INTERNATIONAL STANDARD

ISO 5-4

Second edition
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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

Reference number
ISO 5-4:1995(E)

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.

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.

International Standard ISO 5-4 was prepared by Technical Committee ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 5-4:1983), which has been technically revised.

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

— *Part 1: Terms, symbols and notations*

— *Part 2: Geometric conditions for transmission density*

— *Part 3: Spectral conditions*

— *Part 4: Geometric conditions for reflection density*

Annexes A and B of this part of ISO 5 are for information only.

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Introduction

This part of ISO 5 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 viewing 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.

The geometric conditions specified in this part of ISO 5 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 part of ISO 5.

It is important to recognize that, unless otherwise stated in this part of ISO 5, the specimen should be in contact with a backing material which is spectrally non-selective and diffuse-reflecting (no perceptible specular reflection) and has an ISO reflection density of 1,50 ± 0,20. Deviations are allowed only if it can be demonstrated that any other backing gives the same results on the particular type of sample being measured. Determination of such is of course the burden of those reporting such densities.

Measurements used for in-house process control need a commonality based on accepted procedures that are usually specific to the production task at hand. Standards are often useful though not essential for such in-house closed-loop control procedures. Since conditions in general use vary so widely, it is not possible that standards can define each of these application practices.

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Photography — Density measurements —

Part 4:
Geometric conditions for reflection density

1 Scope

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

It 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 part of ISO 5 is also applicable to the measurement of these characteristics for other materials.

This part of ISO 5 serves three primary functions:

a) to aid in the calibration and certification of densitometers, or spectrophotometers used as densitometers, by allowing for the generation of SRMs (Standard Reference Materials) with numerical values traceable to fundamental physical phenomena;

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

c) to provide a referee function to resolve seemingly different measurement data between systems.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5-1:1984, *Photography — Density measurements — Part 1: Terms, symbols and notations.*

ISO 5-3:1984, *Photography — Density measurements — Part 3: Spectral conditions.*

3 Definitions

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

3.1 reflectance factor (R)**:** Ratio of the measured reflected flux from the specimen (Φ_ϱ) to the measured reflected flux from a perfectly reflecting and perfectly 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[1]) (D_R): The logarithm to the base 10 of the reciprocal of the reflectance factor, R. (See annex B.)

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

4 ISO standard reflection density

4.1 Influx and efflux geometry

Reflection measurements shall be made with an annular[2] 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 figure 1. The annular efflux mode would be illustrated by figure 1 if the arrows showing flux direction were reversed and the "Influx" and "Efflux" labels were interchanged.

These modes can be described geometrically in terms of an annular distribution and a normal directional 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 different points in the sampling aperture and its surrounding area. This source shall have an area whose maximum is 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.

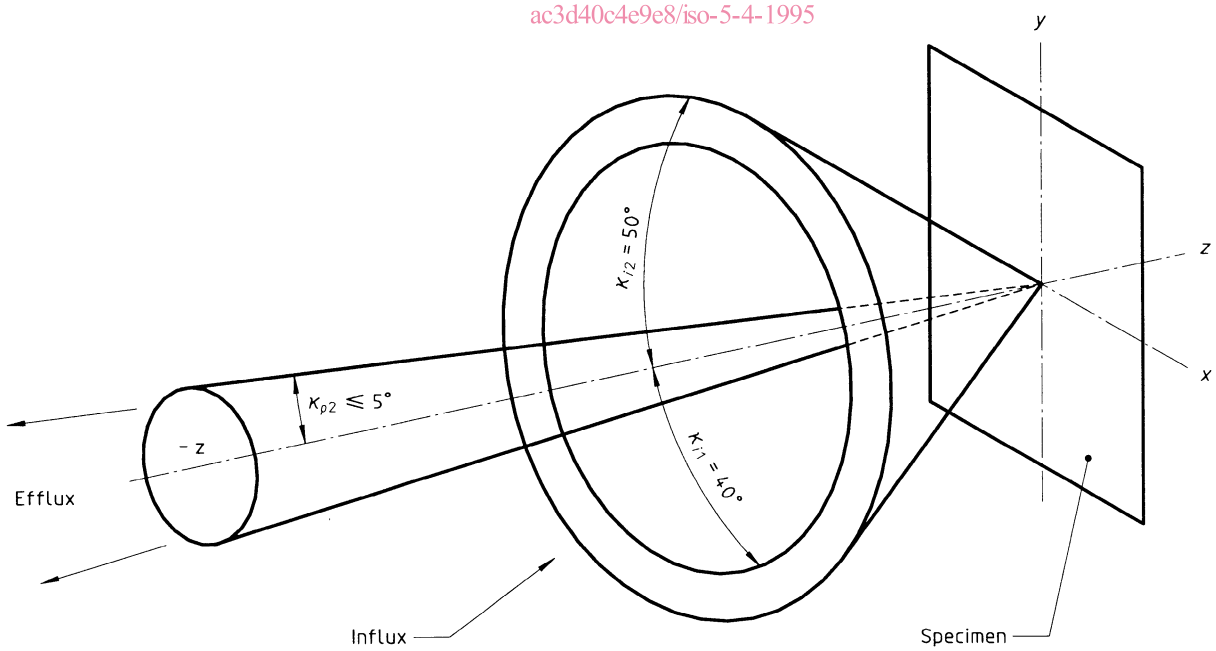

Figure 1 — Geometry of the annular influx mode

1) The International Commission on Illumination (CIE) designates the measurement referred to as "reflection density" in this part of ISO 5 as "reflectance factor density" in CIE Publication 17-4:1987, *International Lighting Vocabulary*.

2) That is, having the form or shape of a ring.

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 not more than 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 distribution of influx radiance or the 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 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 whose acceptance cone angle is no greater than 1° 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 and measuring the flux passing through the aperture in various directions, using a detector of appropriate size and shape 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 change as it is rotated in its own plane, the illumination or sensing 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 upon this orientation if the illumination or sensing is not uniformly distributed about the annulus.

4.5 Normal directional distribution

The distribution of influx radiance or the distribution of sensitivity in the normal directional 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 of surfaces exposed to the specimen in accordance with good photometric practice.

4.7 Backing material

This part of ISO 5 specifies that when reporting ISO standard reflection density the specimen shall be firmly positioned in the measurement plane and in contact with a backing material which is:

a) spectrally non-selective; i.e. the total range of spectral diffuse reflection density throughout the wavelength interval from 400 nm to 700 nm shall not exceed 5 % of the average density obtained over the same interval;

b) diffuse-reflecting; i.e. no perceptible specular reflection when viewed at any angle under typical indoor office room illumination conditions; and

c) have an ISO visual reflection density of 1,50 ± 0,20 (see annex A).

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

NOTE 1 There may be in-house applications where it is desirable to use a "white" backing. When reporting such densities outside of the internal application, the characteristics of spectral neutrality, diffusion, fluorescence and ISO reflection density of the backing should be specified by the user.

4.8 Reference standard

ISO 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 are acceptable for use in maintaining calibration. The density relation between these and the perfect material shall be known and utilized in determining ISO standard reflection densities. Densitometer manufacturers and national standardizing laboratories can generally provide the ISO standard 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° to 50°; S:5°; s) or D_R (5°; S:40° to 50°; s) where S and s are defined as the spectral characteristics of 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). The spectral conditions for measuring reflection density are specified in ISO 5-3.

Annex A
(informative)

Backing materials

A.1 Black backing

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, this part of ISO 5 calls for the backing material to be spectrally non-selective, diffuse-reflecting (no perceptible specular reflection), and have an ISO reflection density of 1,50 ± 0,20. This choice was made to reduce reading variability introduced by the backing material. This is important for metrology purposes as well as process-control purposes, since many specimens used in photography, printing and publishing are generally not totally opaque, and printing or imaging on the reverse of a substrate will affect measurements, sometimes substantially. Problems associated with maintaining the backing surface from the standpoint of spectral neutrality, density and physical requirements are greatly reduced with a high-density backing compared to using a low-density backing. It should be noted that experience has shown that it is very difficult to find a durable matt surface with a density greater than the specification allows. 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.

The impact on the value of measured density resulting from not using black backing materials increases as papers get thinner and their transmission densities (without image) decrease. Initial research by PSI Associates[3)] into this topic indicates that, for graphic art papers, the density difference for a paper sample when measured with white backing and black backing varies in the worst case of a non-image-bearing area from 0,05 for a transmission density of 0,3 to only 0,002 for a transmission density of 1,2. As the density of the image builds up, this difference becomes progressively less severe.

The family of curves in figure A.1 illustrates the two effects with a paper stock whose transmission density, without printed image, is 0,30. The density differences for six different backings are shown as the nominal reflection density of a spectrally neutral image increases from 0,11 to 1,5. The white used for this research was a white ceramic tile with no fluorescence and a reflectance of 89 %; the black backing was the GCA (Graphic Communications Association) BackStop conforming to ANSI/ISO requirements.

To provide practical insight into transmission density values of paper, PSI evaluated several sheets, discovering that thin papers, such as those used for multipart forms or bibles, have a transmission density of 0,30. The transmission density for 20 pound (75 g/m^2) white wove offset is 0,60; for 80 pound (300 g/m^2) coated cardstock it is 0,90, and for 120 pound (450 g/m^2) cardstock it is 1,2. This research indicates as well that photographic papers follow a similar pattern, although have a different curve shape.

Understanding that a black backing minimizes measurement variation, use of the standard black backing is especially important in the following situations.

a) Instrument calibration (note that calibrating targets used in densitometry set-ups should also be backed with the black backing unless the target itself is opaque).

b) Job specification (e.g. printing a job to specified aims) unless a different backing is specified.

c) Industry specification (e.g. printing types of products, such as magazine advertisements, to specified aims) unless a different backing is specified.

d) Communication of measurement values between organizations or physical locations unless a different backing is specified.

3) A testing laboratory in North Greece, New York, USA.