INTERNATIONAL STANDARD

ISO 14981

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Graphic technology — Process control — Optical, geometrical and metrological requirements for reflection densitometers for graphic arts use

Technologie graphique — Contrôle du processus — Exigences optiques, géométriques et métrologiques relatives aux densitomètres par réflexion utilisés dans l'industrie graphique

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Contents

Page

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.

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 14981 was prepared by Technical Committee ISO/TC 130, *Graphic technology.*

Annexes A and B form a normative part of this International Standard.

Introduction

Densitometers used in the graphic arts for process control possess a number of features which are specific to the graphic arts. Whereas the photography standards ISO 5-1 [1], ISO 5-3 and ISO 5-4 [2] are considered to be the basis, the measuring instruments used in graphic technology require specific requirements and tolerances.

In principle, reflection densitometers and reflection colorimeters (of photoelectric or spectrophotometric type) are both reflectometers measuring the reflectance factor of reflection copy materials. Densitometers conforming to ISO 5 and colorimeters conforming to ISO 13655 possess a common geometry type, namely either 45/0 or 0/45. It is also noted that reflectometers of the spectrophotometer type can, in principle, be used both as a densitometer and as a colorimeter. The definition of the colorimeter used in this International Standard follows CIE 17.4, the International Lighting Vocabulary. In graphic arts, the geometry 45/0 (influx at 45° and efflux at 0°), or the geometry 0/45 are preferred over that with an integrating sphere because they correspond to the usual geometry under which glossy graphic products are being viewed to minimize the effect of gloss typically seen by the human observer, see also ISO 13655:1996, annex E. The introduction of polarizing means is an additional measure to remove first-surface reflection; for matt surfaces this is the only possibility.

Notwithstanding the similarities between instruments for densitometry and colorimetry, there are fundamental differences between them: Firstly, the illuminant used in densitometry is CIE standard illuminant A whereas ISO 13655 specifies CIE standard illuminant D_{50} for colorimetry in the graphic arts. Secondly, for the chromatic colours the weighting of the reflectance factors is different between densitometry and colorimetry. Only the "visual" weighting function, used for the densitometry of achromatic colours (such as black), is the same as that for the tristimulus value *Y* in colorimetry.

The aim of colorimetry is to provide a measuring instrument response which simulates, as well as possible, the visual characteristics of a sample as seen by 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 of the spectrophotometric or photoelectric type, with small sampling apertures, has also permitted the use of colorimetry in process control as a complement to densitometry. This should eliminate the use of densitometers for colour matching.

The aims of densitometry in graphic arts are the control of the ink film thickness or, more general, the control of the amount of colorant per area, and the determination of tone values or other 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.

The concept of this International Standard is based on the general principles specified for photography in the ISO 5 series of International Standards; for the spectral products it refers to certain tables of ISO 5-3. Just as the ISO 5 series it does not directly address the end user but the densitometer manufacturer or a suitably equipped laboratory. Directions for the end user are to be provided by ISO 13656, which will also give an overview on the various types of densitometers.

Graphic technology — Process control — Optical, geometrical and metrological requirements for reflection densitometers for graphic arts use

1 Scope

This International Standard specifies requirements for measuring instruments to be used for the measurement of the reflection densities and the tone values on half-tone or continuous-tone multi-colour graphic arts reflection-copy material.

This International Standard is applicable equally to measuring instruments that measure status density directly using filter/bandpass limiting techniques and to measuring instruments which measure spectrally and compute status density. This International Standard is not applicable to measuring instruments used for continuous-tone original art.

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 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*.

ISO 2846-1:1997, *Graphic technology — Colour and transparency of ink sets for four-colour-printing — Part 1: Sheet-fed and heat-set web offset lithographic printing*.

ISO 13655:1996, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*.

ISO 13656:2000, *Graphic technology — Application of reflection densitometry and colorimetry to process control or evaluation of prints and proofs*.

ISO 14807:—[1)], *Photography — Method for the determination of densitometer performance specifications*.

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

1) To be published.

3 Terms and definitions

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

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

3.1
achromatic (perceived) colour
colour devoid of hue, such as black and grey. For transmitting objects, the descriptions colourless or neutral are also used [CIE 17.4, 845-2-26], [6]

NOTE In printing practice, achromatic colours can be produced either by a single ink or three chromatic inks suitably balanced.

3.2
calibration
set of operations that establish, under specified conditions, the relationship between quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or reference material, and the corresponding values realized by the standards [5]

NOTE Contrary to a common misconception, calibration is not the process of adjusting a measurement system such that it produces values that are believed to be correct but may be the cause for such an action.

3.3
certified reference material
CRM

reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence [ISO 15790]

3.4
chromatic (perceived) colour
opposite of achromatic colour [CIE 17.4, 845-02-27], [6]

NOTE The process inks cyan, magenta and yellow are the chromatic primary colour inks.

3.5
gloss suppression factor
factor by which the reflectance factor of a polarization test object is reduced by installing polarization means into the measuring instrument

Unit: 1

3.6
illuminated area
part of the surface of the specimen that is illuminated by the illumination source

3.7
mechanical aperture
aperture created by an opaque mask used to position the measuring instrument on the specimen

3.8
process colours (for four-colour printing)
yellow, magenta, cyan and black [3]

3.9
receiver
detection means for radiation

3.10
reflectance factor
R
ratio of the radiant or luminous flux reflected in the directions delimited by the given cone to that reflected in the same directions by a perfect reflecting diffuser identically illuminated [CIE 17.4, 845-04-64], [6]

Unit: 1

3.11
sampling aperture
part of the sample surface determined by the angular field of sensitivity of the receiver

3.12
screen ruling; screen frequency:
number of image elements, such as dots or lines, per length in the direction which produces the highest value [3]

Unit: cm^{-1}

3.13
screen width
reciprocal of screen ruling [3]

Unit: µm

3.14
spectral products
Π
products of the spectral power of the influx spectrum and the spectral response of the receiver, wavelength by wavelength

Unit: 1

NOTE The spectral response of the receiver includes the photodetector and all intervening components between it and the sampling aperture.

4 Requirements

4.1 Influx and efflux geometry

4.1.1 General

Measurement shall be made either

— with an annular (ring-shaped) illuminator and with a directional receiver which senses in the direction normal to the sampling aperture (annular influx mode); or

— with the illumination normal to the sampling aperture and an annular receiver (annular efflux mode).

4.1.2 Annular influx mode

The illumination shall be uniform around the annulus. If the reflection characteristics of the specimen do not change as it is rotated in its own plane, the illumination need not be uniform around the annulus.

NOTE For applications where graphic arts materials have been shown to have a slight sensitivity to directional effects the following are suggested compromises to the requirement of annular uniformity: The influx should be coming either from two illumination sources positioned at azimuth angles which are 90° apart, or, preferably, from more than two illumination sources, with equally spaced azimuth angles. A directional dependence is considered to be slight, if the averages over five repeated density measurements differ by no more than 0,03 over the directions 0°, 45° and 90°.

At the centre of the sampling aperture, the angular distribution of the illumination shall be at its maximum at 45° ± 2° to the sampling aperture and shall be negligible at angles that differ by more than 5° from the angle of the maximum, see Figure 1.

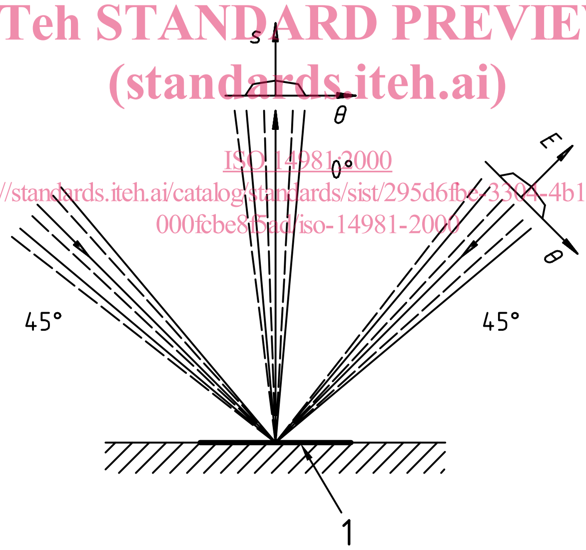
The receiver shall sense in the direction normal to the sampling aperture. At the centre of the sampling aperture, the angular distribution of the receiver sensitivity shall be at its maximum no further than 2° from the normal to the sampling aperture and shall be negligible at angles that differ by more than 5° from the angle of the maximum, see Figure 1.

4.1.3 Annular efflux mode

The sensing by the receiver shall be annular, its sensitivity shall be uniform around the annulus. If the reflection characteristics of the specimen do not change as it is rotated in its own plane, the sensing distribution of the receiver need not be uniform around the annulus.

NOTE For applications where graphic arts materials have been shown to have a slight sensitivity to directional effects the following are suggested compromises to the requirement of annular uniformity: The efflux should be detected either by two receivers positioned at azimuth angles which are 90° apart or by more than two receivers with equally spaced azimuth angles. A directional dependence is considered to be slight, if the averages over 5 repeated density measurements differ by no more than 0,03 over the directions 0°, 45° and 90°.

At the centre of the sampling aperture, the angular distribution of the receiver sensitivity shall be at its maximum at 45° ± 2° to the sample aperture and shall be negligible at angles that differ by more than 5° from the angle of the maximum.



Key

1 Sampling aperture

Continuous lines: nominal angles of the maximum and associated tolerances

Broken lines: example for 2° deviations of the angles of the maximum.

Also shown are example distributions of the irradiance E and the detector sensitivity s, both versus the colatitude angle θ.

Figure 1 — Annular influx mode — Cross-section showing the radiation cones at the centre of the sampling aperture

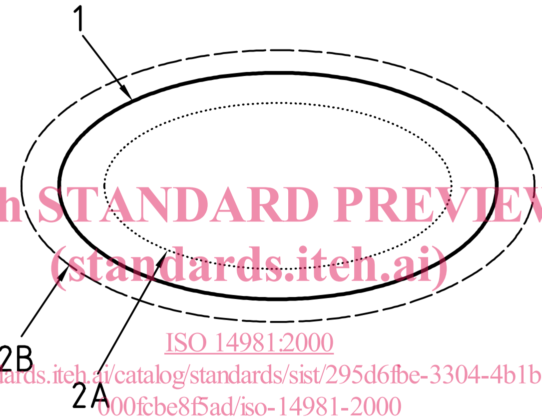
The illumination source shall illuminate the sampling aperture in the direction normal to this plane. At the centre of the sampling aperture, the angular distribution of the illumination shall be at its maximum no further than 2° from the normal to the sampling aperture and shall be negligible at angles that differ by more than 5° from the angle of the maximum.

4.2 Mechanical aperture and sampling aperture

The inner boundary of a mechanical aperture, if present at all, shall lie at least 0,5 mm outside of the boundary of the sampling aperture.

The diameter of a circular sampling aperture should be not less than 15 times the screen width; it shall be not less than 10 times the screen width that corresponds to the lower limit for the screen ruling stated by the vendor, see 4.7. The area of non-circular sampling apertures shall not be smaller than that required for circular sampling apertures.

NOTE The relationship between the minimum size of the sampling aperture and the screen width is identical to that contained in ISO 12647-1 [3] and ISO 13656.



Key

1 Sampling aperture

2A Smaller illuminated area

2B Larger illuminated area

Figure 2 — Schematic representation of the boundaries of the sampling aperture and the two possibilities for the illuminated area

4.3 Illuminated area

The full length of the boundary of the illuminated area shall lie either inside or outside of the boundary of the sampling aperture by at least 0,5 mm, see Figure 2.

NOTE 1 This requirement reduces the lateral translucency error, which is the error in the measured reflectance factor when light is scattered laterally from points inside to points outside the sampling aperture of the instruments receiver. The reflectance factor will then normally be lower than in a situation where all of the reflected light were collected.

NOTE 2 In practice, it is preferred to make the illuminated area smaller than the sampling aperture.

NOTE 3 There is no requirement for the uniformity because in graphic arts, densitometric measurements are usually made with very small sampling apertures in control patches of even tone value.