INTERNATIONAL STANDARD

ISO 5-2

Fifth edition
2009-12-01

Photography and graphic technology — Density measurements —

Part 2:
Geometric conditions for transmittance density

Photographie et technologie graphique — Mesurages de la densité —

Partie 2: Conditions géométriques pour la densité de transmittance

Reference number
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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 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 5-2 was prepared by ISO/TC 42, *Photography*, and ISO/TC 130 *Graphic technology*, in a Joint Working Group.

This fifth edition cancels and replaces the fourth edition (ISO 5-2:2001), 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 for transmittance densitometry, primarily (but not exclusively) as practised in black-and-white and colour photography and graphic technology. This part of ISO 5 is intended to specify geometrical conditions for the measurement of optical densities that are close to those used in practice. Diffuse transmittance densities are, among other things, relevant for contact printing and rating films on viewing boxes. Viewing films on light boxes is one of the most important applications where diffuse transmittance densities are relevant. Therefore, the specified conditions for the measurement of diffuse transmittance densities consider the properties of viewing boxes concerning diffusivity and the spectral reflectance factor. Another important application is the measurement of the diffuse transmittance density and hence the opaque area percentage of lithography-type black-and-white films for graphic technology. This part of ISO 5 also describes the geometric conditions for two types of projection density. The spectral conditions are specified in ISO 5-3.

The primary change between the first edition of this part of ISO 5 (published in 1974) and the second edition (published in 1985) was the replacement of the integrating sphere method with a diffuser (typically “opal glass”) as the basis for specifying ISO 5 standard diffuse transmittance density. Although any means of diffusion that meets the specifications of this part of ISO 5 can be used, the method is often denoted simply by the words “opal glass” in order to differentiate it from the integrating sphere method. Slightly smaller density values are generally obtained compared to those based on the integrating sphere method because of inter-reflections between the opal glass and the specimen. The effect is dependent on the reflectance characteristics of the opal glass and the surface of the specimen facing the diffuser.

Diffuse transmittance density is a measure of the modulation of light by a film that is diffusely irradiated on one side and viewed from the other, as when a film is viewed on a diffuse transparency illuminator. The geometric conditions of projection with diffuse illumination are nearly equivalent to the conditions of viewing a film on a diffuse illuminator, the projection lens taking the place of the eye. When film is on a diffuse illuminator or in contact with a print material, light is inter-reflected between the film and the nearby surface. This inter-reflection affects the density and is best taken into account in a measuring instrument by the use of an opal-glass diffuser or integrator, rather than an integrating sphere. Apart from this fundamental reason for using densitometers employing opal-glass diffusers, such instruments are preferred because they are more durable and more convenient to manufacture and use.

Projection density is a measure of the modulation of light by a film that is regularly illuminated on one side and is projected by way of a regular collection system. Equipment employing optical condensers is used to view microfilm, motion pictures, and slides, and to make projection prints. The conditions defined in this part of ISO 5 for projection density simulate the geometric conditions affecting the transmitting characteristics of a small area on a negative or transparency at the centre of the frame of a typical projection system employing condensers. The area under consideration can be defined by a small opening, known as the “sampling aperture”, in an otherwise opaque sheet in the frame.

The measured density depends on the half-angle of the cone of incident rays and the half-angle subtended by the projection lens at the sampling aperture. These half-angles can be indicated either in degrees or by f-numbers. Since the f-number is usually marked on projection lenses, the two types of ISO 5 standard projection density specified in this part of ISO 5 are identified by f-numbers, namely f/4,5 and f/1,6. The f/4,5 type is frequently used, since it is representative of microfilm readers. The f/1,6 type is considered representative of motion-picture projectors.

Significant changes from the fourth edition of this part of ISO 5 are explained below.

a) The terminology “transmission density” has been replaced by the term “transmittance density” for both diffuse and projection densities. Both densities require measurements relative to the incident flux (influx), and therefore the regular or diffuse transmittance of the specimen is measured. As explained in ISO 5-1, the correct density term corresponding to regular transmittance is “transmittance density”.

b) A distinction is made between *ideal* and *realized* parameters for transmittance density. The definition of ISO 5 standard transmittance density is based upon ideal values specified for each parameter. However, actual instruments require reasonable tolerances for physical parameters, which are specified by the realizable parameters.

Photography and graphic technology — Density measurements —

Part 2:
Geometric conditions for transmittance density

1 Scope

This part of ISO 5 specifies the geometric conditions for measuring ISO 5 standard diffuse and f/4,5 and f/1,6 projection transmittance densities.

ISO 5 standard diffuse density is primarily applicable to measurements of photographic images to be viewed on a transparency illuminator, or viewing box, to be contact printed, or to be projected with a system employing diffuse illumination.

ISO 5 standard projection density is primarily applicable to measurements of photographic images to be projected with systems employing optical condensers.

Although primarily intended for the measurement of photographic images, the densitometric methods specified in this part of ISO 5 are often applied to optical filters and other transparent 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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5-1 and the following apply.

3.1
diffusion coefficient
β_{dc}
measure of the diffusivity of the illuminating or receiving system

NOTE See Annex A.

3.2
transmittance
τ
ratio of the transmitted flux to the incident flux under specified geometrical and spectral conditions of measurement

NOTE 1 In practical instruments for transmittance measurements, the incident flux is defined by the combination of all of the components that are placed before the reference plane (influx), so the incident flux is provided by the surface of the opal diffuser for diffuse transmittance and by the film gate for projection density.

NOTE 2 Adapted from ASTM E284.

[ISO 5-1:2009, definition 3.22]

3.3
transmittance density
D_τ
negative logarithm to the base 10 of the transmittance

NOTE The subscript is the lower case Greek letter tau.

[ISO 5-1:2009, definition 3.23]

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 ISO 5 standard transmittance density measurements.

5 Distinction between ideal and realized parameters

The unambiguous definition of ISO 5 standard density requires that geometric, as well as spectral, parameters be exactly specified. However, the practical design and manufacture of instruments requires that reasonable tolerances be allowed for physical parameters. The definition of ISO 5 standard transmittance 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 B.

6 Requirements for ISO 5 standard diffuse transmittance density

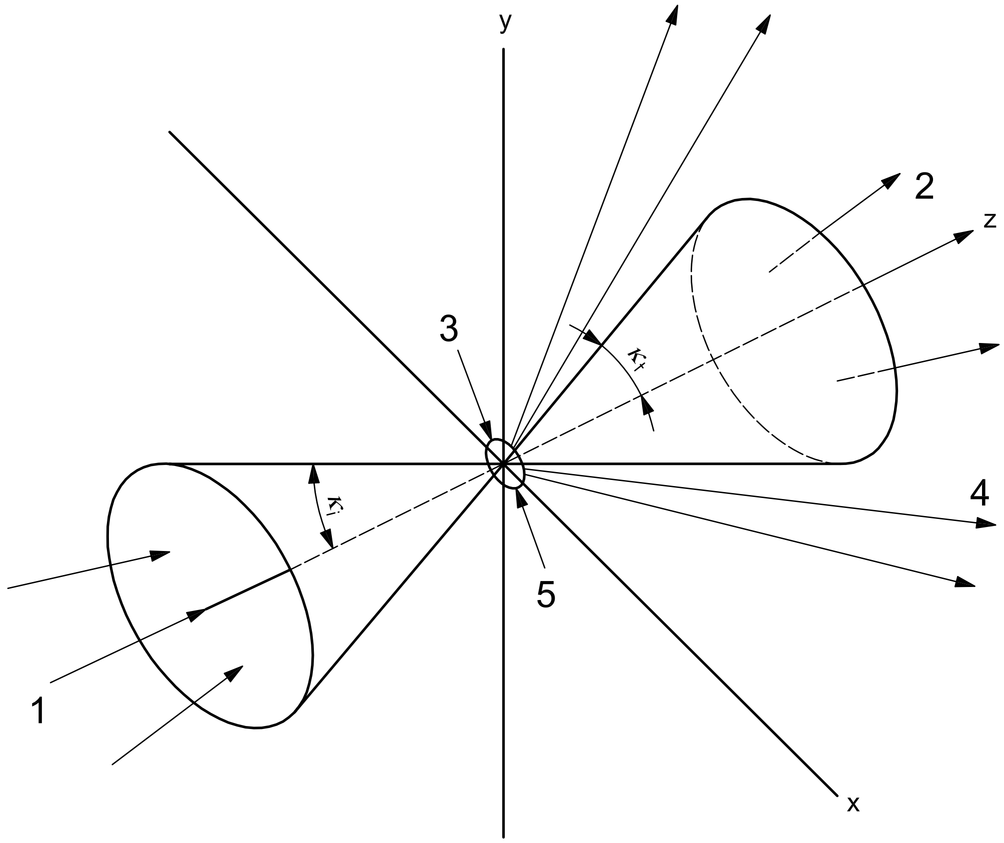
6.1 Geometric modes

Diffuse transmittance density measurements may be made with two equivalent measurement geometries. In the “diffuse influx mode”, the geometry of the illuminator is diffuse and the geometry of the receiver is directional, while in the “diffuse efflux mode”, the geometry of the illuminator is directional and the geometry of the receiver is diffuse. These modes are defined in Figure 1. A diffuse illuminator projects radiant flux onto the sampling aperture from all directions within the hemisphere, while a diffuse receiver collects radiant flux transmitted by the sampling aperture in all directions within the hemisphere. The modes can be described in terms of specified diffuse and directional distributions of illumination radiance or receiver responsivity, depending on the mode. The cone half-angle, κ, is the angle between the angle of illumination or view and the marginal ray. A cone half-angle of 90° indicates that the illuminator or receiver has a diffuse geometry.

Referring to the cone half-angles shown in Figure 1, the *ideal* angles of illumination and view and half-angles for the diffuse influx mode are $\theta_i = 0°$, $\kappa_i = 90°$, and $\theta_t = 0°$, $\kappa_t = 10°$. For the diffuse efflux mode, the *ideal* angles of view and illumination and half-angles are $\theta_t = 0°$, $\kappa_t = 90°$, and $\theta_i = 0°$, $\kappa_i = 10°$.

The *realized* angles of illumination and view and half-angles for the diffuse influx mode are $\theta_i = 0° \pm 2°$, $\kappa_i = 90°$, and $\theta_t = 0° \pm 2°$ $\kappa_t = 10° \pm 2°$. For the diffuse efflux mode, the *realized* angles of view and illumination and half-angles are $\theta_t = 0° \pm 2°$, $\kappa_t = 90°$, and $\theta_i = 0° \pm 2°$, $\kappa_i = 10° \pm 2°$.

NOTE The 90° specification implies physical contact between the specimen and the diffuse illuminator or receiver.



For diffuse density measurement with diffuse influx: $\kappa_i = 90°$ and $\kappa_t = 10°$.

For diffuse density measurement with diffuse efflux: $\kappa_i = 10°$ and $\kappa_t = 90°$.

For projection density measurements, for *f*/4,5: $\kappa_i = \kappa_t = 6{,}4°$.

For projection density measurements, for *f*/1,6: $\kappa_i = \kappa_t = 18{,}2°$.

Key

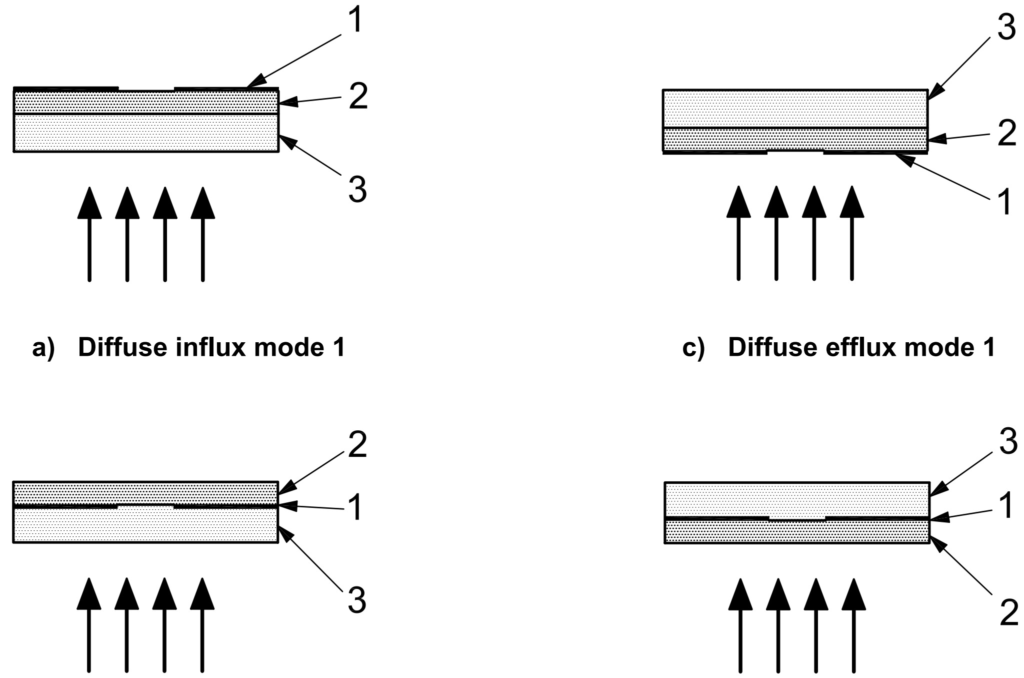
1 influx geometry
2 efflux geometry
3 sampling aperture
4 aperture simulating the entrance pupil of projection lens
5 point O

Figure 1 — Geometry for ISO 5 standard transmittance density measurements

6.2 Sampling aperture

The extent and shape of the area on which density is measured is the sampling aperture. Physically, the sampling aperture is realized by a diaphragm, which shall be in contact with the specimen to be measured. Figure 2 shows the four combinations which may be applied: two for the diffuse influx mode and two for the diffuse efflux mode. All other combinations are excluded.

NOTE 1 Figure 2 shows, for combinations b) and d), that the opaque material of the diaphragm constitutes a smooth surface with the diffusing material. This can be obtained by grinding the opal glass and filling the recess with an appropriate opaque material. Since these combinations are rather costly, combinations a) and c) will be preferred in practice.



a) **Diffuse influx mode 1**

c) **Diffuse efflux mode 1**

b) **Diffuse influx mode 2**

d) **Diffuse efflux mode 2**

Key

1 diaphragm

2 specimen

3 opal glass

Figure 2 — Geometrical arrangement of the diaphragm for diffuse influx mode and diffuse efflux mode

In combinations a) and d) of Figure 2, the diaphragm is part of the receiver, and the illuminator region (i.e. the area over which the specimen is illuminated) shall be larger than the size of the diaphragm. In combinations b) and c) of Figure 2, the diaphragm is part of the illuminator, and the receiver region (i.e. the area over which the specimen is viewed) shall be larger than the size of the diaphragm.

The size and shape of the sampling aperture is not critical

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

— if no dimension is so small that the granularity of the film, the finite specimen thickness, diffraction effects, or the halftone dot structure is significant.

In the case of periodic halftone screens, 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.

Measurements on areas less than 0,5 mm diameter border on, or involve, micro-densitometry and are subject to special considerations not dealt with in this part of ISO 5. The angle from the centre of the optical component limiting the directional distribution to the edge of the sampling aperture shall not be greater than 1°. The angle from the centre of the sampling aperture to the edge of the optical component limiting the directional distribution shall not be greater than 10°.

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 2 Lack of uniformity is immaterial when uniform images are measured, but can be an important source of error in measurements on non-uniform images.

The size of the diffuser relative to the sampling aperture shall be large enough to prevent its rim or support from affecting density measurement. The specimen to be measured shall be placed in contact with the diffuser. In the case of photographic films and plates, the emulsion surface shall face the diffuser. The side of the diffuser in contact with the specimen shall be polished.

6.3 Diffuse distribution

The angular distribution of radiance from the illuminator (for the diffuse influx mode), or of responsivity for the receiver (for the diffuse efflux mode), shall have an *ideal* diffusion coefficient of 0,92. The *realized* diffusion coefficient shall be $0{,}92 \pm 0{,}02$. The definition and measurement of the diffusion coefficient are given in Annex A.

For the spectral range specified in ISO 5-3, the *ideal* spectral reflectance factor $R_{\text{di:8}}$ of the diffuser shall be 0,55. The *realized* spectral reflectance factor shall be $0{,}55 \pm 0{,}05$.

NOTE 1 Realized diffusion coefficients and spectral reflectance factors specified above yield errors in density measurements that are generally less than 0,01.

NOTE 2 Density measurements are sensitive to variations in the reflectance factor and surface polish of the diffuser because of the effects on the inter-reflections that occur between it and the specimen.

NOTE 3 Such a distribution has often been produced by the use of a plate of opal glass to diffuse the incident radiant flux, or to integrate the transmitted radiant flux, but the use of opal glass is not required if the specified optical conditions are met by other means.

NOTE 4 Opal glass is a material consisting of very small colourless particles embedded in a clear glass matrix. It is available in two forms:

— flashed opal, which consists of a thin layer carried by a clear glass substrate, and

— pot opal, which has diffusing particles throughout its entire thickness.

6.4 Directional distribution

6.4.1 General

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.

6.4.2 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.

6.4.3 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 at any point 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.

6.5 Designation

Density values obtained using the specifications given in 6.1 to 6.4 shall be referred to as "ISO 5 standard diffuse transmittance density." In functional notation, this shall be denoted as

— D_τ(di; S_H: 0°, 10°; s) for the diffuse influx mode, or

— D_τ(0°, 10°; S_H: di; s) for the diffuse efflux mode,

where S_H is the spectral power distribution for transmittance density (see ISO 5-3), and s is the spectral responsivity of the receiver.

The adjective describing the spectral product as defined in ISO 5-3 shall be inserted before the word "diffuse".

EXAMPLE "ISO 5 standard visual diffuse transmittance density"

7 Requirements for ISO 5 standard projection transmittance density

7.1 Geometric modes

For f/4.5 ISO 5 standard projection density, the *ideal* angles of illumination and view and half-angles are $\theta_i = \theta_t = 0°$ and $\kappa_i = \kappa_t = 6{,}4°$, while for f/1,6 ISO 5 standard projection density, the *ideal* illumination and view angles and half-angles are $\theta_i = \theta_t = 0°$ and $\kappa_i = \kappa_\tau = 18{,}2°$. These half-angles define the influx and efflux cones.

The *realized* angles of illumination and view and half-angles are $\theta_i = \theta_t = 0° \pm 2°$ and $\kappa_i = \kappa_\tau = 6{,}4° \pm 0{,}2°$ for f/4,5 ISO 5 standard projection density, and $\theta_i = \theta_t = 0° \pm 2°$ and $\kappa_i = \kappa_\tau = 18{,}2° \pm 0{,}1°$ for f/1,6 ISO 5 standard projection density.

NOTE The relationship between f number and half-angle is

$$f \text{ number} = \frac{1}{2n \sin \kappa}$$

where n is the refractive index of the image space.

7.2 Sampling aperture

The sampling aperture shall be small compared with the remainder of the optical system, in order to limit the variation of geometric conditions across it. Its diameter shall not exceed one-sixth of that of the entrance pupil of the projection lens. The diameter of the sampling aperture shall not be less than 0,5 mm.

7.3 Directional distributions

7.3.1 General

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 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.

7.3.2 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 standard 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.

7.3.3 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 standard efflux cone, and the signal from the receiver is recorded at each angle. The signal at any point 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.

7.4 Designation

Density values obtained using the specifications for the f/4,5 type given in 7.1 to 7.3 shall be referred to as "ISO 5 standard f/4,5 projection transmittance density". In functional notation, this is denoted as D_{τ}(0°, 6,4°; S_{H}: 0°, 6,4°; s).

Density values obtained using the specifications for the f/1,6 type given in 7.1 to 7.3 shall be referred to as "ISO 5 standard f/1,6 projection transmittance density". In functional notation, this is denoted as D_{τ}(0°, 18,2°; S_{H}: 0°, 18,2°; s).

8 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.

NOTE Such CRMs are typically available from the National Institute of Standards and Technology (NIST) in the United States and other national standardizing laboratories.

Annex A
(normative)

Diffusion coefficient

The diffusion coefficient for the diffuse influx mode, β_{dc}, is defined as the ratio of two radiant fluxes, Φ_1 and Φ_2, as shown in Equation (A.1):

$$\beta_{dc} = \frac{\Phi_1}{\Phi_2} = \frac{\int AL_1(\Omega)\cos\Theta d\Omega}{\int AL_2(\Omega)\cos\Theta d\Omega} \quad \text{(A.1)}$$

where

L_1 is the radiance and Φ_1 the total radiant flux of the diffuse illuminator;

L_2 is the radiance and Φ_2 the total radiant flux of a Lambertian source;

A is the area of the diffuse illuminator;

Ω is the solid angle;

Θ is the angle relative to the normal of the surface of the diffuse illuminator (see Figure A.1).

The integration shall be performed over the half sphere. L_1 can vary with the direction, whereas L_2 is a constant. For the purposes of normalization, L_1 and L_2 are taken as equal where $\Theta = 0$.

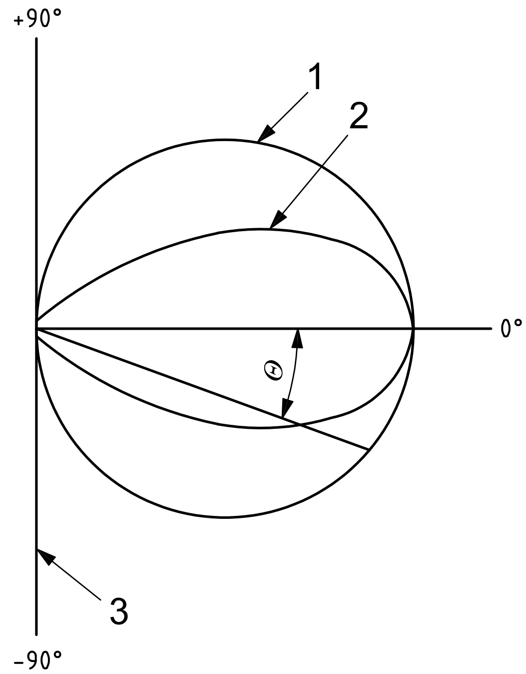
NOTE For simplicity, the formulas are given for the illuminator, but they naturally hold in the same form for a diffuse receiver.

If the radiance, $L_1(\Omega)$, is rotationally symmetrical about the normal (L_2 is symmetrical, by definition), then β_{dc} can be expressed by Equation (A.2):

$$\beta_{dc} = \frac{\int L_1(\Omega)\cos\Theta d\Omega}{\int L_2(\Omega)\cos\Theta d\Omega} = \frac{\int 2\pi\sin\Theta \cdot L_1(\Theta)\cos\Theta d\Theta}{\int 2\pi\sin\Theta \cdot L_2(\Theta)\cos\Theta d\Theta} = \frac{\int L_1(\Theta)\cos\Theta\sin\Theta d\Theta}{L_1(\Theta = 0)\int \cos\Theta\sin\Theta d\Theta} \quad \text{(A.2)}$$

The diffusion coefficient of a system which is rotationally symmetrical about the normal can be obtained by placing the front surface of the diffuse illuminator over the centre of rotation of an arm, upon which is mounted a radiometer. Radiometer readings are recorded at various angles as the arm is rotated from the normal to the 90° marks (see Figure A.2).

To ensure the diffuse illuminator is isotropic about its optical axis (the normal), this procedure should be repeated at a variety of rotational positions of the diffuse illuminator about its optical axis. If the diffuse illuminator is not rotationally symmetrical about its optical axis, the diffusion coefficient shall be calculated by Equation (A.1).



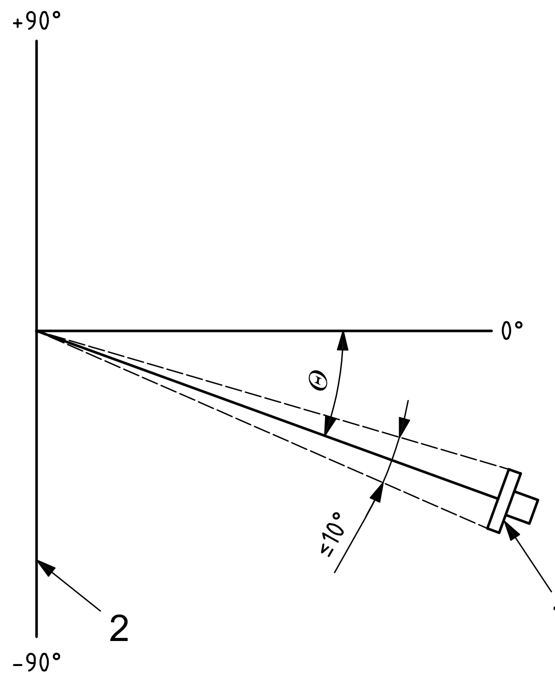
Key

1 perfect diffuse distribution [$L_2(\Theta)\cos\Theta$]

2 imperfect diffuse distribution [$L_1(\Theta)\cos\Theta$]

3 front surface of diffuse illuminating system

Figure A.1 — Geometrical distribution of a diffuse illuminator



Key

1 radiometer

2 front surface of diffuse illuminating system

Figure A.2 — Scheme of the radiometer

The radiometer field of view shall be limited to 10°, and care should be taken to baffle stray light from the system. The measurements are performed with equally spaced angular increments, not exceeding 10°.

The diffusion coefficient shall be measured in the same configuration as used for the measurements of optical density, e.g. with the diaphragm installed.

If the diffusion coefficient is measured in accordance with Figure A.2, the readings $R(\Theta)$ of the receiver are proportional to $L_1(\Theta)\cos\Theta\,\Delta\Omega$, where $\Delta\Omega$ is the solid angle determined by the receiver area. The diffusion coefficient can then be determined by Equation (A.3):

$$\beta_{\mathrm{dc}} = \frac{\sum R(\Theta)\sin\Theta}{R(\Theta=0)\sum\cos\Theta\sin\Theta} \quad \text{(A.3)}$$

In the case of the diffuse efflux mode, a point-like light source is moved on a semicircle around the diffuse receiver and the readings $R(\Theta)$ are taken at angular increments, not exceeding 10°. The diffusion coefficient is calculated using Equation (A.3).

For the determination of the diffusion coefficient, the same spectral conditions shall hold as when measuring optical densities. Not only shall the spectral products be the same, but also the spectral distributions of radiant flux of the illuminator and sensitivity of the detector shall be identical.

Annex B
(normative)

Determining conformance with tolerances

B.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.

B.2 Statement of conformance with specification

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

$$L_{\text{LS}} + |U| < y < L_{\text{US}} - |U| \tag{B.1}$$

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 1 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. $L_{\text{LS}} = 43°$ and $L_{\text{US}} = 47°$. 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°.

EXAMPLE 2 The tolerance stated in this part of ISO 5 for the spectral reflectance factor of the opal is 0,55 ± 0,05, i.e. $L_{\text{LS}} = 0{,}50$ and $L_{\text{US}} = 0{,}60$. Suppose, as an example, that the expanded uncertainty associated with the measurement of the spectral reflectance factor is 0,02 ($k = 2$). Hence, conformance with the specified tolerance is demonstrated if the measured value of the reflectance factor is between 0,52 and 0,58.

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

Annex C
(informative)

Unmatched influx and efflux angles

Although projection transmittance density is a function of both influx and efflux geometries, represented in this part of ISO 5 by half-angles, the measured value varies markedly with changes in the larger of the two, but very little with changes in the smaller. For this reason, either of the half-angles can be reduced by a small amount without affecting the measured density.

Instrument designers can take advantage of this fact and avoid the problem of aligning apertures with identical coverage. If this technique is used, the large half-angle shall meet the requirements of 7.1.

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