International Standard 5/4

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Photography — Density measurements — Part 4: Geometric conditions for reflection density

Photographie — Mesurage des densités — Partie 4: Conditions géométriques pour la densité instrumentale par 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 developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5/4 was developed by Technical Committee ISO/TC 42, *Photography*, and was circulated to the member bodies in December 1982.

It has been approved by the member bodies of the following countries:

Australia	Germany, F.R.	Poland
Belgium	Hungary	United Kingdom
China	Italy	USA
Czechoslovakia	Japan	USSR
France	Netherlands	

No member body expressed disapproval of the document.

Photography — Density measurements — Part 4 : Geometric conditions for reflection density

0 Introduction

This International Standard defines the geometric conditions for reflection density measurements. These conditions correspond approximately to practical situations for viewing reflection-type photographs or graphic reproductions. This calls specifically for illuminating the print at angles between 40 and 50° to the normal to the surface and viewed along the normal. These conditions tend to reduce surface glare and maximize the density range of the image. This is sometimes referred to as annular 45° : 0° (or 0° : 45°) reflection densitometry. Such illuminations and viewing is generally used for critical viewing such as in judging prints submitted for competition or exhibition.

The geometric conditions specified here are intended to simulate 45° illumination for viewing or photographing a sample. There may be some engineering advantages in designing a measuring instrument with normal illumination and 45° collection. Reversing the geometry, in this way, has no known effect on the measured values, so both geometric arrangements are included in this International Standard.

This International Standard specifies illumination at all azimuth angles. These measurements are not sensitive to directional reflections from textured surfaces. It does not cover those situations where light has been deliberately polarized.

Although intended primarily for use in the measurement of the reflection characteristics of processed photographic materials, this International Standard is also applicable to the measurement of these characteristics for other materials.

It is important to recognize that this International Standard specifies that the surface behind the specimen shall be spectrally non-selective, diffuse-reflecting, and has an ISO reflection density above 1,50. Some reflection density standards have generally specified backing materials with much lower reflection density.

The spectral conditions for measuring reflection density are described in Part 3 of this International Standard.

1 Scope and field of application

This part of ISO 5 specifies the geometric conditions for measuring reflection density of photographic materials.

2 References

ISO 5/1, *Photography — Density measurements — Part 1: Terms, symbols, and notations.*[1)]

ISO 5/3, *Photography — Density measurements — Part 3: Spectral conditions.*[2)]

3 Definitions

3.1 reflectance factor (R): The ratio of the measured reflected flux from the specimen, Φ_ϱ, to the measured reflected flux from a perfect-reflecting and perfect-diffusing material, $\Phi_{\varrho A}$, located in place of the specimen.

$$R = \frac{\Phi_\varrho}{\Phi_{\varrho A}}$$

3.2 reflection density (or reflectance factor density[3)]) (D_R): The logarithm to the base 10 of the reciprocal of the reflectance factor, R.

$$D_R = \log_{10} \frac{1}{R} = -\log_{10} R$$

4 ISO standard reflection density

4.1 Influx and efflux geometry

Annular reflection measurements may be made with an annular illuminator and a normal directional receiver, or a normal directional illuminator and an annular receiver. These modes shall be known as the "annular influx mode" and the "annular efflux mode", respectively. The annular influx mode is illustrated in the figure. The annular efflux mode would be illustrated by the figure if the arrows showing flux direction were reversed.

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1) At present at the stage of draft. (Revision of ISO 5-1974 and ISO/DIS 6136.)

2) At present at the stage of draft. (Revision of ISO 5-1974.)

3) The International Commission on Illumination (CIE) proposes to designate the measurement referred to as "reflection density" in this International Standard as "Reflectance Factor Density".

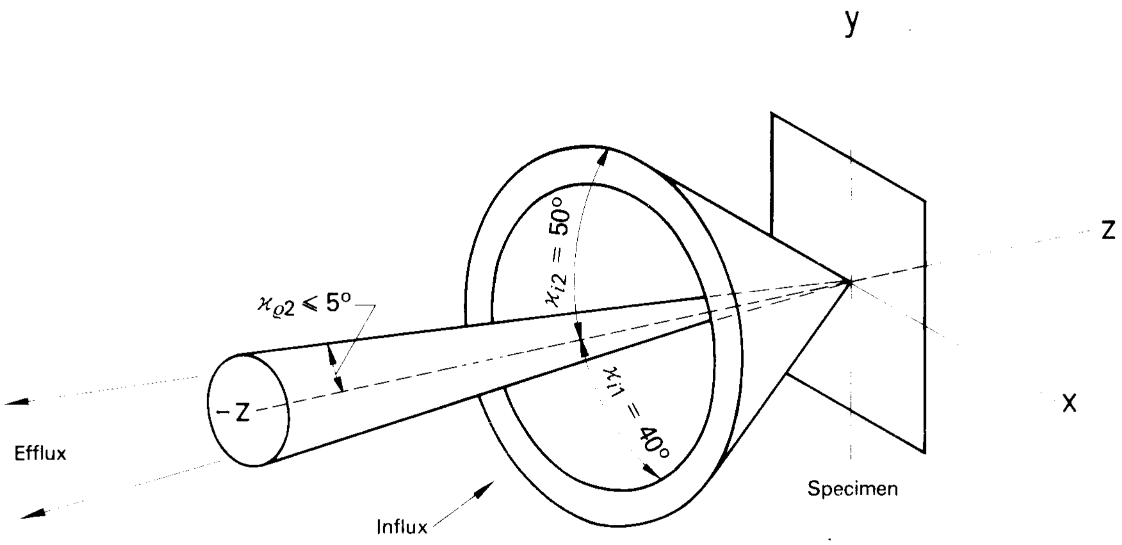

Figure — Geometry of the annular influx mode

These modes can be described geometrically in terms of an annular distribution and a normally directed distribution. The distribution may be a distribution of radiance or a distribution of sensitivity, depending on the mode. The distribution of sensitivity includes the effect of all of the optical components in the receiver.

4.2 Sampling aperture

Geometric aspects of the optical system of an instrument limit the measurement to a well-defined region of the specimen plane, called the "sampling aperture". The sampling aperture shall be determined by the angular field of sensitivity of the receiver. If a mechanical aperture is used in the plane of the specimen, its area shall be greater than the sampling aperture, and its boundary shall lie at least 2 mm beyond the boundary of the sampling aperture.

The sensitivity of the receiver to radiation from each point in the sampling aperture and its surrounding area should ideally be constant from point to point within the sampling aperture and zero at all points in the surrounding area. The sensitivity may be measured by the response of the receiver to a small constant radiant source placed at the different points in the sampling aperture and its surrounding area. This source shall have an area equal to one-tenth of the area of the sampling aperture.

The response for any position of the source in the sampling aperture shall be not less than 90 % of the maximum response. The response for any position of this source in the surrounding area shall be not greater than 0,1 % of the maximum response obtained within the sampling aperture.

The maximum size of the sampling aperture depends on the dimensions of the receiver optical system used for the measurement of the reflectance factor or reflection density. The sampling aperture may be any size for which the angular conditions specified in 4.4 and 4.5 are satisfied for every point in the sampling aperture, but not so small that granularity, specimen texture and diffraction would have to be considered. For non-uniform specimens, the size of the sampling aperture should be specified.

4.3 Irradiated area

The irradiated area of the specimen shall be greater than the sampling aperture, and its boundary shall lie at least 2 mm beyond the boundary of the sampling aperture. Ideally, the irradiance should be uniform over the irradiated area. The variation of the irradiance shall be measured with a photodetector having an aperture similar in shape to, but one quarter the size of, the sampling aperture. The irradiance measured at any point in the irradiated area shall be at least 90 % of the maximum value. Lack of uniformity is immaterial when uniform specimens are measured, but can be an important source of error in measurements on a non-uniform specimen.

4.4 Annular distribution

The angular distribution of influx radiance or the angular distribution of sensitivity shall be at its maximum at 45° to the normal to the sampling aperture at the centre of the sampling aperture and shall be negligible at angles less than 40° or more than 50° to the normal at any point on the sampling aperture. The symbols G_a or κ_{i1} to κ_{i2} are used to represent this annular distribution of the influx in functional notation as described in ISO 5/1.

An influx distribution of this kind may be measured by placing a small aperture in the specimen plane and measuring the flux passing through the aperture in various directions, using a detector of appropriate size and shape at a given distance.

A sensitivity distribution of this kind may be measured by placing a small aperture in the specimen plane, irradiating it with a constant source of appropriate size at a given distance, moving the source about to irradiate the receiver at various angles, and noting the corresponding response.

If the reflection characteristics of the specimen do not depend on the longitudinal angle of illumination or viewing, the distribution need not be uniform around the annulus. However, for some materials, such as those embossed to simulate the surface texture of fabric, the measured density may depend on the longitudinal orientation of the grain of the specimen with respect to the instrument, if the annular illumination or sensing is not uniformly distributed longitudinally. If the specimen is rotated about the z-axis, in its own plane (x, y plane), and there is no change in the measured value, the annular distribution is sufficiently uniform in any longitudinal direction for such a specimen.

4.5 Normal directional distribution

The angular distribution of influx radiance or the angular distribution of sensitivity in the normally directed distribution shall be at its maximum on the normal to the sampling aperture at the centre of the sampling aperture, and shall be negligible at angles of more than 5° from the normal, at any point on the sampling aperture. This distribution may be measured for either mode by the methods described in 4.4.

4.6 Stray flux

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

4.7 Backing material

This International Standard specifies that the specimen shall be in contact with a backing material which is spectrally non-selective and diffuse-reflecting and has an ISO reflection density above 1,50 (see annex A).

4.8 Reference standard

ISO reflection density is determined by using a perfect-reflecting and perfect-diffusing material as a reference standard. Since such a perfect material does not exist, a reference material such as a check plaque or barium sulfate is often used to maintain calibration. The density relation between these and the perfect material shall be known and utilized in determining ISO reflection densities. Densitometer manufacturers and national standardizing laboratories can generally provide the ISO reflection density of such reference materials.

5 Designation

Density values obtained using the specifications given above may be referred to as "ISO standard reflection density" or simply "ISO reflection density". In functional notation they may be denoted as $D_R(40° \text{ to } 50° ; S : 5° ; s)$ or $D_R(5° ; S : 40° \text{ to } 50° ; s)$ where S and s are defined as the spectral characteristics of the influx and the photodetector system respectively.

The adjective defining the spectral condition should be inserted before the word reflection (i.e., ISO visual reflection density).

Annex A

Backing material

(This annex does not form part of this standard.)

It is necessary to specify the characteristics of the material used behind a specimen when determining reflection density to define unequivocally the measurement. For ISO reflection density, the backing material shall be spectrally non-selective, diffuse-reflecting, and have an ISO reflection density above 1,50. This choice was made to reduce reading variability introduced by the backing material. This is important since most specimens are generally not opaque. Problems associated with maintaining the backing surface from the standpoint of spectral, density, and physical requirements are greatly reduced compared to using a low density surface. It also permits the calculation of absorption directly from density readings. This practice also provides density values that correlate well with the way most photographic prints are viewed; i.e., hand held with none of the transmitted light reflected.

It is recognized that this would not generally be the case for prints that are mounted or viewed in albums. Also, in the printing industry, specimens are often viewed by backing them with two layers of the same substrate. There is no reason that ISO densities of a specimen consisting of a combination of an image bearing material along with substrate cannot be read together. However, precautions shall be taken to identify the readings as being from the combination of the image layer and substrate and not the image layer by itself.

Annex B

Reflectance density and reflection density

(This annex does not form part of this standard.)

The need to specify accurately the geometric conditions for measuring either reflectance or reflectance factor cannot be over emphasized.

Reflectance is defined as the ratio of the reflected flux to the incident flux under specific geometric conditions of illumination and viewing.

Reflectance: $\varrho = \dfrac{\Phi_\varrho}{\Phi_i}$

Reflectance density: $D_\varrho = -\log \varrho$

Reflectance can never be greater than one because no surface can reflect more light than is incident.

The reflectance factor is the ratio of the reflected flux from a surface to the flux reflected by a perfect-reflecting and perfect-diffusing material under identical geometric conditions of illumination and viewing.

Reflectance factor: $R = \dfrac{\Phi_\varrho}{\Phi_{\varrho A}}$

Reflection density: $D_R = -\log R$

To illustrate the difference between reflectance and reflectance factor, consider a glossy surface. Such a surface reflects much more light at certain angles than a perfect-reflecting and perfect-diffusing material. Therefore, the reflectance factor can be much greater than one for example when the angle of viewing is the angle of reflection for collimated incident light on a glossy surface.