
**Graphic technology — Guidelines and
recommendations for multicolour
(CMYKOGV) print characterization**

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

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

Multicolour process packaging printing

Print technology and quality has improved in the past decades. Mechanical print characteristics perform at a higher level, as have customer expectations. For cyan, magenta, yellow, and black (CMYK), colour standardization has been adopted and customers expect a specific colour gamut and conformance to a characterization data set when printing with CMYK. The result of technology integration in all print processes has provided improvement in productivity and print quality. The research of Neugebauer (1937)^[18], Murray (1936)^[17], and Yule (1967)^[22] presented a view of colour reproduction, which has evolved from imaging systems based on silver halide photography technology leading to today's digital pixel-by-pixel access to colour image data.

Print systems have also evolved from four-colour (CMYK) on four unit presses to CMYK plus additional colours as noted in research and recognized patents. Often called multicolour process printing (MCP), additional terms used are Extended Colour Gamut (ECG) printing, Expanded Gamut Printing (EGP), Fixed-palette (FP) printing, N-colour printing, High-Fidelity (HiFi) printing. Examples of research include Kueppers (1989), Mills Davis/HiFi project (1991), Ostromoukhov^[20], Boll^[9], Mahy & De Baer^[16], Bernasconi (1998), Herbert and DiBernardo (1998), Lo (1997), Viggiano and Hoagland^[21], and Ingram and Simon^[14]. In most of these references, additional colours were added to enhance image elements of the selected CMYK ink set. Viggiano and Hoagland provide methodology for colourant selection. Package printing often requires spot colours to be matched to aims within tolerances, with colour remaining consistent throughout the print run. This document describes insight concerning the selection of colourants to expand or enhance colour print gamut with orange, green, and violet (OGV) and recommended characterization procedures. The colourant selection may be restricted by the print process characteristics^[12].

Previous efforts recommend adding an ink containing pigment Green, an ink containing Violet, and an ink containing an orange pigment. Due to ink curing systems, difficulty remains making a specific recommendation on a single orange pigment. Clemson University studies by Ingram and Simon^[14], and Zeleznik^[23] were able to recommend Colour Index International (C.I.)^[10] pigment Orange-16 and C.I. pigment Orange-64. C.I. values are a common database reference for manufactured colour products, which can be communicated based upon a specific source. The recommended CMYKOGV pigment set provides increased colour gamut as seen in the colour gamut comparison as follows.

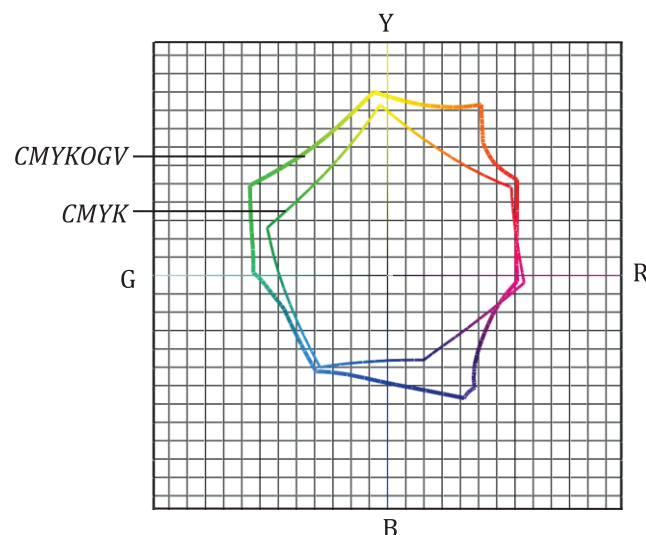


Figure 1 — CIELAB Colour Boundary Comparison of CMYK to CMYKOGV Hue Aims^[15]

Use of a standardized multicolour printing target is required. Previous efforts have used an IT8.7/3 or IT8.7/4 colour characterization target. Four data sets are produced: 1. CMYK, 2. CMVK-complementary substituted ink, 3. CGYK-complementary substituted ink, and 4. OMYK-complementary substituted

ink. The measured spectral data sets were combined to produce a master CMYKOGV data set. A custom seven-colour characterization target may also be used. The colour data set is then analysed to calculate the colour gamut fit. Lastly, a technology capable of producing a compatible ICC n-colour profile is needed to complete a colour-managed workflow utilizing the CMYKOGV data.

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Graphic technology — Guidelines and recommendations for multicolour (CMYKOGV) print characterization

1 Scope

This document provides guidelines and a procedure to generate a multicolour characterization dataset. Specifications for colour printing with CMYK + Orange, Green, and Violet are presented. Also, this document provides a recommendation on CMYKOGV ink pigment selections to produce an optimum colour gamut for specific printing processes or use cases. The recommended CMYKOGV ink pigment selections might not be suitable or available for all printing or digital processes or use cases. The procedure in this document is also applicable for CMYK plus any subset of O, G or V.

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 3664, *Graphic technology and photography — Viewing conditions*

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

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

ISO 28178, *Graphic technology — Exchange format for colour and process control data using XML or ASCII text*

ISO/TS 19303-1, *Graphic technology — Guidelines for schema writers — Part 1: Packaging printing*

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 calibration

comparison and adjustment between printing systems – one of known behaviour or correctness, made with a set of reference colours, and another printing system made to print in as similar a way as possible with the reference device

Note 1 to entry: The G7 methodology is one form of printing system calibration where the reference colours are 3-colour overprints made to match as closely as possible the optical properties of a series of black-only prints.

Note 2 to entry: ISO/PAS 15339-1 describes another process for calibration of a printing system to a Characterized Reference Printing Condition.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

3.2

colour characterization data

tabulation of data that represents the relationship between device code values (e.g. CMYK, CMYKOGV) and the colour (spectral and CIELAB values) produced on the printed sheet by those values in a specific printing process

Note 1 to entry: The colour characterization data may be used to create an ICC profile as in ISO 15076.

3.3

Colour eXchange Format

CxF/X

format for the communication of colour and process control data and the associated metadata for its proper interpretation detailed in ISO 17972-1

Note 1 to entry: For example, CxF/X-1 is used to communicate process colour information and other metadata related to the colour data including tone values, ink amounts and spectral data. CxF/X-4 files are used to communicate spot colour ink data that requires spectral data and transparency metadata.

3.4

hue angle

angular component of the polar representation of a colour based on CIELAB, calculated by $h_{ab} = \arctangent(b^*/a^*)$

3.5

printing condition

set of primary process parameters that describe the conditions associated with a specific printed output and defined colourimetric and/or densitometric aim values

3.6

packaging

process of designing, evaluating, and producing packages

Note 1 to entry: For this document, use of the term specifically refers to the materials used to produce colour graphics and information displayed on the substrate.

Note 2 to entry: Methods for production may include direct printing, lamination, or labels.

3.7

primary process colour

colour that is the outcome of a colour separation process (typically CMYK)

Note 1 to entry: A process colour reproduction typically requires one or more printing units and process inks to be reproduced.

Note 2 to entry: The ink set is specified in the ISO 12647 series.

Note 3 to entry: The colours OGV are typically added in MCPP.

3.8

characterized reference printing condition

CRPC

identified printing condition (3.11) and its colour characterization data used as the aim for a particular printing task (job)

Note 1 to entry: ISO/PAS 15339-1 provides 7 Characterized Reference Printing Conditions (CRPC).

3.9

spot colour tone value

SCTV

value that describes the apparent halftone area for a non-process ink as described in ISO 20654

3.10 multicolour process printing MCP

printing with more than a single colour ink with a multi-unit printing system

Note 1 to entry: It is also called expanded colour gamut printing where process colour printing uses more than 4 primary inks, for example orange, green, and violet inks, so as to increase the volume of colour space which can be reproduced using halftone combinations of the primary plus extra inks.

3.11 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. Also, a set of primary process parameters that describe the conditions associated with a specific printed output and defined colourimetric and/or densitometric aim values

4 Guidelines and requirements associated with specific tasks

4.1 Basic support requirements

4.1.1 Viewing conditions

The viewing and illumination conditions used for visual assessment of printed products shall be in accordance with ISO 3664.

4.1.2 Measurement and colour computation

The measurement of colour shall be made with instruments, standardized according to the manufacturer's guidelines and capable of producing data in accordance with ISO 13655. Further, it is recommended that ISO 20654 should be used to determine tonal values, also CMYK near neutral or TVI methods are applicable. When substrate corrections are necessary, calculations should follow ISO/PAS 15339-1. When the OBA content is high or moderate and the expected viewing condition contains UV, measurements shall be made with M1 measuring mode. When the OBA content is low or faint (i.e. $UV-UVX \leq 8$ when measured D65 Brightness with UV and with UV cut-off filter), M0, M1 or M2 may be used since comparable results are expected. Where the expected viewing condition doesn't contain UV, the use of M2 is recommended.

NOTE When viewing in a UV free environment the use of M2 provides measurements consistent with viewing.

4.1.3 Data evaluation tools

Colour data, resulting from the characterization print run, should be analysed to confirm its fit to the determined colour aims. Software tools for determining these colour differences may include commercial software tools, spread sheets or 3D gamut applications. Tone values for the CMYKOGV ink prints may also be analysed with such tools.

4.2 Colour definition

4.2.1 Process colours

Prior agreement on identified reference printing conditions and their tolerances shall be obtained between all stakeholders of the characterization materials and procedures before beginning characterization work.

In the case of flexographic printing, [Table 1](#) provides an example of the specifications for CMY process colour inks and overprints for flexographic printing. For other printing technologies, refer to the appropriate parts of ISO 12647.

Table 1 — Example metric hue angle (degrees)^a [13]

Colour	Traditional inks	Light-fast inks
Cyan	233°	233°
Magenta	357°	12°
Yellow	93°	100°
Red ^b	36°	40°
Green ^b	160°	162°
Blue ^b	290°	296°

^a Metric hue angles are taken from ISO 12647-6 for primary process colours.

^b Red, Green and Blue are two colour builds from the CMY components (not to be confused with the additional primaries added to the process set).

Stakeholders should determine tolerances based on the printing technology and ink systems used, as specified in the appropriate part of ISO 12647.

4.2.2 Pigment Selection

In ink specification, it is desirable to select pigments that will most likely permit printing the greatest colour gamut, whilst retaining the four primary process colours defined in the appropriate part of ISO 12647. [Tables 2](#) and [3](#) show example of ink pigments, based on colour attributes and printability for analogue printing (offset lithography, flexography, and gravure). Other printing technologies and substrates within the substrate colour range may require different ink selection and hence produce different CMYK and OGV values.

Table 2 — Example colour pigment and hue angle^{[12],[14]}

Cyan - PB 15:3 / 233°	Orange - PO 16 / 54°
Magenta - PR 57:1 / 357°	Orange - PO 64 / 55°
Yellow - PY 14 / 93°	Green - PG 7 / 181°
Black - PB 7 / na	Violet - PV 23 / 310°

Table 3 — Example CIELAB aims for OGV^[12]

Ink	L*	a*	b*	C*	h _{ab}
Orange	70	56	80	98	55
Green	66	-73	-1	73	181
Violet	24	46	-55	71	310

The recommended CMYKOGV ink pigment selections are intended to produce an optimum colour gamut, they might not be suitable or available for all printing processes or use cases.

[Annex C](#) provides guidance for selecting pigments for expanded gamut applications.

4.2.3 Substrate selection

Substrates should be light (typically CIELAB L* > 85) and reasonably neutral (-3 < CIELAB a* < 3, -6 < CIELAB b* < 5).

4.3 Colorimetric/spectral data reporting

Colorimetric data shall be communicated as referenced by ISO 17972-1 Colour eXchange Format or ISO 28178.

4.4 Printing for the development of characterization data

4.4.1 Input data for characterization of multicolour printing

Printing the selected CMYK and OGV inks shall be performed on a verified calibrated device (described in 4.4.2) using a defined multicolour characterization input data set such as the “Global Expanded Colour Gamut (ECG) Characterization Target”. A method for utilizing ISO 12642-2^[8] is also suitable as described by Ingram and Simon^[14].

4.4.2 Printing device setup

Printing devices shall be calibrated and said calibration verified and documented. A near neutral calibration or TVI technology is recommended for press calibration of CMYK colours. For ECG inks, specifically OGV colours, the SCTV based calibration is recommended. In that case a linear (1:1) reproduction is recommended for the SCTV calibration. [Annex A](#) provides an example of process steps to develop characterization data.

4.4.3 Printing device verification

For packaging use case, measurement and documentation referenced in ISO/TS 19303-3^[14] should be consulted for print device verification.

4.4.4 Colour Communication

Print process colour qualification should be made with spectral data measurement described in ISO 13655. For press qualification, given reference Lab values for a specified ink film thickness or ink quantity, control during characterization process can be performed by press operators by CIELAB measurements. Once the colour is correct, maintain with any suitable process control to meet the process colour aims. Colour difference (CIEDE2000) may be used for process control.

Non-CMYK process colour qualification should be made with spectral data measurement. Colour differences may be analysed from colorimetric data derived from the spectral data to determine the precision and accuracy of the results and therefore acceptability of the results.

4.4.5 Verification and reporting

ISO/TS 15311-1^[10] provides details regarding verification and reporting of data for materials. Specifically, the Certificate of Analysis (CoA) and Certificate of Conformance (CoC), as defined in ISO/TS 19303-1^[14], should be used to confirm that the specifications and deviations or tolerances that were agreed upon by all involved suppliers of the characterization data, have been met. For packaging use case, measurement and documentation for the CoA provides all the required specification and test results about a particular material [a description of the test or examination method(s) used; limits of the test or examinations; and actual results of the tests or examinations], to demonstrate that end user/customer requirements are met. The CoC is a document certifies that the supplied services or goods meet the required specifications.

The CoC for materials used in the colour characterization shall be kept on file to be used as reference for communication and confirmation that specified materials were acquired for the colour characterization. Items described include substrate(s), inks, and additives specific to the print process used.