INTERNATIONAL STANDARD

ISO 13656

First edition
2000-02-01

Graphic technology — Application of reflection densitometry and colorimetry to process control or evaluation of prints and proofs

Technologie graphique — Application de la densitométrie par réflexion et de la colorimétrie pour la maîtrise ou l'évaluation des procédés des imprimés et épreuves

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Reference number
ISO 13656:2000(E)

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Printed in Switzerland

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13656 was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

Annexes A to C of this International Standard are for information only.

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Introduction

Reflection densitometers and reflection colorimeters (of tristimulus photometric or spectrophotometric type) are both reflectometers measuring the reflectance factor of reflection copy materials. Densitometers conforming to ISO 5-4 and ISO 14981, and colorimeters conforming to ISO 13655 possess a common geometry type, namely either 0°/45° or 45°/0°. It is further specified in ISO 5-4 that densitometric measurements shall be made on a specified black backing; ISO 13655 specifies the same condition for colorimetry in graphic arts. Finally, it is noted that reflectometers of the spectrophotometer type can, in principle, be used as both a densitometer and as a colorimeter.

Notwithstanding the similarities of the instruments, there are fundamental differences between them. The first of these is that the typical densitometer used in graphic arts, as its name implies, displays density values (logarithm of the reciprocal of a weighted average of the spectral reflectance factor) although it may also display other parameters calculated from these values. A colorimeter, on the other hand, normally displays differently weighted averages of the spectral reflectance factor, although frequently it can also display various transformations from these values which may be required for a number of reasons. One such reason is the need to define a more uniform colour space such as CIELAB.

ISO 5-3 requires that for reflection densitometry the incident flux has a spectral power distribution that conforms to CIE illuminant A. In colorimetry, ISO 13655 specifies a spectral power distribution that conforms to CIE illuminant D50 but accepts that such a source is not easily realisable. It requires that D50 be used to calculate the tristimulus values which, together with the weighting functions specified, effectively defines the spectral response whether it be achieved by the use of filters or calculation from spectrophotometric data. In practice most colour measurements in graphic arts today are made with spectrophotometers using a source with a spectral power distribution similar to illuminant A. The measured spectral reflectance data is used to calculate both densitometric and colorimetric data and illuminant D50 is used to calculate the tristimulus values as specified in ISO 13655. The implication of this for colour measurement is that it gives erroneous results when samples fluoresce.

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The aim of colorimetry is to provide an instrument response which simulates, as well as possible, that of the standard observer. In graphic arts, colorimetry serves mainly for colour matching and the establishment of colour standards. The availability of inexpensive, hand-held colorimeters, with small sampling apertures, has also permitted the use of colorimetry in process control as a complement to densitometry.

Densitometers are primarily designed for indirect measurement and control of the amount of colorant material of a specified type present in, or on, a substrate. ISO 5-3 defines a number of statuses, each of which is deemed appropriate for a particular application. The primary aim of densitometry for graphic arts is to monitor the amount of colorant per area on a print or proof. For a half-tone print this is a function of the ink film thickness and tone values. However, densitometry is also used for the determination of other process control quantities. A distinctly different task is the evaluation of the density ranges of colour separation input material; this type of densitometry is not covered by this International Standard.

Historically, colour densitometers for reflection type material were first used in preparation for colour separation for determining the density ranges of continuous-tone, coloured original artwork, as measured through the wide-band filters used for colour separation. As the quality of the printed products improved, however, reflection densitometers were also applied to process control in printing. Here, the areas measured consist typically of single-colour patches contained in control strips, printed with the process colours cyan, magenta, yellow and black.

For the control of the chromatic colours, especially yellow, it was later discovered that measurements made with narrow-band filters, each centred on the main absorption maximum of one of the process ink colorants, provided features which can be advantageous for certain control applications. These are:

— reduction of the influence of slight hue shifts on density,

— bringing the yellow densities and tone values within the range of those of cyan and magenta,

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- improvement of inter-instrument agreement,
- extension of the linear relationship between density and ink film thickness to higher densities,
- reduction of the magnitude of density additivity failure.

It was also found that the readings obtained from densitometers with a means for cross-polarisation to minimise the influence of first-surface reflection were less affected by ink dry-back. Polarisation also contributes to the last two features above. The need for the instrument designer to correct for it in computing the spectral response is described in ISO 5-3 and also in annex B of this International Standard. Standardisation of the minimum efficiency of polarisation is covered by ISO 14981.

The wide range of applications for which densitometry is used, mean that both wide and narrow band instruments, as well as the optional use of polarisation, are in common use in graphic arts. Furthermore, colorimetry is becoming increasingly widely used and all of these options present many alternatives for process measurement within the industry. It is for this reason that this International Standard has been produced. Since the industry increasingly needs to communicate process control information between various participants in production it is essential that this be defined unambiguously. By defining terms, specifying preferred test methods and the requirements for control strips, and defining reporting procedures, such ambiguity should be kept to a minimum.

Many of the parameters measured or calculated in graphic arts process control, including some of those defined later in this International Standard, do not require any specific spectral response to be effective. They are comparative measurements and are in many cases calculated directly from the reflectance data from which density and colorimetric parameters are themselves derived. In isolated production environments various parameters, each of which may be derived from any reasonable spectral product, can be equally effective for process control. It is not the intent of this International Standard to preclude their continued use in such a situation. However, in some situations there are advantages in using specific parameters or spectral products and, furthermore, to aid communication in a distributed production environment it is essential that graphic arts metrology is based on agreed procedures. It is in this context that this International Standard specifies colorimetric and densitometric test methods for the most common process control procedures in graphic arts and specifies the reporting procedures to be employed.

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Graphic technology — Application of reflection densitometry and colorimetry to process control or evaluation of prints and proofs

1 Scope

This International Standard applies to process control and evaluation of single and multi-colour proofing and printing in the graphic arts using densitometry and colorimetry. This International Standard:

— defines terms;

— specifies minimum requirements for control strips;

— specifies test methods;

— specifies reporting procedures for the results.

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2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5-3, *Photography — Density measurements — Part 3: Spectral conditions.*

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

ISO 12647-1, *Graphic technology — Process control for the manufacture of half-tone colour separations, proof and production prints — Part 1: Parameters and measurement methods*.

ISO 12647-2, *Graphic technology — Process control for the manufacture of half-tone colour separations, proof and production prints — Part 2: Offset lithographic processes*.

ISO 12647-3, *Graphic technology — Process control for the manufacture of half-tone colour separations, proofs and production prints — Part 3: Coldset offset lithography and letterpress on newsprint*.

ISO 12647-4[1)], *Graphic technology — Process control for the manufacture of half-tone colour separations, proof and production prints — Part 4: Gravure processes*.

ISO 12647-5[1)], *Graphic technology — Process control for the manufacture of half-tone colour separations, proof and production prints — Part 5: Screen printing*.

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

1) To be published.

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ISO 14981[1)], *Graphic technology — Process control — Optical, geometrical and metrological requirements for reflection densitometers for graphic arts use*.

ISO 15790[1)], *Graphic technology and photography — Reflection and transmission metrology — Documentation requirements for certified reference materials, procedures for use, and determination of combined standard uncertainty.*

DIN 16536-2:1995, *Colour density measurements on on-press or off-press prints; Part 2: Instrument specifications for reflection densitometers and their calibration*.

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply; they are given in alphabetical order. Where appropriate they have been taken directly from the CIE International Lighting Vocabulary, ISO 5-1 to 5-4, ISO 12637-1 and ISO 12647-1 as indicated at the end of the definition.

3.1
aperture
see sampling aperture

3.2
colorimeter
instrument for measuring colorimetric quantities, such as the tristimulus values of a colour stimulus

[International Lighting Vocabulary 845-05-18]

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NOTE A tristimulus colorimeter achieves this by the analogue integration of the spectral product of object reflectance or transmittance factor, illuminant and filters which are defined by the standard observer functions. A spectrophotometric colorimeter achieves this by calculation from the spectral reflectance or transmittance factor data.

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3.3
control patch
area produced for control or measurement purposes

[ISO 12647-1]

NOTE This definition is independent of whether the control patch is produced on film, a printing forme or a print substrate by conventional or direct methods.

3.4
control strip
one-dimensional array of control patches

[ISO 12647-1]

3.5
core density (on a half-tone film)
transmittance density in the centre of an isolated opaque image element such as a half-tone dot or line. Unit: 1

[ISO 12647-1]

3.6
density
See reflection density

NOTE (Optical) density can be defined for both transmitting and reflecting samples. However, in the context of this document it is usually only appropriate to reflecting samples. The document uses the term density freely; it should be understood to be reflection density unless otherwise specified.

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3.7
doubling/slur patch
control patch for the assessment of the true rolling condition

3.8
film (separation)
image carrier which contains black and white information in analogue form

NOTE Although normal use of the word film would also include colour film materials they are not included in this definition which is restricted to monochrome half-tone film separations, of which there is one for each colour ink to be printed.

3.9
film polarity
polarity (of a film)
positive if clear and solid areas on the film correspond to unprinted and solid areas on the print, respectively; negative if clear and solid areas on the film correspond to solid and unprinted areas on the print, respectively

[ISO 12647-1]

3.10
fringe width (of an isolated opaque image element)
average distance between the density contour lines corresponding to 10 % and 90 % of the minimum core density specified for the printing process under consideration

[ISO 12647-1]

NOTE Fringe width is expressed in millimetres.

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3.11
half-tone
image composed of dots which can vary in screen ruling (number per centimetre), size, shape, or density, thereby producing tonal gradations

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[ISO 12637-1]

NOTE Used especially with printing processes like offset lithography where the ink film thickness or the amount of colorant per unit area is constant throughout the image. However, it is sometimes used in gravure printing where the half-tone dot density may also vary.

3.12
image element
See half-tone

3.13
incident flux
flux incident on the sampling aperture defining the specimen area on which the measurement is made

[ISO 5-1]

3.14
ink-trap
I
for an overprint, 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

NOTE 1 Ink-trap is expressed as a percentage.

NOTE 2 Not to be confused with trap employed in colour separation to attenuate mis-register effects.

NOTE 3 Apparent ink-trap is measured optically; gravimetric ink-trap by weight.

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3.15
mid-tone balance control patch
a half-tone control patch, containing all three chromatic process inks, used for assessing the balance between the inks; the cyan tone value is normally in the range between 40 and 60 and the magenta and yellow tone values are selected to approximately produce an achromatic colour

3.16
non-periodic half-tone
image in which the elements composing it do not have a regular frequency

3.17
OK print
OK sheet
during production printing the production print singled out as reference for the remaining production run

[ISO 12647-1]

3.18
overprint
condition where two or more layers of colorant, usually ink, are printed on top of another

3.19
print substrate
material bearing the printed image

[ISO 12647-1]

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3.20
process colours (for four-colour printing)
yellow, magenta, cyan and black

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[ISO 12647-1]

3.21
reflectance factor
R
ratio of the measured reflected flux from the specimen to the measured reflected flux from a perfect-reflecting and perfect-diffusing material located in place of the specimen. Unit: 1

[ISO 5-4]

3.22
reflection density[2)]
reflectance factor (optical) density[3)]
logarithm to base ten of the reciprocal of the reflectance factor. Unit: 1

3.23
reflectometer
photometer for measuring quantities pertaining to reflection

[International Lighting Vocabulary 845-05-26]

2) ISO 5-4.

3) [International Lighting Vocabulary 845-04-67].

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3.24
relative density
density from which the density of a reference such as the film base or the unprinted print substrate, has been subtracted. Unit: 1

[ISO 12647-1]

3.25
sampling aperture
area of the sample that contributes to the measurement

NOTE This is not necessarily the same as the illumination aperture which is the area of the sample illuminated by the instrument or the mechanical aperture created by an opaque mask used to position the densitometer on the specimen. ISO 5-4 makes very specific requirements on the relationship between each of these.

3.26
screen frequency
screen ruling
number of image elements, such as dots or lines, per unit of length in the direction which produces the highest value. Unit: cm^{-1}

[ISO 12647-1]

3.27
screen width
reciprocal of screen ruling. Unit: cm

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[ISO 12647-1]

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3.28
solid
image of uniform coloration intensity with no half-tone structure

3.29
spectral product
product of the spectral power of the incident flux and the spectral response of the receiver, wavelength by wavelength

3.30
spectral response (of the receiver)
product of the spectral sensitivity of the photodetector and the transmittance of the optical elements associated with it

3.31
tone value
dot area (on a print)
A
percentage of the surface which appears to be covered by colorant of a single colour (if light scattering in the print substrate and other optical phenomena are ignored) calculated from the formula:

$$A\,(\%) = 100\left[1 - 10^{-(D_t - D_0)}\right] \Big/ \left[1 - 10^{-(D_s - D_0)}\right]$$