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Photography and graphic technology — Density measurements —

Part 4: Geometric conditions for reflection density

Photographie et technologie graphique — Mesurages de la densité — Partie 4: Conditions géométriques pour la densité de réflexion

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5-4 was prepared by ISO/TC 42, *Photography*, and ISO/TC 130, *Graphic technology*, in a Joint Working Group.

This third edition cancels and replaces the second edition (ISO 5-4:1995), which has been technically revised. This technical revision introduces the concept of ideal and practical conditions. In the course of this technical revision, all parts of ISO 5 have been reviewed together, and the terminology, nomenclature and technical requirements have been made consistent across all parts.

ISO 5 consists of the following parts, under the general title *Photography and graphic technology — Density measurements:*

— *Part 1: Geometry and functional notation*

— *Part 2: Geometric conditions for transmittance density*

— *Part 3: Spectral conditions*

— *Part 4: Geometric conditions for reflection density*

Introduction

This part of ISO 5 specifies the geometric conditions that are used to define ISO 5 standard reflection density and to make measurements of ISO 5 standard reflection density. These conditions correspond approximately to practical situations for viewing reflection-type photographs or graphic reproductions, which specifically requires illuminating the print at an angle of 45° to the normal to the surface and viewing along the normal. These conditions tend to reduce surface glare and maximize the density range of the image, which is sometimes referred to as annular 45°:0° reflection densitometry.

The geometric conditions specified in this part of ISO 5 are intended to simulate 45° illumination for viewing or photographing a specimen. There might be some engineering advantages in designing a measuring instrument with normal illumination and 45° collection. Reversing the geometry in this way has no demonstrated effect on the measured values in most cases, so both geometric arrangements are included in this part of ISO 5. However, work by Voglesong[11] has demonstrated that there are times when measurements of the same printed sample with 0°/45° & 45°/0° can be significantly different. This part of ISO 5 attempts to specify unambiguously the geometric conditions that define reflection densitometry by providing what is termed “ideal requirements”. The actual design and manufacture of instruments, however, require tolerances around these ideal conditions which, in this part of ISO 5, are shown as practical specifications.

This part of ISO 5 serves three primary functions:

a) to provide the basis for unequivocal measurements that are needed for specifications, for communication between organizations, and for contractual agreements;

b) to provide a reference to assist in resolving seemingly different measurement data between systems; and

c) to aid in the calibration and certification of densitometers, or spectrophotometers used as densitometers, by allowing for the generation of certified reference materials (CRMs) with numerical values traceable to fundamental physical phenomena.

For graphic arts applications, guidance in the use of densitometry is provided in ISO 13656.

Photography and graphic technology — Density measurements —

Part 4: Geometric conditions for reflection density

1 Scope

This part of ISO 5 specifies the geometric conditions for the definition of ISO 5 standard reflection density. It also recommends tolerances on geometric conditions that can be used in the design of instruments. The spectral conditions are specified in ISO 5-3.

This part of ISO 5 also specifies the requirements for polarization (if that feature is included) and for backing material, and makes recommendations regarding accuracy and linearity.

Although intended primarily for use in the measurement of the reflection characteristics of photographic and graphic arts materials, this part of ISO 5 is also applicable to the measurement of these characteristics for other materials.

2 Normative references

The following referenced documents are indispensable for the application 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 5-1, *Photography and graphic technology — Density measurements — Part 1: Geometry and functional notation*

ISO 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

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

IEC 60050-845:1987[1)], *International Electrotechnical Vocabulary. Lighting*

1) IEC 60050-845:1987 is a joint publication with the International Commission on Illumination (CIE). It is identical to CIE 17.4:1987, *International Lighting Vocabulary*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5-1, IEC 60050-845:1987 | CIE 17.4:1987 and the following apply.

3.1
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

NOTE Adapted from ISO Guide 30.

3.2
gloss suppression factor
P
numerical expression of the polarization efficiency of a densitometer with polarizing means

NOTE For a precise definition of P, see Annex D.

3.3
receiver
portion of the densitometer that senses the efflux, including the collection optics and detector

3.4
reflection density
D_R
negative logarithm to the base 10 of the reflectance factor

NOTE The International Commission on Illumination (CIE) designates the measurement referred to as “reflection density” in ISO 5 as “reflectance factor density”. (See IEC 60050-845:1987 | CIE 17.4:1987.)

[ISO 5-1:2009, definition 3.19]

3.5
reflectance factor
R
ratio of the reflected flux to the absolute reference reflected flux under the same geometrical and spectral conditions of measurement

[ISO 5-1:2009, definition 3.17]

3.6
screen ruling
number of image elements, such as dots or lines, per unit of length in the direction which produces the highest value

NOTE Adapted from ISO 12647-1.

3.7
screen width
reciprocal of screen ruling

NOTE Adapted from ISO 12647-1.

4 Coordinate system, terminology and symbols

The coordinate system, terminology and symbols described in ISO 5-1 are used in this part of ISO 5 as a basis for specifying the geometric conditions for reflection density measurements.

5 Distinction between ideal and realized parameters

The unambiguous definition of density requires that geometric, as well as spectral, parameters be exactly specified. However, the practical design and manufacture of instruments require that reasonable tolerances be allowed for physical parameters. The definition of ISO 5 standard reflection density shall be based on the *ideal* value specified for each parameter. The tolerances shown for the *realized* parameter values represent allowable variations of these standard parameters, which for many applications have an effect of less than 0,01 on the density values resulting from measurements made with instruments. A method for determining conformance of a realized parameter with the tolerances is given in Annex A.

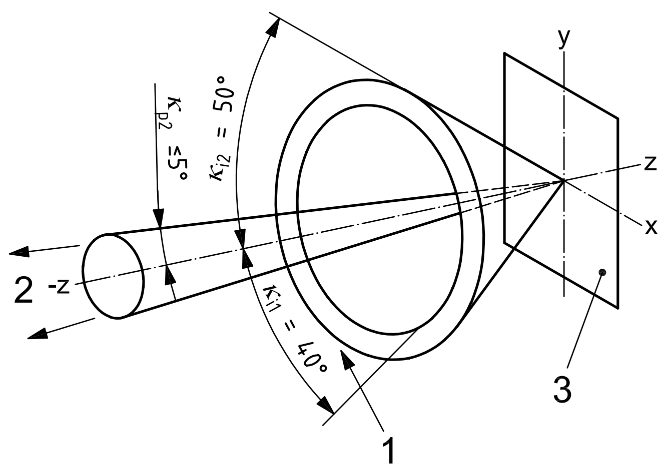
6 Requirements

6.1 Influx and efflux geometry

ISO 5 standard reflection measurements may be made with two equivalent measurement geometries. In the “annular influx mode”, the geometry of the illuminator is annular and the geometry of the receiver is directional. In the “annular efflux mode”, the geometry of the illuminator is directional and the geometry of the receiver is annular. The annular influx mode is illustrated in Figure 1. The annular efflux mode would be illustrated by Figure 1 if the arrows showing the radiant flux direction were reversed and the labels were interchanged. The modes can be described in terms of specified annular and directional distributions of illumination radiance (subscript i) or receiver responsivity (subscript r), depending on the mode. The cone half-angle κ (lower case Greek kappa, κ) is the angle between the angle of illumination or view (lower case Greek theta, θ) and the marginal ray.

The *ideal* angles of illumination and view and half-angles for the annular influx mode are $\theta_i = 45°$, $\theta_r = 0°$, $\kappa_i = 5°$, and $\kappa_r = 5°$. The *realized* angles of illumination and view and half-angles for the annular influx mode are $\theta_i = 45° \pm 2°$, $\theta_r = 0° \pm 2°$, $\kappa_i = 5° \pm 1°$, and $\kappa_r = 5° \pm 1°$.

For the annular efflux mode, the *ideal* angles of illumination and view and half-angles are $\theta_i = 0°$, $\theta_r = 45°$, $\kappa_i = 5°$, and $\kappa_r = 5°$. The *realized* angles of illumination and view and half-angles for the annular efflux mode are $\theta_i = 0° \pm 2°$, $\theta_r = 45° \pm 2°$, $\kappa_i = 5° \pm 1°$, and $\kappa_r = 5° \pm 1°$.



Key

1 influx

2 efflux

3 specimen

NOTE Angles indicated represent the practical tolerances for the half-angle of the cone.

Figure 1 — Geometry of the annular influx mode

6.2 Sampling aperture

The extent and shape of the area on which density is measured are the sampling aperture. Physically, the sampling aperture is realized by the optical systems of the illuminator and receiver. The size and shape of the sampling aperture are not critical

a) if no dimension is so large that the influx and efflux geometric conditions vary materially over the sampling aperture, or

b) if no dimension is so small that the effects of granularity, specimen texture, diffraction, or half-tone dot structure become significant.

For case b), the diameter of a circular sampling aperture should not be less than 15 times the screen width; it shall not be less than 10 times the screen width that corresponds to the lower limit for the screen ruling for which the instrument is recommended by the manufacturer. The area of non-circular sampling apertures shall not be smaller than that required for circular sampling apertures.

The sampling aperture is defined as the smaller of the illuminator region and the receiver region. Ideally, the larger shall be greater than the smaller to the extent that any increase in size of the larger region has no effect on the measurement result. The specimen characteristics over the illuminator region should be the same as those over the receiver region.

NOTE 1 This requirement prevents lateral diffusion error.

The realized boundary of the larger of the illuminator region and the receiver region shall be outside the boundary of the smaller by at least 2 mm. Where small sampling apertures are required, this dimension shall be at least 0,5 mm. The magnitude of the resulting lateral diffusion error should be accepted as part of the overall measurement uncertainty, or a greater boundary differential should be used.

NOTE 2 These dimensions are an acceptable compromise between the need to measure small areas and a negligible uncertainty of measurement.

Any physical aperture present in the reference plane that is not used to limit either the illuminator region or receiver region shall be kept well clear of both the influx and efflux beams.

The *ideal* illuminator radiance and receiver responsivity distributions shall be uniform over the sampling aperture. The *realized* distributions shall be uniform to within 10 %. This can be determined by scanning the sampling aperture laterally with a geometrically similar aperture, similarly oriented and having dimensions no more than one-quarter of those of the corresponding dimensions of the sampling aperture. The radiance at any place on the sampling aperture shall be at least 90 % of the maximum radiance.

NOTE 3 Lack of uniformity is immaterial when uniform specimens are measured, but can be an important source of error in measurements of non-uniform specimens.

6.3 Annular distribution

The *ideal* angular distribution of radiance from the illuminator (influx) or of responsivity of the receiver (efflux) shall be uniform for angles within the cone defined by the illuminator or receiver axis and half-angle and zero for angles outside the cone. The *realized* angular distribution shall be uniform to within 10 % within the cone and less than 2 % of the maximum of the cone distribution outside the cone.

The distribution of radiance from the illuminator or responsivity of the receiver shall be uniform around the annulus, unless the reflection characteristics of the specimens to be measured do not change as they are rotated in their own plane, in which case the realized radiance or responsivity need not be uniform around the annulus.

For applications where specimens have been shown to have only a slight dependency on directional effects (i.e. if density measurements made at azimuthal angles of 0°, 45°, and 90° differ by an amount that is less than the tolerance acceptable for the intended application), strict uniform annular distribution may be replaced by a distribution in which either:

— the illuminator has a directional geometry at two azimuthal angles 90° apart (or, preferably, at more than two equally spaced azimuthal angles), or

— the receiver has a directional geometry at two azimuthal angles 90° apart (or, preferably, at more than two equally spaced azimuthal angles).

6.4 Normal directional distribution

The *ideal* angular distribution of radiance from the illuminator (influx) or of responsivity of the receiver (efflux) shall be uniform for angles within the cone defined by the half-angles and zero for angles outside the cone.

The *realized* angular distribution shall be uniform within 10 % within the cone and less than 2 % of the maximum of the cone distribution outside the cone.

6.5 Determination of illuminator radiance distribution

The illuminator radiance distribution can be determined by placing a receiver having uniform angular response over a conic distribution with a half-angle of 2° at the centre of the sampling aperture. Anormal angles are scanned with the receiver both inside and outside the ideal influx cone, and the signal from the scanned receiver is recorded at each angle. The signal at any angle within the influx cone shall be at least 90 % of the maximum signal recorded. Outside the influx cone, the signal shall be less than 2 % of the maximum signal recorded within the influx cone.

6.6 Determination of receiver responsivity distribution

The receiver responsivity distribution can be determined by placing a small beam with a conic distribution having a half-angle of 2° at the centre of the sampling aperture. Anormal angles are scanned with the beam both inside and outside the ideal efflux cone, and the signal from the receiver is recorded at each angle. The signal for any angle within the efflux cone shall be at least 90 % of the maximum signal recorded. Outside the efflux cone, the signal shall be less than 2 % of the maximum signal recorded within the efflux cone.

6.7 Polarization efficiency

Ideally, for ISO 5 standard density measurements made with polarization, gloss suppression shall be infinite for every available spectral channel.

Practically, for measuring instruments with polarization means, the gloss suppression factor, as defined in Annex D, shall be not less than 50 for every available spectral channel.

NOTE 1 Instruments with polarization means are common only in some graphic technology applications.

NOTE 2 Measurements made with polarization means will generally not match to those made without polarization.

6.8 Scattered flux

Scattered flux shall be reduced to a negligible amount by the use of clean optical components and appropriate baffles, and by suitable blackening of surfaces exposed to the specimen, in accordance with good photometric practice.