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Graphic technology — Colour conformity of printing workflows

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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

The printing industry comprises a variety of workflows that produce a variety of printed products. For tone and colour reproduction, many ISO standards specify aims and tolerances and they are necessary for the implementation of a colour-managed and standardized workflow.

Even though relevant standards can specify aims and tolerances, the printer's ability to demonstrate conformity of their entire production workflow to these standards often becomes a technical issue as well as a business issue.

Printed colour reproduction quality depends on printing workflow operation. Printing workflow operation is made up of colour definition (what colour to specify), process colour reproduction requirements (what to control) and colour conformity (verify the outcome of the process).

There is a need to provide printers, suppliers, customers and independent bodies with guidelines that will allow them to implement and/or assess a printing workflow in order to achieve and demonstrate conformity of printed products.

This document recognizes and makes provisions for the following:

- a) conditions and test methods for file generation conformity;
- b) conditions and test methods for file colour separation conformity;
- c) conditions and test methods for spot colour and/or composite colour conformity;
- d) conditions and test methods for soft proofing conformity;
- e) conditions and test methods for hard proofing conformity;
- f) conditions and test methods for viewing conditions conformity;
- g) conditions and test methods for the evaluation of process, print and colour conformity with respect to specified reference printing conditions (RPCs).

This document is applicable to all printing applications including CMYK, CMYK + spot, spot only, non-CMYK-based processes and multicolour printing.

This document defines the three main production stages of a printed product as follows:

- 1) colour definition: the first stage where the customer and design services choose the desired brand and visual colours;
- 2) colour reproduction: the production process which starts upon reception of the job file and ends when the job is printed;
- 3) colour conformity: the stage which is necessary for the evaluation of the conformity of a printed job.

This document provides:

- a reference framework description for a typical standardized printing workflow (CMYK, CMYK with spot, non CMYK, spot only and multicolour);
- required International Standards applicable at each stage of a standardized printing workflow;
- a description of expected setup, calibration and process control operations required at each stage of printing workflow according to the appropriate International Standards;
- a definition of test conditions for colour conformity activities when these are not clearly mentioned in the relevant standard.

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Graphic technology — Colour conformity of printing workflows

1 Scope

This document defines the requirements of printing workflows and evaluation methods for their tone and colour reproduction.

It applies to any printing process using any colourant, such as CMYK, CMYK with spot, non-CMYK, spot only or multicolour.

This document refers and points to international or national standards and can be used to define, evaluate and audit any printing workflow in whole or in part.

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 12646, *Graphic technology — Displays for colour proofing — Characteristics*

ISO 12647 (all parts), *Graphic technology — Process control for the production of halftone colour separations, proof and production prints*

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

ISO 14861, *Graphic technology — Requirements for colour soft proofing systems*

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

ISO 17972-4, *Graphic technology — Colour data exchange format (CxF/X) — Part 4: Spot colour characterisation data (CxF/X-4)*

CIE 15, *Colourimetry — Third edition*

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

actual printing condition

APC

printing condition of the actual printing device or printing process

3.2

colourant

physical substance such as ink or toner which is used alone or as part of a set of colourants in order to produce a colour

3.3

comp

mock-up

proof formed to the shape of the final product indicating whether or not it is colour accurate

3.4

device colour build

colour destined to be printed using a process colourant combination

Note 1 to entry: It is typically used to define device-specific values that allow reproduction of a colour using only process colourants.

3.5

preflight check

file inspection to determine that the digital data contained therein will process such that all data can be accurately imaged to an image carrier or substrate

3.6

print buyer

person or organization that prepares job data and files in order to deliver them to a print service provider

3.7

print service provider

person or company that receives job data and files for the purpose of printing them

3.8

printing condition

set of primary process parameters which describe the conditions associated with a specific printed output and define spectrally or colourimetrically aim values

Note 1 to entry: Such parameters include printing process, substrate, colourant, colourant sequence and screening. Aim values typically comprise colourants and tone reproduction curves description.

Note 2 to entry: For the purposes of colour management, a printing condition should be fully characterized by giving the relationship between process input values (as stipulated in ISO 12642-2 for CMYK) and the corresponding measured colourimetric values.

3.9

process colour

colour that is the outcome of a colour separation operation and that typically requires one or more printing units and process colourants to be reproduced

3.10

process colourant

colourant that is used to print process colours

3.11

reference printing condition

RPC

aim printing condition for the job

3.12**metameric index**

difference between spectral radiance distributions within the visible spectrum for two specimens with identical tristimulus values for a given reference illuminant and reference observer

Note 1 to entry: The procedures concerned with a special metamerism index for a change from a reference illuminant to a test illuminant of different spectral composition, or that for a change from a reference observer to a test observer of different colour-matching functions, are called the determination of special metamerism indices.

Note 2 to entry: Requirements for metameric index are specified in CIE 15.

Note 3 to entry: A measure of metamerism for the two specimens is the colour difference between the two metameric specimens caused by substituting an illuminant, "special metamerism index: change in illuminant", and caused by substituting an observer, "special metamerism index: change in observer". The colour difference is evaluated using a CIE colour difference formula and it shall be clearly stated which formula has been used.

Note 4 to entry: It is recommended that for two specimens whose corresponding tristimulus values ($X_1 = X_2$, $Y_1 = Y_2$, $Z_1 = Z_2$) are identical with respect to a reference illuminant and observer, the metamerism index, M , be set equal to the colour difference ΔE^*_{ab} between the two specimens computed for the test illuminant or for the test observer.

$$MI = \sqrt{(\Delta L^*_1 - \Delta L^*_2)^2 + (\Delta a^*_1 - \Delta a^*_2)^2 + (\Delta b^*_1 - \Delta b^*_2)^2}$$

3.13**spot colour**

colour typically used for the definition of brand colours or special design effects that is usually chosen with the intent of being printed using one printing unit and one spot colourant and that is usually not blended with other colourants

3.14**spot colourant**

colourant that is primarily used to print a spot colour even if it can replace or be blended with process colourants to obtain a specific colour gamut or colour reproduction

3.15**substrate-corrected colourimetric aim****SCCA**

colour data that are corrected in order to compensate for the colourimetric difference between reference substrate and production substrate colours, assuming that the primary difference between them lies in the colour of the substrates

3.16**system qualification**

assessment operation used to qualify the ability of a print device or a printing process to reproduce a defined colour data set

Note 1 to entry: This qualification, also named "extended scrutiny", cannot usually be performed by print providers during production as it requires specific testing conditions and protocols.

4 Printing workflow requirements**4.1 Job colour definition****4.1.1 General**

As illustrated in [Figure 1](#), colour definition is the first step of a printing workflow. This is where a brand owner or a designer chooses the desired spot and visual colours for the printed product.

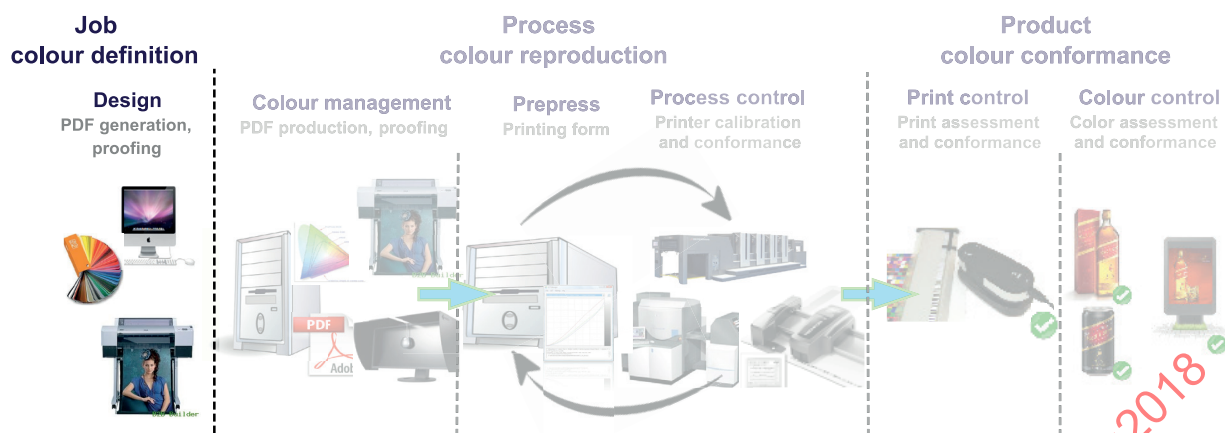


Figure 1 — Universal printing workflow — Job colour definition

4.1.2 Digital file creation

File format shall be mutually agreed between provider and receiver. The print service provider should provide its customers with a detailed specification detailing the technical properties of the digital files to be received (e.g. format, resolution, metadata, colour definition). If no agreement is present then files shall be prepared in conformity with the ISO 15930 series.

4.1.3 Graphic content

Print buyer specifications shall be clearly defined and mutually agreed on with the print service provider in terms of:

- reference printing condition (RPC);
- conformity (process, print, colour conformity, criteria, aims and tolerances).

4.1.4 Spot colour and device colour build

4.1.4.1 General

Spot colour definition is important because it is often associated with a brand or product identification. A specific colour can also be defined as a device colour build made of process colourant composite.

4.1.4.2 Spot and device colour for commercial printing

In commercial applications, spot colours shall be defined by colourimetric values (CIELAB, CIELCh) and should be defined by spectral values.

4.1.4.3 Spot and device colour for packaging printing

In packaging applications spot colours shall be defined by their spectral response curves.

4.2 Process colour reproduction

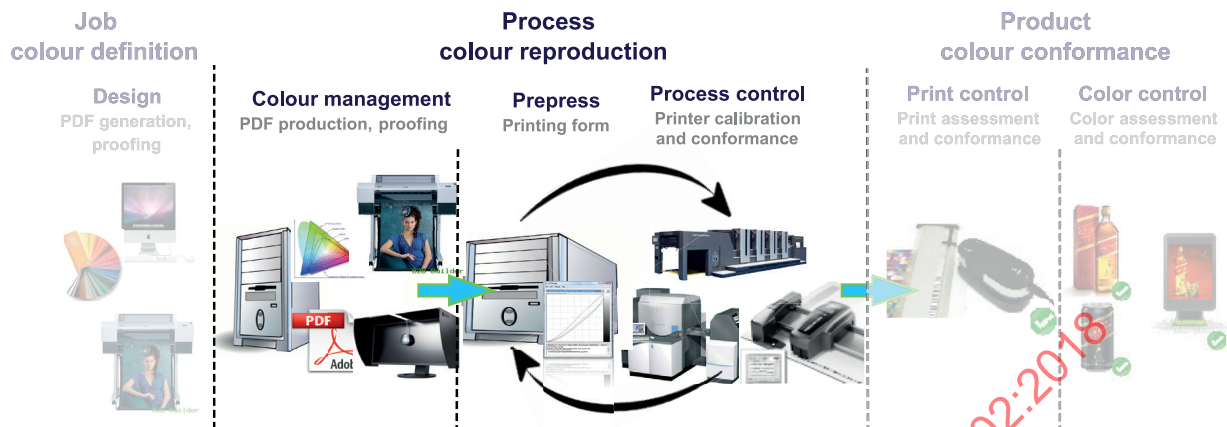


Figure 2 — Universal printing workflow — Process colour reproduction

As illustrated in [Figure 2](#), the colour reproduction stage of a printing workflow can be divided into three main areas:

- colour management [adapting PDF RPC to actual printing condition (APC)];
- prepress (printing form preparation);
- process control (print device calibration and conformity).

4.2.1 Colour management

4.2.1.1 Digital file reception

The print service provider should perform a preflight check on files upon job file reception in order to identify print buyer expectations and intended printing conditions. Any concern shall be notified immediately to the print buyer.

To enable a reliable colour management, the following job file metadata should be available in PDF XMP fields or in another machine-readable file format:

- RGB or CMYK working colour space used;
- rendering intents;
- output intent.

4.2.1.2 Proof and validation print

Digital job files should be delivered with digital proofs that conform with the requirements of [5.1.3.2](#).

If the print service provider has applied any colour conversion or substrate colour correction on the received file in order to match RPC with APC, a new hard proof should be produced with this modified file.

Hard proof margin information shall clearly mention production date, proofing system information, date of last calibration, simulation profile or characterization data [including substrate-corrected colourimetric aim (SCCA) parameters: RPC, reference white point and actual white point].

When no hard proof is available, a validation print should be provided even though it cannot be considered as a mandatory reference target. It is also common practice in packaging to provide printed packaging mock-ups and comps.

4.2.2 Prepress

Print production quality also depends on the colour content of a print job. As a consequence, colour standardization and control of prepress parameters are the key.

A printing form shall be prepared and its physical properties checked for the selected printing process and printing conditions.

All files, proofs and printing forms should be proofread for content, geometry, structure and colour separation. Printing form shall also be measured and proper calibration verified. The supporting documentation shall be easily referenced on a per-job basis.

Prepress operators should have a broad understanding of the print device calibration and characterization conditions and operations. Tone reproduction curves adjustment and ICC profiles shall be generated, controlled and updated as frequently as necessary to maintain the consistency and accuracy of printing conditions.

4.2.3 Process control

Process control is used to verify that print device solids, tone reproduction curves and colour space conform with the expected APCs.

It is the print service provider's responsibility to choose the most appropriate calibration method (e.g. tone value increase, neutral print density curve, device link profile) for their printing process.

Process control procedures shall conform with the requirements of the appropriate part of the ISO 12647 series.

The print service provider shall have a process control procedure and tools in order to measure and assess APCs.

Process control patches should include the following: solids, overprints, tone scales (highlights, quartertones, mid-tones, three-quartertones and shadows), grey balance (shadows, three-quarter, mids, quarters, highlights), slur gauges, inking gauges, size and scrap permitting.

Routine measurements of process, spot and device colours builds shall be documented, stored and retrievable. All pertinent press-run measurement data shall be documented for future reference and analysis.

4.3 Product colour conformity

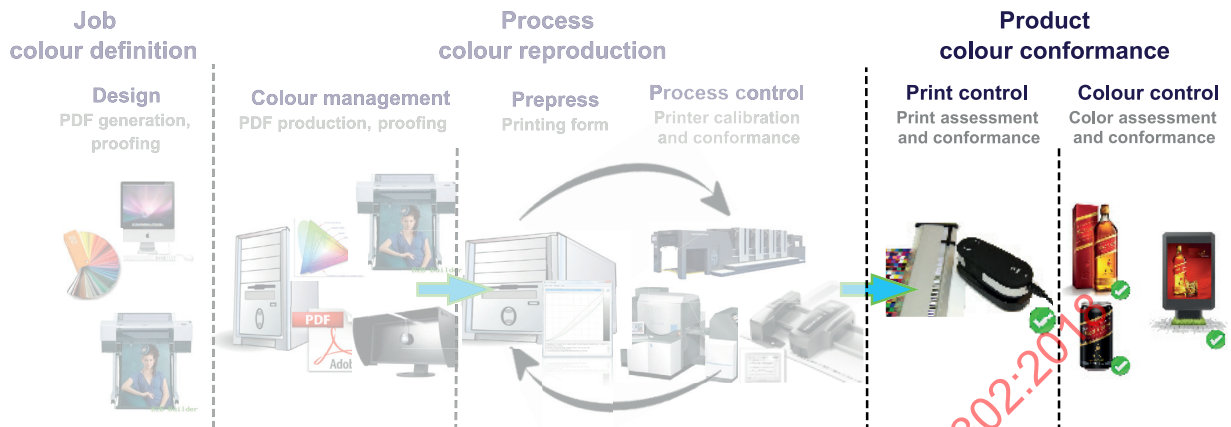


Figure 3 — Universal printing workflow — Product colour conformity

4.3.1 General

To match reference data set and/or spot colour on the actual print device, print colour control should be checked (see [Figure 3](#)).

4.3.2 Print control

Data set conformity shall address the following:

- colour deviation: the difference between aims values and measured values;
- within-sheet uniformity: deviation between different patches with the same device or colour values;
- colour variation: variation of the printing process during the production run.

Individual prints (colour deviation and uniformity) as well as the entire production (colour variation) shall conform with the agreed aims and tolerances.

4.3.3 Colour control

Spot colour and device colour builds conformity shall address the same deviation, uniformity and variation criteria as print control (see [4.3.2](#)).

4.3.3.1 Colour control for commercial printing

Conformity of spot colour for commercial printing shall be based on colourimetric measurements and ΔE_{2000} difference formulae.

4.3.3.2 Colour control for packaging printing

Conformity of spot colour for packaging printing should be based on spectral measurements, ΔE_{2000} and the metameric index. Colour targets shall be colourimetric and should be spectrally defined according to CxF/X file format as specified in the ISO 17972 series.

Documentation containing colour targets (CxF/X files) and approved contract colour proof and drawdowns with accompanying reports should be press side during all press runs (initial run and additional reprints). In addition, reruns should have a signed unconverted original (containing process control targets). Physical samples or digital data shall be collected and should be stored properly.

5 Printing workflow standards requirements

5.1 Job colour definition

5.1.1 Digital file creation

If no agreement is present, digital files shall be prepared in conformity with the ISO 15930 series (PDF/X). They shall be prepared as specified in ISO 15930-7 (PDF/X-4) for packaging.

For spot colour definition, CxF/X-4 spot colour characterization data with spectral definition as specified in ISO 17972-4 should be used.

5.1.2 Validation print production

Validation print supplied by the print buyer to the print service provider shall be produced as specified in ISO 12647-8.

5.1.3 Proofing

5.1.3.1 Soft proof

Soft proofing shall be carried out as specified in ISO 12646 and ISO 14861.

5.1.3.2 Hard proof production

A hard proof provided by the print buyer to the print service provider shall be produced in conformity with ISO 12647-7.

5.2 Process colour reproduction

5.2.1 Colour management

5.2.1.1 General

Colour management should be used to adapt data with an RPC to an APC.

Colour management tools and software should conform with ISO 15076-1 (ICC specification), ISO 18619 (black point compensation) and ISO/TS 10128 (CMYK to CMYK multi-dimensional transform method).

5.2.1.2 Digital file reception

Unless agreed otherwise between stakeholders, every file should go through a preflight check and conform with the appropriate part of the ISO 15930 series.

5.2.1.3 Hard proof and validation print control

Hard proof and validation print shall be identified and controlled according to ISO 12647-7 and ISO 12647-8, respectively, before being transferred to a production workshop. If no proof is provided by the customer or if the provided proof or validation print fail, a conforming proof or validation print should be produced locally. In this case, the printer should inform the customer, and, if the job contains brand colours, the printer should ask for brand owner approval before printing the job.

Regardless of the conformity results, a control report shall be attached to the proof or validation print.

If SCCAs have been used for soft proof, hard proof or validation print, the SCCA parameters shall be specified. The reference paper white point colour and the actual paper white point colour shall be stated on the document, as described in [4.2.1.2](#).

5.2.2 Prepress

Prepress should be able to demonstrate an ability to adjust the printing form using tone reproduction curves adjustment according to ISO/TS 10128.

Prepress shall be able to demonstrate ability to adjust job data files using colour management according to ISO 15076.

5.2.3 Prepress for commercial printing

Tone response curves shall be adjusted and maintained to enable conformance to the chosen printing standard, such as ISO 12647-2 to ISO 12647-6 or ANSI/CGATS TR015.

5.2.4 Prepress for packaging printing

Tone response curves shall be adjusted and maintained to enable conformance to the chosen printing standard, such as ISO 12647-2 to ISO 12647-6 or ANSI/CGATS TR015.

Tone response curves for spot colours shall be characterized. The characterization curve shall be used to adjust the printing form to provide a desired printed tone reproduction.

Spot tone value increase should be computed according to the measurement and calculation methods specified in ISO 20654.

5.2.5 Process control

5.2.5.1 General

Process control is used to check that a print device solids and tone reproduction curves and colour space are in conformity with its defined printing conditions.

Process control is used during production to ensure that device settings, calibration and stability are within tolerance.

5.2.5.2 Conformity requirements

Process conformance shall be made according to defined aims and tolerances. Such aims can be extracted from relevant standards such as the ISO 12647 series, ISO/PAS 15339-2, or any other agreed-on colour characterization data set.

5.2.5.3 Control strip and colour bar

The control strip shall conform with the normative requirements of process control standards.

If a spot colourant is used, the control strip and colour bar shall include at least one solid patch and one tint value for each spot colour.

5.3 Product colour conformity

5.3.1 Print control

Print control is used to check the ability of a print device to reproduce a colour data set.

These process colours can be defined in a characterization chart such as ISO 12642-2, generally known as an IT8.7/4. In this case print control allows a printing process to be checked for conformity with the data set and enables printing system qualification.

Print or data set conformity shall be checked according to specified aims and tolerances.

Print control aims are extracted from the characterization data set that has been mutually agreed on between stakeholders. The targeted characterization data set can be ISO/PAS 15339-2 or any other colour characterization data set.

5.3.2 Colour control

5.3.2.1 General

Criteria of conformity for spot and device colour build are solids and tone value increase.

When these criteria tolerances are mentioned in a pertinent ISO standard, this pertinent ISO standard shall be used. If not, and unless otherwise agreed on with the customer, [Annex A](#), [Table A.1](#) and [Table A.2](#) give examples of applicable tolerances.

NOTE ISO/PAS 15339-1:2015, Annex B and Annex C give useful measurement guidance.

5.3.2.2 Colour control in commercial printing

In commercial applications, colour control is limited to:

- spot colour solids and tone value increase;
- device colour.

5.3.2.3 Colour control in packaging printing

In packaging printing, colourant qualification shall be made with spectral data measurements. After colourant qualification, operators will be given reference values for process control during production.

Communication of spot colour data shall conform with ISO 17972-4.

The spot colour special metamerism index shall be evaluated according to CIE 15 via a three-step process:

- 1) find an exact match between a pair of colours under a primary or reference illuminant ($\Delta E = 0,00$);
- 2) compute the CIELAB colour difference under a test illuminant and the magnitude of the difference is the level of metamerism;
- 3) if step 1 is not met, then the tristimulus values of the pair under the reference illuminant shall be scaled until there is a 0,000 colour difference. Then the tristimulus values of the pair shall be scaled under the test illuminant by the same factor used to adjust the colours under the reference illuminant.

The effects of metamerism are of concern and importance in many colour formulation and production applications, in particular in packaging.

5.4 Measurement conditions

5.4.1 General

Measurement conditions shall be specified and communicated between the different stakeholders. Communication of such information is necessary to avoid any misunderstanding about data interpretation or conformity results that would be caused by inconsistent measurement conditions. Measurement conditions during process control should match those used for RPC data.

Measurement conditions include illuminant, observer viewing angle, aperture size, geometry and M conditions.

5.4.2 Measurement conditions for commercial printing

For (0°:45°) or (45°:0°) geometry measurement devices, colourimetry values should be computed using D50/2° computation of process colour density values. CIELAB colour coordinates and CIELAB colour differences shall be made according to ISO 12647-1, ISO 13655 and ISO 5-4.

5.4.3 Measurement conditions for packaging printing

For (0°:45°), measurement devices colourimetry values should be computed using the D50/2° measurement device. Computation of process colours density values, CIELAB colour coordinates and CIELAB colour differences shall be made according to ISO 12647-1, ISO 13655 and ISO 5-4.

For D: 8° measurement devices colourimetry values should be computed using D50/2°. Computation of CIELAB colour coordinates and CIELAB colour differences shall be made according to ISO 2469 and ASTM 1164-07.

5.5 Viewing and illumination

Viewing and illumination conditions used for visual evaluation of printed products shall conform with ISO 3664.

The print service provider should be able to provide proof of conformity for viewing cabinets or areas used for visual colour appraisal.

5.6 Sampling

As a general rule, the higher the number of measured production samples, the higher the certainty of the assessed production metric. However, in daily production, it can be impractical and sometimes impossible to measure a high percentage of production samples. Process, print and colour control shall be based on statistical process control. The number of samples should be sufficient to be representative of an entire production run; however, sampling procedure should not slow down productivity.

Sampling shall take into account:

- size of production to sample;
- expected quality level and tolerances;
- printing process capability related to purchaser requirements.

Sampling can be normal, relaxed or stringent depending on:

- printing process stability;
- criticality of defect;
- accepted error rate.

Samples should be labelled and stored for a period of time to be determined by the print provider or in agreement between the print provider and the customer. Taking into account the potential risk of having to deal with customer claims, records of sample measurements should be saved and archived.

Without any other agreement with the customer, sampling should follow methods described in existing ISO standards such as ISO/TS 15311-1 or ISO 19301¹⁾.

1) Under preparation. Stage at the time of publication: ISO/DIS 19301:2018.

6 Scoring schema

[Annex C](#) provides a notation and scoring system for each criteria of a standard that can be used to assess the conformity of a printing workflow.

Three types of scoring schemas are available:

- process colour reproduction;
- product colour conformity;
- colour control.

To reflect the overall quality of a printing process, individual scores, evaluation or audit based on ISO standards involved in the implementation of this document should be added and combined into one score and one ranking system.

The scoring schemas given in [Annex C](#) can be used as they are, or can be customized to meet print-provider-, customer- or certification-body-specific requirements.

7 Reporting

When requested by the print buyer, the print service shall provide a digital file or a report containing information pertaining to the job production conditions. An example of such information is given in [Annex B](#).

This digital file or report can include any agreed information between the print buyer and the print service provider.

Annex A (informative)

Colour control

Without any other agreement, [Table A.1](#) and [Table A.2](#) below give an example of deviation and variation tolerances applicable to spot and device colour build.

Table A.1 — Spot and device colour build maximum deviation and variation for commercial production printing

	Deviation tolerance of OK sheet from aim values	Variation tolerance of production print from OK sheet
Solids	$\Delta E_{00} \leq 2$	$\Delta E_{00} < 1,5$
30 % to 60 % input tone value ^a	$\pm 4 \%$	$\pm 4 \%$
^a Only for spot colours, according to the spot colour tone value (SCTV) method specified in ISO 20654.		

Table A.2 — Spot and device colour build maximum deviation and variation for packaging production printing

	Deviation tolerance of OK sheet from aim values	Variation tolerance of production print from OK sheet
Solids	$\Delta E_{00} \leq 2$ and $\Delta h_{ab} < 8$ degrees	$\Delta E_{00} < 1,5$
30 % to 60 % input tone value ^a	$\pm 3 \%$	$\pm 3 \%$
^a Only for spot colours, according to the spot colour tone value (SCTV) method specified in ISO 20654.		

In addition, the variation of spot colour solids and device colour can be restricted on the condition that for at least 68 % of the production prints the colour differences and tone value increase differences between printed sheets and specified aims do not exceed the appropriate variation tolerance specified in Table A.1 and Table A.2.