple technologies —

# Part 1: Principles

## 1 Scope

This document establishes principles for the use of colour characterization data as the definition of the intended relationship between input data and printed colour for file preparation, job assembly, proofing, and graphic arts production printing. It specifies the procedure used to adjust colour characterization data for the normally expected range of substrate colour.

## 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 12642-2, *Graphic technology — Input data for characterization of 4-colour process printing — Part 2: Expanded data set*

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

ISO 15930 (all parts), *Graphic technology — Prepress digital data exchange using PDF*

## 3 Terms and definitions

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

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

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

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

**3.1**
**colour characterization data**
tabulation of data that represents the relationship between device code values (e.g. CMYK) and the colour (CIELAB) produced or intended to be produced on the printed sheet

Note 1 to entry: Where such a set of colour characterization data are used as a reference, it is referred to as a characterized reference printing condition (CRPC).

**3.2**
**colour profile**
set of transforms, encoded according to the rules of ISO 15076-1, that convert data between (to and from) device space and profile connection space

Note 1 to entry: The transforms contained within a colour profile can include manipulation of gamut compression/expansion, tone reproduction, colour separation, black generation, printing limitations (e.g., total area coverage), etc.

**3.3**
**colour gamut**
region of CIELAB colour space containing all printable colours

Note 1 to entry: For comparison purposes, the CIELAB values of the primaries and secondaries along with the substrate are often an adequate, if sparse, definition of a colour gamut. The surface values of the measurements of a target such as that included in ISO 12642-2 can provide a more complete definition.

**3.4**
**characterized reference printing condition**
**CRPC**
*identified printing condition* (3.4) and associated *colour characterization data* (3.1) intended for use with multiple printing processes

**3.5**
**process independent**
independent of the printing process (offset, flexography, gravure, digital, etc.), to be used for production of printed material

**3.6**
**identified printing condition**
printing condition documented in a national or international standard or industry publication in a way that allows it to be replicated by an industry practitioner

# 4 Requirements

## 4.1 Principles and assumptions

One of the key principles upon which this document is based is that colour content data can be adjusted such that any printing processes capable of achieving a specified colour gamut can produce the within-gamut image colours specified by the appropriate reference colour characterization data. This allows printing aims to be process independent.

A second principle is that process control aims and tools should be based on (extracted from) the reference colour characterization data selected and not based on a priori assumptions. Many of the parameters used in process control such as tone value increase, grey balance, etc. are contained within, or can be derived from, the colour characterization data chosen as a reference. Local site tools can also be used for initial setup processes where these are based on the known differences between the colour characterization data aims and the colour characterization of the actual printing system being used. The aim values extracted from characterisation data should match or be aligned with the aim values specified in the appropriate part of ISO 12647 when printing using the process from which the characterisation data was derived. Where this is not the case, the process control principles and tolerances should still be used.

NOTE 1 The ISO 12647 series specifies process control aims and requirements. When aim values extracted from characterisation data meet the requirements of the applicable part of ISO 12647, conformance with both standards is possible.

Where similar characteristics, such as tone reproduction, are desired between different characterized reference printing conditions (different colour gamuts), these shall be built into the colour characterization data associated with these characterized reference printing conditions. Characterized reference printing conditions, and their associated colour characterization data, can be thought of as a virtual printing system (press) and as such the characterization data can be manipulated mathematically to fine tune results to achieve smoothness, uniformity and/or other characteristics.

NOTE 2 The key requirement for successful application of these principals is that the reference colour characterization data and the characterization data for the printing system being used shall have the same gamut and be sufficient to allow the necessary data adjustment. See ISO/TS 10128 for recommended procedures to implement such data adjustment.

## 4.2 Data encoding

In the absence of other prior agreement, the electronic colour content data to be used as the intermediate storage and exchange media between file preparation, job assembly, proofing, and printing shall be encoded in accordance with one of the ISO 15930 series. Any deviation from this, such as encoding in ISO 12639 or in some other format, and shall include communication of the reference characterization data of the intended printing condition and, as necessary, a colour profile to transform any data not supplied in the process colour model of the reference.

## 4.3 Data preparation

All print elements shall be prepared either as device code values or as colorimetrically defined data. However, both types of data if present in print elements shall be prepared for a single characterized reference printing condition. This condition shall be provided in the PDF/X output intent in the case of an ISO 15930 exchange or shall be communicated by mutually agreed upon methods in other situations. Unless otherwise agreed between sender and receiver, the characterized reference printing condition shall be a data set defined in a publicly available characterization data registry.

## 4.4 Characterized reference printing conditions and colour characterization data

For alternate printing processes that do not use colorants that align with the hue angles of a characterization data set, the colour values may be simulated by the appropriate combination of the colorants available, assuming the colour gamut of those colorants encompasses the gamut of the characterized reference printing condition selected. For convenience this document will continue to refer to single-colour solids, two-colour overprints, etc. recognizing that alternate printing systems may simulate these values using appropriate combinations of available colorants. ISO/TS 10128 provides methods to align files to the reference printing conditions. ISO/TS 18621-11 provides procedures for comparing sample data to the reference dataset.

All colorimetry shall be measured according to ISO 13655. Measurement conditions of M0/M1/M2 and backing material shall be recorded within the characterized reference printing conditions.

## 4.5 Use selection criteria for choice of characterized reference printing condition

It is anticipated that the printing industry (with support from the ink and paper organizations) will begin to develop tables of substrate types and printing processes that will support and/or be most appropriate for each of the characterized reference printing conditions. Where reproduction of the same content is required by more than one process or on more than one substrate, a gamut common to the multiple needs should be selected. Where only a single substrate and printing system is required, the typical choice should be the largest gamut that choice will support.

The chosen characterized reference printing condition shall be used as the basis for design and content creation.

Communication of the intended printing condition between all parties (preparation, proofing, and printing) only needs to identify reference characterization data to be used along with information relating to any limitations of the intended printing process that should be considered during preparation, proofing, or printing.

Not all printing processes that can achieve the same colour gamut are subject to the same limitations. Offset, gravure, flexography, electrophotographic, inkjet, etc., each have limitations that should be considered in the final data preparation for printing. These typically include limitations of total ink coverage, minimum and maximum printable dot sizes, etc., therefore gamut alone cannot be used to select a characterized reference printing condition (CRPC).

## 4.6 Adjustment of data for substrate colour differences

The substrate colour is identified in the characterization dataset or ICC profile, in case of multiple substrate entries in the dataset the average value should be used.

Where the printing substrate to be used has a colour that differs from that of the reference printing condition selected for data preparation and data exchange, correction of the data for such differences can be beneficial. The use of a single method to accomplish correction enhances the ability of different users to achieve similar results. Annex A provides one conversion method that produces reasonable results for halftone type images. Where substrate adjustment is done, the method used (if other than Annex A), and the values of the intended substrate shall be communicated to all involved. In all cases the colour of the assumed black point used in the calculation shall be communicated.

Where the printing substrate to be used has a colour that differs from that of the reference printing condition selected for data preparation and data exchange by less than 2 CIEDE2000 units the user can elect to use the data without modification.

Where the printing substrate to be used has a colour that differs from the characterized reference printing condition selected for data preparation and data exchange by more than 2 but less than 5 CIEDE2000 units the method defined in Annex A (see also ISO 13655) should be used to adjust the data before proofing and printing.

Where the difference in substrate colour is greater than 5 CIEDE2000 units, this correction may be used but the user is cautioned that special colour characterization data might be required.

When data adjustment is done using the tristimulus correction technique defined in Annex A, the colour values of all data points in the colour characterization data set are changed, including the aim values for the single colour solids.

Where characterization data are exchanged that has been modified for changes in substrate colour, it can no longer be simply referenced as *ISO/PAS 15339, CRPCx*. Where the exchange between participants is not a blind exchange, agreements concerning the substrate to be used and the substrate correction can be exchanged and included in private metadata. For blind, exchange it can be treated as an alternate printing reference (see 4.7).

### 4.7 Alternate printing reference

Where one of the sets of reference colour characterization data defined in the ICC characterization data registry[1)] is appropriate for the intended printing condition because of the inks, paper, or printing process to be used, all parties involved before file preparation work is started and the colour characterization data to be used and any colour management profiles shall be communicated with the job content files.

### 4.8 Colour profiles

The use of colour profiles is an important part of the data preparation process and colour profiles with specific characteristics are often specified by industry trade associations to restrict and provide more commonality in user input. It is important that colour characterization data and colour management profiles are not confused. While profiles are based on characterization data, they also contain additional data processing information. Profiles are required when data are transformed into, or from, CMYK and other working colour spaces. According to ISO 15076-1, an output device profile is required to contain tags that define the transforms between profile connection space and the device values (and reverse) for perceptual, saturation, and colorimetric intents. In addition, the transforms include gamut mapping, colour separation methodologies, tone reproduction, and process limits such as tone value sum. These determine the device-space values that will be created from input data linked through profile connection space.

## 5 Preparations for printing

### 5.1 General

Although printing is considered to be the responsibility of the local facility, some basic principles are important and represent a change from traditional practices used before the widespread availability and use of electronic data for content interchange.

1) Available from https://www.color.org/chardata/drsection1.xalter

In general, the major steps in printing from characterization data are:

1) Optimize the printing system performance to be as stable as possible to the gamut of the characterized reference printing condition.

2) Determine the colour characterization of the printing system at the intended gamut.

3) Determine the content data adjustment required to allow printing system operating in a stable mode to match the input data to printed colour relationship defined by the selected CRPC. See ISO/TS 10128 for further guidance.

4) Maintain the performance of the running printing system consistent with conditions that produced the colour characterization data in step 2) using appropriate process control tools.

5) If necessary, provide job content specific adjustments as temporary variations of step 4).

NOTE Additional information for process control print processes can be found in the ISO 12647 series.

## 5.2 Printing to intended gamut

At this step in the press preparation, stable printing at the intended gamut is the most important criteria.

The goal is that the apexes of the outer gamut of the printing system to be used match the apexes of the characterized reference printing condition. Where hue differences of the colorants make this impossible, the usual procedure is to adjust the printing system so that the apexes of the characterized reference printing condition are contained within the outer gamut of the printing system. In this way, it is possible to print the values at the apex of the CRPC using colour management or other techniques.

NOTE A spreadsheet is available at https://standards.iso.org/iso/15339/-1/ed-1/en which extracts process control aims from a characterization data set and performs calculations related to substrate correction.

Where none of the data sets in the ICC characterization data registry[16] are appropriate for the intended printing because of the inks, paper, or printing process to be used, a user selected printing condition should be used. The colour characterization data of the selected printing condition shall be used to define the gamut and other printing parameters. The data points of the ISO 12642-2 target and the CRPC data that define important colours affecting the printing gamut in CIELAB are listed in Table 1.

**Table 1 — ISO 12642-2 target data points that identify important colours affecting the printing gamut**

| Colour | Patch ID number | Tone value % | | | |
|---|---|---|---|---|---|
| | | Cyan | Magenta | Yellow | Black |
| **Paper** | 1 | 0 | 0 | 0 | 0 |
| **Cyan** | 73 | 100 | 0 | 0 | 0 |
| **Blue** | 81 | 100 | 100 | 0 | 0 |
| **Magenta** | 9 | 0 | 100 | 0 | 0 |
| **Red** | 657 | 0 | 100 | 100 | 0 |
| **Yellow** | 649 | 0 | 0 | 100 | 0 |
| **Green** | 721 | 100 | 0 | 100 | 0 |
| **Black** | 1260 | 0 | 0 | 0 | 100 |
| **3-colour solid** | 729 | 100 | 100 | 100 | 0 |
| **4-colour solid** | 1286 | 100 | 100 | 100 | 100 |

## 5.3 Determine colour characterization

Once the conditions that achieve the desired gamut and also represent a repeatable and stable printing condition are established, the ISO 12642-2 colour characterization target and any other process control elements to be used shall be printed.

It is important that the test targets and process control elements are similar to the image structure of the intended work. For offset this includes colour separation, screening, and tone value sum. For gravure, the cylinder engraving parameters are critical. For flexography, the engraving of the ink transfer rollers plays a key role. Both industry trade associations and industry groups provide guidelines that facilitate consistent work across various classes of printing.

The test printing condition (including printing forme making and any other imaging transfer step) should not include any adjustment curves or other data manipulation. The plate-making conditions shall be repeatable and all data necessary to allow consistent making of plates to the same tonal conditions shall be recorded.

The colorimetric values of the appropriate patches of the ISO 12642-2 target shall be measured. One of the three procedures described in ISO/TS 10128 should be used to determine the data adjustment necessary to allow the selected printing condition to create printed images that are close to the corresponding values in the reference colour characterization data.

If used, these data adjustments (single channel curves or multi-dimensional transforms) shall be recorded and used to prepare subsequent work for that aim condition.

## 5.4 Maintain running characteristics of the printing device — Tools and procedures

Once the preferred operating condition of a printing device is determined colorimetrically, it often makes more sense to use traditional process control tools to maintain those conditions. Density, TVI, grey balance, etc. can be more sensitive tools and more familiar to the operators involved. The printing of the intended process control elements along with the colour targets allows these to be measured with other instrumentation (e.g., densitometers, dot meters, etc.) to establish aims in these data spaces for subsequent process control.

Such process control is not part of ISO 15339 but is the responsibility of the printing establishment involved.

## 5.5 Job content specific adjustments

Within the printing industry, it is not unusual for a customer to require colour adjustment beyond that defined by the selected colour characterization data. This can be required to achieve a closer match to physical references, products, or simply buyer preferences. This is often referred to as the OK press sheet. This cannot be avoided.

Where the values defined in the agreed upon characterized reference printing condition are changed based on buyer instructions, the values used shall be recorded.

# Annex A
(informative)

# Correction of colorimetric data for variation in substrate colour

Although there are a number of computational techniques used or proposed for the correction of colorimetric data for variation in substrate colour, the consistent use of a single method enhances the ability of different users to achieve similar results.

One conversion method that produces reasonable results for halftone type images is based on the observation that if the differences of CIE X, CIE Y, and CIE Z between measurements made of identical images on substrates having different colours are plotted versus CIE X, CIE Y, and CIE Z for measurements on either substrate, the best fit result is approximately a straight line. This leads, as an approximation, to a linear conversion as shown in Formulae A.1 and A.2.

For CIE X:

$$X_c = X_d \times (1 + C) - X_{min} \times C \quad \text{(A.1)}$$

with

$$C = \frac{X_{sc} - X_{sd}}{X_{sd} - X_{min}} \quad \text{(A.2)}$$

where

$X_d$ is the value of $X$ of a colour in the data set;

$X_c$ is the computed value of $X$ of the colour on the printing substrate;

$C$ is a constant;

$X_{sd}$ is the value of $X$ of the substrate in the data set;

$X_{sn}$ is the value of $X$ of the printing substrate;

$X_{min}$ is the minimum value of $X$ in the data set.

In practice, the X, Y and Z values of the 4-colour solid (ID 1286 in ISO 12642-2) are very close to, or equal to, the minimum values and may be used as a reference black point.

Conversion of CIE Y and CIE Z is accomplished in an analogous manner and new CIE L*, a* and b* CIELAB values are computed.

This colorimetric conversion method is referred to as the tristimulus correction method.

NOTE 1 This is similar to, but not necessarily identical to, the International Color Consortium method referred to as media relative colorimetric transforms.

To use this method to adjust M0 data to approximate M1 data, it is necessary to have a valid M1 measurement of the substrate. The method does not correct all of the effects of the fluorescence from the substrate in a halftone print but it does compensate for the majority of the errors.

NOTE 2 Printing substrates vary not only in colour but also in physical properties. Changes in physical properties impact ink/substrate interaction and light scattering. Changes in ink/substrate interaction and light scattering often result in changes in the tone values of the printed material for the same ink laydown. Therefore, a change in a printing substrate usually requires changes in colorimetric aims (due to paper colour) and changes in tone reproduction and process control aims to correct for the changes in tone value (resulting from changes in physical characteristics). The correction technique described in this Annex only accounts for the changes in substrate colour.

NOTE 3 A spreadsheet which performs these calculations is available at https://standards.iso.org/iso/15339/-1/ed-1/en.