INTERNATIONAL STANDARD

ISO 5-4

Third edition
2009-12-01

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

Reference number
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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.

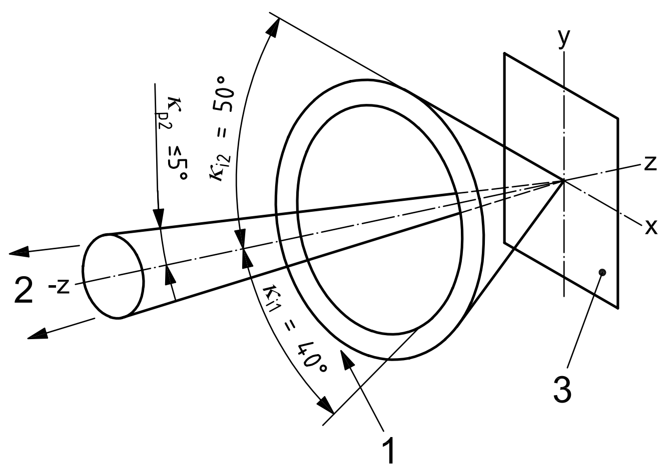
6 Requirements

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.

6.9 Backing material

6.9.1 General

When measuring ISO 5 standard reflection density, the specimen shall be firmly positioned in the measurement plane and backed by either a black or white backing that satisfies the characteristics specified in 6.9.2 and 6.9.3. While density measurements may be made over either a black or white backing, a black backing is the default condition and, unless otherwise indicated, shall be assumed to be the backing used. Where white backing is used, the measurements shall be identified as being made “over white”.

Deviations from these criteria are allowed only if it can be demonstrated that another backing gives the same results on the particular type of specimen being measured. In particular, the backing for opaque specimens is not critical and need not meet these criteria.

See Annex E for additional discussion of backing materials.

6.9.2 Black backing

For measurements made over a black backing, the backing shall have all of the characteristics listed below.

a) The backing shall have an infinite ISO 5 standard reflection density for all spectral products of interest. For practical applications, the specimen shall be in contact with a backing material that has an ISO 5 visual reflection density of at least 1,30.

b) The backing shall be spectrally non-selective, i.e. the total range of spectral reflection density throughout the wavelength interval from 400 nm to 700 nm shall ideally be zero, while practically it shall not exceed 5 % of the average density obtained over the same interval.

c) The backing shall be diffuse-reflecting, i.e. it shall have no perceptible specular reflection when viewed at any angle under any illumination conditions.

d) The backing shall be essentially opaque (one whose own reflection density does not depend on the presence of or type of backing material used in its measurement).

As black backing is the default condition, unless otherwise noted, measurements shall be assumed to have been made over black.

6.9.3 White backing

For measurements made over a white backing, the backing shall conform to the white backing specified in ISO 13655. Such measurements shall be reported as being made “over white”.

NOTE 1 Density is a measure of the amount of light absorbed by the specimen. A white backing scatters light that was not modulated by the specimen back into the receiver and thus lowers the density. ISO 13655 contains a recommendation for white backing, but this measurement condition, while allowed for compatibility with ISO 13655, is not recommended for the measurement of reflection density.

NOTE 2 The use of white backing is usually encountered in the graphic arts and colour management areas where measurements of spectral data are used to compute both density and colorimetry.

6.10 Reference standard

ISO 5 standard reflection density is defined in relation to a perfectly reflecting and perfectly diffusing material. Since such a perfect material does not exist, reference materials such as ceramic check plaques or barium sulfate ($BaSO_4$) are acceptable for use in maintaining calibration. The density relation between these and the perfect material shall be known and utilized in determining ISO 5 standard reflection densities. Densitometer manufacturers and national standardizing and metrology institutes can generally provide the ISO 5 standard reflection density of such reference materials.

6.11 Designation

Density values obtained using the specifications given in 6.1 to 6.10 shall be referred to as “ISO 5 standard reflection density”. In functional notation this shall be denoted as

— D_R(45 a°, 5°; S: 0°, 5°; s) for the annular influx mode, or

— D_R(0°, 5°; S: 45 a°, 5°; s) for the annular efflux mode,

where S is the spectral power distribution for reflection density, and s is the spectral responsivity of the receiver. The allowed values for S and s shall be as given in ISO 5-3.

NOTE 1 The values for S identified in ISO 5-3 for reflection densitometry are A, M1, M2 and M3, where M3 also denotes polarization.

NOTE 2 The values for s identified in ISO 5-3 for reflection densitometry are V, A, T, E, I and narrow-band.

The adjective describing the spectral product as defined in ISO 5-3 may be inserted before the word “reflection”, and if a graphic arts influx is used, that may be added as a suffix.

EXAMPLE “ISO 5 standard status E reflection density – M3”.

If a measurement is made over a white backing, it shall be identified as “over white”.

6.12 Conformance testing

Physical tolerances of specific instruments may vary depending on the application and materials being measured, so that final determination of conformance will include an understanding of the application of the measurements. It is the responsibility of the user, in conjunction with the instrument manufacturer, to determine conformance of measured density to density as defined by this part of ISO 5. The use of appropriate certified reference materials (CRMs) is recommended for testing of measurement systems.

Annex A
(normative)

Determining conformance with tolerances

A.1 General

This part of ISO 5 gives tolerances for realized parameters. This annex defines a decision rule for determining conformance with these specified tolerances, taking into account the estimated uncertainty associated with the measurement of these parameters. This annex adopts the ideas and notations presented in ISO 14253-1, which extensively discusses the matter of proving conformance with given specifications.

A.2 Statement of conformance with specification

A densitometer conforms with this part of ISO 5 if the result of measurement y is between $L_{LS} + |U|$ and $L_{US} - |U|$ (denoted in ISO 14253-1 as the "conformance zone"), as shown in Equation (A.1):

$$L_{LS} + |U| < y < L_{US} - |U| \quad \text{(A.1)}$$

where

L_{US} is the upper specification limit: a specified value giving the upper boundary of the permissible values of a particular densitometer characteristic;

L_{LS} is the lower specification limit: a specified value giving the lower boundary of the permissible values of a particular densitometer characteristic;

y is the result of measurement: a value attributed to measurand Y (particular quantity subject to measurement), obtained by a measurement;

U is the expanded uncertainty: a quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand (see ISO/IEC Guide 98-3).

The coverage factor, k, is a numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty. It is based on the level of confidence desired. For the purposes of this annex, a coverage factor (k) of 2, equivalent to a confidence level of approximately 95 %, shall be used in the determination of the expanded uncertainty.

EXAMPLE The tolerance stated in this part of ISO 5 for the half-angle of maximum radiance in the annular influx mode is 45° ± 2°, i.e. $L_{LS} = 43°$ and $L_{US} = 47°$. Suppose, as an example, that the expanded uncertainty associated with the measurement of the half-angle of the influx cone is ±1° ($k = 2$). Hence, conformance with the specified tolerance is demonstrated if the measured value of the half-angle of maximum radiance is between 44° and 46°.

NOTE ISO/IEC Guide 98-3 provides additional material on this subject.

Annex B
(normative)

Determination of accuracy and linearity of a densitometer

After standardization of the densitometer on all channels in accordance with the manufacturer's instructions, the reflection densities of a CRM set conforming to ISO 15790 shall be measured with the instrument under evaluation. On at least three CRMs covering a nominal ISO 5 standard reflection density range of (0,1 ± 0,1) to (2,0 ± 0,5), the measured density shall agree with the density reported in the documentation accompanying the CRM. The extent of this agreement (i.e. the accuracy) is best specified by the user, in accordance with the requirements of the application. In the absence of such a specification, a generally acceptable accuracy is ± 0,02 % or ± 2 %, whichever is the greater.

For measuring instruments with polarizing means, the CRMs shall, in addition, conform to the requirements of Annex C.

NOTE The CRMs conforming to Annex C can also be used for measuring instruments without polarizing means.

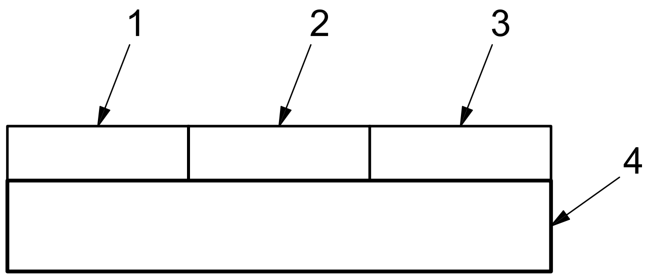
Annex C
(normative)

Certified reference materials for measuring instruments with polarizing means

A CRM for linearity testing of measuring instruments with polarizing means shall consist of a white ceramic plate with at least three “neutral density” absorptive glass filters attached to the surface (see Figure C.1). The ceramic base plate shall have a plain matt white surface. The neutral absorptive glass filters shall be optically polished, plain, and essentially spectrally non-selective (see 6.9). They shall be adhered to the ceramic plate using a spectrally non-selective cement (see Figure C.1).

The filters should be selected such that the following ISO 5 visual reflection densities are realized by the finished CRM set: 0,0 to 0,2; 1,0 ± 0,2; 2,0 ± 0,5.

In the documentation accompanying the CRM, the (absolute) ISO 5 standard reflection densities and their uncertainties at a stated level of confidence shall be reported for the spectral conditions, including ISO 5 visual reflection density and at least one of the following sets: ISO 5 status T, ISO 5 status I or ISO 5 status A.



Key

1, 2, 3 spectrally non-selective glass filters

4 ceramic base plate

Figure C.1 — Cross-section of the test object for measuring instruments with a polarizing means

NOTE 1 This construction of a CRM set provides an opportunity for calibration of measuring instruments with and without polarization means, using the same set.

NOTE 2 For further information, see Reference [10].

Annex D
(normative)

Polarization efficiency

D.1 Determination of polarization efficiency

D.1.1 For simplicity, the method described in this annex applies to the case of a densitometer that is intended to be used by placing it on top of a horizontal test object, but this does not preclude other types of use.

D.1.2 Use a polarization test object (an example is described in D.2) and, for every spectral channel of the measuring instrument, carry out the steps described in D.1.3 to D.1.9.

D.1.3 Remove the polarization means from the measuring instrument, and set it to zero on a white reference.

D.1.4 Mount the polarization test object horizontally and place the measuring instrument on it.

D.1.5 Adjust the horizontal position of the measuring instrument, such that the reflection density reaches a minimum.

D.1.6 Adjust the vertical position of the pointed cylinder, such that the reflection density again reaches a minimum value, D_1. If the detector and accompanying electronics operate outside their linear operating range, or if an error condition is otherwise indicated, insert attenuating means into the light path and make sure they do not disturb the geometry.

EXAMPLE The insertion of a thin, spectrally non-selective density filter.

D.1.7 Reinstall the polarization means into the measuring instrument, and set it to zero, as in D.1.3.

D.1.8 Place the measuring instrument back on the polarization test object at the same location at which the minimum density was achieved in D.1.5.

D.1.9 Read the new reflection density, D_2.

D.1.10 Calculate the gloss suppression factor, P, as shown in Equation (D.1):

$$P = 10^{D_2 - D_1} \tag{D.1}$$

where

D_1 is the density determined in D.1.5 (without polarization means);

D_2 is the density determined in D.1.8 (with polarization means).

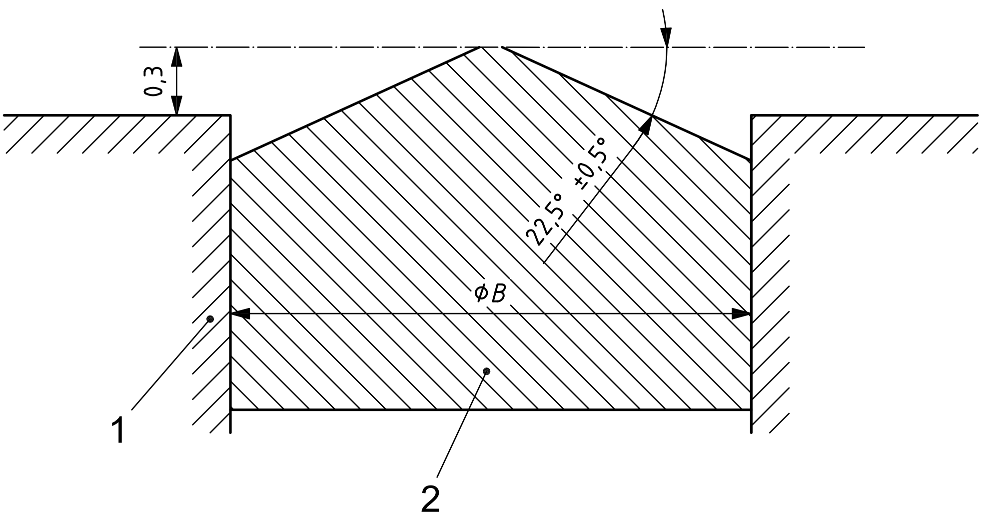
D.2 Example polarization test object

The following description provides a means of realizing a practical polarization test object, but any other design that can be shown to give essentially identical results is acceptable.

The test object should consist of a plate with a central, vertical and circular hole from which a snug-fitting metallized cylinder should protrude partly (see Figure D.1). The diameter of the cylinder should be at least 4 mm greater than the widest dimension of the sampling aperture. The cylinder should have a conical point with an angle of approximately 135°. The surface of the cone should be (22,5 ± 0,5)° from the surface defined by the plate. The conical point should be spherically blunted at its very top, and the cone should be chromium-plated and highly polished. The vertical position of the pointed cylinder should be adjustable from below by small increments.

NOTE For further information, see Reference [10].

Dimensions in millimetres



Key

1 base plate

2 circular cylinder with conical point

Figure D.1 — Cross-section of polarization test object

Annex E
(informative)

Backing materials

For ISO 5 standard reflection density, previous editions of this part of ISO 5 specified that the backing material should be spectrally non-selective and diffuse-reflecting (no perceptible specular reflection) and should have an ISO 5 visual reflection density of at least 1,30. This choice was made to reduce measurement variability introduced by both the backing material and the presence of printing or imaging on the reverse of a substrate.

On thinner substrates and ones with lower transmission densities, the reflectance density of the backing has a greater impact on the value of the reflection density measured. This impact is non-linear and is dependent on both the opacity of the substrate and the density of the sample being measured. In all cases, the greatest impact is on the measurement of the substrate alone (without either halftone or continuous tone image areas). In the extreme, for a transparent substrate such as clear polyethylene film, the reflection density measurement of the substrate alone is essentially a measurement of the backing material.

Although it is also much easier to specify and consistently maintain a high density (black) backing than it is a low (white) density backing, there are many situations where measurements over a black backing are meaningless; e.g. halftone images on clear polyethylene.

ISO 13655 has addressed this issue by also specifying a “standard white” backing which has also been adopted for use in measurement of ISO 5 standard reflection density. Use of a “standard white” backing is important where spectral reflectance measurements are used to compute both colorimetric data and density data and the application of the colorimetric data requires white backing. A typical example of this requirement is where proofs, which are typically made on a rather opaque substrate, are to be compared to printed images made on a translucent substrate. In such a situation, both process control density data and image evaluation colorimetric data need to have a common base that can only be provided if a white backing is used for the measurements of the printed material on the translucent substrate.

The default measurement of ISO 5 standard reflection density is still based on use of black backing. However, the introduction of a “standard white” backing is critical for many applications of reflection densitometry. Where a white backing is used, it is important that its use be reported along with the data.

For those situations where traditional black backing can be used, its use should be maintained and encouraged. Problems associated with maintaining the backing surface from the standpoint of spectral neutrality, density and physical requirements are greatly reduced with a high-density black backing compared to using a white backing. It should be noted that experience has shown that it is very difficult to find a durable non-glossy surface with a density greater than 1,7. Therefore, if the density of the backing material reads greater than 1,7, it is most likely that the diffuse character of the surface has been damaged and some specular reflections are falling outside the pickup cone angle of the densitometer, in which case the material should be replaced.

Annex F
(informative)

Reflectance density versus reflectance factor density

The ISO 5 standard densities referred to in this part of ISO 5 are not reflectance densities, but reflectance factor densities (often referred to as reflection densities). Thus, it is important to note the difference between reflectance and reflectance factor, as described below.

a) Reflectance, ρ, is defined as the ratio of the reflected flux, Φ_r, to the incident flux, Φ_i, in the given conditions, as shown in Equation (F.1):

$$\rho = \frac{\Phi_\mathrm{r}}{\Phi_\mathrm{i}} \qquad \text{(F.1)}$$

Reflectance density, D_ρ, is calculated as shown in Equation (F.2):

$$D_\rho = -\log_{10} \rho = -\log_{10} \frac{\Phi_\mathrm{r}}{\Phi_\mathrm{i}} \qquad \text{(F.2)}$$

b) Reflectance factor, R, is the ratio of the flux reflected from the specimen, Φ_r, to the flux reflected by a perfectly reflecting and perfectly diffusing material, Φ_rA, under identical geometric and spectral conditions of illumination and sensing, as shown in Equation (F.3):

$$R = \frac{\Phi_\mathrm{r}}{\Phi_\mathrm{rA}} \qquad \text{(F.3)}$$

Reflection density (reflectance factor density), D_R, is calculated as shown in Equation (F.4):

$$D_R = -\log_{10} R = -\log_{10} \frac{\Phi_\mathrm{r}}{\Phi_\mathrm{rA}} \qquad \text{(F.4)}$$

It should be noted that, since some samples contain fluorescing materials, it is possible that under certain spectral conditions such samples can have an apparent reflectance factor greater than 1,0.

Bibliography

[1] ISO 5-1:2009, *Photography and graphic technology — Density measurements — Part 1: Geometry and functional notation*

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[3] ISO 13656, *Graphic technology — Application of reflection densitometry and colorimetry to process control or evaluation of prints and proofs*

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