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Graphic technology — Process control for the production of half-tone colour separations, proof and production prints —

Part 1: **Parameters and measurement methods**

Technologie graphique — Maîtrise de procédé pour la production des séparations de couleur en ton tramé, des épreuves et des tirages en production —

Partie 1: Paramètres et méthodes de mesure

Reference number
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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).

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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 130, *Graphic technology.*

This third edition cancels and replaces the second edition (ISO 12647-1:2004), which has been revised by an update relating to the extensive usage of digital data in the printing and publishing world and a general clean-up towards an updated and stringent structure of the multi-part standard.

ISO 12647 consists of the following parts, under the general title *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints*:

— *Part 1: Parameters and measurement methods*

— *Part 2: Offset lithographic processes*

— *Part 3: Coldset offset lithography on newsprint*

— *Part 4: Publication gravure printing*

— *Part 5: Screen printing*

— *Part 6: Flexographic printing*

— *Part 7: Proofing processes working directly from digital data*

— *Part 8: Validation print processes working directly from digital data*

Introduction

When producing a colour reproduction, it is important that the people responsible for colour separation, proofing and printing operations have previously agreed on a minimum set of parameters that uniquely define the visual characteristics and other technical properties of the planned print product. Such an agreement enables the correct production of suitable colour separated data (without recourse to "trial-and-error") and subsequent production of proof prints from these data. The purpose of digital proof prints or press proof prints is to simulate the visual characteristics of the finished print product as closely as possible. It should be further noticed that this International Standard provides aims for printing using typical printing equipment and tools for quality control under the given economical constraints.

It is the purpose of this part of ISO 12647 to list and explain the minimum set of primary process parameters required for process control to uniquely define the visual characteristics and related technical properties for the contract or press proof print as well as the production print. Other parts of ISO 12647 define either specific values for these parameters that are appropriate for specific processes (such as lithography) or define matching tolerances based on a given characterization data set. Given an established fully characterized printing condition by means of a set of characterization data, ISO 12647-7 and ISO 12647-8 specify requirements for systems in order to produce a "Contract proof" or, at a less stringent level, a "Validation print".

For some processes certain parameters are more significant than others and may be specified as mandatory while the remainder are optional. However, in this part of ISO 12647, all parameters are treated equally.

Primary process parameters are defined here as having a direct bearing on the visual characteristics of the image. They depend on the pertinent printing process but typically comprise printing sequence, press, ink, the print substrate and the screening. Those parameters constitute a printing condition to be defined in the pertinent parts of this International Standard. Such a printing condition is characterized by means of associated colorimetric and/or densitometric process control aims. This is usually facilitated by means of defined solid colorations (to be named here colorant descriptions) and tone response curves.

A printing condition is therefore understood to refer to a set of primary process parameters and the resulting colorimetric and/or densitometric characterization.

Subordinate, formerly secondary, parameters are defined as those which may influence the image indirectly by changing the values of primary parameters. They are highly dependent on the relevant printing process. In case of offset printing typical influencing factors are speed, printing additives, blankets, and fountain solution types. Depending on the given combination of materials and machine setup, a press adjustment (also known as process calibration) might be necessary to achieve the colorimetric and/or densitometric process control aims of the printing condition of interest. This is typically accomplished using one-dimensional curve adjustments.

Even under standard conditions, i.e. a suitable data preparation that accounts for the different strengths and weaknesses of the individual printing conditions and a reproducible printing process that has minimal variations both within a run and between runs, it is practically not possible to hit a given set of primary parameters exactly. Differences due to typical production tolerances or due to differences in press, ink or substrate are generally unavoidable and have to be accepted by the print buyer. On the other hand, for global data exchange and colour separation purposes, an elaborate colorimetric characterization of every printing condition is required. Such data can be extracted from one or more prints that were produced under carefully and tightly controlled (nearly laboratory) conditions followed by mathematical correction procedures that are specifically designed to compensate for the differences remaining, i.e. zero tolerance toward given aim values. Such a fully characterized printing condition is suitable to evaluate and examine the colour gamut and should not be confused with the colorant description that only comprises colorimetric definitions of the solids (typically CMYK; MY, CY, CM and CMY).

By facilitating modern methods of electronic data manipulation it is possible, as described, to establish characterization data sets that fully reflect the aim values of a given set of primary process parameters. This allows both process control aims for printing operations (to be connected with a general printing condition) as well as colorimetric aims for digital proofing processes in the prepress arena to be in concert.

Given a fully characterized printing condition and a definition of the achromatic perception (see 3.11) it is possible to extract the exact grey condition, namely the colorimetric values needed (under specified viewing conditions). Such a grey condition (not to be confused with the grey balance that represents the needed tone values for cyan, magenta and yellow in order to achieve a neutral grey) might be used both for process calibration and monitoring the printing process.

The general principles of this International Standard can be easily extended to printing conditions not defined in ISO 12647, e.g. printing with high pigmented inks or the usage of substrates not fully addressed by the relevant parts of ISO 12647.

In order to facilitate communication between prepress, print buyer and printer, it is recommended to use a press proof or digital print compliant to ISO 12647-7 (“Contract proof”) or ISO 12647-8 (“Validation print”). The proof print reliably shows the quality of the prepress work and serves as the colour reference for the production run and, if necessary, may be used in case of a dispute between the print buyer and printer.

Graphic technology — Process control for the production of half-tone colour separations, proof and production prints —

Part 1: Parameters and measurement methods

1 Scope

This part of ISO 12647 defines and explains the minimum set of primary process control parameters required to uniquely specify the visual characteristics and related technical properties of process-specific production prints and process-independent simulations of fully characterized printing conditions.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

ISO 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*

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

3 Terms and definitions

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

NOTE For quantities, the preferred unit is given together with the definition. By definition, the unit of the so-called dimensionless quantities is 1.

3.1
achromatic colour
perceived colour devoid of hue, in the perceptual sense

Note 1 to entry: The colour names white, grey and black are commonly used or, for transmitting objects, colourless and neutral.

Note 2 to entry: In printing practice, achromatic colours can be produced either by a single black ink or three chromatic (and one achromatic) inks suitably balanced.

[SOURCE: CIE 17.4, 845-02-26]

3.2
axis of a screen
one of the two directions in which the half-tone pattern shows the highest number of image elements, such as dots or lines, per unit length

3.3
chromatic colour
perceived colour possessing hue, in the perceptual sense

Note 1 to entry: The process inks cyan, magenta and yellow are the chromatic colour inks.

[SOURCE: CIE 17.4, 845-02-27]

3.4
CIEDE2000 colour difference
CIEDE2000 total colour difference ΔE_{00} as defined in ISO 13655

3.5
CIELAB chromaticness difference
difference ΔC_h between two colour stimuli of approximately the same lightness projected onto a constant lightness plane in the CIELAB colour space

Note 1 to entry: This is calculated the same way as ΔEc stipulated in ISO 12646.

3.6
CIELAB colour difference
CIE 1976 ***L*a*b**** colour difference
difference between two colour stimuli defined as the Euclidean distance between the points representing them in L^*, a^*, b^* space

Note 1 to entry: The unit is 1.

[SOURCE: CIE 17.4, 845-03-55]

3.7
CIELAB colour space
CIE 1976 ***L*a*b**** colour space
three-dimensional, approximately uniform colour space produced by plotting L^*, a^*, b^* in rectangular coordinates

[SOURCE: CIE 17.4, 845-03-56]

3.8
control patch
area produced for control or measurement purposes

Note 1 to entry: Important control patches are doubling/slur patches for the assessment of the true rolling condition or ink trap control patches, a relative measure for the average amount of colorant per unit area of the second-down colorant layer that is deposited on to the first down colorant layer.

3.9
control strip
one or two-dimensional array of control patches used for characterization and proof control

3.10
digital proof print
digital proof produced as a reflection copy on a proofing substrate

Note 1 to entry: It usually serves as the reference in dispute, as the colour reference for the production print and as an indicator of the image quality of the content data; also known as Contract Proof.

3.11
grey balance
set of tone values of the data set that appears as an achromatic colour under specified viewing conditions if printed under specified printing conditions

Note 1 to entry: There are three practical definitions for grey: “a colour having the same CIELAB a^* and b^* values as the print substrate”, “a colour that has the same CIELAB a^* and b^* values as a half-tone tint of similar L^* value printed with black ink” and a functional (linear or nonlinear) combination of both.

3.12
grey reproduction
set of colorimetric values of the print that appears as an achromatic colour under specified viewing conditions if printed under specified printing conditions to be used for process control

Note 1 to entry: The printing of composed greys facilitating a fully characterized printing condition, by means of practically identical tone response curves, might result in slightly achromatic appearance. For process control means a slightly different set of tone values of the print than in the characterization data set might be necessary to achieve a neutral reproduction for the specific printing condition.

3.13
ICC colour management
communication, by means of an ICC profile, of the associated data, required for unambiguous interpretation of colour content data and application of colour data conversions using this profile, as required, to produce the intended reproductions

Note 1 to entry: Text, line art, graphics, and pictorial images, in raster or vector form can all contain colour data all of which can be colour managed.

Note 2 to entry: Colour management considers the characteristics of input and output devices in determining colour data conversions for these devices.

[SOURCE: ISO 15076-1, modified]

3.14
ICC profile
set of colorimetric transforms prepared in accordance with ISO 15076

3.15
image orientation
orientation of text and images, designated right-reading if text appears as it is intended to be read and images are in the orientation intended for viewing by the end user and wrong-reading for the opposite

3.16
mid-tone spread
S
difference between maximum and minimum deviations of tone values (print) for chromatic plates and defined by the equation

$$S = \max[(A_c - A_{c0}),(A_m - A_{m0}),(A_y - A_{y0})] - \min[(A_c - A_{c0}),(A_m - A_{m0}),(A_y - A_{y0})]$$

where

A_c is the measured tone value of the cyan process colour image;

A_{c0} is the specified tone value of the cyan process colour image;

A_m is the measured tone value of the magenta process colour image;

A_{m0} is the specified tone value of the magenta process colour image;

A_y is the measured tone value of the yellow process colour image;

A_{y0} is the specified tone value of the yellow process colour image.

EXAMPLE 1 For measured values $A_c = 22$, $A_m 17$ and $A_y = 20$ and specified values $A_{c0} = 20$, $A_{m0} = 20$ and $A_{y0} = 18$):

EXAMPLE 2 $S = \max[(22-20),(17-20),(20-18)] - \min[(22-20),(17-20),(20-18)] = 2-(-3) = 5$

3.17
non-periodic half-tone screen
half-tone screen without a regular half-tone dot pattern; typically known as 'stochastic' or 'frequency modulated' screening

Note 1 to entry: The usage of different screenings within a print job is known as cross modulated screening (XM).

3.18
OK print
OK sheet
production print (during production printing) singled out as the reference for the remaining production run

3.19
OK print tolerance
permissible difference between the *OK print* (3.18) and the values defined by the reference printing condition

Note 1 to entry: The OK print tolerance is often termed as a deviation tolerance.

3.20
press proof print
print produced by press printing (production or conventional proof press) whose purpose is to show the results of the colour separation process in a way that closely simulates the results on a production press

Note 1 to entry: It usually serves as the reference in dispute, as the colour reference for the production print and as an indicator of the image quality of the content data; also known as Contract Proof or wet proofs. But it is more and more replaced by digital proof prints.

3.21
principal axis
axis of a screen that coincides with the direction of the longest diameter of an oblong-shaped (e.g. elliptical or diamond-shaped) half-tone dot

Note 1 to entry: Circular and square shaped half-tone dots do not have a principal axis.

3.22
print substrate
material bearing the printed image

3.23
printing condition
set of primary process parameters which describe the conditions associated with a specific printed output, associated with colorimetric and/or densitometric aim values

Note 1 to entry: Such parameters usually include (as a minimum) printing process, print substrate, printing ink, screening and printing sequence. The aim values typically comprise the colorant description and tone value increase aims.

Note 2 to entry: For the purposes of colour management, a printing condition is fully characterized by giving the relationship between the CMYK digital input values (as defined in ISO 12642-2) and the corresponding measured colorimetric values.

Note 3 to entry: Based on a given set of characterization data according to NOTE 2, and a definition of achromatic perception, a grey condition might be extracted.

3.24
printing forme
physical medium whose surface is prepared such that some parts transfer printing ink whereas other parts do not

3.25
process colours
⟨four-colour printing⟩ cyan, magenta, yellow, black

3.26
production print tolerance
permissible difference between the *OK print* (3.18) and a specified upper limit of selected production copies

Note 1 to entry: Production print tolerance is often termed as a variation tolerance.

Note 2 to entry: Variation tolerance is calculated by standard deviation.

Note 3 to entry: The number of samples to be taken should be defined in the relevant parts of this multipart standard.

3.27
reference direction
⟨image⟩ horizontal direction as viewed by the end user

3.28
spectral reflectance factor
R_λ
ratio of the reflected flux to the absolute reference reflected flux under the same geometrical and spectral conditions of measurement, as a function of wavelength

Note 1 to entry: The unit is 1.

3.29
reflection densitometer
instrument which measures *reflectance factor density* (3.30)

3.30
reflection density
reflectance factor density
D
logarithm to base ten of the reciprocal of the *spectral reflectance factor* (3.28)

Note 1 to entry: This definition for reflection density is taken from ISO 5-4.

Note 2 to entry: This definition for reflection factor density is taken from CIE 17.4.

Note 3 to entry: The unit is 1.

3.31
relative density
density from which the density of a substrate such as the unprinted print substrate, has been subtracted

Note 1 to entry: The unit is 1.

3.32
sampling aperture size
dimensions of the surface area of a specimen that contributes to the measurement, governed by the design of the instrument

3.33
screen angle
angle (for oblong-shaped half-tone dots) which the principal axis of the screen makes with the *reference direction* (3.27), or the smallest angle (for circular and square dot shapes) which an axis of the screen makes with the reference direction

Note 1 to entry: Screen angle is expressed in units of degrees.

3.34
screen frequency
screen ruling
number of image elements, such as dots or lines, per unit of length in the direction of *screen angle*

Note 1 to entry: Screen frequency or screen ruling is expressed in units of reciprocal centimetres or inches.

3.35
screen width
reciprocal of *screen ruling* (3.34)

Note 1 to entry: Screen width is expressed in units of micrometres and also known as period.

3.36
surface finishing
process by which a print is either covered by varnish (lacquer) or laminated with a transparent polymeric film

3.37
tone value
A
⟨data⟩ proportional printing value encoded in a data file and interpreted as defined in the file format specification

$$A = 100 \times \left(\frac{V_p - V_0}{V_{100} - V_0} \right)$$

where

V_p is the integer value of the pixel;

V_0 is the integer value corresponding to a tone value of 0 %;

V_{100} is the integer value corresponding to a tone value of 100 %.

Note 1 to entry: Tone value is expressed in units of percent.

Note 2 to entry: Most files store these data as 8-bit integer values, i.e. 0 to 255. The tone value of a pixel is typically computed from the equation.

3.38
tone value
A
⟨colorimetric⟩ value encoded in a characterization data set or as a percentage of the surface, which appears to be covered by primary (or single) colorant calculated from the equation

for cyan: $A = 100 \times (X_0 - X_t)/X_0 - X_s)$

for magenta and black: $A = 100 \times (Y_0 - Y_t)/Y_0 - Y_s)$

for yellow: $A = 100 \times (Z_0 - Z_t)/Z_0 - Z_s)$

where

X_0, Y_0, Z_0 are the CIE XYZ tristimulus values of the unprinted print substrate;

X_t, Y_t, Z_t are the CIE XYZ tristimulus values of the half-tone;

X_s, Y_s, Z_s are the CIE XYZ tristimulus values of the solid.

Note 1 to entry: The largest differences between the colorimetrical and the densitometrical tone values occur in Cyan.

3.39
tone value
A
⟨printing⟩ percentage of the surface which appears to be covered by colorant of a primary colorant (if light scattering in the print substrate and other optical phenomena are ignored), calculated from the equation

$$A = 100 \times \left(\frac{1 - 10^{-(D_t - D_0)}}{1 - 10^{-(D_s - D_0)}} \right)$$

where

D_0 is the reflectance factor density of the unprinted print substrate, or the non-printing parts of the printing forme;

D_s is the reflectance factor density of the solid;

D_t is the reflectance factor density of the half-tone.

Note 1 to entry: Formerly also known as apparent, equivalent or total dot area. “Dot area” is a deprecated term.

Note 2 to entry: The synonym dot area can be applied only to half-tones produced by dot patterns.

Note 3 to entry: This definition can be used to provide an approximation of the tone value on certain printing formes.

Note 4 to entry: Tone values can be designated when other modes than M0, stipulated in ISO 13655, are used for measuring the pertinent densities.

Note 5 to entry: There are other definitions or modifications such as ISO/TS 10128, especially for Cyan.

3.40
tone value increase
ΔA
difference between a tone value (printing) measured on a printed sheet and the tone value (data) in the digital data file that corresponds to the same point in an image

EXAMPLE The tone value (printing) of the control strip patch on the print is 55 % that on the data are 40 %. The tone value increase is 15 %.

Note 1 to entry: Tone value increase is expressed in units of percent.

Note 2 to entry: The synonym dot gain may be applied only to half-tones produced by dot patterns.

Note 3 to entry: Formerly known as dot gain. “Dot gain” is a deprecated term.

3.41
tone value sum
at a given image location, the sum of the tone value (data) of the used colours

Note 1 to entry: Tone value sum is expressed in percent.

Note 2 to entry: Formerly known as the total dot area (TDA) or total area coverage (TAC). “Dot area” and “area coverage” are deprecated terms.

Note 3 to entry: Beside special marks such as for registration tone value sum should normally be restricted (especially for large areas of high tone value sum).

3.42
validation print
print produced directly from digital data early in the production chain, meeting the requirements of ISO 12647-8 representative of the concept for the final product

Note 1 to entry: A validation print can have reduced accuracy compared to a contract proof.

4 Requirements

4.1 General

The following subclauses provide a number of properties and primary parameters that uniquely define the visual characteristics and other technical properties of a print product. Where appropriate, measurement methods and specific values are provided.

Documents and/or images to be printed should be accompanied by a proof print (digital proof print or press proof print), unless there is agreement to the contrary by all parties concerned. When present, the digital proof print shall simulate the intended production printing condition (also known as reference printing condition) as defined in ISO 12647-7.

The usage and implementation of a control strip to be placed on any print shall be defined.

4.2 Data files and printing formes

4.2.1 Data delivery

Data files should be delivered as PDF/X data files as defined in ISO 15930 or TIFF/IT data files as defined in ISO 12639. Where TIFF/IT data files are used colour information shall be included using tag 34675 or tag 34029.

NOTE 1 PDF/X requires that the intended printing condition be indicated. Where the intended printing condition is included in the registry of characterizations maintained by the ICC, and the digital data are CMYK, the name used in the ICC registry may be used for identification in lieu of including an ICC output profile. If the intended printing condition is not included in said registry, PDF/X requires that an ICC output profile be included. If the data are other than CMYK, the data are required to be defined colorimetric using an ICC input profile or another mechanism and an ICC CMYK output profile is required to be included; the rendering intent to be used when converting each of these elements with the output profile is required to be communicated.

NOTE 2 In cases where the data delivered is not PDF/X additional information may be necessary to define the intended printing condition clearly. In such cases a PDF/X document or an agreed equivalent is created and agreed between the printer and print buyer.

4.2.2 Printing forme quality

In order to permit the reproduction of maximum number of tone value steps, the resolution of the image setter or plate setter should be set accordingly.

4.2.3 Screen frequency (periodic screens)

For periodic screens for every set of printing forme, the screen frequency (screen ruling) shall be specified in reciprocal centimetres, cm^{-1}. If the set includes more than one screen frequency, each printing forme shall be specified individually or the exception to the screen frequency specified for the set shall be reported explicitly.

4.2.4 Screen dot size (non-periodic screens)

For four-colour work, the screen dot size for non-periodic screening shall be specified by a minimum spot size in µm.

NOTE The screen dot size is also known as the writing dot size.

4.2.5 Screen angle (periodic screens)

For every colour, the screen angle shall be specified. The measurement method shall be as specified in 5.3; the reporting should be as specified in A.1.

4.2.6 Dot shape and its relationship to tone value (periodic screens)

The mid-tone dot shape (e.g. circular, square, and elliptical) should be specified and, in the case of screens with a principal axis, the tone values (data) should be specified where the half-tone dots show the first and second link-ups. The reporting should be as specified in A.2.

4.2.7 Tone value sum

The highest permitted tone value sum and the corresponding minimum size (area restriction) of all elements shall be specified. Where useful, the tone value of the black process colour image should be specified separately.

4.2.8 Grey reproduction and grey balance

The CIELAB values needed to achieve a neutral grey (for a given printing and viewing condition) as well as the resulting cyan, magenta and yellow tone values (data) might need to be defined. If necessary, a calculation method should be provided.

4.3 Proof or production print

4.3.1 General

Colour-characterization data obtained by printing and measuring the basic data set of ISO 12642 contain all of the information to be specified. They can be used to define a printing condition usually facilitated by a print substrate, a colorant description, a printing sequence and a screening description.

Requirements for contract proofs and validation prints are defined in ISO 12647-7 and ISO 12647-8 while the production prints are defined in the remaining parts.

4.3.2 Visual characteristics of image components

4.3.2.1 Print substrate colour

For the unprinted print substrate, the CIELAB colour coordinates (L^*, a^*, b^*) of the relevant substrate or substrate categories and, if necessary, CIELAB colour difference tolerances (ΔE^*_{ab}) shall be specified as defined in ISO 13655.

In many cases print substrates contain optical brightening agents (OBA). In order to minimize the systematic errors introduced by the interaction of substrate fluorescence and variations in the spectral power distribution of the measurement device and the sample illumination, the measurement condition for measuring the unprinted print substrate and the potential impact of the associated solid coloration shall be specified.

If useful, a maximum limit of the OBA concentration should be specified by using delta D65 Brightness according to ISO 15397.

NOTE The colour values of the colorant description are among others subject to the amount of optical brighteners in the print substrate. Hence two print substrates with identical colour values (to be measured with ISO 13655-M2) but different OBA amounts result in different colour values of the colorant description when measured with ISO 13655-M0/M1.

4.3.2.2 Print substrate gloss

The gloss of the unprinted print substrate and a tolerance should be given for information. Where the print is to be surface-finished, the gloss of the surface-finished, but unprinted, print substrate as well as potential changes on the data preparation or other required adjustments should be specified. The reporting should be as specified in A.5.

4.3.2.3 Ink set colours (colorant description)

The CIELAB colour coordinates *L**, *a**, *b** and tolerances for colour-difference between OK print and production print shall be specified by means of the four process colours on the intended print substrate. Specifying the printing ink only by stating the conformance to the pertinent part of ISO 2846 shall not replace this requirement.

In addition, the colour coordinates of the overprints (in the printing sequence used) of cyan + magenta, cyan + yellow, magenta + yellow shall be specified. Where the print is to be surface-finished, the *L**, *a**, *b** values of the surface-finished print product should be specified as well.

For a better definition of ink set colours, the following eight additional colours should be specified:

— 3 two-colour overprints: black with cyan, magenta, yellow (C-K, M-K, Y-K);

— 4 three-colour overprints of process colours (C-M-Y, M-Y-K, C-M-K, C-Y-K);

— 1 four-colour overprint of all process colours (C-M-Y-K).

The measurement method shall be made as specified in 5.1; the reporting shall be made as specified in A.6.

Though density values may be practical, it should be recognized that there might be cases where densitometric and colorimetric matching to a specification lead to different results. Therefore, reflection densities should be given only as additional information together with colorimetric data. Density measurement should be carried out using a black backing in accordance with ISO 5-4.

4.3.2.4 Ink set gloss

The gloss of solid tone colours may be specified. The measurement method should be as specified in 5.4, reporting should be as specified in A.5.

4.3.3 Tone value reproduction limits

For every process colour, the lowest tone value in the data that transfers onto the print in a uniform and consistent manner shall be specified. Likewise, the highest tone value (printing) that is useful for carrying image information shall be specified. The reporting should be as specified in A.2.

4.3.4 Tone value increase and spread

The aim values and tolerances for the tone value increase and spread shall be specified. If necessary it shall be reported if separate tolerances for the OK print (also known as deviation tolerances) and the production run (also known as variation tolerances) are needed.

Where the print is to be surface-finished, the tone value increase values of the surface-finished print product should be specified as well.

In addition the required position of the control strip and means of statistical evaluation should be specified.

NOTE A colorimetric assessment of the spread might be preferred over a densitometric one if the chosen primary and secondary parameters don't correspond to typical overprint behaviour. This might also be the case for practically identical tone response curves.

4.3.5 Tolerance for image positioning

The maximum deviation between the image centres of any two process-colour images shall be specified in micrometres or millimetres, if necessary relative to the format and mass per area of the print substrate.

NOTE Traditionally, the tolerance for image positioning was related to the screen width used for the images to be printed. However, in view of the proliferation of half-tone screen types, print substrates and formats, a single reference might not be adequate.

4.3.6 Conformance

In order to report conformance of a printed product according to this International Standard the relevant parts of ISO 12647 should define:

— provisions for the necessary control patches (as part of the control strip) and their position on the printing forme;

— provisions for the colour and density measurements by means of a statistical evaluation;

— a summary of all necessary requirements by means of a suitable reporting protocol.

5 Measurement methods

5.1 Computation of CIELAB colour coordinates and CIELAB colour differences

The colour measurements shall be made as specified in ISO 13655. The density measurements shall be made as specified in ISO 5-3 and ISO 5-4. The measurement mode (M0, M1, M2 or M3) and the used backing (white or black) shall be specified.

The computation of CIELAB colour coordinates shall be made as specified in ISO 13655.

From two sets of colour coordinates (L_1*, a_1*, b_1*) and (L_2*, a_2*, b_2*), the CIELAB colour differences shall be calculated as detailed in ISO 13655 using CIEDE2000 or CIELAB 1976 colour difference. For achromatic colours the CIELAB chromaticness difference should be used.

NOTE When defining tolerance limits by stipulating a normative (e.g. CIELAB 1976) and additionally an informative (e.g. CIEDE2000) metric the user has to be cautious since there are occasions where both formulae are not consistent.

5.2 Control strip

There are a number of variables that must be controlled in order to produce predictable results in colour reproduction. For a given substrate the most important process variables are the colours of solid patches of the individual process inks, their overprints, slur/doubling and tone value (data). For grey reproduction control grey balance patches will be useful.

NOTE For print setup and process calibration purposes special process dependent test elements for doubling, slur, registration and tone value reproduction limits (tone values (data) of 1 %, 2 %, 3 % and 97 %, 98 %, 99 % for the primaries) could be useful.

The control elements of the control strip(s), identified in the list below, shall be positioned where appropriate and shall be labelled with the nominal tone values (data):

a) solid tones of the primaries CMYK and their secondaries MY, CY, CM, CMY;

b) highlight-, mid- and shadow tones of the chromatic and achromatic colours CMYK;

c) three-colour overprints of process colours reflecting a typical grey balance for one to three lightness values (shadow-, mid- and light-tones);

d) substrate colour;

e) doubling/slur patches, single-colour and overprint patches for the process colour solids, namely K, C, M, Y, (C+M), (C+Y), (M+Y) and (C+M+Y);

f) spot colour and it tone values, if present.

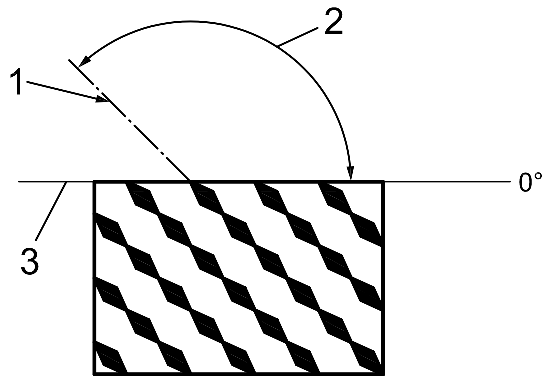
The minimum patch size shall not be less than 3 × 3 mm unless a measurement technique is used that reliably demonstrates a correlation facilitating smaller measurement spots. All elements shall be clearly identified.

The screen ruling of the control strip need not be identical to those of the subject. In cases where different screens will be used within one printing forme the screen ruling of the control strip should be identical to those reflecting the most important image areas.

5.3 Screen angles of prints

Identify a tone value patch of a primary colour and orient it as viewed by the end user. Determine the principal axis of the screen. As shown in Figure 1, with an anticlockwise-ascending scale protractor, measure the smallest positive angle between the principal axis and the horizontal reference direction (3 o'clock direction). If there is no principal axis: of the two axes, use that which produces the smallest angle. The value measured is the screen angle.

NOTE It is recognized that both clockwise measurements from the vertical axis of the forme and counter-clockwise measurements from the horizontal of the forme have been used for defining screen angles. In the absence of a generally accepted method, the present angle definition was selected because it yields identical values for all films, irrespective of film generation, and for all printing formes and prints.



Key

1 principal axis

2 screen angle

3 reference direction

Figure 1 — Measurement of screen angles: Angle definition for right-reading material

5.4 Gloss

Measure the specular gloss of the print substrate or a solid printed area of a process ink with light incident at an angle appropriate to the gloss level of the print substrate of the particular printing process in question. Details of the appropriate measurement methods shall be as specified in the relevant part of ISO 12647.

5.5 Apparent ink trap

From a solid overprint and the single colour prints of the first down and second down inks, set the densitometer to the colour channel (spectral product) which gives the highest value for the second down ink and determine I_p from the Preucil formula:

$$Ip = \left(D_{12} - D_1\right) / D_2$$

where

Ip is the densitometry ink trap;

D_{12} is the density of the overprint alone, measured in second down ink's channel;

D_1 is the density of the first down ink printed alone, measured in second down ink's channel;

D_2 is the density of the second down ink printed alone, measured in second down ink's channel.

NOTE 1 The apparent trap percentage obtained using the Preucil formula is not an absolute measure of the amount of the second down ink applied to the first down ink. The value obtained is dependent on the colour sequence. Even if the amounts of ink transferred were identical in both cases the apparent trap would differ because of variations in the opacity of the inks but more importantly the choice of colour channel used. It is clear from the procedure above that a different colour channel is used for each sequence which of itself will provide a different result.

NOTE 2 The true (weight based) ink trap percentage can be obtained using a gravimetric method. Microscopic examination of the overprint and image analysis techniques can provide additional information on how the inks lay on the substrate and each other, which is not obtained from the apparent trap percentage.

NOTE 3 Apparent trap percentages can be used in process control to monitor changes in trap during a production run.

NOTE 4 Apart from the well-known Preucil formula, numerous others have been proposed. Most of those are derived from the Preucil formula but contain adjustable parameters. None of them is entirely free from the shortcomings mentioned in NOTE 1.

5.6 Doubling and slur

Set the instrument to the colour channel which gives the highest reading for the process colour of interest. Determine the densities of each of the line screen patterns of different orientation within the doubling/slur control patches. The reflection density difference is a relative measure for doubling and/or slur.

5.7 Density or relative density of a process colour solid

Select the colour channel which gives the highest reading for the process colour of interest. Measure the density of the solid and the density of the unprinted substrate. For density, report the measurement obtained from the solid; for relative density compute:

$$D_R = D_S - D_0$$

where

D_R is the relative density;

D_S is the density of the solid (relative to the absolute white reflector);

D_0 is the density of the unprinted substrate (relative to the absolute white reflector).

Report densities to two decimal places together with the following:

— the spectral characteristics, preferably by quoting ISO 5-3 Status E, I or T;

— the density of the unprinted print substrate;

— the sampling aperture size;

— the backing material, if not in accordance with ISO 5-4;

— whether polarization was used.

EXAMPLE 1 "The density of the cyan solid was 1,45; that of the substrate was 0,15; both measured on a black backing in accordance with ISO 5-4, with a ISO Status T spectral response, 10-mm^2 sampling aperture, without polarization."

EXAMPLE 2 "The relative visual density of the black solid was 1,85 with regard to the substrate (visual density 0,07), both measured with the XYZ model of ZYX Company, on a black backing in accordance with ISO 5-4, 3-mm diameter sampling aperture, with polarisation."

NOTE 1 As optical densities are so-called dimensionless quantities, the unit is 1.

NOTE 2 Looking at the spectral shape of the X tristimulus function, one sees that in the region above 575 nm the absorption of the cyan ink is determining the response. However below this value the response is primarily due to the substrate. This correction equation is based on the assumption that when measuring a cyan ink, the Z tristimulus response is a relative measure of the unwanted spectral response of the X tristimulus function to the substrate instead of the cyan ink. The value 0.55 is based on the average value for a sampling of printing inks.

5.8 Variation of the coloration on a single print

5.8.1 General

As well as the need to control the uniformity of inking across the press it is often useful to characterize the variation in inking across or along the printing direction. For example, to quantify the effects of mechanical ghosting in offset and other printing defects. It is normal to make such measurements on solid areas of colour, usually on a single ink, in order to locate the cause of the problem most precisely. In such circumstances densitometry is the preferred method because of the higher sensitivity to variation in inking.

However, if it is necessary to determine the variation in colour of solid areas or an overprint of mixed halftone values it will normally be to define the effect rather than the cause. In this case colorimetry is preferred because it defines the perceived colour differences more accurately.

5.8.2 Densitometry

Set the instrument to the colour channel, which gives the highest reading. Measure the densities on the single colour solids. Calculate the quantity:

$$100 * \left((D_{max} / D_{min}) - 1 \right)$$

where

D_{max} is the maximum density value obtained on the single colour solids on the print;

D_{min} is the minimum density value obtained on the single colour solids on the print.

Report the variation in percent.

5.8.3 Colorimetry

Determine the CIELAB colour differences between locations with identical composition (e.g. “K12C60M45Y100”, “K 100 %”, “balance patch C75M70Y70”) across the print. Report the differences stating the composition of the measurement locations and clearly indicate which patch was used as the reference.

Annex A
(informative)

Reporting

A.1 Screen angles

For the printed image, report angles in degrees for C, M, Y and K.

EXAMPLE "The screen angles were C 15°, M 45°, K 75°, Y 0°."

If the angle cannot be expressed by a whole number, use two decimal places or report the angle in degrees and minutes.

A.2 Tone value in the file

Report tone values in percent.

EXAMPLE "The tone value (data) of the shadow-tone patch of the control strip is 75 %."

A.3 Tone value on the print

Together with the tone value, in percent, report the spectral response of the instrument used, the instrument model, the sampling aperture size and whether polarization was used. If the tone value calculation is based on tristimulus values that fact should be clearly reported.

A.4 Tone value increase (TVI) on the print

Report the tone value increase in the same manner as tone values on the print; see A.3.

A.5 Gloss

Report the gloss value and the measurement method.

EXAMPLE "The gloss of the unprinted substrate was 45 % as measured with 75°/75° geometry following the TAPPI official measurement method T 480 om-85."

A.6 Colour coordinates and CIELAB colour differences

Report the L^*, a^*, b^* values or CIELAB colour differences and state that they refer to the spectral measurement and calculation conditions specified in ISO 13655. In addition, report the brand and model of the instrument used and the sampling aperture size. If, for additional information, conditions other than those specified in ISO 13655 have been used, such as illuminant D65, this fact should be stated.

NOTE As colour coordinates are so-called dimensionless quantities, the unit is 1.

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